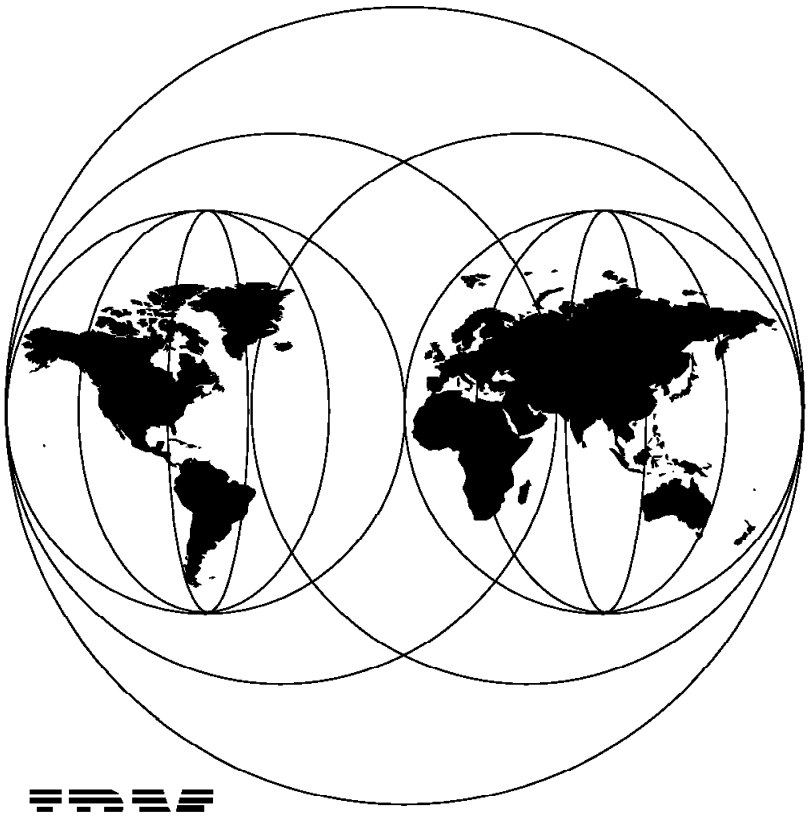
SG24-4586-00

International Technical Support Organization

Object REXX for OS/2
Rexx Bytes Objects Now
or
Taking the ″Oh, oh!″ out of OO

September 1996



IBM
International Technical Support Organization
San Jose Center

SG24-4586-00

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Take Note!

Before using this information and the product it supports, be sure to read the general information under “Special Notices” on page xix.

First Edition (September 1996)

This edition applies to Object REXX for use with OS/2 Warp.

Notice

This book is now available from Prentice Hall under ISBN number 0-13-273467-2. It can also be ordered from IBM under the number SG24-4586-00. The book is accompangied by a CD containing Object REXX and all the sample programs.

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Abstract

Object orientation (OO) is a topic of great interest and concern today. Some developers who use OO claim that it significantly increases productivity; others view it as good for rocket science, not for business.

Many OO languages seem complicated and alien to programmers familiar with procedural languages such as COBOL. This book introduces Object REXX, a new OO language that breaks the OO barrier. Object REXX is based on a tried and trusted language used around the world today. Because it has the most complete and easy-to-use set of OO features of any language, it offers a simple way for programmers with a procedural background to enter the new world of objects. Object REXX also supports distributed objects written in many other languages through Common Object Request Broker Architecture (CORBA) technologies, such as IBM′s System Object Model (SOM).

This book demonstrates a practical approach to using Object REXX and OO techniques to develop commercial systems to meet changing business requirements. It tells the story of how Hanna, Steve, and Curt design and implement a commercial application system step-by-step using object persistence in file systems and relational databases, GUI builders, existing SOM-based objects, the OS/2 Workplace Shell, and Internet Web pages. Extensive code examples are provided to illustrate every step.

To Hanna, Curt, and Steve, the hard-working people at the fictitious Hacurs company. Originally loosely defined, they inspired the writing of real-life dialog to portray a small company trying to find a niche in the marketplace. Any resemblance to real people is completely coincidental.

To my wife Ingrid, for the love and patience that she showed while her husband labored over recalcitrant programs and screeds of text.

Trevor

To my wife, Patricia, for her ongoing support and understanding of long hours at work. To the staff at the ITSO-San Jose center for making work a joy, at least most of the time.

Ueli

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Special Notices

This publication is intended to help programmers use the new Object REXX language to create object-oriented applications. The information in this publication is not intended as the specification of any programming interfaces that are provided by Object REXX for OS/2 Warp. See the PUBLICATIONS section of the IBM Programming Announcement for OS/2 Warp Version 3.x for more information about what publications are considered to be product documentation.

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Preface

In this book we describe the new object-oriented language, Object REXX. We list all the incremental improvements that Object REXX offers over and above classic REXX and describe the object-oriented features that Object REXX includes. To illustrate its capabilities we develop some fairly large applications.

REXX has long had great strengths in the area of linking to other programs and services. Here we demonstrate Object REXX′s ability to link to DB2/2 Version 2 to carry out sophisticated binary-large-object (BLOB) handling as well as conventional record processing.

The number of OO applications alive and running is growing around the world. There is increasing demand to allow these objects to communicate with one another, even if they are written in different languages and run on different computers. The Common Object Request Broker Architecture (CORBA) standards specify a way in which this can be done. The number of implementations of CORBA by various vendors is burgeoning. IBM′s version is the System Object Model (SOM). We show that it is easy for the Object REXX programmer to access and use SOM objects.

Object REXX also includes powerful facilities for concurrent programming. We show a graphical user interface (GUI) that exploits Object REXX′s concurrent programming facilities.

Detailed syntax diagrams covering all the new and changed features of Object REXX are included, with brief descriptions.

This book is intended for programmers who know and love REXX and would like to learn what the new facilities in Object REXX look like, and the kinds of problems they can solve. It contains lots of sample code, which we hope will provide a useful starting point for new projects. Programmers who currently use REXX to build large and complex systems will be well aware of its limitations in terms of splitting large programs into smaller, manageable components. Object REXX has excellent facilities that allow and encourage this process. We describe them and illustrate their use.

This book is also for programmers who would like to start learning and using OO techniques, but who do not have access to an OO language and compiler; or who *do* have access to one, but find it too complicated and alien to really get into. REXX is above all an accessible language. It is simple, obvious, and unintimidating, and Object REXX provides an easy entry into the world of objects.

How This Document Is Organized

The document is organized as follows:

- Part 1, “Introducing Object REXX”

  Part 1 is an overview of the object-oriented (OO) facilities of Object REXX. It is also a description of why OO in general, and Object REXX in particular, are such valuable and important technologies.

- Chapter 1, “Introducing Object REXX”

  In this chapter we introduce Object REXX and describe why OO is important.

- Chapter 2, “How Does Object REXX Implement OO?”

  In this chapter we describe how Object REXX implements OO through objects, classes, and methods, including support for inheritance and polymorphism. It also touches the Object REXX-provided class library.

• Part 2, “The Car Dealer Scenario”

  In part 2 we illustrate a broad range of Object REXX′s facilities by describing the way that a hypothetical software company might use them to design and implement a fairly realistic application for various car dealers.

- Chapter 3, “The Car Dealer Application”

  In this chapter we introduce the hypothetical software company Hacurs. We describe the car dealer application that Hacurs wants to develop, and the process that Hacurs goes through to design the system using OO techniques. It presents the Object REXX facilities that Hacurs decides to use in support of the implementation. Extracts of source code are included for illustrative purposes, while comprehensive source listings are included in Appendix A, “Car Dealer Source Code” on page 243.

- Chapter 4, “ASCII User Interface”

  In this chapter we describe how Hacurs designs and builds Object REXX classes and methods to implement a simple ASCII character-oriented user interface for the system. The company builds one class to manage the display of information on the user′s screen, and another to store, display, and interpret the many menus the system requires. Anticipating the need for a future GUI interface, Hacurs uses OO design principles to isolate the application code from the user-interface code.

- Chapter 5, “Persistent Objects on Disk”

  In the base car dealer system, all updates to objects are lost when the application terminates. In this chapter, Hacurs designs and builds Object REXX classes and methods to add persistent storage behavior to the objects within the system. The object data is stored in flat ASCII files.

- Chapter 6, “Graphical User Interfaces”

  Chasing a new opportunity to sell its car dealer application, Hacurs builds and implements a GUI interface to it. The initial GUI package the company uses is Dr. Dialog; then VisPro/REXX and Watcom VX·REXX alternatives are added. The problems that arise when Object REXX class and method definitions are included in the code generated by these GUI builders are resolved.

- Chapter 7, “Persistent Objects in DB2”

  Seeing yet another opportunity to market the application, Hacurs develops new classes that give objects persistent storage in a DB2 database. The new methods can support large volumes of data by selectively loading only when needed and caching frequently used data in storage as objects.

- Chapter 8, “Using Advanced DB2/2 Facilities”

  Hacurs further extends the car dealer application by adding multimedia facilities. The code makes use of the powerful new BLOB handling facilities of DB2/2 Version 2 to store and retrieve the multimedia data. Audio, bit maps, and video facilities are incorporated.

- Chapter 9, “Data Security with Object REXX and DB2”

A serious concern that arises over the security of DB2/2 data accessed by dynamic SQL from client PCs is resolved by developing code that exploits DB2/2 Version 2′s stored procedure mechanism.

- Chapter 10, “Configuration Management with Object REXX”

  A proliferation of different versions of the code required to meet different customers′ needs threatens to get out of hand and result in a big code-maintenance burden. Hacurs develops a sophisticated system for managing many different code configurations within a multiple subdirectory structure, using different configuration files to pull the right pieces together. This allows common code to be reused without being cloned.

  Hacurs develops a GUI Object REXX program that allows users to select the application configuration they need, and installs it.

- Chapter 11, “Object REXX, SOM, and Workplace Shell”

  Still another marketing opportunity arises, but to win the business, Hacurs needs to interface the car dealer Object REXX code to SOM objects. Hacurs develops a simple SOM object in C++ and modifies the Object REXX code to import and use this SOM object.

  The OS/2 Workplace Shell (WPS) is SOM-enabled and can thus be accessed directly from Object REXX code by importing the WPS SOM classes. Hacurs experiments with this facility to build displays of car dealer objects in WPS folders on the desktop. This stimulates thinking about building objects in Object REXX that can be assembled with commodity objects for new applications.

- Chapter 12, “Object REXX and the World Wide Web”

  Hacurs decides to advertise its car dealer application on the World Wide Web, often called the Internet. It installs a Web server and creates a simplified version of the application to present car dealer data as Web pages. It uses the Common Gateway Interface (CGI) to invoke Object REXX programs from the Web server. The Object REXX programs dynamically create Web pages with the information from the database.

  Any Web browser can point to the Hacurs server and interact with the car dealer application. An extension of the application even enables a Web browser user to add a car to the database and create a work order.

- Part 3, “Object REXX and Concurrency”

  - Chapter 13, “Object REXX and Concurrency”

    In this part we describe the concurrent-processing facilities of Object REXX. After a short introduction, we solve with Object REXX the problem of the dining philosophers, a classic illustration of concurrent processing. The code to build a GUI application illustrating five philosophers sitting down to dine is developed and discussed. GUIs are developed in Dr. Dialog, VisPro/REXX, and Watcom VX·REXX.

- Part 4, “Installing the Sample Applications”

  - Chapter 14, “Installing and Running the Sample Applications”

    In this part we describe how to install both sample applications, the car dealer and the dining philosophers. Installation of the code and the setup for DB2 are explained in detail, including instructions on how to run the examples.

- Part 5, “New Features and Syntax in Object REXX”

  - Chapter 15, “New Features in Object REXX and Migration”

    This part contains a comprehensive set of syntax diagrams that show the new instructions, functions, classes, and methods that are a part of Object REXX, as well

as the extensions made to REXX. The syntax diagrams are accompanied by explanatory text.

Differences between REXX and Object REXX are explained in a small migration section.

- Appendixes

  The appendixes contain the source listings of the car dealer application and instructions on how to read the syntax diagrams.

Related Publications

The publications listed in this section are considered particularly suitable for a more detailed discussion of the topics covered in this document.

- *Object REXX Reference for OS/2*, G25H-7598
- *Object REXX Programming Guide for OS/2*, G25H-7597

The two books listed above are not orderable yet but are available on OS2TOOLS in the OBJREXX PACKAGE.

- *Client/Server Programming with OS/2 2.1*, by Robert Orfali and Dan Harkey, published by John Wiley & Sons, Inc., 1993, G325-0650-02, ISBN 0-471-13153-9.
- *The Essential Client/Server Survival Guide*, by Robert Orfali, Dan Harkey, and Jeri Edwards, published by John Wiley & Sons, Inc., 1994, SR28-5572-00, ISBN 0-471-13119-9.
- *The Essential Distributed Objects Survival Guide*, by Robert Orfali, Dan Harkey, and Jeri Edwards, published by John Wiley & Sons, Inc., 1995, SR28-5898-00, ISBN 0-471-12993-3.

International Technical Support Organization Publications

- *OS/2 REXX: From Bark to Byte*, GG24-4199
- *Object-Oriented Databases, ObjectStore, Introduction and Sample Application*, GG24-4128

  (This book is based on the same car dealer application that we use in our book.)

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```
http://www.redbooks.ibm.com/redbooks
```

IBM employees may access LIST3820s of redbooks as well. Point your web browser to the IBM Redbooks home page:

```
http://w3.itso.ibm.com/redbooks/redbooks.html
```

ITSO Redbooks and Sample Code on the Internet

If you do not have World Wide Web access, you can obtain the list of all current redbooks through the Internet by anonymous FTP:

```
ftp ftp.almaden.ibm.com
cd /redbooks
get itsopub.txt
```

This FTP server also stores the sample code developed for this redbook. To retrieve the sample files, issue the following commands from the *redbooks* directory:

```
lcd d:\carinst   <=== any local directory for the installation files
binary
cd SG244586
mget *.*
```

For IBM people without access to the external FTP server the code is also available as OREXXRED PACKAGE on the OS2TOOLS conference disk.

To install the sample code follow the directions in Chapter 14, “Installing and Running the Sample Applications” on page 203.

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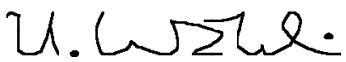
Acknowledgments

This book would not have been possible without the help of the following people who contributed to the content of the book:

- Eddie Griborn from IBM Sweden ported the Philosopher′s Forks application to VisPro/REXX and Watcom VX·REXX, and wrote about the concurrency and new features of Object REXX.
- Norio Furukawa from IBM Japan coded the implementation of persistence objects on disk and ported the car dealer GUI application to VisPro/REXX and Watcom VX·REXX.

Many thanks to Maggie Cutler for editing the book and making the dialog interesting. Thanks also to Jens Tiedemann, manager of the ITSO-San Jose, for the investment of resources into the Object REXX projects on OS/2 and Windows NT and 95.



Ueli Wahli

Part 1. Introducing Object REXX

Chapter 1. Introducing Object REXX

OS/2 Warp Version 4 contains a new implementation of the system procedures language, REXX. Apart from numerous detailed improvements, this version of REXX includes a full set of object-oriented (OO) facilities. It is now called Object REXX. This chapter outlines some of the good things that have been added to REXX with the OO version of the language.

Object REXX is available first in OS/2 for Intel processors, next in Windows NT and Windows 95, and possibly other operating systems and platforms in the future.

What's New in Object REXX?

Object REXX has many important new facilities; indeed it is almost a new language. Chapter 15, "New Features in Object REXX and Migration" on page 223 describes these in detail, and Chapter 2, "How Does Object REXX Implement OO?" on page 13 contains an overview of how Object REXX has implemented its OO facilities. The concurrency capabilities of Object REXX are described in Chapter 13, "Object REXX and Concurrency" on page 181.

But here are a few of the highlights. Object REXX has:

- A full set of object-oriented facilities
- Direct access to System Object Model (SOM) objects under OS/2
- Concurrency—the ability to do several things at once
- Improved ability to create subroutines with private variables
- Ability to embed source files using the *requires* command
- Ability to handle the error conditions that might arise in a called subroutine
- A *do over* command that visits every variable defined on a stem
- A *parse* command that has more case-handling options
- A *signal* command that can handle five new conditions

Object REXX has been designed to be upward-compatible with the previous versions of REXX. With a few minor exceptions described in "Migration Considerations" on page 242, all existing REXX programs should run under Object REXX with no change.

Despite its upward compatibility with prior versions, however, Object REXX is radically different from its predecessors. In classic REXX, every variable that the programmer created is conceptually a character string—even numbers appear to be stored this way. We say "conceptually" because under the covers, REXX implementations are at liberty to store numbers either in integer or floating-point format, just so long as they are always presented in string format when the programmer asks to see them. Since humans represent both numbers and text in string format when they communicate with one another, why shouldn't they continue to do so when talking to computers? This makes programming in classic REXX very simple and intuitive.

In Object REXX, every variable now refers to an object! String objects still behave just as they have always done in classic REXX, and arithmetic can still be performed on strings that happen to contain numeric values. But Object REXX introduces a number of new object

types, and includes facilities for programmers to create even more of their own. We will be looking at these in some detail later. So while the internals have changed a great deal, Object REXX still behaves very much the same as classic REXX used to—if you ask it to do the same things.

Perhaps we should mark the end of classic REXX′s reign and the start of Object REXX′s with the proclamation that traditionally greets the death of a monarch and the automatic and immediate succession of his heir:

“The King is dead! Long live the King!”

Why REXX?

The REXX language is only about 15 years old but is already very widely used on IBM operating systems. The first version ran under VM/CMS only, but since then IBM has made REXX a standard component of the following operating systems:

- VM/ESA
- MVS/ESA
- OS/400
- OS/2
- PC DOS Version 7
- AIX (as a PRPQ)
- Netware (as a PRPQ)

Other vendors have developed REXX interpreters for various other operating systems. And many vendors have developed packages that are coded in REXX and/or generate REXX programs automatically. Some examples of these packages, each of which is a GUI builder and execution environment for REXX, are:

- VisPro/REXX
- Watcom VX·REXX
- Dr. Dialog

The thing that makes REXX so popular is that it is very easy to learn, and REXX code is easy to read and understand—compared to most other computer languages, that is! The language is *interpretive* in style, which means that there is no requirement to pass the source code through a compiler or linker before executing it. REXX programmers can change their code and test the changes immediately. The other great advantage to programmers is that REXX is nondeclarative. Programmers do not have to tell REXX how to store the variables they create. Conventional compiled languages such as COBOL and C do require declarations of this sort, and this roughly doubles the number of lines of code that have to be developed.

Even if we ignore the OO features that Object REXX contains, this new version of the language contains a number of significant improvements that make REXX easier to use and capable of producing more robust code.

Why Object Orientation?

Object orientation is the flavor of the year, perhaps the decade. Most new language announcements that hit the press include the magic OO phrase, even if the applicability of OO to the product in question is sometimes unclear. Old languages such as C, COBOL, and Pascal have been extended to include OO features. Is OO a silver bullet that will solve all our programming problems, or is it just a fad?

The computer language that introduced OO concepts to the world is Smalltalk. This was originally designed in the 1970s as part of an experiment to see whether children could learn to use computers. We now know that the answer to that question is a resounding "yes!" (It is less clear, however, whether their parents can do likewise.) Smalltalk underwent significant change, but by 1980 it had the features that are indelibly associated with OO today:

- Objects grouped in classes
- Inheritance
- Polymorphism

These concepts are described in Chapter 2, "How Does Object REXX Implement OO?" on page 13. But before we get into the nuts and bolts of how OO works, we should spend some time discussing the question of whether OO is worth doing at all.

The Productivity Problem

A clinical discussion of OO features does very little to explain *why* they are valuable. There is much talk today of the need for programmers who have been trained in conventional procedural languages such as COBOL to undergo a paradigm shift before they can start to understand and exploit the benefits that OO has to offer.

The benefits claimed for OO design and programming include much greater reuse of code as well as simpler programs, easier to understand and modify. Electronic computers have been around for about 50 years. Programmer productivity has improved radically over this time. But even so, the biggest inhibitor to the more extensive use of computers remains our inability to produce good, reliable code quickly enough to meet our users′ needs. The tools and techniques that we use today to develop computer applications are still very labor-intensive when compared to those in other industries. Most people have heard the proud boast of the computer hardware industry:

> If the airline industry had been able to improve its technology as rapidly as has the computer hardware industry, today′s airliner would be able to fly anywhere in the world in half an hour, carry 10,000 passengers, at a cost of $1.

Sounds impressive. Unfortunately, we in the computer software industry do not have nearly as much to boast about. It has been said that

> If the airline industry had improved its technology at the same rate as has the computer software industry, today′s airliner would be built from parts on the runway by the crew each time it flew, fueled with the finest Scotch whiskey, and used to haul garbage.

Things are not really that bad in the software industry. Our technology has advanced rapidly and consistently since the advent of computers, at a rate that is impressive when measured against any criterion except one—our users′ needs. The biggest problem facing software developers is that computer hardware keeps getting cheaper and faster all the time. Applications that were technically possible but completely unaffordable 10 years ago are more than just affordable today; they are compulsory if a business is to compete in the current market.

Fortunately, there is a vast and rapidly growing number of off-the-shelf computer packages. Smaller businesses can often meet all their application needs from these packages. Larger businesses also make extensive use of packages but often need to supplement them with applications that support their core business. In many cases, a company's core computer applications give it the competitive edge that enables it to grow and prosper.

The Reuse Solution

To summarize the previous section: there are not enough programmers and there is not enough time to hand-craft all the code required to meet our users' needs. The challenge is to deliver much more function, much more quickly. The only way out of the dilemma is not to try to develop all the code we need but instead to reuse existing code.

Programmers have been reusing code for a very long time. Early operating systems included subroutines to handle the complexities of driving I/O devices, and early languages such as Fortran (first built in 1957) included extensive libraries of subroutines that implemented the complex algorithms needed to calculate trig functions and logs. Most languages allow programmers to develop their own subroutine libraries to handle common requirements, and most IT departments make use of these facilities (every installation has at least one date-handling subroutine, for example).

So if we already practice code reuse, what is so special about OO? Properly used, OO allows us to change the way we design and code applications, but to do so we must make a fundamental shift from the *procedural* to the *object-oriented* approach. Changing from procedural to object-oriented application design can be difficult. The experiments in teaching children to use Smalltalk referred to in "Why Object Orientation?" on page 5 showed that children can learn and use OO concepts quite easily, but for those of us who have been conditioned to design and code with procedural languages, the change to OO requires some unlearning.

Let us try to illustrate the differences between classic procedural design and OO design.

The Waterfall Method

Procedural design has converged on a process called the waterfall method. This consists of a series of steps. Each step should in theory be completed before the next is started. The steps are:

- Gather the business requirements
- Analyze the requirements
- Produce a high-level design
- Produce detailed specifications
- Code and unit test the specified modules
- System test the modules together

It has long been known that this approach has a serious drawback inasmuch as the users have to express their needs fully and formally on paper and then wait 6 to 18 months before they get to see what the IT specialists thought they wanted. It is, in fact, very difficult for anyone to envisage an IT solution to a business need using just paper specs. Usually the system has to be modified once the users understand how it works. But the limitations of procedural languages strongly encourage this approach, and it is the norm.

The Spiral Method

OO tools can be used with the waterfall technique, but a more common approach is the *spiral* method. In this, IT specialists and the users plan to go through the design and implementation phases many times over before the project is complete. The analysts work with the users to identify the various business procedures they need to automate. They then work through the details of each procedure and document them in what is generally called a *use case*. Next the coders build a small and simple prototype that implements the user interface plus just enough logic behind that to make the interface behave as expected. There are no databases or even data models at this stage. The IT specialist and the users then work through the use case with the prototype. The users get an early idea of how the proposed system will help or hinder them in the execution of their responsibilities. They tend to become very involved and excited and then identify changes and new features that they need. It is also easier to see which features deserve a lower priority.

On the basis of this feedback, the designers revise their use cases and designs, and the coders modify the prototypes to implement the new behavior. The users work with the new prototypes and identify more changes. The whole process repeats several times, and then the final version is fleshed out into a robust and reliable application and delivered to the users. Experience shows that applications designed in this way fit the users′ real needs far better than is normally achieved with the waterfall approach.

Prototyping

Prototyping is not a new concept. The idea has been around for a long time. The problem has always been that the classic procedural languages such as COBOL, PL/I, C, and Assembler are not wellsuited to developing prototypes. It takes too long to build a prototype, and once developed, the investment in the prototype code is so large that the programmers cannot afford to abandon it. It is very hard to make extensive design changes to procedural code, so the first prototype often ends up being the final product, regardless of how well it fits the users′ needs. Further problems arise when several independently prototyped components must be integrated to form the complete application. They often do not fit together, and extensive changes may be required. It is exactly because of these problems that the waterfall method was developed. The users and analysts are required to anticipate every code module that will be required and ensure that all the components will fit together. Many experienced users view this as a shrewd maneuver on the part of the IT department, designed to shift the blame for humanity′s inability to predict the future from the shoulders of the IT department to those of the users.

Object-oriented languages enable programmers to take a very different approach to building prototypes. Experience shows that OO prototypes are easier to modify and extend and can be changed to meet the users′ changing perceptions of what they really need. While the parts of the overall application may be developed independently of each other, OO languages allow these different components to be integrated, forming a working whole with little disruption to any of the parts. The transition from prototype to production code is a smooth process with few ugly surprises.

The Paradigm Shift

The fundamental difference between procedural and OO designs arises from the fact that procedural languages cannot be extended. Every procedural language programmer can use only those features that were built into the procedural language by the vendor that supplies it. The programmer cannot add new commands or data types to the language, no matter how much these may be needed in a given situation.

OO languages on the other hand *are extensible*. Designers and programmers can add new data types to the OO language to meet their unique business needs. These are called *objects*. They can add new operations called *methods* to the OO language to manipulate

existing or new data types. New objects can be built on top of existing data types within the OO language and on top of other objects that the programmers have already defined.

If, for example, OO COBOL had been available 20 years ago, life would have been much simpler for the software vendors who introduced major new database management systems (DBMSs) at that time. They could have extended COBOL′s capabilities to include support for their DBMSs by developing new class libraries. Lacking this ability, many chose to create completely new computer languages called 4GLs, to allow easy access to the features of their DBMSs. A new computer language is a major investment for the vendor that builds it, the programmers who learn to use it, and especially the companies that accumulate legacy code in it.

Procedural languages force the designer and programmer to follow a process known as "stepwise refinement." The designer first specifies a business requirement at a high level. There are no features in the procedural language that can directly implement the objects described in this design, nor the actions which must be performed on them. So then the designer must break each object down into a collection of simpler objects, and each action down into a series of simpler steps. This process has to be repeated until at last the objects are so simple that they can be directly represented in the primitive data types supported by the procedural language, and the actions can be equated to the primitive operations implemented by the procedural language. The entire stepwise refinement procedure takes place on paper, not in code. Only the final step in the process is captured as code and appears in the application. All prior steps in the process are captured on paper and are not delivered as part of the running application.

Suppose we compare the design and coding of an application in a procedural language to the growth of a tree. The high-level design would correspond to the trunk and major branches of the tree. The detailed designs would correspond to its smaller branches, spreading out into twigs. The actual code would correspond to its leaves. When the application is handed over to the maintenance programmers, they regard the code as the most important thing they get. The design documents usually do not correspond exactly to the code, because the users ask for changes late in the implementation process, and changing the design document is usually low on everyone′s priority list. As time goes by and the application undergoes maintenance, the design documents are seldom updated. After a while they are so far out of step with the code that they are useless, and ignored.

To go back to our tree analogy, the maintenance programmers can now see only the leaves, not the branches or twigs that used to join them all together. From the outside (the users′ view) it still looks and behaves like a tree—for a while, but from the inside it becomes increasingly difficult to see how the whole thing hangs together.

Is this gradual loss of visibility and understanding of the program′s structure important? Yes it is, vitally so. Every program has an invisible component which we can call the *flow of control*. It′s the way the computer sees the program when it executes. And this is the most important view of the program, because it determines absolutely what the program does, regardless of what the programmers think it should do. Well-structured programs help the programmer to see what the flow of control will be, and hence what the program will do. Most programs are not well structured—not so much because what they contain is badly structured, but because of what they do *not* contain—the tree′s trunk, branches, and twigs, to return to our analogy. Maintenance changes start to have unexpected side effects. Someone saws off a branch without knowing what leaves it supports, someone bends a branch to support new leaves and cuts off the flow of sap to some other leaves inadvertently. After a while the tree no longer looks anything like a tree from the inside—it looks like a bowl of spaghetti. Then it is time to throw the whole thing out and start again from scratch. And that is a waste of time and money.

Suppose now we compare the design and coding of an application in an OO language to the growth of a tree. Once again, the design would correspond to the trunk and branches of the tree. But this time the components of the design *can and should* be written into the code of the final application, rather than written on paper and then discarded. Because OO languages are extensible, the objects and actions described in the design can be written

directly into code. If the design speaks of customers ordering, taking delivery, and paying for products, then the programmers should create new object types called customers and products and methods that allow product objects to be ordered, delivered, and paid for by customer objects. The high-level program logic can then reflect the high-level design because it talks about exactly the same objects and actions (methods) as does the design document.[1]

In essence, we can turn the design and coding process on its head when we build OO applications. Instead of proceeding with stepwise refinement from a high-level design through successively lower-level, paper-based designs until we get down to the level of the procedural language and then writing the code, we can start by writing the design in code as if all the objects and actions it requires were already part of our target language. Then we use the language's OO facilities to *define* what these objects are, and how they behave. As we define these objects and their behavior, we often find that there is still a gap between the level of abstraction at which we are working and the built-in features of our language. Once again, we boldly code our new definitions in terms of lower-level objects and actions *as if they already existed*.[2] We will come back later and define these lower-level objects and actions and continue in this way until at last all the objects and actions we need are actually present in the OO language we are using.

But please note the use of the word *can* in the preceding paragraph. It is unfortunately quite possible for programmers trained in procedural languages to ignore the capabilities of OO languages to preserve design, and to use OO in exactly the same way that they previously used COBOL or C to produce the low-level code only. Proper training and motivation are required if the transition to OO is to be fruitful.

Better Reuse from the OO Approach

The way we design and build applications using OO languages should therefore be very different from the way we build them using procedural languages. This change is the biggest one that procedural programmers and analysts must make when moving to OO. Why do we do it this way? What are the benefits?

- The biggest long-term benefit is that most of the application's design is encapsulated in its code. It cannot be discarded or ignored. All changes to the application automatically update the detailed design document, because it is a living part of the code. This makes long-term maintenance of the application easier and more accurate.
- Much of the application logic is written in terms of high-level objects that correspond directly to the objects with which the users work. Programmers and users can speak

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[1] People with experience of real-life application construction may at this stage be throwing up their hands in horror. Building new applications tends to generate a huge volume of paper, usually referred to as "The Documentation." We do not suggest that a 1,000-page mound of paper be shovelled into the code. Most of the documentation exists to explain, criticize, measure, report, and mend the design. Entity-relationship diagrams, data-flow diagrams, action diagrams, and their ilk are a good way of representing design concepts graphically. Gantt charts are a good way of representing plans and progress graphically. All these things generate an amazing amount of paper, which is often pasted up on the walls to show the users how productive the designers have been. But they are not the design. It is our belief that a well-structured OO program that contains its own design will be no bigger than the equivalent program coded with no embedded design in a procedural language. The OO programmers will write much of their logic at a high level against smart objects, while procedural languages constrain us to write all our logic at a low level against dumb objects.

[2] We are not suggesting that we should embark on the design and implementation of a major system without careful analysis and planning. If we simply write a program as thoughts pop into our heads, the results will be as poor with OO languages as they are with procedural ones. We will get "stream of consciousness" programs, or what we might call Kerouac code. It may make for entertaining reading, but trying to make it work correctly will be much less fun. Good methods and tools are available to help the OO analyst identify the objects and methods that should form the basis of a new system. But in this section we are trying to identify what is *different* about OO analysis and design, not what is the same.

the same language, because they are speaking about the same objects and actions (methods).

- Less code needs to be written, because it deals with high-level smart objects, such as products, that can do complex things like get ordered by customers, rather than dumb objects, such as integers, that can only do simple things like arithmetic.
- Objects like customers have their data and associated actions (methods) neatly packaged together in OO language definitions. It becomes much easier to locate and reuse customer objects and their associated behavior in other applications.
- When programmers reuse an object, they do not need to know how it works internally. The author of the object can carry out maintenance on it to add new data or functions without impacting any of the programs in which this object is used.
- OO languages all come with an extensive library of built-in classes, which can be used to define new objects. These inherit a wealth of high-level function. Much of the tedious low-level coding required to build an application can be eliminated by making use of these class libraries.

Communities of Cooperative Objects

In dealing with the benefits of OO, we have so far restricted ourselves to those that are currently being enjoyed and reported by installations that have made the switch. But there is a sea change taking place right now in how objects will be exploited in the future, and it is going to affect all of us.

Bloated PC Software

It is a well-known fact that shrink-wrap applications are getting bigger and better every year—with most of the emphasis falling on *bigger*. Ten years ago, the most sophisticated spreadsheet package came on a single floppy. Now it takes a diskette caddy to load the simplest. Have our needs changed that much over the past 10 years? Has life really become 10 times more complex? Why is shrinkwrap software so bloated? It costs the vendors a fortune to build applications of this size and complexity, so you can be sure they are not doing it for fun. And it is a fact of life with software, the bigger, the buggier.

Ten years ago, PC enthusiasts used to sneer at the “big, clumsy, slow” programs that ran on mainframes and rejoice in their tiny, nippy applications. They have stopped talking about it. Many are watching what is happening in numb silence.

PC software is suffering from “creeping featureritis.” One vendor puts in a great new feature, all the competitors put it in too. Plus a few more unique features of their own. More bullets on the side of the shrinkwrap box. More check-boxes in the endless assessments that PC software magazines run. More entries in the already crowded menu bar. More chapters in the phonebook-sized product manual. More days on the education program. More space on the hard drive. More RAM tied up. More bucks on the bill. Where is it all going? Is this trip really necessary? Most of us use only a small fraction of the features of the PC software we run.

Standard Software Components

There is another way, and it is based on the notion of building software from a host of standard, reusable components. We touch on this in “The Productivity Problem” on page 5 with those not-so-funny comparisons between the IT and airline industries. When hardware engineers want to build a system, they pick standard parts out of a catalog and wire them together. Little or none of the componentry that they need has to be invented on the fly. The parts are highly standardized and uniform in their behavior, and there are few surprises when they are clicked together. Generally, the new system works.

Software engineering is light-years away from this model. The way we hand-craft code today is reminiscent of the way our ancestors used to manufacture[3] products before the industrial revolution. Programming is still in the "cottage industry" phase of development.

Liberating Objects from Applications

All this is due to change soon—indeed is changing already. Objects have shown that they can deliver specific functions while at the same time encapsulating all their internal workings so that the programmers using them do not have to know what goes on inside. Currently, the object's horizon is limited to the application that contains it. If you want to build a lot of function into an OO application, you have to put a lot of objects into it. About six years ago, the folk in the emerging world of objects realized that objects would become much more useful if they could be used across different applications, even if the applications were written in different languages—and even if they ran on different computers, maybe even under different operating systems (this democratic vision is not shared by all in the industry).

The CORBA Standard

To make any of this happen, standards are an absolute necessity. A cross-industry standards group called the Object Management Group (OMG) was formed in 1989 to develop and publish standards in this area. The OMG has been very industrious and successful, and its membership has risen to over 500. Almost every company involved in building objects is in the OMG and is busy enabling its object software to conform to the OMG standards. The biggest "umbrella" standard from OMG is called the Common Object Request Broker Architecture (CORBA). As with all standards, the longer the name, the more arguments and reconciliations went into its formation. The CORBA standard was widely and hotly debated by the members of the OMG, and what came out of the crucible is case-hardened steel.

IBM's CORBA-compliant object broker implementation is called SOM (System Object Model). It is a standard component of OS/2 and AIX and will soon be standard in MVS/ESA and OS/400 too. Probably every popular operating system will have a CORBA-compliant object broker from one vendor or another by the end of 1996.

We pick up on this theme again in Chapter 11, "Object REXX, SOM, and Workplace Shell" on page 133, and in more detail in "Applications Assembled from Components" on page 148. The topic is far too big to fit into the confines of this book. Several excellent publications already exist on this topic alone. We particularly recommend *The Essential Distributed Objects Survival Guide* by Robert Orfali, Dan Harkey, and Jeri Edwards (see full reference in "Related Publications" on page xxiv).

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[3] *Manufacture:* verb, from Latin *manus* a hand, and *facto* I make.

So Why Object REXX?

In the preceding sections we have reviewed how successful REXX has been and how useful OO facilities are. The marriage of the two is an obvious and welcome step, bringing to the programmer a language with the strengths of both. Object REXX is likely to be widely and enthusiastically embraced by the REXX programming community for the following reasons:

- It′s free! Everyone is talking about OO nowadays, but getting access to an OO language costs money. Object REXX is distributed as a standard component of OS/2 at no extra charge, and Object REXX is a full-function OO language. What better way to get your feet wet in the OO puddle than by using the language you know and love?
- Object REXX lets you learn about OO incrementally. While it enables you to build totally nonprocedural code, you can also start adding OO features to existing procedural programs. You do not have to abandon your legacy REXX code or your existing skill base.
- The standard REXX trace and debug facilities are still available, even for OO code. You can step through your programs line by line, displaying and setting variables as you go. This makes it easy to understand what is going on.
- Object REXX includes new features that make it much easier to build structured and modular applications. REXX is being used to build some very large and complex systems, and these new structuring capabilities are most welcome.
- One of the key benefits that OO gives is reuse. REXX programmers are in general very familiar with the reuse approach. Programs coded in other languages can be invoked directly from within REXX programs. Commands for other programming environments such as XEDIT under VM and the EPM editor, DB2/2 and CPI-C under OS/2 can be embedded in REXX code. Most REXX programmers are comfortable with a “mix and match” approach. Object REXX extends the range of resources available to the REXX programmer to include objects developed in Object REXX itself, and OS/2 SOM objects.
- It is easier to interact with the OS/2 Workplace Shell (WPS) from Object REXX. Professional application installation routines do more than just copy files into a new subdirectory; they also instruct WPS to build the folders and other icons the users need to drive their systems.

Learning how to exploit object orientation does not have to be a white-knuckle experience. Object REXX provides an easy path into the world of objects, building on and enhancing existing REXX skills.

Chapter 2. How Does Object REXX Implement OO?

Object REXX has a very comprehensive set of OO facilities, including multiple inheritance and metaclasses (see “Methods” on page 21). It has support both for static class and method construction through embedded declaratives, and for dynamic class and method construction through messages that may be issued at runtime to the built-in Class and Method classes. Here we use only the static, declarative forms.

Object REXX can import and use SOM objects and classes (see Chapter 11, “Object REXX, SOM, and Workplace Shell” on page 133). The Object REXX manuals referenced in “Related Publications” on page xxiv contain an excellent description of OO concepts and how Object REXX implements them. We give only a brief and incomplete outline of these capabilities here for the reader’s convenience.

We need to start by emphasizing that the magic of OO does not lie in its definition. Many people have labored over descriptions of OO, seeking the philosopher’s stone that will transform dull gray code into glistening gold in the concepts of objects, classes, inheritance, and polymorphism. Try as you will, you will not find it there. What is important about OO is the changes it *allows*—but does not *require*—designers and programmers to make in the way they structure programs. We have tried to explain this in “Why Object Orientation?” on page 5.

Objects

All of us deal with objects every day of our lives. Things like faucets, toasters, refrigerators, cars, telephones, photocopiers, fax machines, and televisions are objects. We use objects to do things. We give commands to objects. We might open a faucet, push down the cook lever on a toaster, start a car, depress an accelerator or brake pedal, turn a steering wheel, dial a number on a telephone or fax machine, or press a channel change or mute button on a TV remote control.

Objects must be able to obey the commands we issue. They need some built-in, predefined behavior. In the OO world these are called *methods*.

Object REXX uses the ~ (tilde) operator to invoke a method on an object.

Invoking methods on an object

```
car~start
car~turn('right')
car~speed(55)
```

The word preceding the tilde is the object, and the word following it is the method. Those familiar with classic REXX can think of invoking a method as something similar to invoking a function. Consider the following code:

Invoking methods compared to functions

```
aString = 'Hello, World'
say aString              (gives:  Hello, World)
say reverse(aString)     (gives:  dlroW ,olleH)
say aString~reverse      (gives:  dlroW ,olleH)
```

If every object we encountered was different from all others and had its own unique set of commands, we would never cope with the daily demands of living. Humans have learned to standardize the way similar objects behave and are controlled. Different car models made by different manufacturers in different countries all have similar controls and respond in a similar way when these controls are used. Even if we have to fly to a distant country, we can still operate the cars we find there with reasonable success. Every car is different. Each has a unique number plate and engine and chassis serial numbers. Each has its own unique collection of scratches and bumps and little quirks, such as the way it hesitates when you floor the accelerator at 50. But cars, and trucks for that matter, behave similarly enough that drivers can move from one to another and cope.

Classes

The world in which programmers must operate is also populated by objects. They too have their own unique attributes and built-in behavior. Programmers cannot cope with the diversity of objects they must manage unless they simplify and standardize the behavior and appearance of these objects as far as possible. Quite often, programmers will impose a greater degree of standardization than exists in the real world. A program may insist, for example, that every human has a surname and one or more given names. While this is a common practice in some European countries, in Nordic countries it is not. And the people on other continents have very different practices. But we have learned to live with generalizations like these so that programmers need cope only with a subset of the problems the real world contains.

In order just to cope with the innate complexity of the world, programmers must seek and impose similarities in behavior across groups of related objects. In OO terminology, a group of related objects is called a *class* or *type*. Once they have identified a class of objects, programmers can define and code the routines or *methods* that give these objects their common behavior.

Object REXX uses *directives*, placed at the end of the program, to define classes and methods. A directive starts with two colons (::).

Directives for a class definition

```
::class Car
::method start
   ...
::method turn
   ...
::method speed
   ...
```

Note: Class definitions can also be placed into separate files by using the *::requires* directive. (See “The Requires Directive” on page 62.)

Inheritance

So far we have done little more than coin some trendy new OO terms to describe well-established programming practice. Now we start to add something new and exciting. It's called *inheritance*. It stems from the fact that although we want to group objects into classes and enforce a common behavior across all of them, some stubbornly refuse to fit a common mold. Cars and dump trucks have similar controls to drive them, but dump trucks have extra controls to manage the dumping mechanism. How can we cope with this irritating diversity? We might be tempted to build the code needed to manage cars, then clone it and extend it to handle trucks. It gets the job done, and we score extra brownie points if our productivity is measured in lines of code. But it creates an extra maintenance burden that will last for as long as the code runs.

OO languages offer an elegant way of coping with the problem of similar but different classes. Given the problem described above, we could define a Car class that implements the behavior that is common to both cars and dump trucks (for example, starting, steering, and stopping) and then define a new class called DumpTruck that is a subclass of the Car class (see Figure 1).

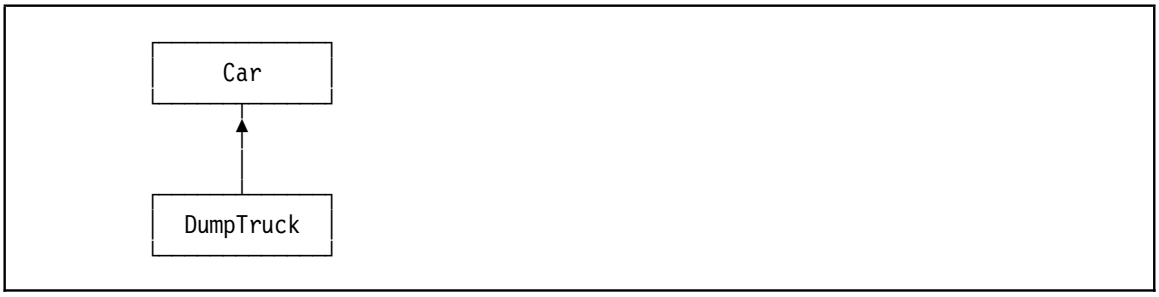


Figure 1. Car and DumpTruck Class Inheritance Diagram

The Object REXX class definition directives might look as follows:

Class directives for inheritance

```
::class Car
::method start
   ...
::class DumpTruck subclass Car
::method dump
   ...
```

A subclass *inherits* all the behavior (attributes and methods) of its parent class but can add new attributes and methods of its own. We can add to our DumpTruck class just the new behavior that is unique to dump trucks—the ability to dump. So any dump truck objects that we create will automatically inherit all the methods they need to be driven, plus the methods they need to dump. We have achieved the equivalent of cloning code without actually cloning code. Maintenance is simplified.

A nice side effect of this approach is that when we add new methods to the base car class to handle new behavior such as fuel consumption, all of its subclasses automatically inherit these new methods as well.

Abstract Classes

But what would happen if we needed to add some new methods to the Car class that we did *not* want its subclasses to inherit? Suppose we needed to add information about a car's trunk capacities and optional extras—sidewalls, two-tone color schemes, and such? We could abstract from the Car and DumpTruck classes all the attributes and methods we want them to have in common and put them in a new *abstract* class called Vehicles. We would make both Car and DumpTruck subclasses of the Vehicle class (see Figure 2).

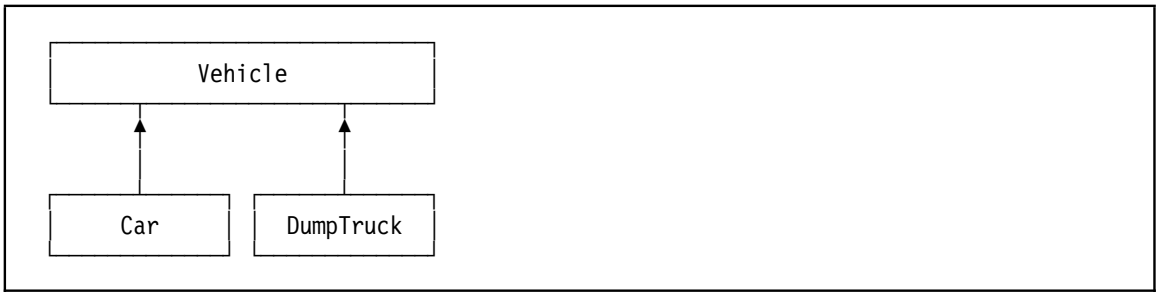


Figure 2. Abstract Class Inheritance Diagram

Each would inherit all the common behavior it needs from the base Vehicle class, and we could then add to each the behavior that it alone requires. We might never create an object directly from the Vehicle class. It would serve just as a handy place to keep common behavior. Since we do not change the names of the Car and DumpTruck classes, none of the code that deals with them will be affected. All the changes we make are hidden inside the class definitions. This is an example of *encapsulation*, one of the major benefits of object orientation.

The Object REXX directives required in this case might look like this:

Class directives for an abstract class

```
::class Vehicle
::method start
   ...

::class Car subclass Vehicle
::method trunk_capacity
   ...

::class DumpTruck subclass Vehicle
::method dump
   ...
```

Can we take this further? Suppose the need arises to deal with trucks other than just dump trucks. How would we handle this situation? In Figure 3 on page 17, we abstract the behavior that is common to dump trucks and tanker trucks and put it in a new abstract class called Truck. We then define TankerTruck and DumpTruck as subclasses of Truck. They both inherit the behavior of the base Vehicle abstract class plus the behavior of the Truck abstract class, and then each adds its own unique behavior to its own class.

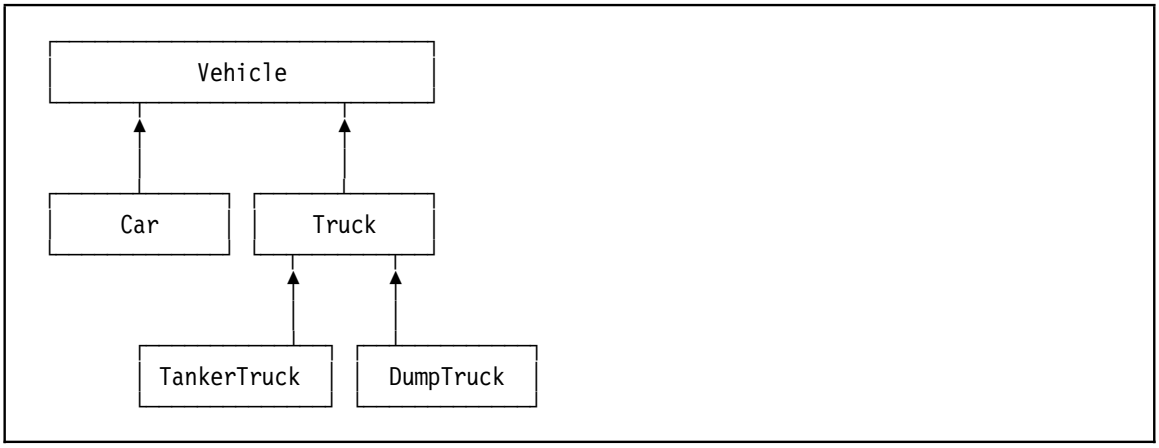


Figure 3. Multilevel Class Inheritance Diagram

The Object REXX directives required in this case might look like this:

Class directives for multilevel inheritance

```
::class Vehicle
::method start
   ...

::class Car subclass Vehicle
::method trunk_capacity
   ...

::class Truck subclass Vehicle
::method hitch_horse
   ...

::class DumpTruck subclass Truck
::method dump
   ...

::class TankerTruck subclass Truck
::method fill_tank
   ...
```

We can continue in this way to create as many levels of inheritance as we need.

Multiple Inheritance

The inheritance story could have ended here, but Object REXX takes it further. The Smalltalk language allows each class to have only one parent class from which it can inherit behavior. But Object REXX allows classes to inherit from one or many parent classes. Only one can be the direct parent. The other parents are called *mixin* classes. Like abstract classes, they are not used to generate instances. They serve only as containers for attributes and methods that other classes can inherit from them.

Suppose we need to add information about engines to our vehicle fleet. In the old class structure, engine information was contained in the Vehicle class. We observe that the same sort of engine is often used in different types (classes) of trucks, and some engines are common between light trucks and cars. We want to separate out the engine information from the rest of the vehicle, which we will call the Body. We might do this as shown in Figure 4 on page 18.

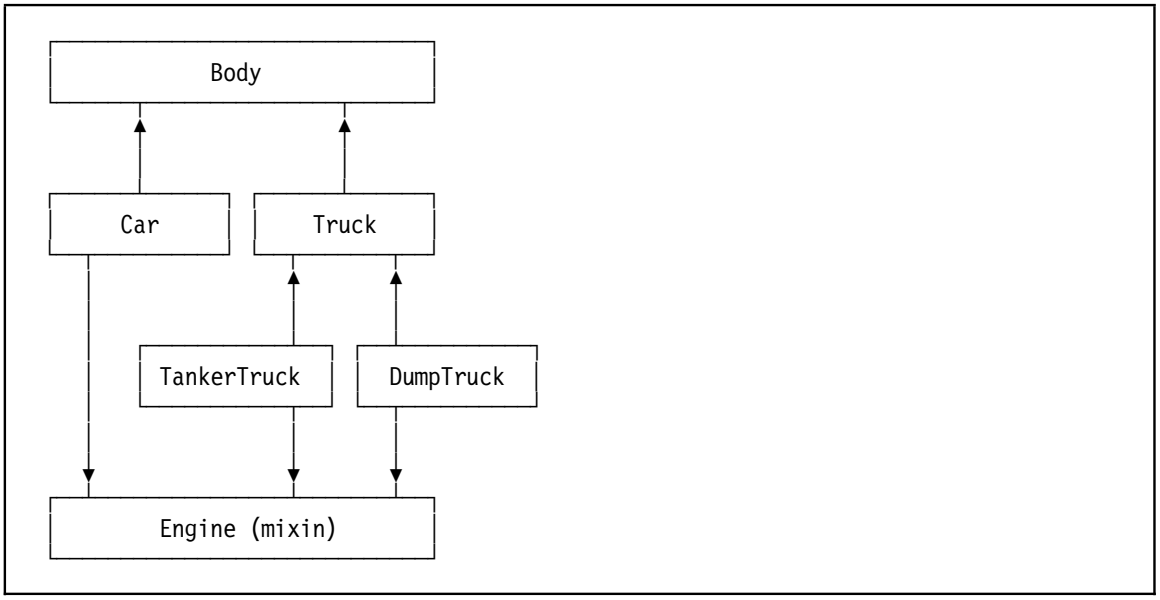


Figure 4. Mixin Class Multiple Inheritance Diagram

The Object REXX directives required in this case might look like this:

Class directives for multiple inheritance

```
::class Body
::method rattle
   ...

::class Engine mixinclass Object
::method start
   ...

::class Car subclass Body inherit Engine
::method trunk_capacity
   ...

::class Truck subclass Body
::method hitch_horse
   ...

::class DumpTruck subclass Truck inherit Engine
::method dump
   ...

::class TankerTruck subclass Truck inherit Engine
::method fill_tank
   ...
```

The old Vehicle abstract class has disappeared, its attributes and methods split into two new abstract classes called Body and Engine. Body becomes the direct parent of Car and Truck, while Engine becomes a mixin class. Each vehicle now obtains its body and engine behavior from two different classes.

Object REXX Variable Pools

In classic REXX, by default each .cmd file has its own variable pool. Variables set by code within the .cmd file are available to all other code within the same .cmd file. The programmer can change this by coding the procedure instruction after a label, for example:

```
aProcedure: procedure
```

When aProcedure is called, REXX creates a new and private variable pool for aProcedure. This remains in effect until aProcedure terminates. In this example, none of the code within aProcedure can access any of the variables set by the code in the command file, and vice versa.

The programmer can obtain a limited degree of exposure of the variable pool external to aProcedure by using the expose option. For example:

```
aProcedure: procedure expose variable1 variable2 stem.
```

The variables and stems listed after the `expose` keyword map directly onto the corresponding variables in the variable pool that was active when aProcedure was called. Changes that aProcedure makes to these exposed variables remain in effect when aProcedure terminates. Existing REXX programs work the same way in Object REXX as they do in classic REXX, to preserve compatibility.

Objects are new in Object REXX, and they are handled differently. Each object usually has several variables, or *attributes*, associated with it. If you have 100 employee objects active, each one may have its own name, number, address, and other attributes. Object REXX associates a separate variable pool with each object.

An object's attributes can be accessed only by the methods that are defined within the object's class; in OO terminology, all data is private or *encapsulated*. Each method must specify which of the object's attributes it needs to access by listing them on an *expose* instruction immediately after the ::method directive.

Example of a method

```
::method tag
   expose name address salutation
   separator = 'at:'
   return salutation name separator address
```

In this example, the variables name, address, and salutation are part of the associated object's variable pool. All the other methods in the class that contains this method may access and set these variables if they first expose them. Any variables a method uses that are not in its expose list are local variables and are discarded as soon as the method terminates. In this example, *separator* is a local variable.

Note: If an object inherits methods from different classes, it will have different variable pools in each class. A method defined in one class cannot share a variable with a method in another class. If methods need to share information, the owner of the variable must implement methods to get and set this variable, and the would-be sharer must invoke them.

The benefit that flows from this arrangement is that different groups can build and maintain different classes quite independently. Multiple inheritance can make bedfellows of complete strangers. If a new class claims parentage from two independently developed classes, there is no danger that the accidental use of the same variable name in the two parent classes will cause collisions and corruption of the variable. The methods of each parent class will

continue to operate in their separate variable pool. This approach mirrors the way in which SOM classes manage their variables.

The down-side of this arrangement is that it is a little difficult to split the definition of what the programmer may regard as a single class over more than one source file. Each class definition must be completely contained in a single file. Different files will therefore contain different class definitions. The methods in these files may be pooled by using inheritance, but they will not be able to gain access to one another's variables except through get and set methods created specifically for this purpose.

As in SOM, Object REXX provides a very simple way of creating get and set methods for a given variable. If one codes:

```
::method aVariable attribute
```

then Object REXX will automatically create both a get and a set method for aVariable. One can then get the value of aVariable by coding

```
something = anObject~aVariable
```

and set aVariable by coding:

```
anObject~aVariable=(aValue)
anObject~aVariable=aValue
```

Note: Unless a `SIGNAL ON NOVALUE` or a `SIGNAL ON ANY` instruction is included in the code, the methods may happily appear to use variables to which they actually have no access, if these variables happen to lie in a separate variable pool, for reasons described above. It is probably a good discipline to include the `SIGNAL ON NOVALUE` instruction in code while it is being debugged, and to leave it in while it is being used in production.

Object Instances

We have introduced objects and classes, but how do we actually create and delete objects within a class? Individual objects are often called *instances*.

Object Creation

Most OO languages provide a *new* method (operator) to create an instance of a class. This is also how object creation is implemented in Object REXX.

Object creation

```
mycar = .Car~new
  ...

::class Car
::method start
  ...
```

Note: A Car class defined using the class directive (::class) is available in the program as .Car, and the new method is invoked against this class object. In Object REXX, even classes are themselves objects.

We will often need to initialize the variables of a newly created object. Object REXX automatically invokes the *init* method of a new object, if an init method has been defined.

The init method can accept parameters to initialize object variables and set additional variables to default values.

Initializing a new object

```
mycar = .Car~new(12345,'Ford','Mustang')
   ...

::class Car

::method init
   expose serialNumber make model saleDate
   use arg serialNumber, make, model          /* parameters of new   */
   saleDate = date('s')                       /* initialize variable */

::method start
   ...
```

Note: The new *USE ARG* statement is used to assign values to variables from the arguments. This is more effective than parsing the arguments and works for any objects passed in as parameters in the method call. See "USE (New)" on page 233 for more details.

Object Destruction

In Object REXX there is no explicit way to delete an object. Object REXX supports automatic garbage collection—that is, objects without any references (variables pointing to them) are removed from memory periodically under system control.

The program can remove references to objects by assigning another value to a variable, or by dropping the variable:

```
mycar = .Car~new
...
drop mycar     /* object is subject to garbage collection */
```

Methods

Methods of a class are defined in the directives section of the program immediately after the class directive. We will often want methods to return a result that can be used by the invoking program, but this is not compulsory.

Methods can be invoked in two ways, through a single tilde (~), or through a double tilde (~~). When a double tilde is used, any result returned by the method is disregarded, and the object to which the method was applied is returned instead. This allows several methods to be applied to a single object in one statement, in a procedure known as *chaining*.

Chaining of method operations

```
car = .Car~new(...)
car~~start~~speed(55)~~for(5m)~mileage
   ...
::class Car
   ...
```

Note: Since the double tilde does not return a result, the subsequent operations work on the same car object until the *mileage* method returns the miles driven in 5 minutes.

Private and Public Methods

Methods invoked from the main program or from other classes are specified as *public* methods. They define the interface of the class, that is, all the possible operations this class can perform.

Methods used only within the class—that is, they are invoked only from other methods of the class—are *private* methods.

By default, methods are public; the `private` keyword is used to define a private method.

Public and private methods

```
::class Car

::method milage                  /* public method for users    */
  self~calculate                 /*   - invoke private method  */

::method calculate private       /* private method             */
  expose time speed              /*   - not available to users */
  return time * speed / 3600     /*   - used by other methods  */
```

Classes and Instance Methods

So far, we have spoken about methods operating on objects. While this is generally the case, some methods cannot operate on specific objects because, for example, the method's purpose may be to *create* a new object, and the code calling the method cannot point it to this new object because it does not exist until after the method has run. When we deal with "normal" methods that operate on objects to do things like print them, shred them, or delete them, then we speak of *instance* methods. They operate on objects, which are also known as instances of their class. When we deal with methods that we cannot pass a specific object to, we call them *class* methods.

This may sound rather technical, but when it comes to writing the code, the distinction will usually be very obvious. Making a method do something to an existing object requires an instance method; otherwise it must be a class method.

Instance methods usually handle the data of an individual object, whereas class methods handle data about the whole class, such as counting the number of objects in the class or managing a collection of all the objects.

Meta Classes

We have spoken about classes inheriting methods from their parents and from mixin classes. Although we did not mention it at the time, a subclass inherits both the instance and the class methods of its direct (and mixin, if any) parents. We spoke of abstract and mixin classes as a handy way to store behavior that can be inherited by a new subclass. Now we introduce meta classes. Like abstract and mixin classes, they are a handy place to store methods and attributes for other classes to inherit. The wrinkle is, when a new class inherits from a meta class, the meta class's *instance* methods become the inheriting class's *class* methods - along with any other class methods it inherits from its direct parent.

If this sounds complex, it is! But seldom will an Object REXX application programmer need to use meta classes. Direct inheritance usually gets the job done, with mixins less often required. The people who really need meta classes are the programmers who build OO languages like Object REXX. They could have kept meta classes hidden and used them for their own purposes only, but they chose to share them with the world. There are good reasons for doing this. If the feature is there, why not make it available? People have built some very complicated and sophisticated systems using OO languages in the past, and we believe that Object REXX will be no exception. And Object REXX needs to interface with the rest of the world. Probably the most important OO interface that Object REXX has is its linkage into SOM, as described in Chapter 11, "Object REXX, SOM, and Workplace Shell" on page 133. SOM is the equivalent of a telephone exchange for objects, allowing them to find and talk to each other no matter where they may be. SOM requires its programmers to deal explicitly with meta classes when class methods must be defined. It is probably a good idea for the Object REXX community to understand what meta classes are all about, and to be able to use them when required.

Polymorphism

Polymorphism is the rather cumbersome name given to a very simple idea that almost every computer language offers. It is the notion that a single operator symbol like + or – or * or / can be used against operands of different types such as short integer, long integer, short float, or long float. The language compiler (or interpreter) determines the type of operand is involved and then uses one of the many available machine instructions to carry out the appropriate operation. So whenever two numbers are added together, a plus sign is written between them, regardless of their data type.

OO languages enable programmers to define their own functions and operators (methods) for the new data types (classes) they create. For example, a *draw* method can be defined for the shape class, and therefore for all its subclasses (triangle, rectangle, circle, ...). The draw method can then be invoked against an object of every subclass of the shape class. Object REXX invokes the implementation of the draw method according to the class of each object.

A very nice example of polymorphism may be found in complex.cmd in the Object REXX sample subdirectory and the associated usecomp.cmd that invokes it. This code creates a class of complex numbers and defines operators to carry out simple arithmetic on them. The programmer is free to choose any method name to denote the addition of complex numbers—complexAdd, for example, which would require the following syntax:

```
a = b~complexAdd(c)
```

But instead, he or she wisely chooses the operator + for this purpose. This allows the programmer using the complex class to code:

```
a = b + c
```

This is, of course, a very familiar notation, and programmers will find it easy to apply these new methods to the new domain of complex numbers, even though complex numbers are not a part of standard REXX.

Just to show that Object REXX permits very useful things without much code, we show below the Object REXX method for adding complex numbers. By way of introduction for those who did not major in math, each complex number has two parts called a *real* and an *imaginary* part. Each of these two parts is a perfectly normal number. Combined, we can use them to do things like position a point on a graph, where we need to know how far to the right it is and how high. These two independent properties can be stored separately in the real and imaginary parts of a single complex number.

The Object REXX method for adding complex numbers

```
1  ::class complex public
2  ::method '+'
3     expose real imaginary
4     use arg adder
5     if arg(1,'o') then
6       return self
7     tempreal = real + adder~real
8     tempimaginary = imaginary + adder~imaginary
9     return self~class~new(tempreal, tempimaginary)
```

1. We use the ::class directive to define the class of complex numbers.
2. We use the ::method directive to start the definition of the + method.
3. We give each complex number two attributes called *real* and *imaginary*. We *expose* them so the method can use them.
4. The + method normally works on two complex numbers. The first is the object in front of the + and the second is the object after it. We access the first object through the built-in name *self*. We access the second through the *use arg* statement and use the local variable name *adder* to reference to it.
5. If arg(1) is omitted, we do not have to do any addition.
6. We just return the object to which this prefix + applies (self).
7. We get the real part of adder and add it to the real part of the complex number we are dealing with.
8. We get the imaginary part of adder and add it to the imaginary part of the complex number.
9. We make a new complex number to return to the caller. We need to find the class of the object we are dealing with, because the method that makes new complex numbers is a *class* method (see “Classes and Instance Methods” on page 22). Self~class gets the class of the object, and class~new invokes the *new* method of the complex class.

The class library that is supplied with Object REXX (see “The Object REXX Class Library” on page 25, below) makes extensive use of polymorphism. For example, the method name [] may be used to refer to an element of any type of collection, be it from the Array, Bag, Directory, List, Queue, Relation, Set, Stem, or Table class. The [] notation has been long and widely used in languages like C to denote subscripting of arrays, so the Object REXX convention exploits and reinforces an association that many programmers already have.

Programmers are encouraged to follow the same convention when they create new methods. If it does something analogous to an existing method of another class, give it the same name. It is easier to remember the name when needed, and it is easier to guess what the method does when only the name is known.

The Object REXX Class Library

Every OO language worthy of the name comes with a set of class definitions. These do a wealth of useful things and spare the OO programmer reinventing the wheel. Object REXX is no exception. Many of its classes relate to managing collections of data. These are called the collection classes and are shown in Table 1. Another group provides a variety of useful functions to the programmer, listed in Table 2. These are very terse lists; for details, please see the Object REXX manuals referenced in “Related Publications” on page xxiv.

Table 1. The Object REXX Collection Classes

Class Name	Purpose
Array	A sequenced collection
Bag	A nonunique collection of objects, subclass of Relation
Directory	A collection indexed by unique character strings
List	A sequenced collection that supports inserts at any position
Queue	A sequenced collection that can accept new items at its start or end
Relation	A collection with nonunique objects for indexes
Set	A unique collection of objects, subclass of Table
Table	A collection with unique objects for indexes

Table 2. The Other Object REXX Classes

Class Name	Purpose
Alarm	Generates asynchronous messages at specific times
Class	A technical class to create new classes
Message	Supports the deferred or asynchronous sending of messages
Method	A technical class to dynamically create new methods
Monitor	Manages the forwarding of messages
Object	A technical class to manage all objects
Stem	A collection indexed by unique character strings
Stream	Supports input and output operations
String	Supports operations on character strings
Supplier	Supplies the elements of a collection one by one

As with any OO language, the Object REXX class library is an extremely valuable asset and will richly repay careful study. We can never claim to know an OO language until we have a fair idea of what its class library contains.

The Object REXX Class Library Browser

Most OO languages contain a facility called a class browser, a program that presents the class library to the programmer on request. It supports lookup by class name or by method name. Object REXX provides this facility through its online reference facility, which should be installed when Object REXX is installed. With its hypertext links it provides far more information than the usual class browser provides. Of course, it can only display the built-in Object REXX class library. There is at this stage no equivalent facility for browsing programmer-defined classes.

Part 2. The Car Dealer Scenario

Chapter 3. The Car Dealer Application

In this chapter we introduce the Hacurs software company and pick up the story of how it uses Object REXX to implement a car dealer application. We look at the objects required for this application and find out how the classes built into Object REXX (its class library) can be used to help construct them.

Introducing the Hacurs Company

It is all too easy to make a book about a computer language read like a catalog of washing machine parts. As we go through the features of Object REXX, we are going to try to bring them to life by showing how useful they are to a fictional but not unrealistic small software company called Hacurs. This company was started one year ago by three friends—Hanna, Curt, and Steve. They studied computer application design and programming together at college, and after graduation they all joined the same company and worked in its IT department. They often spoke of starting their own little software company, and after two years of corporate life they agreed to do it. They decided to design and develop applications for OS/2. They had used C and C++ for some of their college assignments, but most of their corporate experience was based on coding REXX. They recognized that REXX is an extremely powerful and easy-to-use language and chose it as their preferred development language.

Their company name Hacurs is derived from their own names but also stands for their main line business—Handy Applications Coded Using REXX. Hacurs signed up with the IBM Developer Assistance Program (DAP) and the Developer Connection for OS/2 (DEVCON). This gives them access to lots of useful information, as well as some very useful development tools.

The Car Dealer Opportunity

“Hey, team,” yelled Curt as he banged in through the door of the Hacurs office late one afternoon, “we′ve got our breakthrough! I spent most of today with Trusty Trucks looking at their requirements for a car dealer system. They are really keen to automate this part of their business, and I′ve pretty near convinced them that we can build a system that will meet their needs, and that we can do it fast.”

“That′s wonderful,” said Hanna.

“Great going!” exclaimed Steve.

“What do they want?” asked Hanna.

“They service vehicles—cars and trucks,” Curt answered as he put down his bag and sat at his desk. “I tried my hand at developing a use case with them to describe their business process. I captured it on my ThinkPad.” Curt pulled his ThinkPad from his bag, plugged it in

and powered it on. Once it had booted up, he opened a view of his project subdirectory and dragged an icon to the EPM editor.

"This is what we came up with," he said (see Figure 5). "Now before you start criticizing, remember this is the first use case that I've built," said Curt. "We wrote up the steps that have to take place, and then I identified the nouns by making them bold, and all the verbs by making them underscored."

1. **Trusty Trucks** draws up a list of the **parts** it has in stock.
2. **Trusty Trucks** also defines the **services** it offers and lists the **parts** each service needs.
3. **Customers** bring in their **vehicles** for servicing.
4. **Trusty Trucks** records the **customer** and **vehicle** details on a **work order** and itemizes the **services** required.
5. **Service staff** carries out the specified **services** on the **vehicles**.
6. **Clerical staff** prepares **bills** based on the **work orders**.
7. The **customers** pay their **bills** and claim their **vehicles**.

Figure 5. Car Dealer Application Use Case

"We decided not to mark every noun," said Curt. "Some just didn't seem useful to us. All the nouns we highlighted are candidates for objects in the application design. And all the verbs we highlighted are candidates for methods."

"Well that looks very simple and straightforward to me, Curt," said Hanna, "although I'm sure it will turn out to be a lot more complicated when we get down to the details."

"Should we try to draw up a list of the objects you have identified, and their related methods?" asked Steve.

"OK," said Curt. He copied the text of his use case and edited out all words except the highlighted ones. "This brings up a question," he noted. "If I can remember back to my high-school grammars, most sentences have a subject, a verb, and an object. Both the subject and the object are nouns. But when we come to attach methods to objects, does the verb get associated with the subject or the object of the sentence? For example, in the first item I've got

Trusty Trucks staff *draws up* a list of the **parts** it has in stock.

Should *Draws up* be the method of **Trusty Trucks** or of **parts**?"

"Of parts, I think," answered Steve. "The Trusty Trucks object uses the method, but the parts object must implement it. It deals with parts data."

"OK, let's use that approach and see what happens," said Curt. The Hacurs team worked together on this task. After some thought, they derived the table presented in Table 3 on page 33.

Table 3. Car Dealer Objects and Methods	
Object	**Method**
A list of parts	Draw up
Services	Define
Parts	List for each service
Vehicles	Bring in
Customer	Record the details
Vehicle	Record the details
Services	Itemize on a work order
Vehicles	Get services
Bills	Prepare
Bills	Pay
Vehicles	Claim

“It looks like we′ve got some nouns left over,” said Hanna. “Trusty Trucks, the Stores department, Service staff, and Clerical staff acted as subjects but never objects in the use case sentences.”

“That′s interesting,” said Curt. “I discussed these with Trusty Trucks. We recognized that we could identify objects corresponding to various divisions within the company and store them in the database. Trusty Trucks couldn′t see any point in doing so. I suggested that we could capture these in a field within each transaction, to act as an audit trail in case they ever needed to know who did what. They could see the potential value of doing that, but they plan to have a paper audit trail of each transaction and decided against keeping it in the database.”

“We′re starting to see the value of the use case discipline,” said Steve. “It makes you take into account those loose bits and pieces that might otherwise be overlooked in the design. Even if you eventually decide to ignore them, it′s good that you had to think about them.”

“Good point, Steve,” said Hanna. “And Curt, I think you′ve done a great job collecting this information and getting to understand what Trusty Trucks needs. Is this all we have to do? Do we create a class for each of the objects we′ve defined, and a method for each of the verbs?”

“I′m afraid there′s a lot more to it than that,” responded Steve. “We have to decide on the shape that we want our application to take. There′s a lot of technical issues that we still need to discuss.”

“Like what?” asked Hanna.

“Like what kind of user interface we must develop,” Steve answered, “and what database manager we should use.”

“Or if we use a database manager at all,” added Curt.

The Application Model

Hanna, Curt, and Steve sat around a table together, going through the requirements for the car dealer application and trying to identify the objects they would choose to implement in Object REXX. After a couple of hours work, they came up with five objects that seemed to play a dominant role:

Customer
Vehicle
Part
Service
Work order

"This is it," said Curt. "Customers bring their vehicles in for various services. Trusty Trucks records the services each vehicle needs in a work order. Each service requires a standard amount of labor and parts. Those are the objects we have to model. The relationships between the objects look like this." Curt drew a sketch on the white board (see Figure 6).

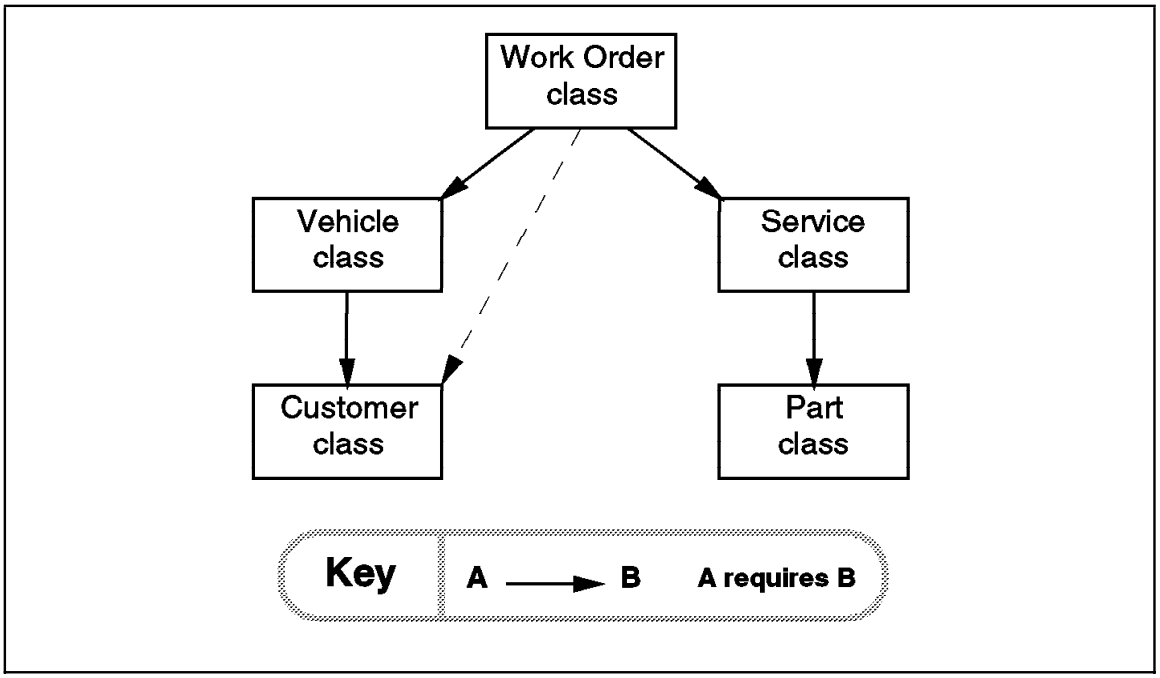


Figure 6. Car Dealer Data Class Relationships

"You don't need a line from the work order class to the customer class," said Steve. "Each work order points to a vehicle, and each vehicle has an owner, and that's who the customer is."

"Not necessarily," said Curt. "Suppose someone rents a truck and bends a fender. He or she might decide to take the truck in to get it fixed, rather than return it dented to the rental company. The customer is the renter, but the owner of the vehicle is the rental company."

"That sounds pretty unlikely to me," said Steve. "Anyhow, Trusty Trucks wouldn't know that it's a rented truck. They would capture the name of the person who brought the truck to them as the owner. All they care about is who's going to pay them."

Hanna broke in with a suggestion: "We can sort out this detail later. Make the line from the work order class to the customer class dotted, and let's carry on."

"How about labor—don't we need that as an object?" asked Steve.

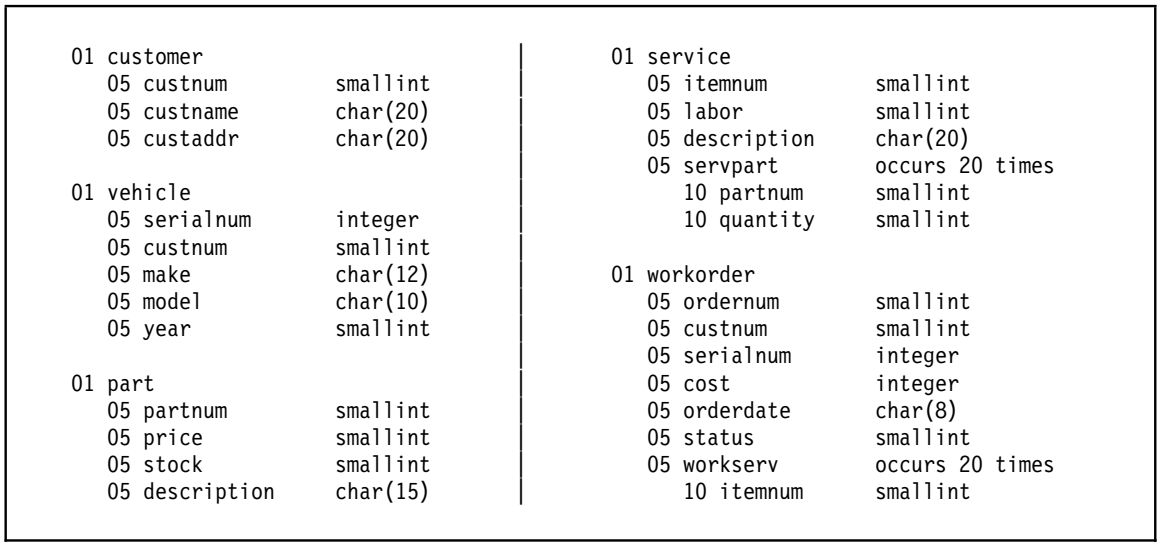
“I don’t think so,” said Hanna. “The only thing we know about it is the standard labor charge for each service. We wouldn’t have any attributes to store in labor if we made it an object.”

“But there are different types of labor, and they charge out at different rates,” said Steve.

“Maybe so, but Trusty Trucks doesn’t want to record that kind of detail in its service records,” said Curt. “Let’s not make this more complicated than it has to be. We have to get a solution working fast if we want to get the business.”

“OK, let’s take those objects as our first cut,” said Hanna. “What attributes do we need to store for each one?”

“I’ve kept a list of the attributes as we went along, and they look like this,” said Curt, laying out a sheet of paper (see Figure 7).



```
01 customer
   05 custnum         smallint
   05 custname        char(20)
   05 custaddr        char(20)

01 vehicle
   05 serialnum       integer
   05 custnum         smallint
   05 make            char(12)
   05 model           char(10)
   05 year            smallint

01 part
   05 partnum         smallint
   05 price           smallint
   05 stock           smallint
   05 description     char(15)

01 service
   05 itemnum         smallint
   05 labor           smallint
   05 description     char(20)
   05 servpart        occurs 20 times
      10 partnum      smallint
      10 quantity     smallint

01 workorder
   05 ordernum        smallint
   05 custnum         smallint
   05 serialnum       integer
   05 cost            integer
   05 orderdate       char(8)
   05 status          smallint
   05 workserv        occurs 20 times
      10 itemnum      smallint
```

Figure 7. Car Dealer Object Attributes

“That looks like a mixture of COBOL and SQL,” said Steve.

“Never mind, it gets the job done,” said Curt.

“You’ve got repeating groups in service and work order,” Steve noted. “We’ll have to normalize[4] the data.”

“Not necessarily,” said Hanna. “The collection classes in Object REXX allow an object to have attributes that are arrays, lists, sets, bags, directories...”

“OK, OK—you’ve made the point,” said Steve. “But when we come to store persistent objects in a relational database we’ll have to normalize the data.”

“Also not necessary,” chimed in Curt. “The new binary-large-object (BLOB) support in DB2 Version 2 would allow us to store the repeating group as an array in a single BLOB column.” Seeing Steve’s look of concern, he added “I would also feel more comfortable if the database was normalized, but the objects in storage don’t have to look exactly the same.”

[4] Normalization of data is a term used in database design. In simple words it makes individual tables of a database nonredundant and all columns of a table nonrepeating and dependent on the key only.

Methods and Variables

"OK, if those are the objects we have to model, what comes next?" asked Hanna.

"We need to work out which methods each object must support and the variables they need," said Curt. "I also kept a note of those as we went through the use cases. First, every object type..."

"You mean 'class,'" interrupted Steve.

"Uh—yes, class," agreed Curt. "OK, each class that manages the objects we've identified (see Figure 6 on page 34) needs the basic CRUD methods: create, read, update, and delete. Then whenever there's a relationship between two different objects, we need a method to maintain it. Who owns which vehicle, for example. We need to be able to track changes in ownership without having to delete the old vehicle and capture it all over again under a new customer."

"Why?" asked Steve. "You said we should keep it simple. Vehicles don't change ownership that often. Why not discard the old vehicle record and capture a new one?"

"What if there's a query relating to work done on the vehicle before it changed hands?" asked Hanna. "If we delete the old vehicle record we would lose any references we had to it in the work order history data."

Steve nodded, so Curt carried on: "Some of these methods relate to a specific object—update and delete, for example. These would have to be implemented as *instance* methods. But others don't relate to a specific object. We would have to implement those as *class* methods."

"Can you give us an example?" asked Hanna.

"Sure," said Curt. "When we create a new object, we can't send the create message to the object because it doesn't yet exist. So we have to send the message to the object's class instead, and it returns the new object to us. And when we want to search our customer set by name, we can't send the message to a particular customer object, we have to send it to the class instead. The class method would come back with a customer object—or a list of customer objects if more than one has the search name, or maybe an empty list if the search fails."

"Speaking of searching customers, how can we find all the customer objects that exist within the customer class?" asked Steve.

"We haven't found any built-in way of doing that," replied Hanna. "We could maintain a variable for the customer class that consists of the set of all customer objects. Suppose we call it *extent*. Whenever a new object is created, Object REXX automatically calls the object's init method. This is normally used to initialize the new object's instance variables. It could invoke a class method that puts the new object into the set of all objects created. And likewise for the other objects that we need to keep track of."

"That's smart," said Curt. "And we can have another class method that removes the reference to the object from the class's extent attribute when the object is deleted."

"Right," said Hanna. "Let's get to work and draw up tables of all of the methods we'll need for each class. We won't worry about how we store the objects on disk in this version. Let's just concentrate on managing the objects in storage." (See Tables 4 – 9.)

Table 4. Methods Required by Every Data Class		
Method	**Type**	**Purpose**
initialize	Class	Initialize the extent variable
extent	Class	Return an array of all objects of the class
add	Class	Add a new object to the extent
remove	Class	Remove an object from the extent
init	Instance	Initialize a new object
setnil	Instance	Clear out the object record
delete	Instance	Delete the object from the class
detail	Instance	Return object details, formatted
makestring	Instance	Default ID for this object
display	Instance	Display object data on standard output

Table 5. Methods Required for Customer Class		
Method	**Type**	**Purpose**
number	Instance	Return the number of the customer
findNumber	Class	Find a customer given the number
findName	Class	Return an array of customers matching name
heading	Class	Return a heading for output
name	Instance	Get or set the customer's name
address	Instance	Get or set the customer's address
update	Instance	Update the customer's data
addVehicle	Instance	Add a new vehicle to the customer
removeVehicle	Instance	Remove a vehicle from the customer
checkVehicle	Instance	Does this vehicle belong to the customer?
getVehicles	Instance	Return the customer's vehicles
findVehicle	Instance	Return a specific vehicle of the customer
addOrder	Instance	Add a work order to the customer
removeOrder	Instance	Remove a work order from the customer
getOrders	Instance	Return all work orders for this customer
ListCustomerShort	Class	List customers on standard output
ListCustomerLong	Class	List customers with their vehicles

Table 6. Methods Required for Vehicle Class		
Method	**Type**	**Purpose**
serial	Instance	Return the serial number of the vehicle
make	Instance	Get or set the vehicle's make
model	Instance	Get or set the vehicle's model
year	Instance	Get or set the vehicle's year
update	Instance	Update the vehicle's attributes
makemodel	Instance	Return make and model formatted
getOwner	Instance	Return the owner of the vehicle
setOwner	Instance	Set the owner of the vehicle
deleteOwner	Instance	Set the owner of the vehicle to nil

Table 7 (Page 1 of 2). Methods Required for Part Class		
Method	**Type**	**Purpose**
findNumber	Class	Return the part's number
heading	Class	Return a heading for output
number	Instance	Return the serial number of the part
price	Instance	Return the price of the part
description	Instance	Return the description of the part

Table 7 (Page 2 of 2). Methods Required for Part Class		
Method	**Type**	**Purpose**
stock	Instance	Return the stock level of the part
increaseStock	Instance	Increase the stock level of the part
decreaseStock	Instance	Decrease the stock level of the part
ListPart	Class	List all parts on standard output

Table 8. Methods Required for ServiceItem Class (services)		
Method	**Type**	**Purpose**
findNumber	Class	Return the service's number
heading	Class	Return a heading for output
number	Instance	Return the number of the service
laborcost	Instance	Return the labor cost of the service
description	Instance	Return the description of the service
usesPart	Instance	Tell service it uses this part
getParts	Instance	Return the parts used by this service
getQuantity	Instance	Return the quantity used of this part
getPartsCost	Instance	Sum cost times quantity of parts used
getWorkOrders	Instance	Return work orders with this service
ListService	Class	List all services on standard output

Table 9. Methods Required for WorkOrder Class (work orders)		
Method	**Type**	**Purpose**
findNumber	Class	Return the work order's number
newNumber	Class	Issue a new work order number
findStatus	Class	Return work orders of given status
number	Instance	Return the number of the work order
cost	Instance	Return the cost of the work order
date	Instance	Return the date of the work order
setstatus	Instance	Set the status of the work order
getstatus	Instance	Get the status of the work order
getstatust	Instance	Get the status of the work order as text
getCustomer	Instance	Get the customer of the work order
getVehicle	Instance	Get the vehicle of the work order
addServiceItem	Instance	Add a service item to the work order
removeServiceItem	Instance	Remove a service item from the work order
getServices	Instance	Return services of this work order
getTotalCost	Instance	Compute the total cost of the work order
checkAndDecreaseStock	Instance	Issue the parts required for the services
generateBill	Instance	Return array of output lines of bill
detailcust	Instance	Return customer and vehicle details
makeline	Instance	Return work order details, formatted
ListWorkOrder	Class	List the work orders on standard output

"Wow! That's a long list of methods," said Curt, looking at the tables they had produced. "Aren't we making this much more complicated than it needs to be?"

"I don't think so," answered Hanna. "The books on object orientation warn that you need a lot of methods to get the job done, but they say that the methods must be very short. Some say that if a method is longer than 30 lines, it's too long. I read that in connection with Smalltalk. I guess it's too soon to say if the same limit should apply to Object REXX."

"What's the benefit of having lots of silly little methods, each of which does very little?" asked Curt. "Why not lump functions together to make fewer, bigger methods?"

"It's like making bricks rather than prefabricating walls," said Steve. "The simpler each method is, the more likely you'll be able to reuse it for other purposes. And the more complex it is, the less likely you'll be able to use it again."

"Hmm," mused Curt. "It sounds good, but I'll reserve judgment on that until we've built our first application and I can see how it works out in practice."

Relationships among Objects

"I know it's getting late, but I'd like to spend a little time talking about the relationships that we need to implement between the different objects," said Hanna. "The way I see it,

- A customer can own one or more vehicles
- A vehicle can be involved in many different work orders over time
- A customer can be involved in many different work orders
- Each work order requires one or more services
- Each service requires zero or more parts

Which of these relationships do we have to keep track of? And from which end?"

"What do you mean, 'from which end'?" asked Steve.

"If we're given a customer, do we need to know which vehicles he owns?" asked Hanna.

"Yes!" chorused Curt and Steve.

"And if we're given a vehicle, do we need to know to which customer it belongs?"

"Yes!" chorused Curt and Steve again.

"Then maybe we need to put a list of vehicles owned into each customer object, and an owner attribute into each vehicle," said Hanna.

"Wait a minute," said Curt, "that doesn't sound possible. If the vehicle object contains the customer object, which in turn contains the vehicle object, which one will really contain the other? Will we put the system into a perpetual loop trying to do what we tell it?"

"No," smiled Hanna. "Objects never actually contain each other, they just contain references to each other. The objects themselves are all kept in Object REXX's system storage. When you assign an object to a variable, you're actually just storing a *pointer* to the object in the variable."

Steve chimed in too: "And if you call a subroutine or method passing a huge BLOB as an argument, the system passes just a pointer to the BLOB."

"Cute," said Curt. "So how do we actually store the relationships that you spoke about? I seem to recall that there is a list class built into Object REXX."

The Object REXX Collection Classes

"There's a whole lot of collection classes built into Object REXX, including Array, Bag, Directory, List, Queue, Relation, Set, and Table," said Steve. "All of them can be used to store sets of related information. All of them have several methods in common, and all have their own unique capabilities. We're spoiled for choice—it's almost embarrassing!"

"OK—so which should we use?" asked Hanna.

Realizing that this would take some time, the Hacurs team phoned out for pizza and went in detail through each of the relationships that Hanna had identified.

"So this is what we've agreed," said Curt, wiping some tomato sauce from the handwritten Table 10 and presenting it to his teammates for their approval.

Table 10. Relationships between the Car Dealer Objects

First Object	Second Object	From 1st to 2nd	From 2nd to 1st	Type
Customer	Vehicle	Set	Attribute	1:m
Customer	Work order	Set	Attribute	1:m
Vehicle	Work order	'none'	Attribute	1:m
Work order	Service	Relation	Relation	m:m
Service	Part	Set	'none'	m:m

"That's cryptic!" exclaimed Steve. "What does it all mean?"

"It's simple, really," replied Curt. "The first two columns list different types of object. The third column shows how we record the relationship from the object in the first column to the object in the second. If we don't, the entry is 'none'. Otherwise it's the name of the Object REXX class we agreed to use. The object that carries the relationship is stored as an attribute in the first object. The fourth column is the same as the third, except the other way round. It shows how we store the relationship in the second object back to the first. In most cases I've written just *attribute*. This means that there's only one object of type one associated with the second object, so we don't have to store a list, only a single object pointer. The fifth column shows the type of relationship we model. We distinguish between many-to-many (m:m) and one-to-many (1:m) relationships."

"Why don't we record the services that use a certain part?" asked Hanna. "Trusty Trucks is not interested in that information, so there is no need to carry it," replied Curt, "and we handle the work orders from the customer directly, without going through the vehicle," he added.

"Now that we see it all," said Steve, "do we really have to use the relation class to implement the relationship between work orders and services? Wouldn't it be simpler to use the same collection class for all our relationships?"

"Maybe, but this will look better on our CVs[5]," replied Curt with a smile.

"I'm more worried about our paychecks than our CVs!" muttered Hanna.

[5] CV = curriculum vitae, or resumé, a short account of one's career and qualifications.

Example of relationship between customer and vehicle classes

```
::class Customer
  ...
::method init                          /****** NEW CUSTOMER ******/
  expose customerNumber cars           /* each customer object   */
  use arg customerNumber               /* has a customer number  */
  cars = .set~new                      /* and a set of cars      */
  ...
::method addVehicle                    /****** ADD NEW VEHICLE ***/
  expose cars                          /* new cars are added to  */
  use arg newcar                       /* the set of cars        */
  cars~put(newcar)
  ...

::class Vehicle
  ...
::method init                          /****** NEW VEHICLE *******/
  expose serialNumber owner            /* each vehicle points to */
  use arg serialNumber, owner          /* the owner (customer)   */
  owner~addVehicle(self)               /* and adds itself there  */
  ...
```

Object Creation and Destruction

"Let's talk through the life-cycle of these objects and make sure they can all be created when needed and discarded when their work is done," suggested Hanna.

"I think we've covered that," said Curt. "We listed the methods that are common to every object (see Table 4 on page 37) and these include *init* to create new objects and *delete* to throw old ones away. We also plan to define an *extent* set as a class variable in each class to keep track of all the objects we have defined within that class. And we plan to have an *add* and a *remove* method for each class. Add will save a pointer to each new object in the extent when it's created, and remove will drop it when it's discarded. The init and delete instance methods will invoke the add and remove class methods."

"That's fine for keeping track of objects in storage," responded Hanna, "but what happens when the user powers-off the PC? Are all the objects lost?"

"Ah! Now you're talking about object persistence," said Curt. "That's a big topic, and this isn't the right time to start getting into it. We've covered a lot of ground today, and I for one am getting tired."

Hanna glanced at her watch. "You're right, it is getting late. OK guys, let's call it a day. Thanks for giving up your time for this project. It will be a big one if we manage to close the business. And with any luck we'll be able to sell the same solution to a number of different companies. This could turn out to be the milk-cow application we need to keep our paychecks rolling in. Sweet dreams!"

Maintaining the set of objects of a class

```
.Customer~initialize                      /* prepare the class        */
cust1 = .Customer~new(101,'Steve')        /* create some customers    */
cust2 = .Customer~new(102,'Hanna')
.Customer~ListCustomerShort               /* list all customers       */

::class Customer
                                          /****** class methods *******/
::method initialize class                 /* prepare the set of cust. */
  expose extent                           /* in variable "extent"     */
  extent = .set~new
::method add class                        /* add new customers to set */
  expose extent
  use arg aCust                           /* Arg passed from new/init */
  extent~put(aCust)                       /* - add it to the set      */
::method ListCustomerShort class
  expose extent                           /* list of all customers    */
  do aCust over extent                    /* iterate over extent      */
     aCust~display                        /* - call instance method   */
  end                                     /*   for each customer      */

::method init                             /****** instance methods ****/
  expose customerNumber name              /* initialize variables     */
  use arg customerNumber, name            /* - from arguments         */
  .Customer~add(self)                     /* add itself to the extent */
::method display
  expose customerNumber name              /* display cust. variables  */
  say 'Customer: number='customerNumber 'name='name
```

Note: This simple example shows how instance methods can invoke class methods (init invokes add), and class methods can invoke instance methods (ListCustomerShort invokes display). The separation is very logical; operations at the class level are implemented as class methods using the `class` keyword in the method directive, and operations at the individual object level are instance methods.

Implementation of the Model in Memory

Figure 8 on page 43 shows the object model with class and instance variables for the sample car dealer application.

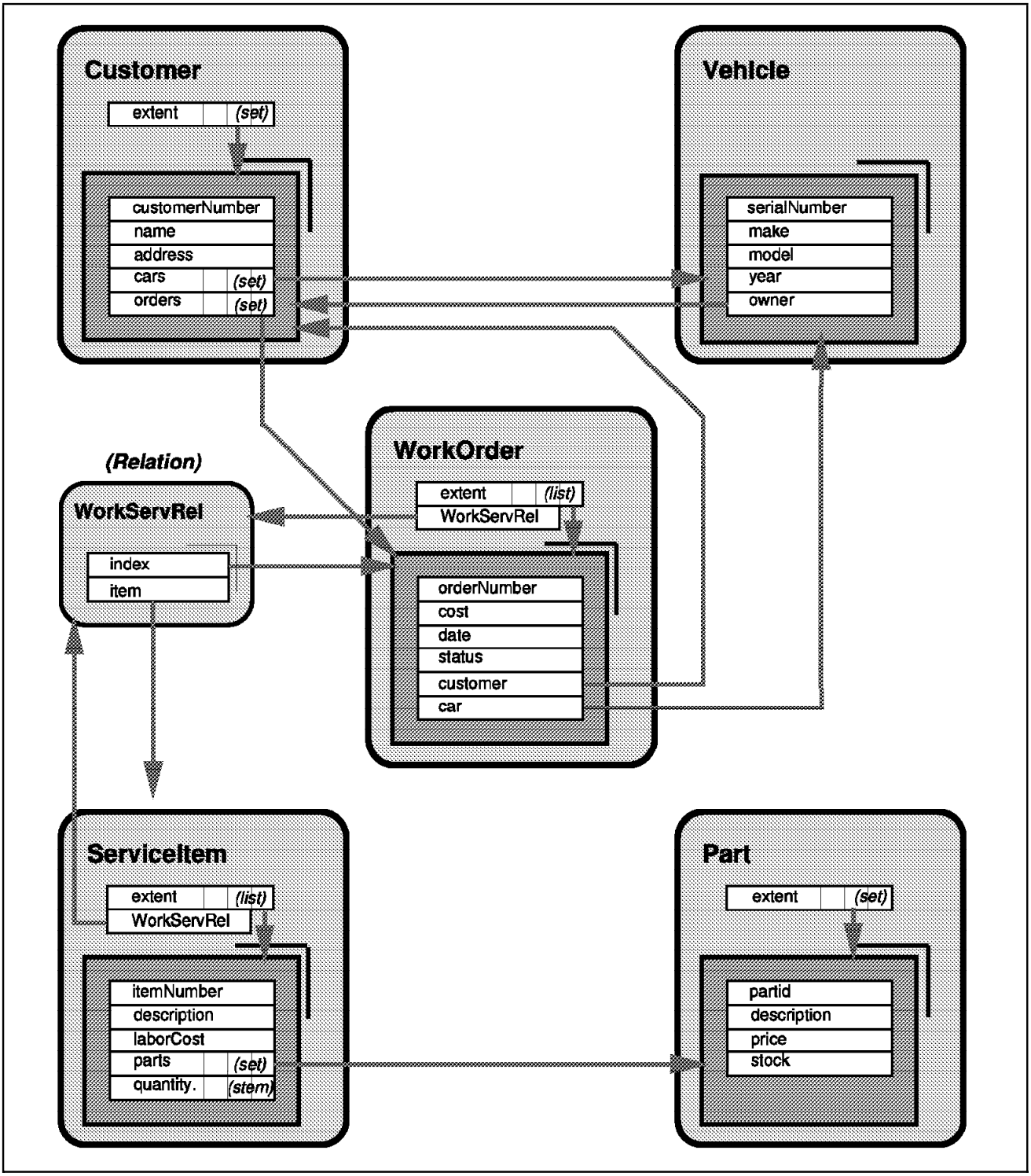


Figure 8. Implementation of the Car Dealer Model. The outer rounded boxes represent the classes, the inner rectangles the instances (objects) of the class. The white boxes in the outer rounded boxes are the attributes of the class; the white boxes in the inner rectangles are the attributes of the instances. Arrows indicate attributes that point to object instances.

Implementation Notes

1. We chose to use set, list, and relation classes to experiment with the features of these collection classes. For work orders, for example, we chose to have a list so that new work orders are added at the top.

2. The relation class is well suited to implement the m:m relationship between work orders and services. It provides methods to get a list of related objects:

```
::class WorkOrder
::method addServiceItem
  use arg itemx
  workserv = self~class~getWorkServRel
  workserv[self] = itemx        /* add a service item to the work order */
::method getServices
  return self~class~getWorkServRel~allat(self)

::class ServiceItem
::method getWorkOrders
  return self~class~getWorkServRel~allindex(self)
```

   The method *getWorkServRel* returns a pointer to the external relation object; and the *allat* and *allindex* methods of the relation class return an array of related objects.

   The relation object is implemented in the local directory (see "The Local Directory" on page 126) as

```
.local[Cardeal.WorkServRel] = .Relation~new.
```

3. The methods to list all the objects of a class (ListCustomerShort, ListPart, etc.) are implemented as *routines* instead of methods. Object REXX provides the ::routine directive to define subroutines (callable procedures):

```
::routine ListPart public
   aui~LineOut('List of' .Part~extent~items 'parts:')
   aui~LineOut(.Part~heading)
   do partx over .Part~extent
      aui~LineOut(partx~detail)
   end
   aui~EnterKey
   return
```

   The decision to use routines is based on the assumption that this code is used only by the ASCII user interface, and not by the GUI.

Sample Class Definition

Figure 9 on page 45 shows an abbreviated listing of the customer class as implemented in memory.

```
::class CustomerBase public

::method initialize class                          /*----- class methods -----*/
   expose extent
   extent = .set~new                               /* prepare set of customers */
::method add class                                 /* add customer to set      */
   expose extent
   use arg custx
   extent~put(custx)
::method remove class                              /* remove customer from set */
   expose extent
   use arg custx
   extent~remove(custx)
::method findNumber class                          /* find customer by number  */
   expose extent
   parse arg custnum
   do custx over extent                            /* - look through the set   */
      if custx~number = custnum then return custx
   end
   return .nil
::method findName class                            /* find customer by name    */
   arg custsearch
   custnames = .list~new                           /* - prepare result         */
   do custx over self~extent                       /* - look through the set   */
      if abbrev(translate(custx~name),custsearch) then do    /* - compare name */
         custstring = custx~number~right(3)|| ,
                      '-'custx~name'-'custx~address
         custnames~insert(custstring)              /* - add one to result      */
      end
   end                                             /* - return the result      */
   return custnames~makearray
::method extent class                              /* return set of customers  */
   expose extent
   return extent~makearray
::method heading class                             /* return a heading         */
      return 'Number      Name                    Address'

::method init                                      /*----- instance methods ---*/
   expose customerNumber name address cars orders
   use arg customerNumber, name, address           /* initialize new customer  */
   cars = .set~new
   orders = .set~new
   self~class~add(self)                            /* add it to the set of cust*/
::method delete                                    /* delete a customer        */
   expose cars orders
   do carx over cars                               /* - and all the cars       */
      carx~delete
   end
   do workx over orders                            /* - and all the orders     */
      workx~delete
   end
   self~class~remove(self)                         /* remove it from the set   */
::method number unguarded                          /* return customer number   */
   expose customerNumber
   return customerNumber
::method name attribute                            /* name, name= methods      */
```

Figure 9 (Part 1 of 2). Customer Class in Memory

```
::method address attribute                          /* address, address= methods*/
::method update                                     /* update customer info     */
   expose name address
   use arg name, address
::method addVehicle                                 /* add vehicle to customer  */
   expose cars
   use arg newcar
   cars~put(newcar)
   newcar~setowner(self)
::method removeVehicle                              /* remove vehicle from cust */
   expose cars
   use arg oldcar
   oldcar~deleteOwner
   cars~remove(oldcar)
::method getVehicles                                /* return vehicles of cust. */
   expose cars
   return cars~makearray
::method findVehicle                                /* find vehicle by serial   */
   expose cars
   use arg serial
   do carx over cars
      if carx~serial = serial then return carx
   end
   return .nil
::method addOrder                                   /* add order to customer    */
   expose orders
   use arg newwork
   orders~put(newwork)
::method removeOrder                                /* remove order from cust.  */
   expose orders
   use arg oldwork
   orders~remove(oldwork)
::method getOrders                                  /* return all orders of cust*/
   expose orders
   return orders~makearray
::method detail                                     /* return a detail line     */
   expose customerNumber name address
   return customerNumber~right(5) '     ' name~left(20) '  ' address~left(20)
::method makestring
   expose customerNumber name
   return 'Customer:' customerNumber name
```

Figure 9 (Part 2 of 2). Customer Class in Memory

Source Code for Base Class Implementation

The source code for the base implementation is listed in “Base Classes” on page 247.

Chapter 4. ASCII User Interface

In this chapter we look at a variety of technologies that can be used to develop the user interface for Object REXX applications. While most of the solutions that we present are graphical (GUI), we also present a simple ASCII character user interface (AUI).

Designing the User Interface

"Come on, Steve, you're late for the meeting!" called Curt.

"I'm busy working," called back Steve.

"You know that work is no excuse for missing a meeting, Steve," responded Curt.

"Meetings are work, man," grumbled Steve, gathering his ThinkPad and stopping to pour some coffee before joining Curt and Hanna in the meeting area.

"Whoops!" said Hanna. "Being late for a meeting is bad enough, but coming in late *with coffee* is a capital offense, Steve. You know the rules!"

"Yeah!" agreed Curt. "You get to buy the cookies for our mid-morning coffee break. Make mine a blueberry muffin, please."

Steve shook his head. "Someone has to do the work while you guys sit around talking to each other, or nothing would ever get done." he said. "I've been designing the user interface for the car dealer application."

"What do you mean, 'designing the interface'?" asked Curt. "You know that Trusty Trucks doesn't want a GUI front-end to the application. All their existing PC applications are character-based, and they want the car dealer app to look exactly the same. Building a character-based user interface is the easiest thing in the world. We don't need to waste time designing it."

"Yes, I know," said Steve, shaking his head. "It's amazing. They've just upgraded all their PCs from DOS to Warp Connect so they can get easy file-sharing and Internet access, and they still want DOS-style interfaces. Surely you could have sold them on the benefits of a good GUI, Mr. Ace Salesman?" He looked pointedly at Curt.

"Be realistic, Steve," responded Curt. "They've got a lot of legacy DOS applications that they have to keep running. One of the main reasons they chose OS/2 is its excellent DOS compatibility. They don't want to redevelop all their old apps with GUI front-ends. In fact, they don't even have source code for some of the older ones. They were built by a little contracting company that went out of business. Like we might too, if we don't get a move on with this project!"

"Exactly!" said Steve. "That's why I was working on the user interface. And for your information, the reason we need to design it carefully is that we plan to sell the same application to other businesses as well. You know that I've been talking to Classy Cars about it, and they're really interested. There's no way they will want a clunky old character

interface app in their smart showrooms with the sort of cars they sell. They want the latest GUI, where the G stands for Gee Whiz! And when I showed them some multimedia with bitmap displays, recorded audio and even a short video clip, they were turning handsprings."

"Multimedia? With audio and video?" snapped Curt. "Steve, are you crazy? This is a simple car dealer application. It handles the booking and tracking of vehicle services. We're talking about guys in greasy overalls crawling under cars. Multimedia has absolutely nothing to offer us in this application. We've got a tight deadline to deliver working code to support a serious business operation, and you're messing around with your multimedia toys again! You're just trying to justify the company money you wasted buying that fancy multimedia ThinkPad."

Steve smirked in reply. "Your trouble is you have absolutely no imagination," he said to Curt. "Sure, we're building a vehicle servicing application. But the reason we chose to build it in Object REXX is that as time goes by its OO facilities will allow us to reuse the objects we build for totally new applications. And while I was talking with Classy Cars, I found that their real hot button is the sale of cars, both new and second-hand. Sure, they need a system to manage car services, but they make more money selling cars. And when I talked through the selling process with them, I soon realized that our application already contains many of the objects needed to support selling. Like vehicles and customers, for example."

"But Steve, we have no multimedia data in our system at all as it stands," said Hanna. "And writing code to handle multimedia will be a major undertaking. Is it realistic to start with something that complicated at this stage?"

"What you guys don't realize is how easy it is to do multimedia in REXX," said Steve. "I developed a little demo on the fly at Classy Cars to show them how it could work. Just look at this."

Steve double-clicked an icon on his ThinkPad's desktop, and a folder opened. In it were several icons, each looking like a car, with captions referring to different popular brands. There were also icons labelled Audio and Video in the folder. Steve dragged one of the car icons and dropped it onto the Audio icon. After a second, they heard his recorded voice saying, "The Gazebo. An ideal outdoor car for the driver who enjoys plenty of fresh air." Steve picked up the same icon again and dropped it onto the Video icon. A window opened on his screen, and the familiar scene of two macaws beaking one another played in it, accompanied by music.

"Is that all it does?" asked Curt. "And how many hundreds of lines of code did you waste building it?"

Hanna looked thoughtful as well. "How many lines of code did it take, Steve?" she asked.

"Hardly any," said Steve. "Look, this is just a demo to show what could be done, not a production system. I used Warp's standard Workplace Shell facilities to put together the folder and icons. I pointed to my audio.cmd in the audio button's setup notebook. When the user drops an icon on Audio, my command gets scheduled with the name of the icon dropped on it as the parameter. I use this name to pick an audio file and play it. Here's the code."

Steve opened an editor window, and there hiding in the top corner were 10 lines of code. "The video works the same way," he added, and brought up the video.cmd for them to see as well.

Hanna was excited. "Hey, Steve, that's really neat. If that's what you were building just now, I'll pay for the cookies in the next coffee break."

"This is just a red herring," said Curt. "We've got to deliver the car-servicing application soon if we want to get Trusty Truck's business. And if we want to stay in business. We don't have time to mess around building multimedia demos."

Steve looked upset and was about to respond, but Hanna cut in. “Wait, Curt. You′re right that we have to deliver Trusty Trucks′ application soon. But Steve′s also right. We′re using Object REXX precisely so we can extend the base application to do different things for different customers in the future. We have to strike the right balance. And the key to that is to design the system right from the start so it can grow to meet new needs as they arise.”

“And that was exactly what I was doing when you interrupted me to come to this meeting,” said Steve. “So why don′t we stop talking and get some work done.” He brought up his notes on his ThinkPad and started talking through them. “We will have to develop both character and GUI versions of our application. I′ve called the character version AUI for short. Most of the functions that we have to implement will be common to both versions, and of course we don′t want to duplicate the code.”

“Why not?” asked Curt. “That′s how we′ve always done it in the past. It′s a clean solution. You can implement a change that one customer wants without messing up the other customer′s versions.”

“Well we didn′t have very much choice in the past,” said Steve. “Classic REXX is procedural, and it′s hard to share procedural code between different versions of an application. It′s even hard to segment a large application into many small files with classic REXX because of the communication barriers between different source files. And if the individual source files are big, automatically they deliver complex functions. The key to reuse is keeping the functions small and simple. That′s where Object REXX shines.”

“Maybe Object REXX makes it easier to share code,” said Curt, “but what′s the advantage? Different customers will want different features added to the application, and it won′t be long before they′ll need different versions of the source.”

“We have to break out of that cycle if we want to be more profitable,” said Hanna. “If you look at the really successful PC software products, there isn′t a different version with different features for each customer. The vendor implements only those features that will be useful to most of the customers, and then they *all* get the new features. We aren′t quite in that kind of business, and we will have to implement some features that only one customer requests. But we should always be on the lookout to make new features available to every customer who might possibly want them, even if it′s some time out in the future.”

“Yes, and Object REXX will allow us to keep a common code base in the form of common class definitions in a shared source file, and then to implement only the differences as source unique to a particular customer,” agreed Steve. “That′s why I′ve been trying to work out how we can implement the ASCII user interface as an object.”

ASCII User Interface As an Object

“Did I hear you right?” asked Curt. “You want to implement the ASCII user interface as an object?”

“That′s right, Curt,” replied Steve. “We′re using an object-oriented language, you know, so why not use its facilities for the user interface too?”

“Well, I′ve got good news for you, Steve,” Curt said. “In Object REXX, every variable and expression is actually an object, and every function is a method on an object. When you code:

```
say aString
```

that′s actually equivalent to:

```
call lineout aString
```

and Object REXX implements that as:

```
.OUTPUT~lineout(aString)
```

where .OUTPUT is a standard object in each process's directory of local values. You need struggle no longer to design an OO interface for the AUI version, Steve. Just use the SAY command!"

"I was trying to work at a *slightly* higher level of abstraction than that," said Steve. "Think about the menus, for example. Our old REXX programs that run in AUI mode are riddled with strings of SAY commands that spill menus out on the screen. Those won't work so well when we have to switch the output from the default .OUTPUT object to a GUI screen driver, will they Curt? We would probably want to make use of the GUI window's menu bar instead,"

"That's why we need a different version of the source for the AUI and GUI versions," replied Curt.

"Can we put the AUI-handling code and menus into a subroutine in a separate file?" asked Hanna. "The GUI version would simply not call that subroutine and not have that code."

"It's not that easy," said Steve. "The logic that handles the menu has to call the code that implements the menu option chosen by the user. The menu code has to be the main routine, and the rest of the system subroutines. If they're in separate files, it's not that easy to pass them all the data they need to run."

"That's why we need a different version of the source for the AUI and GUI versions," parroted Curt.

"We're trying to solve a problem, not score cheap points," said Hanna. "The problem of communicating with subroutines isn't that great with Object REXX—we can encapsulate all the data they need in a single object, if necessary. But tell us the approach you were working on, Steve."

The AUI Class

"Well, we could implement an AUI class to handle all output to the console. Handling the screen-full condition is always a bit messy, and in the past we've written that logic into every piece of code that produces a listing on the screen. The AUI init routine would be called automatically when we create the AUI object, and it could use the REXX *SysTextScreenSize* built-in function to find out how many rows can fit on the screen. Each time the *lineout* method is used it can call the REXX *SysCurPos* built-in function to find out how many screen rows are already used, and handle the screen-full condition automatically."

"Sometimes we need to put out several related lines that we want to stay together on the screen—perhaps a customer with all his or her vehicles," said Hanna. "How would the AUI object handle that?"

"We could build a *checkRows* method for AUI," replied Steve. "You pass it the number of lines you want together on the screen. It checks to see if there's enough space free, and if not, it invokes the screen-clearing logic. With this approach, none of the routines that generate screen output would need to know how many lines the screen has space for, or how many of its lines are already in use. All of this screen-related information would be *encapsulated* in the AUI object."

"That's neat," said Hanna.

The AUI Operations

"Let's define all the operations (methods) needed for the character interface on a sheet of paper," added Curt, and shortly afterwards they had it all ready (see Table 11).

Table 11. Methods Required for AUI

Method	Type	Purpose
init	Instance	Initialize object, store window size
getrows	Instance	Return number of rows in window
ClearScreen	Instance	Clear output window
LineOut	Instance	Output one line of text
CheckRows	Instance	Check if there is enough space for "n" rows
UserInput	Instance	Ask user for input, character or numeric
YesNo	Instance	Ask user for Yes or No input
Enterkey	Instance	Wait until user presses enter key
Error	Instance	Display error message
AckMessage	Instance	Display acknowledgment message

"Why are the methods instance methods?" questioned Curt.

"Well, Curt, it's true we could implement all methods as class methods," replied Steve, "but I think it is cleaner to create an actual AUI object at run time to handle the interactions."

ASCII Menus as Objects

"The other things I'd like to tidy up are the menus. In the past we have implemented them by coding a whole bunch of SAY instructions, outlining the options. Then immediately after these come WHEN instructions, checking for each of the options and implementing some action if that option has been chosen. I'd like to move the menu text and associated actions right out of the REXX programs and store them as parameter files. Then we could define a menu class. Its class init method could read the menu parameter file and set up the menus as a list of objects in storage. It would also have a method to display a selected menu object, check which option the user chooses, and automatically implement the corresponding action."

"Often a menu action will simply display a submenu," said Curt.

"That's right," said Hanna. "In that case the action in the main menu would be an instruction to display the submenu. The menu display method would invoke itself. That's possible, isn't it?"

"Yes," said Curt. "I've been doing some playing around with the concurrency features of Object REXX..."

"So I'm not the only one who plays around!" interrupted Steve.

"...and methods can invoke themselves recursively," continued Curt. "Of course, we would have to make sure we don't send them into an infinite loop by linking a submenu back to one of its parent menus."

"Our menu display process would be user-driven. The user would quit soon enough if it loops back on itself," said Steve.

"That sounds like a good approach," said Hanna. "I'm still not clear on how we'll tie it all together when we build our first GUI front-end, but that's not today's problem. It's time for our coffee break. I'll buy the cookies."

“Great!” said Steve. “In that case, let’s go to the Golden West Coffee Shoppe.”

“Oh no!” groaned Curt. “Don’t tell me that I have to sit and watch him nibble his way through yet another Golden West Monster Munch Chocolate Chip Cookie!”

The Menu Operations

After the coffee break the three sat together and developed the list of menu operations (see Table 12).

Table 12. Methods Required for Menu

Method	Type	Purpose
initialize	Class	Read menu file and build menu objects
findMenu	Class	Find existing menu or allocate new one
init	Instance	Initialize new menu object with array of items
addItem	Instance	Add a menu item to the menu object
getname	Instance	Return name of a menu object
showMenu	Instance	Display the menu, prompt user

Implementing the Menus

The menu input file MENU.DAT has the following structure with fields separated by tab characters (represented as ¬ signs):

Structure of menu data file

```
Main¬CAR DEALER - GENERAL MENU
Main¬List (customer, part, work order, service)¬showMenu List
Main¬Update customer and part information      ¬showMenu Update
 ...
List¬CAR DEALER - LISTING MENU
List¬List customers                  ¬call ListCustomerShort
List¬List customers and vehicles     ¬call ListCustomerLong
 ...
Update¬CAR DEALER - UPDATE MENU
Update¬Create a new customer   ¬call Newcust
 ...
```

The main program uses the menu class as follows to initialize the menu structure and to run the application using the menus:

Menu loop in main program

```
aui = .AUI~new                                    /* allocate AUI object           */
menus=.array~new                                  /* runtime level array of menus  */
menus[1] = .Menu~initialize                       /* build menu objects, store 1st */
level = 1                                         /* start at top menu             */
do until level < 1                                /* run loop until exit           */
   action = menus[level]~showMenu                 /* show the current menu         */
   select                                         /* - user enters an action       */
      when action = .nil then level = level - 1   /* previous menu                 */
      when action~class = .Menu then do           /* user select submenu           */
              level = level +1                    /* - add submenu at lower level  */
              menus[level] = action
           end
      otherwise interpret action                  /* user select an action         */
   end                                            /* - run that action             */
end
```

Appearance of ASCII User Interface

The windows displayed to the user by the menu system are shown in Figure 10 on page 54.

Source Code for ASCII User Interface

The source code for the ASCII user interface and menu implementation is listed in “ASCII OS/2 Window Interface” on page 283.

The source code to run the ASCII user interface is listed in “Command to Run the Car Dealer in ASCII” on page 345.

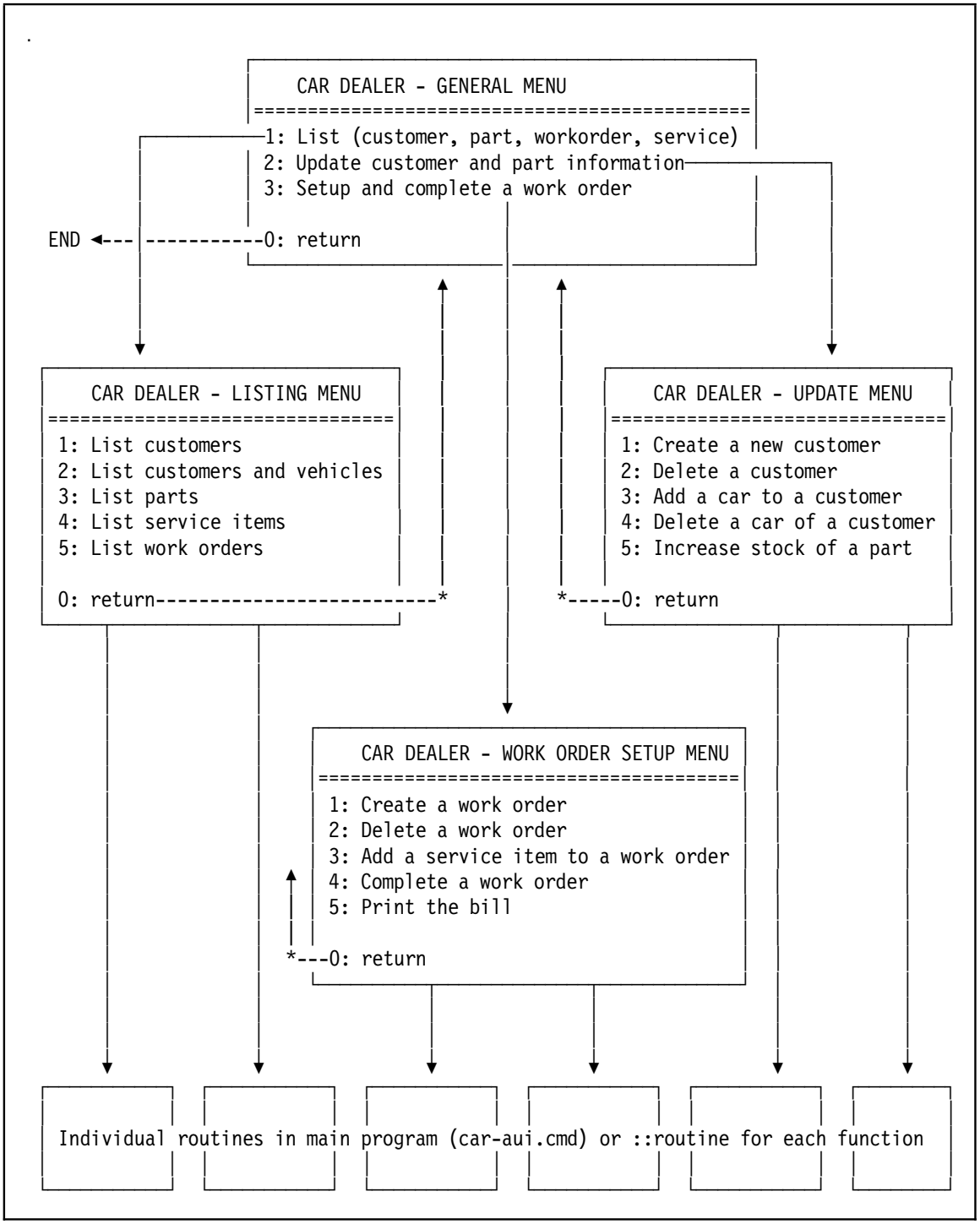


Figure 10. Appearance of ASCII User Interface

Chapter 5. Persistent Objects on Disk

In this chapter we find out how objects can be made persistent by storing them in conventional flat ASCII files. We want to ensure that the objects survive even when the program that creates them ends and are available again the next time that the program runs. For brevity we call this the FAT (File Allocation Table) option, although of course the files may equally well be located on an High Performance File System (HPFS) drive.

Storing Objects in FAT Files

"Great news, team—we're on the last lap of agreeing on the detailed design of the car dealer system with Trusty Trucks!" Curt strode into the Hacurs premises, stripping off his coat and beating a light dusting of snow from it.

"Wonderful!" said Hanna. "We've all spent a lot of time on this application. We need to implement it and bill for it soon."

"The only outstanding area is How are we going to store their objects when they turn off the PC that runs the application?" asked Curt.

"Did you say 'the PC'?" asked Steve. "Aren't they going to run it on multiple machines?"

"No," replied Curt. "We did some performance evaluation with our latest prototype and worked out that they'll be able to handle their current business volumes easily on a single workstation. And Trusty Trucks is too cost conscious to use two PCs to do the job if one will do."

"What if the one PC breaks down?" asked Steve.

"Well, that's part of what we have to discuss and implement," replied Curt. "We need to make sure that all object creations, updates and deletes are recorded on disk, and that the system will recover its objects automatically from disk when it is brought up again. We also have to decide on some kind of disaster recovery scheme."

"The obvious way to do this is to base our object persistence on a database manager like DB2," said Steve.

"Trusty Trucks is a cost-conscious organization, Steve," replied Curt. "They're not like Classy Cars. They don't own a real database management system, and they're not about to buy one just to run our application. We're going to have to find a way of doing the job using conventional ASCII files, if that's possible."

"If only a single workstation needs to access the data, it's entirely possible to do the whole job using ASCII disk files," said Hanna. "In fact that approach would work even if multiple PCs want to read the files at the same time, just so long as only one PC has update access to the files."

"That would be the ideal solution, Hanna," said Curt. "How would you go about it?"

“I don′t think I′m going to like this!” interjected Steve, but the other two ignored him.

Hanna swept her hair back with her fingers, walked to the whiteboard and picked up a pen. Curt and Steve knew she wouldn′t use the pen, just holding it seemed to help her think. “Because we′re using an object-oriented approach to the whole system, we know exactly when a new object is created, or an old one updated or deleted. It can′t happen unless our object methods are called.”

“Right,” said Steve and Curt in unison.

“OK. So all we have to do is change the init method for each object, to write a copy of the new object to disk as soon as it has finished initializing it. And we make similar changes to the delete methods so they can delete the objects from disk, and the update methods so they can rewrite the objects to disk whenever they change.”

“That sounds straightforward,” said Curt.

“How would you delete an object from a disk file if it′s in the middle of the file?” asked Steve. “You can′t just leave a hole in the file.”

“We could shift all the trailing objects one place to the left and leave out the deleted object,” replied Hanna.

“How will we know the position of the object in the file?” asked Steve. “We can′t shift the remaining objects over it unless we know where it is.”

“We could give every object a new attribute called *position,*” suggested Curt. “When we read the objects into storage we could store the positions in which we found them in this attribute. Then when we need to update or delete them, we′ll know where they are on disk.”

“But if they keep shifting around every time you delete an object, you won′t know where they are when it comes time to update them,” reasoned Steve. “It would really be simpler if we used a database manager. It has all the logic needed to sort out problems of this kind.”

“I′ve just told you, Steve...” started Curt, but Hanna interrupted.

“Hold on, guys! Curt, how many objects are there going to be?”

Curt shifted his scowl from Steve and answered Hanna. “A couple of hundred vehicles, somewhat fewer customers, and maybe a thousand service records if they keep six months′ history on line.”

“So why don′t we just rewrite all the objects to disk any time one of them is changed?” suggested Hanna.

“That would be a huge overhead!” Steve objected.

“Not necessarily,” answered Hanna. “We only need to store 30 to 40 bytes of information per object, and if there are a thousand, we have to write 30 or 40 KB. That won′t take long.”

“It would take forever!” said Steve. Curt began tapping on this ThinkPad′s keyboard. “Anyhow,” continued Steve, “if you add up all the objects of all types, it comes to a pretty big file, maybe 120 KB.”

“No, we would split the different object types into separate files,” said Hanna. “Otherwise we′d have a jumble of different object types in the file, and we′d have to write extra logic to separate them. So the biggest file we′d have to handle would be only about 40 KB.”

“That would still take a long time to rewrite,” said Steve.

“Let′s time it,” said Curt. “I′ve just written a little REXX command that takes two parameters—average record length and number of records. It writes a file of this size to disk, and measures how long it takes. So what numbers should I try?” he asked.

“Try a 30 byte record length and 1000 records,” said Hanna.

“OK,” said Curt, and he typed in the command. “That took one second,” he said. “Doesn′t sound too long to me,” he added, looking at Steve.

Steve looked stunned for a while, then his bewildered look cleared up. “Of course! You′re using an HPFS-formatted disk. That gives you high performance to start with, and you′ve probably got ‘lazy write’ on too—that′s the default for HPFS. So OS/2 will accept the write commands into buffer and come back to the program immediately. The data gets written back to disk in parallel with subsequent program execution.”

“That sounds great to me,” said Curt. “Since the operating system takes care of that for us, we really don′t have to worry about performance. And the production system will run on a server at Trusty Trucks. It′s disk is faster than mine. So Hanna′s approach will perform beautifully.”

“Yes, but what if the system goes down while it′s still writing to disk?” asked Steve. “A database manager logs all changes to disk as well as writing the data back, so if something goes wrong while it′s writing the data, it can always fix it up from the log.”

“The data files for Trusty Trucks will be so small we could easily write the data out to a different file name each time round, and cycle through the list of three or so file names for each file,” said Hanna. “When we start up the system, we can use the *query timestamp* operand of the stream command to find out which version of the data is the most recent. We can write a special trailer at the end of each file, so if it′s not there we know the file is incomplete and we should use the next most recent one. It′s easy to solve this kind of problem.”

“I agree,” said Curt. “Let′s get the system going against flat ASCII files and start doing user training and acceptance testing at Trusty Trucks. We can change it later to put in smart recovery logic. The users are waiting for us, and we need the money we′ll get once this system is installed.”

“That′s fine for Trusty Trucks,” said Steve, “but Classy Cars is a much bigger operation. They need to support six to eight separate locations, and they will need update facilities from multiple workstations at the same time. There′s no way a simple ASCII file approach will meet their needs.”

“You′re absolutely right, Steve,” agreed Hanna. “We′ll have to build database support when it′s time to implement the system for Classy Cars. And maybe in the past we would have had to try to persuade Trusty Trucks to use a database manager as well, because we couldn′t afford to support two different versions of the application. But the main reason we′re using Object REXX for this application is so we can customize different versions for different customers and still reuse all the common business logic. Remember?”

“Yes, I guess so,” said Steve, not looking convinced. “Only once we′ve got the ASCII file version going, you′ll probably change your minds and decide that′s the way we have to go for Classy Cars too.”

“We′ll do what′s best for the customer, Steve,” said Hanna. “That′s the only way to make sure that they′ll ask us for help again.”

“OK.” he said, “We′ll build an ASCII file solution for Trusty Trucks, but I′m going to start working out how we can structure the application to get the kind of configuration flexibility we′ll need in the future.”

“That′s a great idea, Steve,” said Hanna. “Now let′s finish this design and get coding. What format should we use for the objects when we write them out to disk files?”

Format of the Objects

"Why not write them out as comma-delimited records, the way a spreadsheet package would export rows?" asked Curt.

"Not bad, but our data could easily include commas in things like address fields," said Hanna. "Let's use tab characters to delimit fields."

"Good idea!" said Curt. "I've got the fields we need on this piece of paper." He rifled through his work file and pulled out a piece of paper (see Figure 7 on page 35). "All we have to do is write the files in this format."

"Just a minute," said Steve. "You've got some *smallint* fields defined there. Those are 2-byte binary integers. Either byte could easily contain the code value for a tab, the ASCII value 9. That would throw you off when you try to decode the record during loading."

"Good thinking, Steve," said Hanna. "We'll have to write the numeric values as strings. No problem, because that's the way REXX writes them out unless you tell it otherwise."

Sample ASCII file for the customer class

```
number name                 address              (¬ = tab key)

101   ¬Senator, Dale        ¬Washington
102   ¬Akropolis, Ida       ¬Athens
103   ¬Dolcevita, Felicia   ¬Rome
...
```

Steve smiled his appreciation for Hanna's compliment, and got more enthusiastic about the design. "We've also got some repeating groups in the service and work order objects," he said. "How are we going to handle those?"

"We can just attach them to the back end of the record, delimited by tabs like the other fields," said Curt. "We'll know what they are when we read the files. There's no chance of confusion."

Sample ASCII file for the work order class

```
number date     cost  complete  custmr  serial  service-items (¬ = tab key)

1      ¬09/06/95¬-1   ¬0        ¬101    ¬123456 ¬1
2      ¬09/06/95¬-1   ¬0        ¬103    ¬398674 ¬10¬9¬4
3      ¬09/06/95¬-1   ¬0        ¬106    ¬911911 ¬7¬6
...
```

"Not exactly third normal form[6]!" said Steve.

"No problem," said Hanna. "No one is going to read these files except us, while we're debugging the code."

"Hmm—I guess so," agreed Steve reluctantly.

[6] Third normal form does not allow repeating fields within a table. A separate table with a row for each repeating value is used in normalized tables.

Implementing the Changes in Code

"Well, I think we've got this all sorted out," said Curt. "We just have to modify the methods we wrote for our objects, to write updates to disk..."

"Hold it!" snapped Steve. "We've just agreed that we're going to have different versions of the system supporting both ASCII files and a database manager, and you want to start carving up our existing methods to hard-wire ASCII file logic into them. Once we've done that, we'll *never* be able to support two different versions while sharing common code."

"Be realistic, Steve!" said Curt. "How are we going to support ASCII files if we don't write some new function into the code? This OO stuff isn't magic, you know."

Steve glared at Curt, then strode to the whiteboard and took the pen from Hanna. She sat down, grateful to give her feet a rest.

"Let's start with customer," he said. "We already have a Customer class defined with its methods to control how customer objects behave once they're in storage."

"Right," said Hanna encouragingly, as Steve drew a box and labelled it *Customer* on the board.

"Currently, the Customer class is a subclass of the Object class by default, since we didn't say otherwise when we defined it." Steve drew a box labelled *Object* above the customer box, and connected the two. "Now let's say we change the name of the Customer class to *CustomerBase*, and define a new class called *FAT Customer*." Steve drew a new box with this label below the customer box, and drew connecting lines to show that CustomerBase was a child of Object and FAT Customer a child of CustomerBase.

"With this structure," Steve added, "we could write the additional methods that we need for object persistence in FAT files as new methods in the FAT Customer class. We could change the CustomerBase class methods to invoke these new persistent methods when object updates need to get written to disk."

"Hold on," said Curt, "'FAT Customer' isn't a valid class name."

"Well, the class name would actually be just Customer," Steve answered, "but we would have different versions of the Customer class definition; one for FAT, another for DB2. We would store them in separate files. I thought of giving both files the same name, but with different extensions to distinguish them—maybe `customer.FAT` and `customer.DB2`, for example."

"That looks fine, Steve," said Hanna, "but how would we switch between the FAT and DB2 versions of the code?"

"Like this," said Steve. He drew a DB2 Customer box next to the FAT Customer box, and then changed the lines as shown in Figure 11 on page 60.

"Let's suppose we need a DB2 version," he said. "We develop a totally separate class called Customer with its own methods to handle persistent storage in DB2 tables. We set up two different configurations. In the FAT configuration, the FAT Customer class inherits its persistent methods from the CustomerBase class, and in the DB2 configuration the DB2 Customer class inherits them from the CustomerBase class. With this approach we can use exactly the same base Customer class and method definitions for both the FAT and the DB2 implementations."

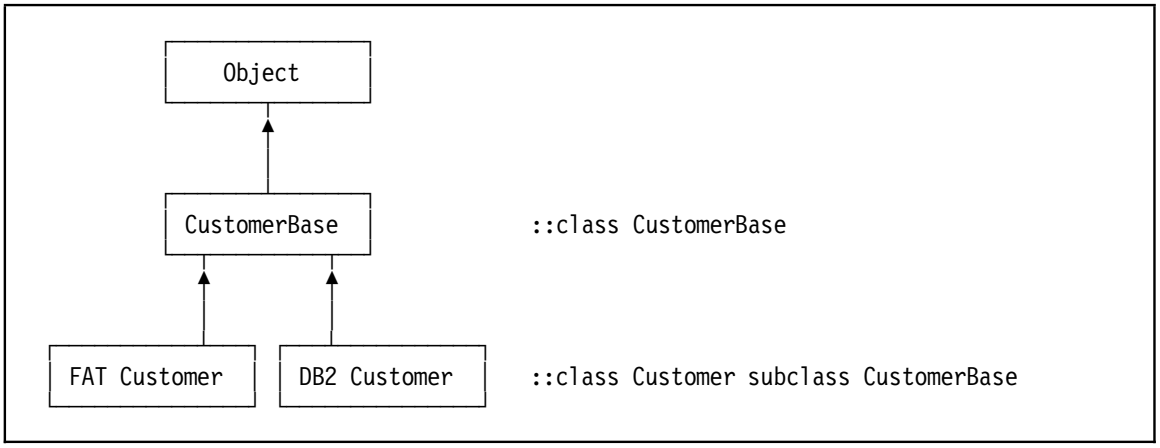


Figure 11. Customer Class Inheritance Diagram

“That’s really neat, Steve,” said Hanna. “That’s using the power of inheritance in Object REXX to solve a real problem. What do you think, Curt?” she asked, turning to him.

“It sounds like it might work,” said Curt, “but I think we should think it through a bit more before we decide on it.”

Hanna turned back to Steve. “Why don’t you try coding-up some sample code, Steve?” she said. “I’ll gladly help you if you need me.”

“I’ll rough something out for Customer, and then we can get together again and check it out,” he replied. “If it works out the way we need, we can split the remaining classes between us and make corresponding changes to them.”

“OK,” said Hanna. “Do you think you’ll have something ready for us to look at tomorrow?”

“Is that a question, or an order?” asked Steve. “I think I’ll have something for you to look at. After all, when you’ve seen one baseball game, you’ve seen them all.”

“Oh Steve, you make me feel terrible!” said Hanna.

“But not as terrible as you’ll feel if you don’t deliver, Steve!” added Curt. And on this note they parted.

The Class Structure

Next morning Steve was in early. When the other two arrived, Steve called them over to his ThinkPad. He had plugged it into the big screen so they could see what he was doing while he worked with the smaller screen of the ThinkPad.

“This turned out easier to do than I expected,” said Steve. “I actually had time to watch the game. Too bad about the result! I’ve defined the new FAT Customer class to handle persistent storage on ASCII disk. It has only six methods.” He pointed to the screen, which showed

- A *persistentLoad* class method to load all customer objects from disk into storage when the system comes up:

```
::method persistentLoad class
   expose file
   file = 'customer.dat'
   call stream file, 'c', 'open read'
   do i = 0 by 1 while lines(file)
      parse value linein(file) with customerNumber '9'x name '9'x address
```

```
      self~new(strip(customerNumber), strip(name), strip(address))
   end
   call stream file, 'c', 'close'
   return i
```

- A *persistentStore* class method to write all customer objects from storage to disk when any customer object changes:

```
::method persistentStore class
   expose file
   call stream file, 'c', 'open write replace'
   do custx over self~extent
      x = lineout(file,custx~fileFormat)
   end
   call stream file, 'c', 'close'
   return 0
```

- Three methods—*persistentInsert, persistentUpdate,* and *persistentDelete*—that simply invoke the persistentStore method; for example:

```
::method persistentInsert
   return self~class~persistentStore
```

- A *fileFormat* method to convert the customer object into a tab-delimited string to be written to disk:

```
::method fileFormat
   return strip(self~number)'9'x || left(self~name,20)'9'x || ,
          left(self~address,20)
```

"There are only 45 lines of code in this class; it's really simple," Steve continued, showing them the code.[7]

"What did you have to do to the original Customer class?" asked Curt.

"A few things," replied Steve, and explained:

- "I had to change the *initialize* class method to invoke persistentLoad. This is the method in FAT Customer that loads all the customer objects from disk into RAM:

```
::method initialize class
   expose extent
   extent = .set~new
   self~persistentLoad
```

- Then I changed the *init* method to invoke persistentInsert for new customer:

```
::method init
   expose customerNumber name address cars orders
   use arg customerNumber, name, address
   cars = .set~new
   orders = .set~new
   self~class~add(self)
   if arg() = 4 then self~persistentInsert
```

---

[7] The source code referred to by Steve is not included in this document. His application structure turned out to have some problems when Hacurs needed to introduce support for DB2. The persistentInsert, persistentUpdate and persistentDelete methods were moved to a separate mixin class called Persistent, as described in "The Persistent Class" on page 63.

- And I changed the *update* method to invoke persistentUpdate:

```
::method update
   expose name address
   use arg name, address
   self~persistentUpdate
```

- Last I changed the *delete* method to invoke persistentDelete:

```
::method delete
   expose customerNumber name address cars orders
   do carx over cars
      carx~delete
   end
   do workx over orders
      workx~delete
   end
   self~class~remove(self)
   self~persistentDelete
```

And that's all I had to do. It was very simple, really," said Steve.

"I don't get it," said Curt. "Why did you define separate persistentInsert, persistentUpdate, and persistentDelete methods if all of them simply invoke the persistentStore method? That looks like a waste of time."

"Well, I'm thinking ahead to how we'll implement the DB2 support," said Steve. "With DB2 we'll use different SQL commands to handle the insert, update, and delete cases. As it happens, we plan to handle these different cases by rewriting all the customer objects to an ASCII file for Trusty Trucks. But we need to invoke different methods in the base customer class so one version can meet both requirements."

"That's good thinking, Steve," said Hanna.

"Yes," said Curt, "so long as he doesn't waste too much time thinking about the DB2 implementation. We've got to deliver this system fast."

"I've done my bit," said Steve. "Why don't you and Hanna make the corresponding changes for the other classes? That's vehicle, service item, part, and work order. You can use my code as the basis for your changes. I've put it on the server in the project directory."

"Great! Let's go." said Hanna.

The Requires Directive

"Wait!" said Curt. "Are you planning to put the class definitions for customer, vehicle, service item, part, and work order into different files?"

"Yes," said Steve, "it makes for a nice clean implementation. None of the class files will be more than a few hundred lines of code."

"That may be so," Curt replied, "but these classes refer to one another extensively. If you put them into separate files, will they still be able to use one another?"

"That's why Object REXX has a *::requires* directive, Curt," Hanna said. "It allows the code in one file to use classes and methods defined in another. As you go through the code, make a note of the classes it refers to, and just make sure that you include a ::requires directive for each class that isn't defined in the same source file."

Example of ::requires directive

In the FAT customer class we require the definition of the base customer class:

```
::requires 'base\carcust.cls'
```

The Persistent Class

Hanna and Curt settled down at their ThinkPads and started looking at the code. Pretty soon, Hanna called out, "Say Steve, we're all going to code exactly the same three persistentInsert, persistentUpdate, and persistentDelete methods for each of the other four classes. Isn't there a better way of doing that?"

"Come on Hanna, just cut and paste," said Curt. "It won't take long."

"But Curt," said Hanna "We talked about several different ways of implementing persistent storage, and settled on our current approach for Trusty Trucks only because their file sizes are going to be small. What happens if their volumes grow, or if we find an opportunity to sell this solution to a bigger business, which still wants a flat file solution but has large volumes?"

"Now you're thinking OO, Hanna!" agreed Steve. "There is an easy way to do what you're asking. I'll move the three methods out of the FAT Customer class and put them into a new class—let's say we call it *Persistent*. Then each of our five FAT classes can inherit these methods from the Persistent class."

"So we should make our FAT classes subclasses of the Persistent class?" asked Curt.

"Yes. No! Wait!!" said Steve. "Let's do this properly. I'll make the Persistent class a *mixin* class. When you define your FAT classes, use the `inherit` clause to inherit methods from my Persistent class. That's what mixin classes are for, after all. It's very simple, really. Look, I'll change the diagram to show how it would work."

Steve drew shadow boxes behind the customer classes to represent the other data classes to be handled—vehicles, work orders, services, and parts. He then added a new Persistent mixin class and showed that the FAT data classes inherited some methods from it (see Figure 12).

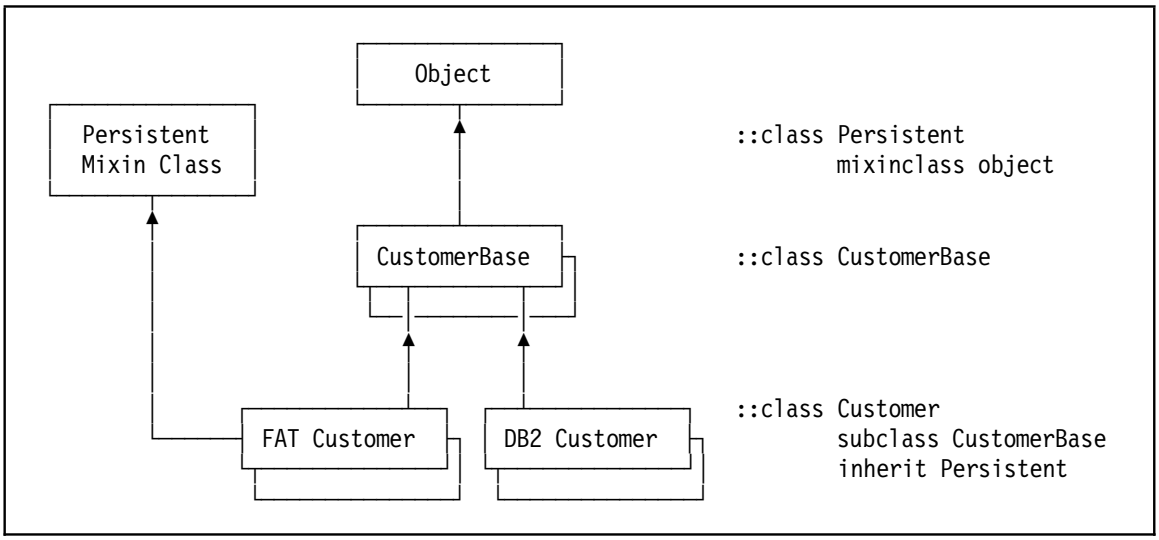


Figure 12. FAT Data Classes Inheriting from a Mixin Class

“What about the persistence methods for the DB2 version, Steve?” asked Hanna.

“The methods for persistence in DB2 will have to contain specific SQL statements for each object type,” replied Steve. “We′ll probably end up coding them directly into the DB2 classes themselves.”

“Is all this messing about really worth the trouble?” asked Curt.

“If we start building it right, we′ll finish building it easily,” said Hanna. “If we start cutting corners while we′re busy laying the foundations, there′s no way we′re going to get the walls square later on.”

Sample code of the Persistent class

```
::class Persistent public mixinclass Object

::method persistentLoad class           /* class methods */
   return 0
::method persistentStore class
   return 0

::method persistentInsert               /* instance methods */
   return self~class~persistentStore
::method persistentDelete
   return self~class~persistentStore
::method persistentUpdate
   return self~class~persistentStore
```

They all settled down to work. Their car dealer application was tested and working off persistent FAT file storage before the end of the day.

“I′m going to take this round to Trusty Trucks first thing tomorrow,” said Curt. “Wish me luck—I may just come back with the specs signed off and a committed implementation plan.”

“I′ll bring in a bucket of ice and some sparkling wine,” said Hanna. “Now don′t disappoint us, or Steve and I will have to drown our sorrows—alone.”

“You′ve got a deal!” said Curt.

Source Code and Sample Data for FAT Class Implementation

The source code for the FAT classes is listed in “Persistence in Files” on page 263.

Sample flat files for the five classes of the car dealer application are listed in “Sample Data” on page 243.

Chapter 6. Graphical User Interfaces

In this chapter we look at a variety of tools that can be used to develop a GUI for the Object REXX car dealer application. These tools are:

Dr. Dialog
VisPro/REXX
Watcom VX·REXX

The Setup

"That was some party!" said Steve. "Do you still have the Trusty Trucks contract, Curt? I hope you didn't turn it into a paper plane."

Curt smiled. "No danger of that, Steve" he said. "This contract is going to pay our salaries for the next few months while I'm busy installing the system and training the users."

"The Trusty Trucks order was a wonderful business win, Curt" said Hanna. "It makes me feel really confident about the future of our company."

"While you're busy skinning this lion, I'll go out and catch another," said Steve. "Classy Cars are very keen on our car dealer application, and they'll feel a lot more confident once they know they won't be the only ones using it. The only thing is, I'll have to develop a GUI front-end for it."

"It would be great if we could sell our system to other customers" said Hanna. "That's the way to get our profits up. We spent a lot of time designing it so that we could easily customize it to different users' requirements. It would be a great shame if that were never put to the test."

"Well, I'm going to start building the GUI today" said Steve. "I'll let you know how easily it fits in with our current design."

"Which GUI builder are you going to use, Steve?" asked Hanna.

"Dr. Dialog," answered Steve. "That's the one I know and love."

"Good luck!" said Hanna. Steve smiled in reply, then started working on his ThinkPad.

The Car Dealer GUI

Two days later, Steve called to Hanna. “Would you like to see the new, improved, GUI version of the car dealer app?” he asked.

“I’d love to,” Hanna answered, pulling a chair across to his desk.

Steve double-clicked a Dr. Dialog resource icon labelled `car-gui.res` and a GUI window opened, as shown in Figure 13.

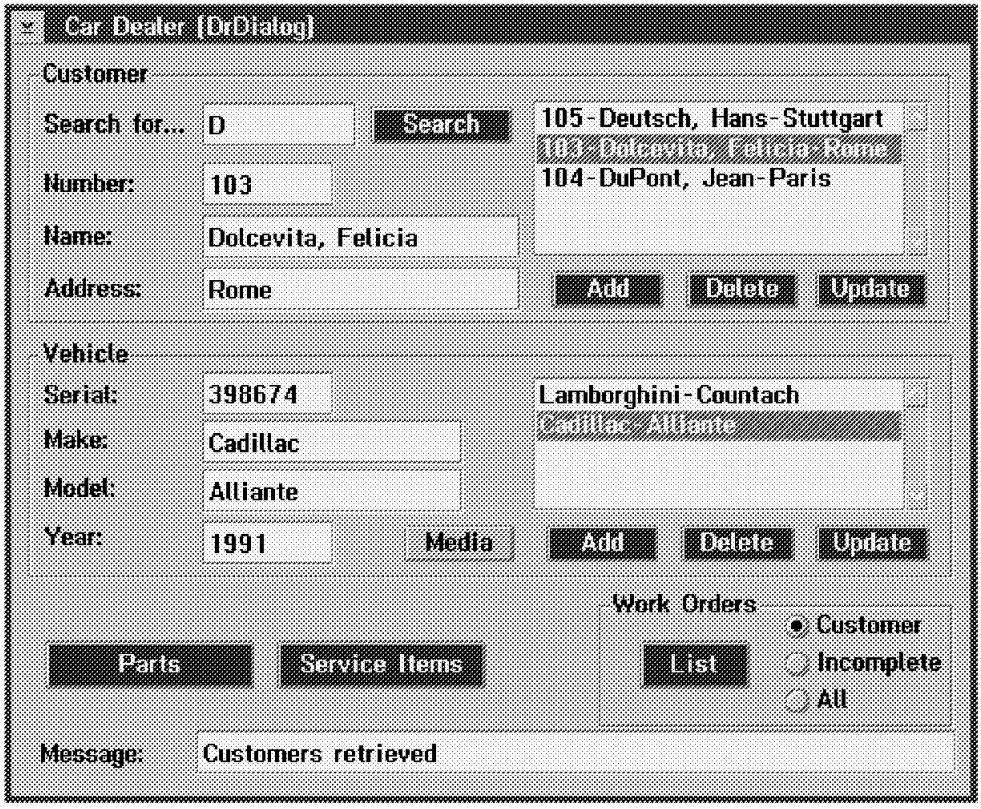


Figure 13. Main Window of Dr. Dialog GUI Application

“This is the main window, and the users can do a lot with only this. The first thing they have to do is identify a customer. They can put a name, or part of a name, in the Search for... entry field, then hit the **Search** button. I fetch all customers whose names match the search pattern entered, and put them in the list box to the right.”

“And if they enter no characters at all in the search field?” asked Hanna.

“Then the customer *findName* class method will fetch all the customers,” answered Steve, demonstrating this as he spoke. “Now if the user clicks on a particular customer in the list box, I fetch that customer’s details—number, name, and address—and display them in the entry fields below.” Steve clicked on a name, and the details were filled in.

“I also fetch a list of the cars owned by that customer, and put them into the vehicles list box” added Steve. “If the user clicks on a particular car in this list, I fetch that car’s details and populate the Vehicle entry fields. And if the customer has only one car in our database, which will happen often, I select that car and fetch its details automatically.”

“That’s neat,” said Hanna.

“I′ve got **Add**, **Delete** and **Update** buttons under the customer list box” Steve continued.

- “To add a new customer, the user fills in the customer′s number, name, and address and then clicks on the **Add** button.
- To update a customer, the user selects the customer, over-types the name or address, and then clicks on the **Update** button.
- To delete a customer, the user selects the customer and then clicks on the **Delete** button.”

“The **Add**, **Delete** and **Update** buttons under the vehicle list box do similar things. And I′ve put a **Media** button there too. It doesn′t do anything yet—it′s just a reminder.”

“If the user clicks on the **Parts** button, I open a Part List window,” he continued, showing this happen as he spoke (see Figure 14).

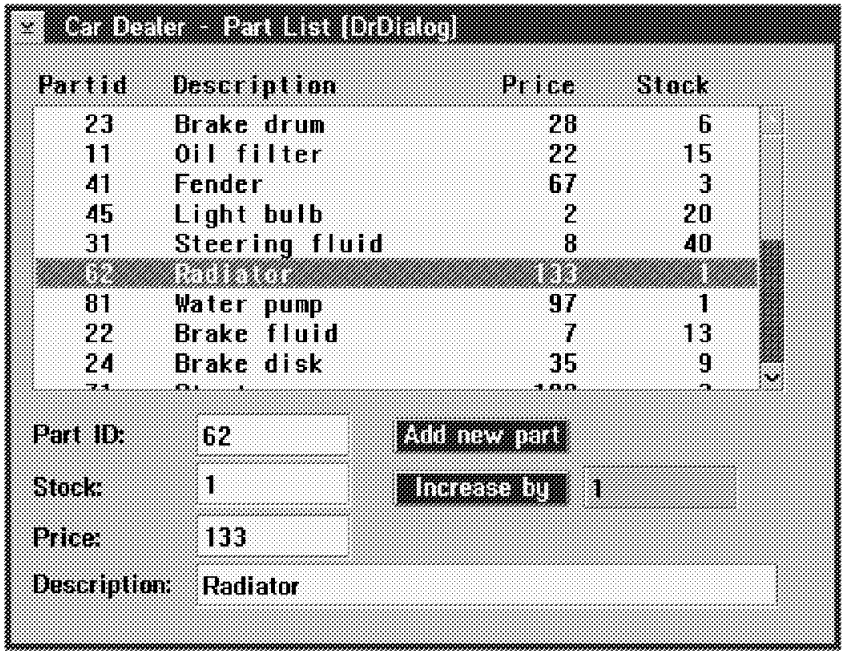


Figure 14. Part List Window of Dr. Dialog GUI Application

“This shows all the part objects available in a list box. If the user selects a particular part, I fetch its details and populate the entry fields at the bottom. The user can increase the Stock field by typing in the amount to increase by, and clicking on the **Increase by** button. To add a new part, the user fills in the entry fields and then clicks on the **Add new part** button.” Steve exercised these options. “This looks great, Steve,” said Hanna.

“Thanks,” said Steve. He closed the Part List window. “If the user comes back to the main window and clicks on the **Service Items** button, the Service Items window opens.” (See Figure 15 on page 68.)

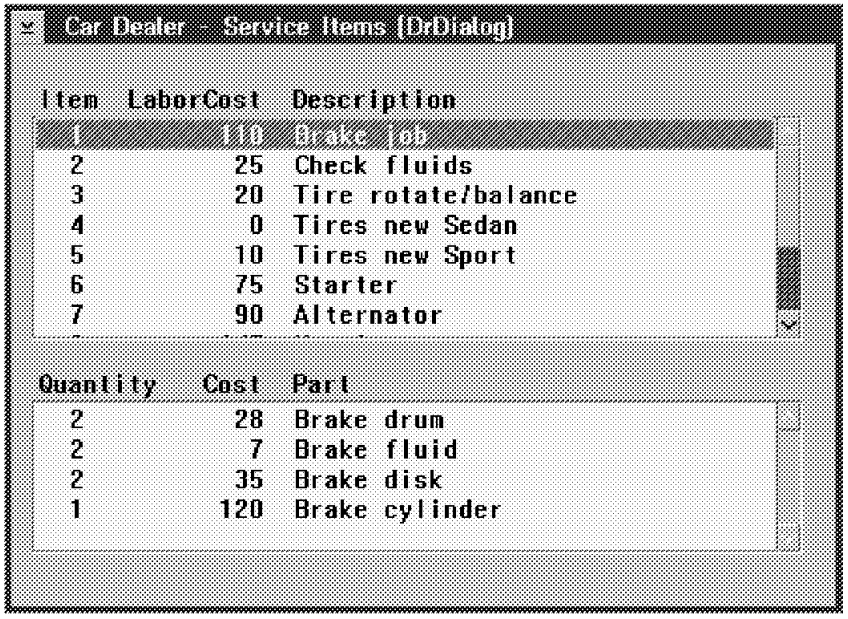


Figure 15. Service Items List Window of Dr. Dialog GUI Application

“This lists all the service items defined, with their associated standard labor cost. When the user clicks on a particular service item, I fetch a list of the parts needed to carry out a service of this type. I display these parts with the quantities required and the cost per part in the lower list box. And that’s all the user does with that window” concluded Steve, closing it.

“The last button on the main window (Figure 13 on page 66) is the work orders **List** button,” he added. “But before we bring that up, notice that I’ve put three radio buttons nearby.

- **Customer**, which lists the currently selected customer’s work orders
- **Incomplete**, which lists all currently incomplete work orders
- **All**, which lists all work orders.”

Steve selected the customer, Felicia Dolcevita, clicked on the **Customer** radio button, and then on the **List** button. “When the user clicks on this, up pops the Work Orders window.” he said (see Figure 16 on page 69).

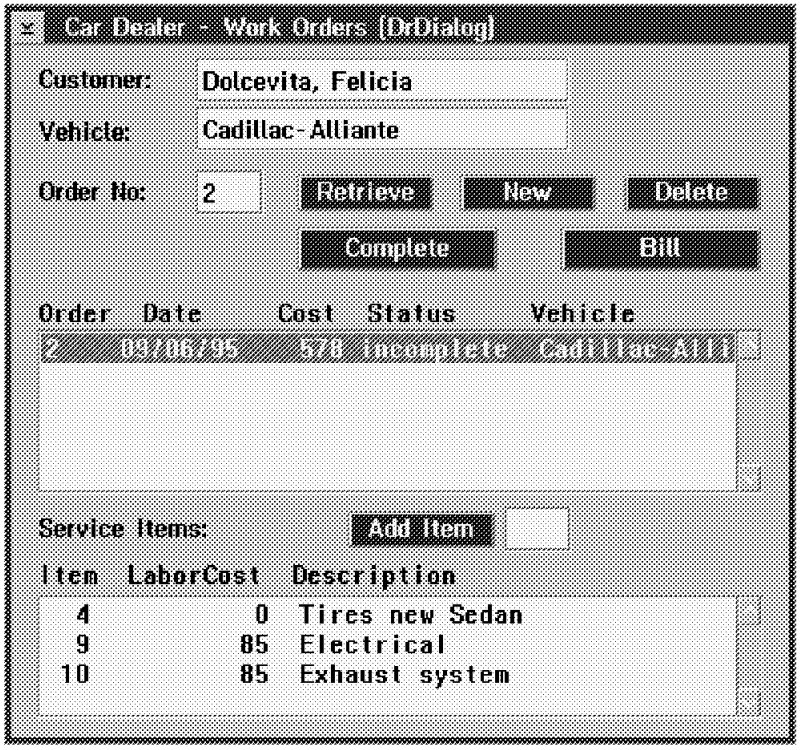


Figure 16. Work Orders Window of Dr. Dialog GUI Application

“This window has space for lots of things. I show the currently selected customer if the user chose the Customer radio button; otherwise the Customer field is blank. Below that I show a list of the work orders. If the user clicks on a particular work order in the list box, I put the vehicle make and model in the Vehicle entry field, and the work order number in the Order No entry field,” Steve continued, clicking as he spoke. “I also show a list of the service items associated with this work order in the Service Items list box. Users can retrieve any work order by number, by keying it into the Order No entry field and clicking on the **Retrieve** button.”

“Wow, Steve, you’ve put a lot of work into this,” said Hanna. “It looks impressive.”

“There’s more to come!” said Steve. “If the user has selected a vehicle, he or she can click on the **New** button to create a new work order for that vehicle.” Steve clicked the button, and a new work order appeared in the list box. It was already selected. “There are no service items on the new work order yet. But I can type a service item number into the entry field just right of the **Add Item** button and click on it. See, the service item appears in the list below,” said Steve, pointing to the screen.

“Can you delete service items from an existing work order?” asked Hanna.

“No!” said Steve emphatically. “That’s a feature they particularly *don’t* want to have. They suspect that there’s some ‘sweethearting’ going on in the service department, where services are performed but not billed. If a service item is added to a work order in error, the clerk responsible has to make out a whole new work order, and get management approval to delete the old one.”

“Once all the service items on a work order have been completed, the users have to mark the work order complete,” Steve continued. “They do so by selecting the work order and clicking the **Complete** button, like so. I compute the final cost of the work order, based on the standard charges for the service items and parts involved, and update the work order to show that it’s complete, and what the final cost is.”

“What happens when you click on the **Bill** button?” asked Hanna.

“This,” answered Steve, clicking on the button. A green window opened (see Figure 17 on page 70). “This is the bill that I need to print for them. It has the same format as the one Curt produces for Trusty Trucks. I don’t have a printer for my ThinkPad at home, so I’m displaying the print image on screen for the time being.”

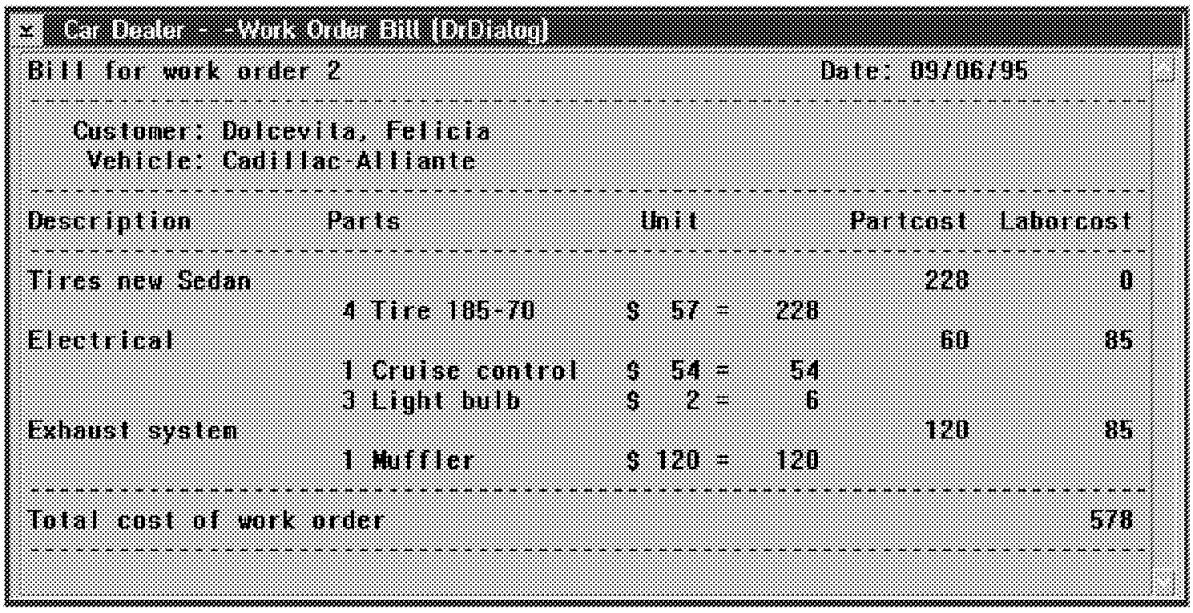


Figure 17. Billing Window of Dr. Dialog GUI Application

“Is that the lot?” asked Hanna.

“I think so, let me just make sure...” answered Steve, opening and closing windows in rapid succession. “Yes, that’s it,” he concluded.

“Well, it looks wonderful to me,” said Hanna. “And it seems pretty robust. I didn’t notice any glitches or crashes.”

“Dr. Dialog has very good debugging facilities,” said Steve. “In addition to that, I really didn’t have to write a lot of code to animate the GUI - only about 300 REXX statements. The final program has about twice as many statements as that, but Dr. Dialog automatically generates a lot of the code you need. Of course, I made use of the class libraries we developed for the Trusty Trucks application. I managed to get a high degree of reuse.”

“That’s exactly what we were trying to achieve, and I’m delighted that it’s working out so well,” said Hanna. “What’s the next step, Steve?”

“I’m due at Classy Cars tomorrow morning to review progress on my GUI development,” said Steve. “I think the code is in good shape. I’m sure they’ll be happy with it. If they are then I can start developing the new classes required to use DB2 for the persistent storage of our objects.”

“Good luck, Steve,” said Hanna. “We’ve got to win the business at Classy Cars. We’ve invested a lot to make this application configurable, and we’ve got to get a return on that investment.”

Steve smiled. “Don’t worry, Hanna,” he said. “I’m sure they’ll sign. They need our system to get better control of their operation.”

Choice of GUI Builders

But things didn't go quite as smoothly as Steve had hoped. He came back into the office about noon the next day looking downhearted. Hanna and Curt were working at their desks when he came in.

"Hi Steve, how did your meeting with Classy Cars go this morning?" asked Hanna. "You don't look to cheerful."

Steve shook his head as he put his ThinkPad bag down on his desk. "It was mixed," he said. "They loved my GUI code. They were really enthusiastic about it. They said that it completely transformed their view of the application and how it could help their business. But then the consultant started asking questions..."

"Which consultant, Steve?" asked Hanna.

"Classy Cars engaged a consultant from the Strategic IT Studies firm to review their IT directions," answered Steve.

"Oh, oh," chipped in Curt, "we aren't their favorite developers. Not since we had to point out some of the holes in the design work they did for Hardbright Steel last year."

"Well, be that as it may, the consultant asked a whole lot of questions," said Steve. "And one of the things he wanted to know is which GUI development package we were using. I told him all about Dr. Dialog and how good it is, but he kept on saying that it isn't a marketed product, and what kind of support can Classy Cars hope to get for a product for which no one is getting any revenue? He kept on asking me what the future plans for Dr. Dialog are, and I didn't have any answers. I kept on telling him that it's a great package as it stands right now, and he kept saying fine, but what about next year, and the year after that?"

"Oops! Sounds like you were in a nasty situation," sympathized Hanna.

"You're right!" agreed Steve. "Anyhow, I reminded them that we had adopted a completely object-oriented approach to our design, maximizing reuse and configurability, and that they shouldn't get hung up on which GUI builder we used. It would be a simple matter to change to another if they ever needed to."

"That's quite true, Steve," agreed Hanna. "We should be able to use other GUI builders without having to change our existing class libraries, and that's where the bulk of our development effort has been invested."

Steve smiled wryly. "I'm glad you agree with me, Hanna," he said, "because they called my bluff. They said that if it's so easy to change to another GUI builder, why don't we go ahead and do it? I said hey, that's extra work we didn't quote for. They said so quote for it, and remember how easy you just told us it would be."

"What a clown!" said Curt. "You really lead with your chin!"

Hanna looked aghast. "Oh no, Steve! They backed you into a corner! We've already invested a lot in this deal. I don't know if we should give it up as a bad job."

"Now you just hold on there a minute!" said Steve fiercely. "We've been sweating blood to design this system so that it's easy to configure and adapt. But the very first time someone takes us up and questions our claims, you all turn chicken and want to run away. Don't you believe in what we did together?"

For long tense moments, Hanna and Curt just stared at Steve in silence. Then Hanna buried her face in her hands, gathered herself, and said, "What you say may be true, Steve. But we've already gone into debt setting up our business. The first few opportunities we've tackled have brought in some money, but it's still touch and go whether we'll survive. Your

arguments are completely valid for a well-established company. But we might be out of business before we even start to see the benefits of reuse."

Steve looked glum, then Curt spoke up. "Steve, how long did it take you to build the Dr. Dialog GUI?" he asked.

Steve thought back. "About five working days," he said.

"And how much of that was GUI design and layout, as opposed to building and debugging logic?" Curt continued.

Steve thought more deeply. "There's always a lot of fiddling round, trying to work out what the user needs to see and how to present it on the screen," he said. "I guess it was about half and half."

"So if we had to port the front-end to another GUI builder, how long would it take?" asked Curt.

"If we keep the layout and logic the same, about two days," Steve answered. "I'm pretty sure we could cut and paste most of the current logic from Dr. Dialog into the new GUI builder, and then customize it to use the new builder's calling conventions."

"And if we do it, will we get the business?" asked Curt.

Steve hesitated. "There's still all the DB2 work to do," he said. "Look, after all I've said to them, if we *don't* do the GUI port, and do it fast, we *won't* get the business. And that's for sure."

Curt turned to Hanna. "Tomorrow's the weekend," he said. "Maybe we can do it by Monday."

Hanna looked at him uncertainly. "But what GUI builder would we use, if not Dr. Dialog?" she asked. "It's very short notice to research the GUI builders available, choose one, get it, install it, and learn to use it before tomorrow."

"The situation isn't that bad," Curt answered. "When we first went out looking for GUI builders for REXX, I found several that could potentially meet the bill. We asked the vendors for evaluation copies. Steve and I both looked at them briefly before we discovered that Dr. Dialog is on DEVCON (The Developer Connection for OS/2) and settled for that."

"That's right," agreed Steve. "I looked at VisPro/REXX pretty closely, and I liked what I saw."

"And I looked at Watcom VX·REXX," said Curt. "I'm sure that it could do the job."

Hanna managed to summon a smile. "So which one should we use?" she asked.

"VisPro/REXX," said Steve. "Watcom VX·REXX," said Curt simultaneously.

"Oh great! Let's use them both!" said Hanna with unaccustomed sarcasm.

"I'm going to do it in VisPro/REXX," said Steve. "I'm sure it will do the job."

"You didn't make a detailed evaluation of it, Steve," said Hanna. "What if you're doing things in Dr. Dialog that you just can't do in VisPro/REXX? You've already shown Classy Cars what you've accomplished. If it happens that you can't get the same things working in VisPro/REXX early next week, will they give us another chance? I think it's just too risky. Maybe we should just call it off."

"Well I looked at Watcom VX·REXX for more than a day" said Curt. "It had all the features needed to build CUA applications. I'm sure that it can do what Classy Cars needs."

"Talking about it isn't going to help," said Steve. "I'll do it in VisPro/REXX this weekend, trust me."

“Oh, it’s ‘Trust me, I’m a programmer’ time, is it?” sneered Curt. “That doesn’t fill me with confidence! I’m going to do it in Watcom VX·REXX this weekend.”

“Don’t be absurd, Curt!” snapped Steve. “If you really have a weekend to waste, why don’t you come in to the office and work on this thing together with me?”

“And what if Monday comes round, and all we’ve done is prove that it can’t be ported to VisPro/REXX for some reason?” asked Curt.

There was a tense silence. Hanna could feel a giggle coming on, and rather than earn their wrath she said “I guess if a thing’s worth doing, it’s worth doing twice.” Curt and Steve smiled thinly at her jest, but neither was going to back down.

“Where’s the code?” asked Curt.

“On the server,” Steve answered.

Both settled down to work in angry silence. Hanna thought seriously about praying.

On Monday morning, Hanna was in early. She hadn’t heard from either Steve or Curt over the weekend, and she waited nervously to discover what they had achieved. There was a clatter at the door, and they walked in together, thumping their bags down onto their desks. They plugged in their ThinkPads. While they were powering up, Curt said “I got the application working with Watcom VX·REXX.”

“Well, I got it working with VisPro/REXX,” replied Steve.

“Well done, guys!” said Hanna. “Sounds like it’s time for a shootout. Let’s compare them to the original Dr. Dialog.”

The threesome lined up their ThinkPads in a row and each brought up a different interface. Hanna put the Dr. Dialog interface through its paces, and Curt and Steve on either side of her mirrored her actions in the new GUIs they had built. Except for a few cosmetic differences and a couple of little bugs, all three GUIs looked and behaved the same.

“Well, that proves we can do the job with any GUI,” said Hanna. “I don’t suppose we can bill them for all three...”

Steve shook his head ruefully. “Well, if this doesn’t knock their socks off, I don’t know what will,” he said. “I’ll take all three interfaces out and show them to Classy Cars. Oh. And thanks, Curt. Your GUI looks great.”

Steve copied the GUI directories across the LAN and headed out for Classy Cars. He was gone half the day. When he came back, he was smiling broadly.

“They were delighted,” he said. “I set up our three different flavors on three of their PCs standing all in a row. Then I walked them through the same exercise we did here this morning. Everything worked perfectly. Well—near enough perfectly. I explained that there’s still quite a bit of rounding off to do, but we need their signature on an order before we can invest the time that will be required. They understood.”

“So which one did they choose?” asked Curt impatiently.

“Huh? Oh, they’re really convinced now that we were right when we said that we could port the application to another GUI any time if we had to,” Steve replied. “So they decided to go with the cheapest solution—Dr. Dialog!”

“What! After all that effort?” said Hanna, and the three of them roared with laughter which had a lot of relief mixed with it too.

How to Include Directives in GUI Builders

The next day, while all three were gathered in their office again, Steve said, “You know, the only really tricky part of that GUI coding exercise was getting my Object REXX directives to the end of the REXX code generated by VisPro/REXX. Object REXX insists that all directives must come at the *end* of the source file that contains them. But VisPro/REXX generates the final REXX source itself. It includes all the procedures I coded, but I can’t tell it what sequence they should come in.”

“Yes, I had exactly the same problem with Watcom VX·REXX,” Curt agreed.

“That’s interesting,” said Hanna. “But Steve, you must have hit this problem when you did the original GUI in Dr. Dialog.”

Directives in Dr. Dialog

“I certainly did,” said Steve. “It took me a while to work out what was going wrong, and then I read the manual. Dr. Dialog stores all the GUI and logic that you feed into it in a .RES file. Each time you save or run the project .RES file, Dr. Dialog checks to see if you have included a file with the same name as the .RES file but with extension .REX. If it finds it, Dr. Dialog copies its contents into the back of the .RES file as a special resource type. When the application runs, this special resource is at the end of the REXX program Dr. Dialog creates. So that was really quite straightforward. You put the Object REXX directives into the .REX file. This becomes part of the .RES file when you save the project, so you don’t have to distribute the .REX file when you distribute the application to other users.”

Directives in Dr. Dialog

1. Assume the GUI dialog is stored under the name `car-gui.res`.
2. Create a file named `car-gui.rex` and put all the directives into that file:

   ```
   ::requires customer.cls
   ::requires vehicle.cls
   ::requires part.cls
   ...
   ```

3. Keep the class definitions in separate files.

The organization of directives using configurations is discussed in more detail in Chapter 10, “Configuration Management with Object REXX” on page 119.

Directives in VisPro/REXX

“That sounds nice and easy,” said Hanna. “How about VisPro/REXX?”

“VisPro/REXX stores the GUI project in several subdirectories,” Steve answered. “After looking around I found out that VisPro/REXX always looks to see if you have put any REXX code in the project’s *SubProcs* subdirectory. If you have, VisPro/REXX includes it at the end of the REXX file that it generates when the project is run, or when an .EXE module is created. There are no rules about the name of the file. Any file name and extension can be used, but be careful, a return statement is automatically added at the end of the file.”

Directives in VisPro/REXX

1. VisPro/REXX generates the executable code in the sequence of the subdirectories.
   - Each GUI window is a separate subdirectory; the initial window is named Main by default.
   - There is a subdirectory for procedures, SubProcs.
   - Subdirectories are included in alphabetical order.
2. Therefore, make sure that all of the windows are stored in subdirectories with names that are alphabetically before SubProcs.
3. Put all directives into the alphabetically last file in the SubProcs directory.
4. VisPro/REXX adds a *return* statement at the end of the file. If that does not fit, put a dummy method last.
5. Keep the class definitions in separate files.

Example:

- Windows are in subdirectories CarBill, CarMedia, CarPart, CarServ, CarWork, and Main.
- Directives are in the `zCargui.cvp` file in the SubProcs directory, after other procedures named CustRetr, CustSele, ..., and VehicLst. The `zCargui.cvp` directives file contains:

```
::requires customer.cls
::requires vehicle.cls
::requires part.cls
...
::class dummy
::method dummy  /* VisPro/REXX adds a return statement */
```

The organization of directives using configurations is discussed in more detail in Chapter 10, “Configuration Management with Object REXX” on page 119.

Directives in Watcom VX·REXX

“And what did you have to do with Watcom VX·REXX, Curt?” asked Hanna.

“It wasn’t too bad, once I broke down and read the manual,” Curt replied. “Watcom VX·REXX allows you to include external code in a Watcom VX·REXX project using something called *shared sections*. You put your code into the shared section, then tell Watcom VX·REXX to include it in the project. I’ll show you how to add a section that contains directives.”

Curt started Watcom VX·REXX project on his ThinkPad and opened the Sections window using the *Section List* action in the *Windows* pull-down of the main project window. He selected the *Add...* action from the *Section* pull-down. A prompt box popped up, and Curt entered `car-gui.cvx`. “That’s the name of the file I coded my directives in,” he said. “You can use absolute or relative file paths. The shared section will be added to the front of the section list.” He showed them his screen:

```
<car-gui.cvx>            <===== file with directives
addcar_Click
addcust_Click
additem_Click
addnewpart_Click
CarDealBill_Close
...
workorders_Click
```

“When the project is run or an executable or macro command file is made,” Curt continued, “the contents of the directives are added to the end of the file. The last statement must be a return, however.”

Directives in Watcom VX·REXX

1. Watcom VX·REXX generates the executable code in alphabetical order of sections.
2. Added sections, which appear within less-than and greater-than signs <name.ext>, are appended at the end of the code. Each file must have a return statement at the end.
3. Therefore put all directives into a separate file and add it to the section list.
4. Keep the class definitions in separate files.

Example:

The `car-gui.cvx` directives file contains:

```
::requires customer.cls
::requires vehicle.cls
::requires part.cls
...
::class dummy
::method dummy
  return       /* required at the end */
```

The organization of directives using configurations is discussed in more detail in Chapter 10, “Configuration Management with Object REXX” on page 119.

“Great!” said Hanna. “So it’s pretty easy to do for each of the GUI builders, once you know how.”

GUI Builder Development Environment

In this section we present some snapshots of the GUI development environments for Dr. Dialog, VisPro/REXX, and Watcom VX·REXX.

Development Environment for Dr. Dialog

The directory for a Dr. Dialog project is shown in Figure 18.

Figure 18. Dr. Dialog Project Folder

The development environment is accessed through the *DrDialog* action in the pop-up menu of the .RES file, as shown in Figure 19.

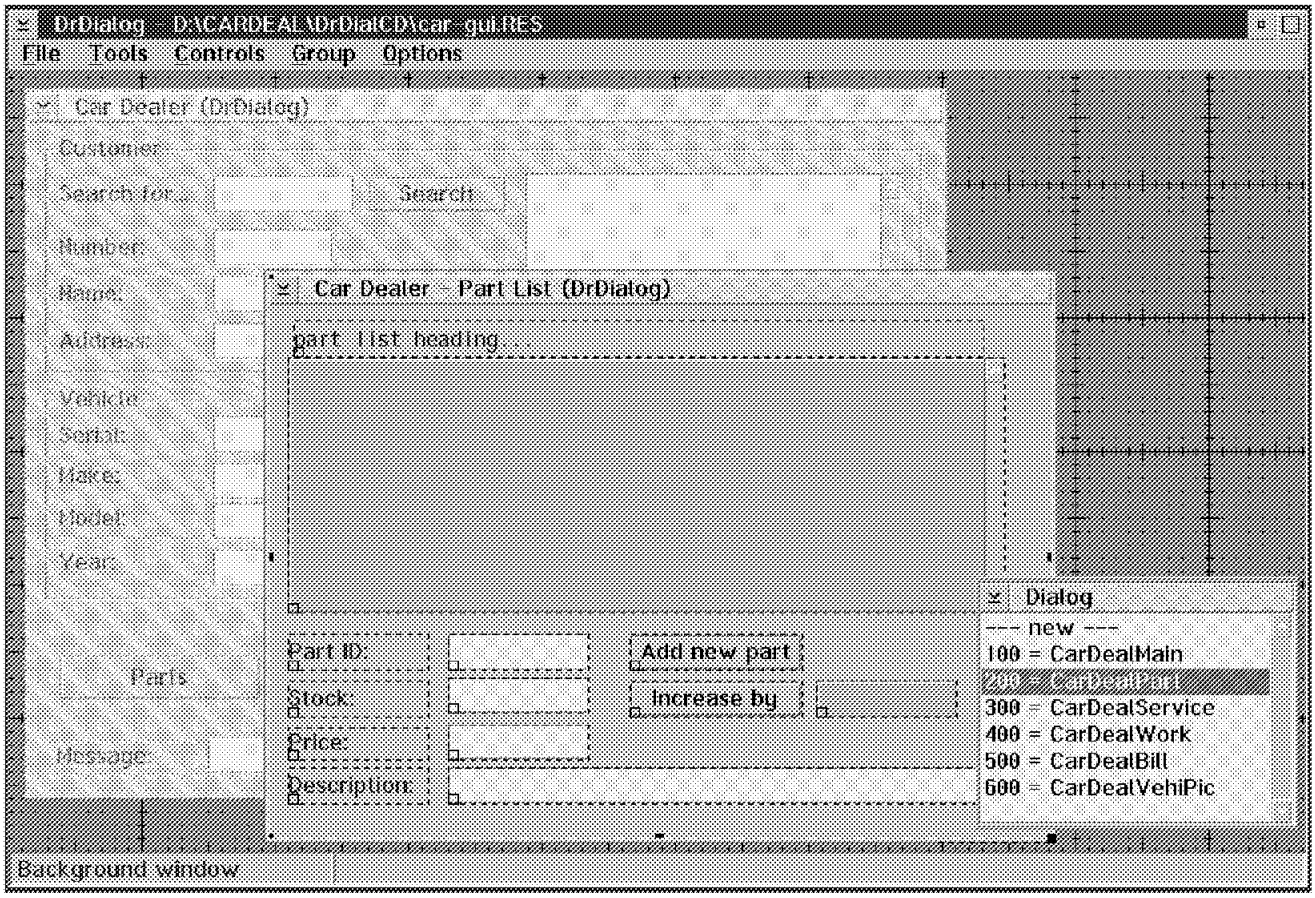


Figure 19. Dr. Dialog Development Environment: Window Layout

All application windows are accessible through the Dialog window. All REXX code is accessible through the DrRexx notebook, as shown in Figure 20.

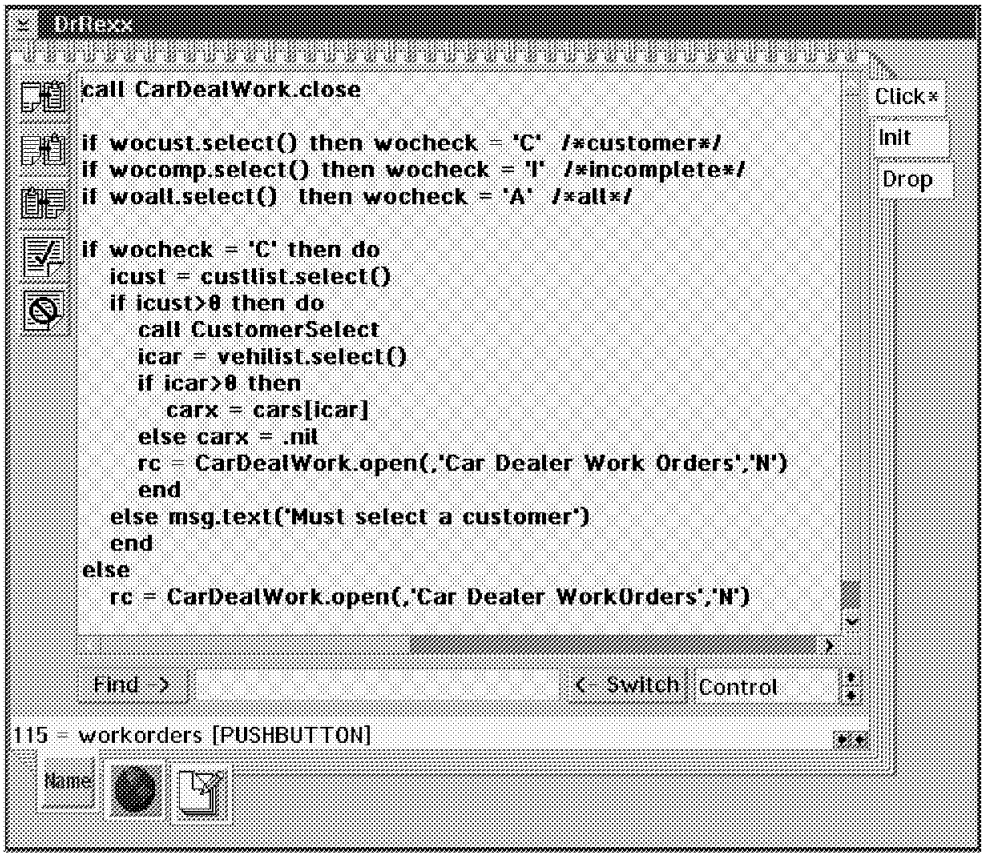


Figure 20. Dr. Dialog Development Environment: DrRexx Notebook

Any control in an application window can be double-clicked on to display the appropriate page of the DrRexx notebook. Alternatively, all controls can be accessed through the **Name** icon at the bottom of the notebook, and all procedures through the **Globe** icon.

Development Environment for VisPro/REXX

The directory for a VisPro/REXX project is shown in Figure 21.

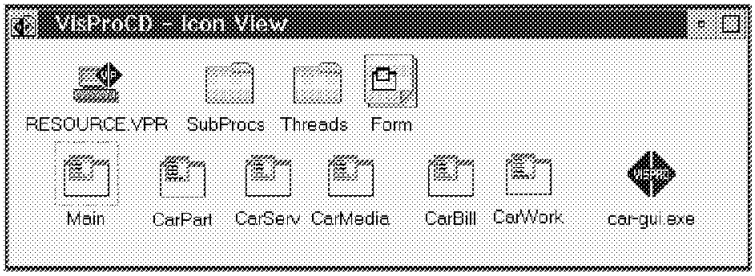


Figure 21. VisPro/REXX Project Folder

Each window is a separate icon in that folder, and the SubProcs folder holds all additional procedures.

Double-click on a window folder to start the Layout View, as shown in Figure 22.

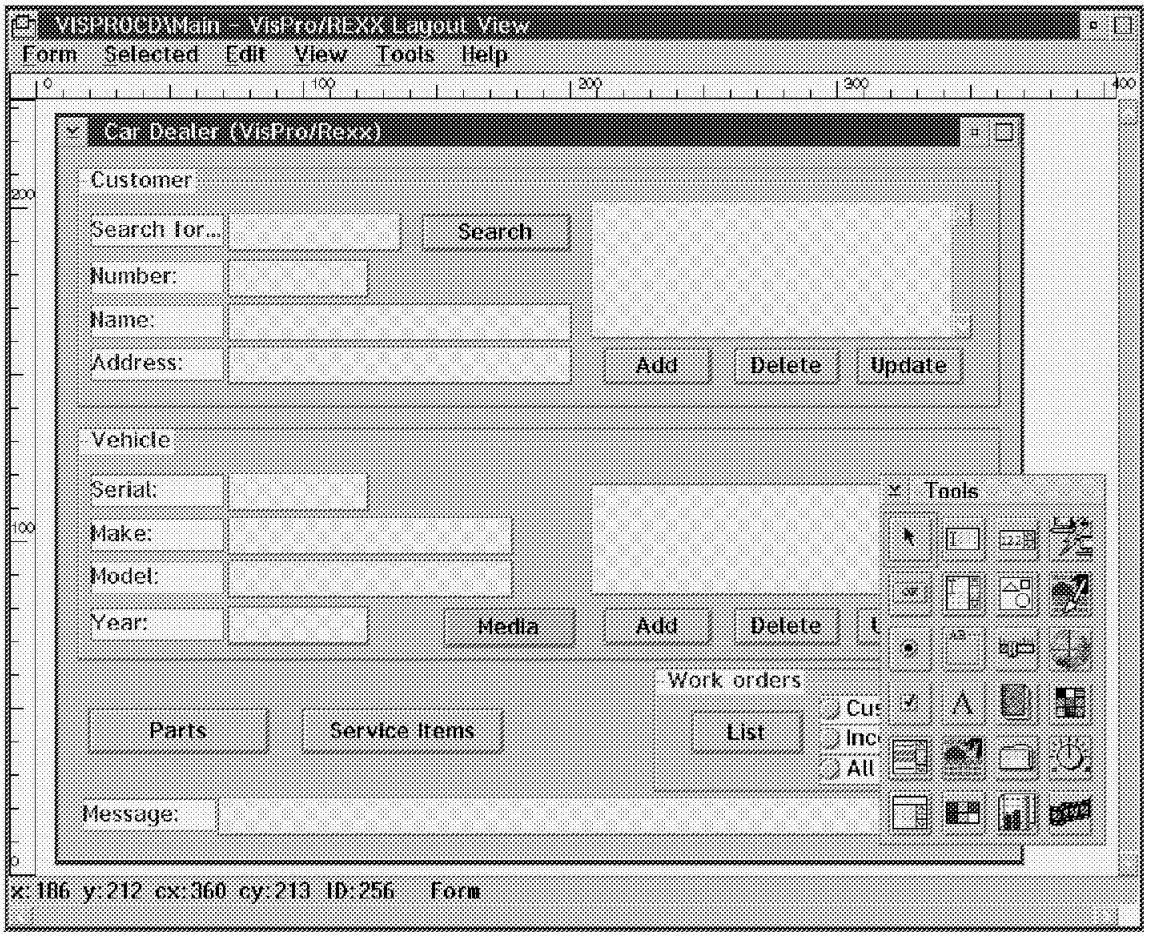


Figure 22. VisPro/REXX Development Environment: Layout View

To access the REXX code, open the Event Tree View of the window, which is shown in Figure 23 on page 80.

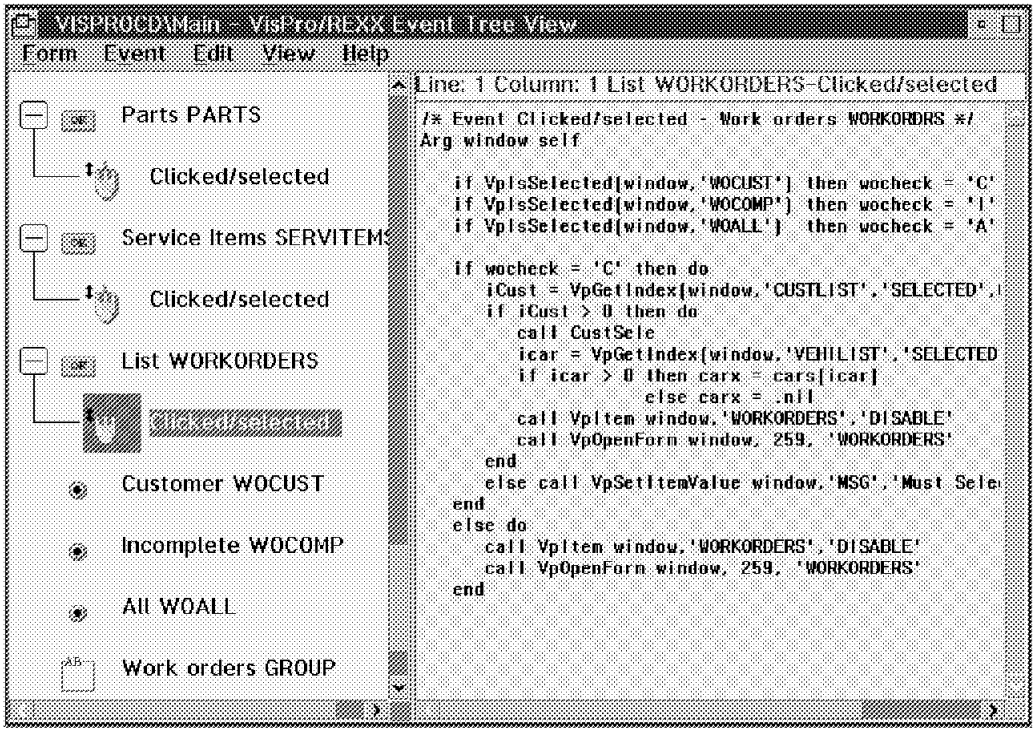


Figure 23. VisPro/REXX Development Environment: Event Tree View

Development Environment for Watcom VX·REXX

The directory for a Watcom VX·REXX project is shown in Figure 24.

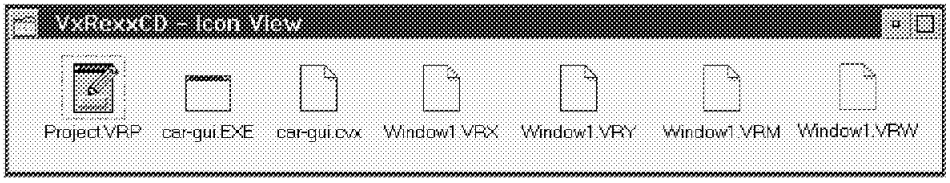


Figure 24. Watcom VX·REXX Project Folder

All definitions are stored in a file named `Project.VRP`. Open this file to access any window (see Figure 25).

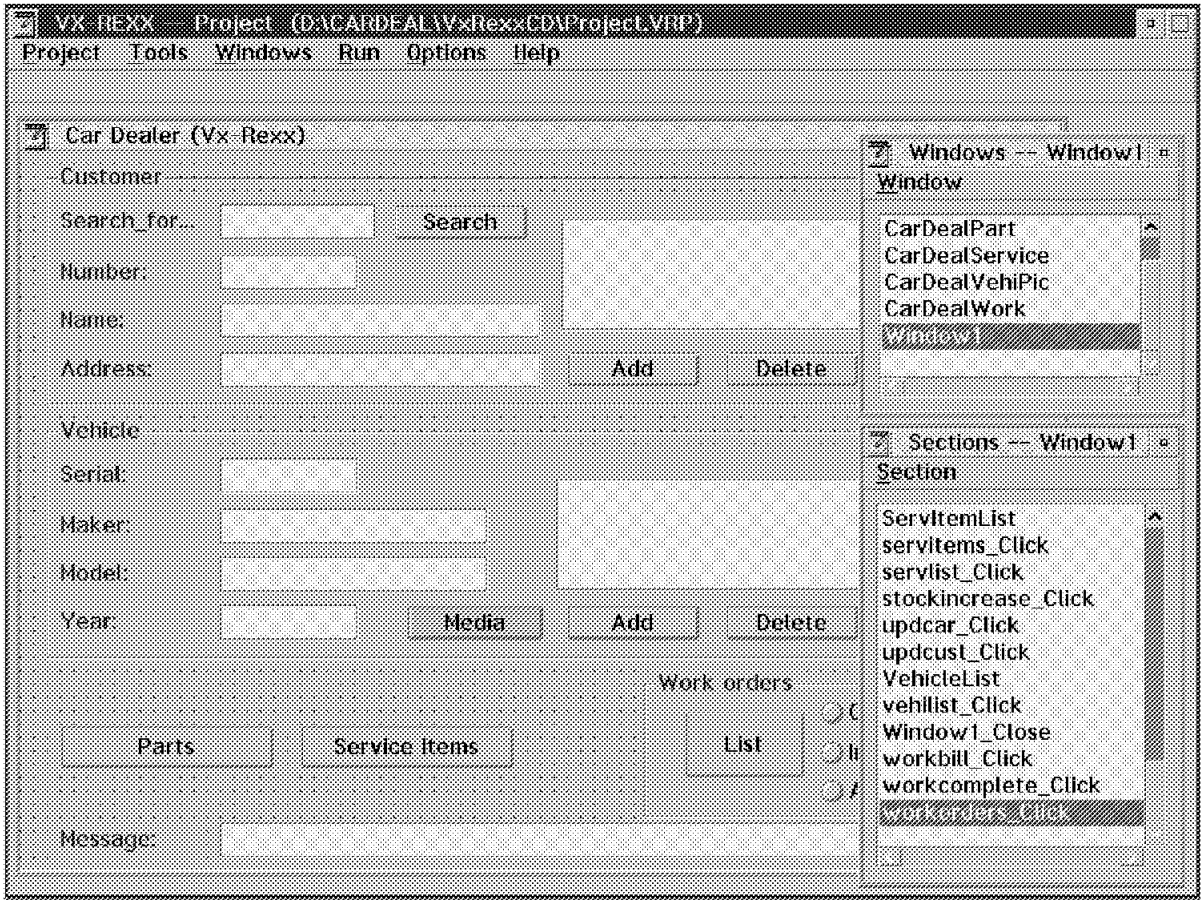


Figure 25. Watcom VX·REXX Development Environment: Window Layout

The windows of the application are accessible through *Windows*.

The REXX code for selected events is defined by using the pop-up menu of each control. The event is then automatically added to the Sections window and can be edited by double-clicking on the item, as shown in Figure 26 on page 82.

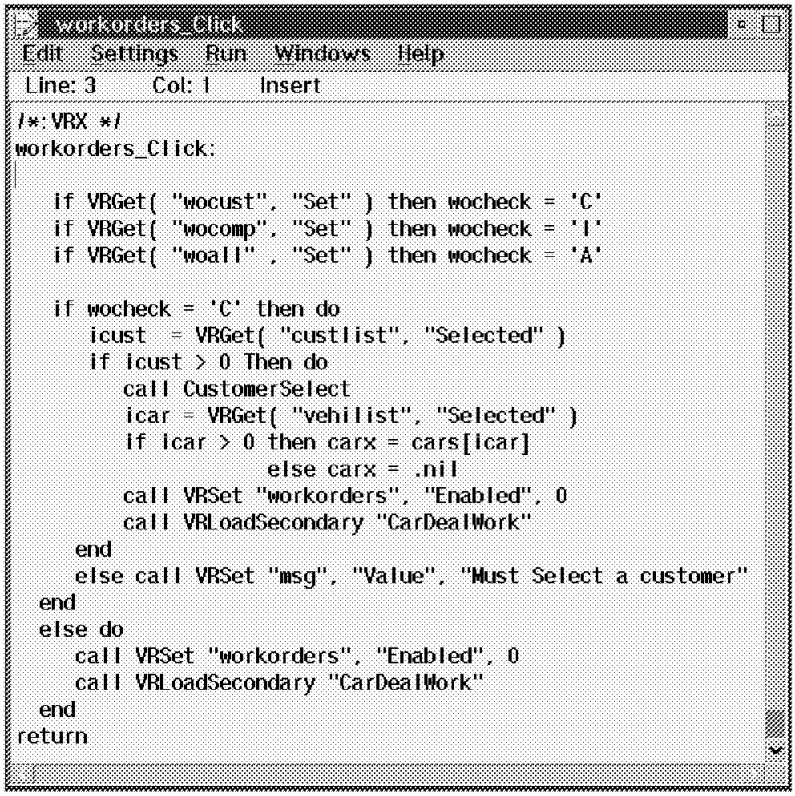


Figure 26. Watcom VX·REXX Development Environment: Event Code

Testing and Generating the GUI Applications

All three visual builders enable the user to test the application from the development environment and generate an executable module (.EXE file):

- Dr. Dialog generates an .EXE with the same name as the .RES file.
- VisPro/REXX generates a file named RUN.EXE, which can then be renamed.
- Watcom VX·REXX prompts for the file name of the executable, default Project.EXE.

Chapter 7. Persistent Objects in DB2

In this chapter we find out how objects can be made persistent by storing them in a DB2 database. We use DB2/2 Version 2 for this exercise. Because DB2/2 is part of the DB2 family and provides connectivity to all other members of the family through DDCS/2, the approach described in this chapter could be used regardless of the platform on which the DB2 databases are stored. We also restricted the SQL functions used in this chapter to a simple subset of the ANSI SQL standard. Therefore the code should be portable with more or less effort across any of several other vendors′ relational DBMSs. In Chapter 8, “Using Advanced DB2/2 Facilities” on page 93, we exploit some of the more advanced functions of DB2/2 Version 2.

Storing Objects in DB2

“Hi Steve,” said Hanna as she walked into the office. “I′ve just been over to see Trusty Trucks. Our car dealer application is running so smoothly, they′re just delighted!”

“That′s great,” replied Steve. “We spent a lot of time designing that system—it should run smoothly! But the real benefits of our approach will surface only when we start building and delivering different versions to meet different customers′ needs.”

“Right,” agreed Hanna. “Speaking of which, how are you doing with the DB2 work for Classy Cars?”

“It′s been really easy to do, Hanna,” replied Steve. “All the trouble we took up front to make sure that we could fit DB2 support into the system later has paid off. Look, here′s a picture of the class inheritance I need to build the DB2 support.” Steve showed Hanna Figure 27 on page 84.

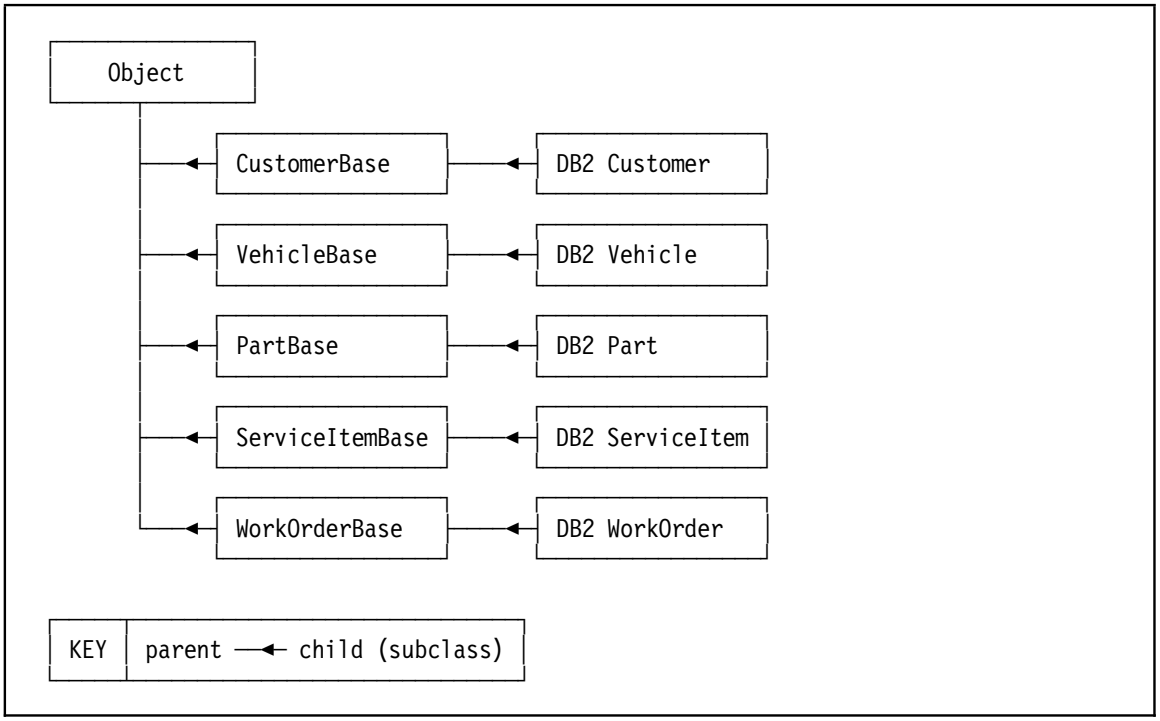


Figure 27. DB2 Class Inheritance Diagram. The DB2 classes could also inherit from the Persistent class. This does not provide an advantage, however, because all methods have to be coded in the DB2 class regardless.

"The base classes contain the methods that are common across DB2 and FAT files, and the DB2 classes contain the DB2-specific methods," Steve explained. "Since the DB2 classes are subclassed from the base classes, they inherit all the methods of the base classes."

"That sounds quite straightforward," said Hanna. "What else do you need to do?"

"Well," said Steve, "I took the data definitions that Curt drew up when we first went through the car dealer requirements." (See Figure 7 on page 35.) "All I had to do was turn his COBOL into DB2 SQL. Oh, and get rid of the repeating groups in the service and work order objects."

"What have you done with them?" asked Hanna.

"I've made them separate tables," said Steve. "Look, here's the table diagram I have drawn up." Steve opened a Freelance picture on his ThinkPad (see Figure 28 on page 85).

"We need a DB2 table for each class," explained Steve. "I've given them the same names as the classes themselves. And then there are two extras to hold the repeating groups. I've called them Servpart and Workserv. Servpart will be used to store the relationship between the service objects and all the parts that each one needs. Workserv will be used to store the relationship between the work orders and the services that each one specifies."

"And here are the SQL commands I think I'll need." Steve opened an editor window on his ThinkPad (see Figure 29 on page 86).

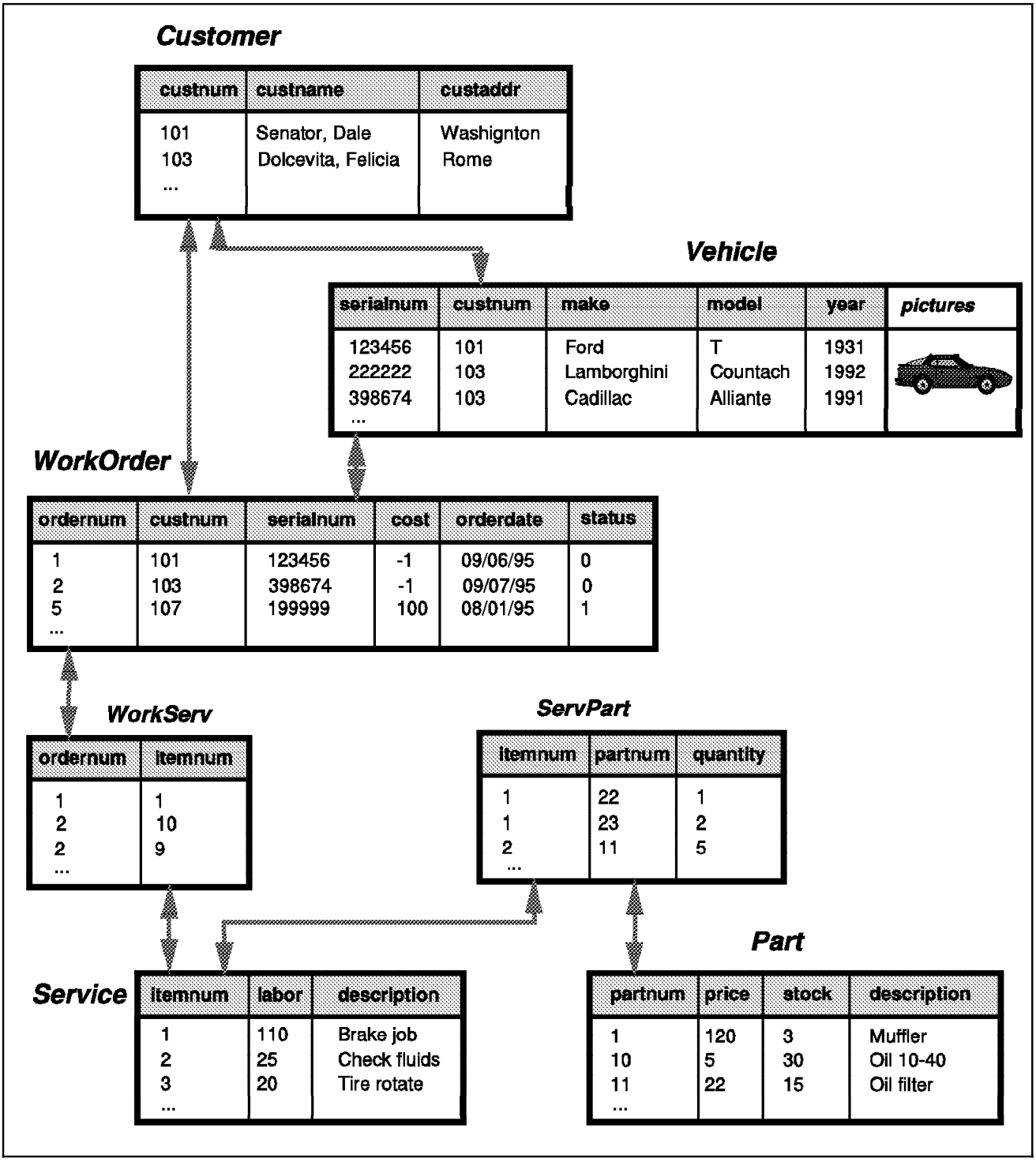


Figure 28. DB2 Tables for Car Dealer Application. The pictures column in the vehicle table is discussed in Chapter 8, "Using Advanced DB2/2 Facilities" on page 93.

```
DROP   TABLE CARDEAL.CUSTOMER;
DROP   TABLE CARDEAL.PART;
 ...
CREATE TABLE CARDEAL.CUSTOMER
    (CUSTNUM             SMALLINT  NOT NULL,
     CUSTNAME            CHAR(20)  NOT NULL,
     CUSTADDR            CHAR(20)  NOT NULL) ;
CREATE TABLE CARDEAL.PART
    (PARTNUM             SMALLINT  NOT NULL,
     PRICE               SMALLINT  NOT NULL,
     STOCK               SMALLINT  NOT NULL,
     DESCRIPTION         CHAR(15)  NOT NULL) ;
 ...
CREATE UNIQUE INDEX CUSTOMER_IX ON CARDEAL.CUSTOMER (CUSTNUM);
CREATE UNIQUE INDEX PART_IX     ON CARDEAL.PART (PARTNUM)
 ...
```

Figure 29. DB2 Table Definitions. Extract of SQL DDL statements for table definitions.

Hanna studied the SQL commands. “Have you set up a database for this yet?” she asked.

“Sure,” answered Steve (see Figure 30).

```
CREATE DATABASE DEALERDB ON D;    -- D is the disk drive letter
```

Figure 30. DB2 Database Definition

“And I’ve run the SQL. I wrote a little REXX command file called `runsql.cmd` (see ‘Command File to Run SQL DDL Statements’ on page 342) to read this file and pass it over to the DB2 command line utility, and I’ve already run these table definitions through it. A couple of times!” he added. “That’s why I’ve got the DROP TABLE commands at the top. There were a few errors in my SQL the first time round.”

Hanna smiled. “I believe you!” she sympathized.

“I’ve also coded up the SQL required to insert our test values into the DB2 tables,” said Steve, dragging an icon from a folder and dropping it on the editor. A long string of insert commands appeared, and Steve scrolled down through them (see Figure 31 on page 87).

```
delete * from cardeal.customer
 ...
commit

insert into cardeal.customer  (custnum, custname, custaddr)
                      values (101, 'Senator, Dale', 'Washington')
 ...
insert into cardeal.vehicle   (serialnum, custnum, make, model, year)
                      values (123456,    101,     'Ford', 'T', 1931)
 ...
insert into cardeal.workorder (ordernum, custnum, serialnum, cost, orderdate, status)
                      values (1,         101,     123456,    -1,   '09/06/95', 0)
 ...
insert into cardeal.service   (itemnum, labor, description)
                      values (1,       110,   'Brake job')
 ...
insert into cardeal.part      (partnum, price, stock, description)
                      values (21,      120,   3,     'Brake cylinder')
 ...
insert into cardeal.workserv  (ordernum, itemnum)
                      values (1,         1)
 ...
insert into cardeal.servpart  (itemnum, partnum, quantity)
                      values (1,       21,      1)
 ...
commit
```

Figure 31. DB2 Sample Table Load. Extract of SQL statements to load sample DB2 tables.

“And this one starts with a whole bunch of delete commands—just in case?” asked Hanna.

“Right!” agreed Steve. “I’ve already made sure that they work too. But the test data is loaded, and now I’m working on the definitions of the DB2 classes. We’re going to need a whole lot of new methods.”

“Oh dear!” said Hanna apprehensively. “I hope this doesn’t turn out to be a lot of extra work.”

Steve’s frustrations boiled over. “Hanna, you and Curt keep challenging me about the DB2 support. But Classy Cars is a much bigger operation than Trusty Trucks. Their turnover was five times bigger last year. They’ve got branches in twenty cities around the country. Sure, it’s going to take work to adapt our application to meet their needs. But we’ll get far more revenue out of them than we’ll ever see from Trusty Trucks. And once we’ve adapted our application to fully support a GUI front-end and a real database, it will be a far more marketable product than it is today. How many businesses want a clunky character interface when they buy a computer package nowadays?”

“You’re 100% right, Steve,” she said soothingly. “All of us recognize that Classy Cars is a wonderful business opportunity. But we’re a very small operation. I’m worried that we may go bankrupt before we get a chance to show them how good we are. We have to make absolutely sure that the Trusty Trucks implementation completes on the due date with no hitches, so we can get paid on schedule.”

“I know that, Hanna,” Steve replied. “The best guarantee for a smooth installation is a good design. That’s why I keep on insisting that we get the design right, instead of jumping into coding.”

Hanna smiled. “You’re right, Steve,” she said. “We’ve all been working hard on this project to make sure it’s a success. So let’s settle down and do some more designing! Have you decided whether you’re going to load all the objects from DB2 into storage when the system starts up, or fetch them as you need them?”

Steve relaxed as he turned back to his design. “The people at Classy Cars haven’t yet decided if they want one centralized database or if each operation will get its own,” he mused. “If it’s centralized, the volumes will be pretty big and we’ll have to go for a *load-on-demand* approach. But if they decentralize, no single operation is so big that its objects wouldn’t fit into storage.”

“So what’s the answer?” asked Hanna.

Persistent Methods for DB2 Support

“We can’t wait for them to make up their minds,” Steve answered. “We have to assume the worst case, and make sure we can handle it. That means loading objects only when required, and updating them directly on disk every time they change. Of course, there’s only a limited number of part- or service-type objects, no matter how big the operation is. We can carry on loading all those into storage when the application comes up. But customers, vehicles, and work orders will have to stay out on disk.”

“Will this mean a lot of extra coding, Steve?” asked Hanna.

“I’ve worked out that we’ll need the following methods,” replied Steve, as he showed her Tables 13 – 17.

Table 13. Methods to Implement Customer Persistent Storage in DB2

Method	Type	Purpose
findName	Class	Find list of customers in DB2 given an abbreviated name
findNumber	Class	Find customer in DB2 given the number; create customer object in memory with cars and work orders
persistentInsert	Instance	Insert a new customer into DB2
persistentUpdate	Instance	Update an old customer in DB2
persistentDelete	Instance	Delete an old customer from DB2
ListCustomerShort	Class	List customers on standard output
ListCustomerLong	Class	List customers and cars on standard output

Table 14. Methods to Implement Part Persistent Storage in DB2

Method	Type	Purpose
persistentLoad	Class	Load all parts from DB2
persistentInsert	Instance	Insert a new part into DB2
persistentUpdate	Instance	Update an old part in DB2

Table 15. Methods to Implement Service Item Persistent Storage in DB2

Method	Type	Purpose
persistentLoad	Class	Load all service items from DB2

Table 16. Methods to Implement Vehicle Persistent Storage in DB2

Method	Type	Purpose
persistentLoadByCust	Class	Load all vehicles of a customer into memory
persistentInsert	Instance	Insert a new vehicle into DB2
persistentUpdate	Instance	Update an old vehicle in DB2
persistentDelete	Instance	Delete an old vehicle from DB2

Table 17. Methods to Implement Work Order Persistent Storage in DB2		
Method	**Type**	**Purpose**
persistentLoadByCust	Class	Load all work orders of a customer into memory
findNumber	Class	Get work order by number
findStatus	Class	Get all work orders by status
newNumber	Class	Make new work order number
persistentInsert	Instance	Insert a new work order into DB2
persistentUpdate	Instance	Update an old work order in DB2
persistentDelete	Instance	Delete an old work order from DB2
persistentInsertServ	Instance	Add a new service to the work order
persistentDeleteServ	Instance	Remove a service from the work order
ListWorkOrder	Class	List work orders on standard output

"Wow, Steve—that looks like a lot!" said Hanna concerned.

"I've already coded up some of the simpler methods," Steve replied, "and I estimate that the whole job will take about twice as many lines of code as the methods we developed to support persistent storage in ASCII files. That's not bad, when you consider all the extra things that DB2 will give us:

- Support for multiple workstations performing updates concurrently
- Automatic rollback of programs that fail
- Logging of all updates
- Recovery of corrupt databases from the log
- The ability to handle large volumes of data
- The ability to run the database on servers as big as an ES/9000."

"Enough, already!" Hanna interrupted him. "You don't have to sell me on the advantages of DB2, you know that I love using it. Are you including all the SQL we'll have to code in your estimates?"

"For sure," responded Steve.

"OK, Steve," said Hanna. "I've got to get back to Trusty Trucks. Curt has everything there pretty well under control, but I want to make sure one more time that the users are ready for the system. If we need you, I'll call you, but in the meantime it would be fine for you to carry on with the DB2 design. It will get us well ahead of the schedule we agreed to with Classy Cars. There's nothing better than getting off to a flying start."

Steve smiled his appreciation. "I'll be here if you need me," he said. "Good luck with the users!"

Implementation of DB2 Support

The steps to add DB2 support are

1. Define the DB2 database
2. Define the tables in the database; an extract is listed in Figure 29 on page 86
3. Load the tables with sample data; an extract of possible SQL commands is listed in Figure 31 on page 87

These three steps are part of the installation program. Then:

4. Write the Object REXX code for DB2 persistence:
   - No changes are necessary to the base classes. They already have the coding to invoke the persistent methods from the FAT implementation. For example, the init method invokes persistentInsert for new application objects
   - Prepare the Object REXX classes as subclasses of the base classes:

     ```
     ::class Customer public subclass CustomerBase
     ```

   - Write all the additional methods for DB2 persistence
   - Implement the creation of memory objects at application start for parts and services, and load-on-demand for customers, vehicles, and work orders

Implementation of Load at Application Start

During initialization of the application, all parts and services are loaded into memory by using the persistentLoad methods, similar to the flat file support but with data from the DB2 database.

Loading of parts at application start (abbreviated)

```
::class Part
::method persistentLoad class
   stmt = 'select p.partnum, p.price, p.stock, p.description' ,  /* SQL select  */
          '  from cardeal.part p order by 1'
   call sqlexec 'PREPARE s1 FROM :stmt'
   call sqlexec 'DECLARE c1 CURSOR FOR s1'
   call sqlexec 'OPEN c1'
   do ipart = 0 by 1 until sqlca.sqlcode \= 0
      call sqlexec 'FETCH c1 INTO :xpartid, :xprice, :xstock, :xdesc2'
      if sqlca.sqlcode = 0 then
         partx = self~new(xpartid, xdesc2, xprice, xstock)       /* part object */
   end
   call sqlexec 'CLOSE c1'
   return ipart
```

Implementation of Load-on-Demand

Customers, vehicles, and work orders are loaded on demand, based on the assumption that there would be too many for all of them to be loaded into memory.

To leave intact the pointer implementation of the base classes between customers, their vehicles and work orders, and the services of a work order, we always load all the data associated with a customer.

Customers are loaded into memory by their number. The *findNumber* method implements the DB2 load of a customer and then invokes the vehicle and work order classes to load all the data associated with that customer.

Loading of customers on demand (abbreviated)

```
::class Customer
::method findNumber class
   use arg custnum                                  /* input is customer number    */
   stmt = 'select c.custname, c.custaddr' ,         /* SQL select statement        */
          '  from cardeal.customer c where c.custnum =' custnum
   call sqlexec 'PREPARE s1 FROM :stmt'             /* prepare  the SQL            */
   call sqlexec 'DECLARE c1 CURSOR FOR s1'          /* define and open a cursor    */
   call sqlexec 'OPEN c1'
   call sqlexec 'FETCH c1 INTO :xcustn, :xcusta'    /* fetch the matching row      */
   if sqlca.sqlcode = 0 then do                     /* found a customer            */
        custx = self~new(custnum, xcustn, xcusta)   /* make an OREXX object        */
        .Vehicle~persistentLoadByCust(custx)        /* load the vehicles ... and   */
        .WorkOrder~persistentLoadByCust(custx)      /* work orders of the customer */
        end
   else custx = .nil                                /* customer not found          */
   call sqlexec 'CLOSE c1'                          /* close the cursor            */
   return custx                                     /* return the customer object  */
```

When accessing work orders directly by number, we retrieve the customer number of the work order from DB2, and then all the data of that customer is loaded as shown above, including the requested work order.

Implementation Notes

1. To define the tables and indexes, we wrote the runsql.cmd program, which reads a file with SQL DDL statements and submits them to the DB2 command processor (DBM.CMD for DB2 version 1, DB2.EXE for DB2 version 2).

2. For the sample application, the DB2 tables are loaded from the same files used for the flat file persistent storage. The installation program, load-db2.cmd, reads the files and loads the DB2 tables.

3. To prepare and set up the DB2 system, we wrote the db2setup.cmd that invokes the runsql.cmd with the proper DDL files to define the tables and indexes, and then the load-db2.cmd to load the sample data into the tables.

4. We did not use DB2 referential integrity to check the relationships between primary and foreign keys in the tables.

5. Customers can also be retrieved by partial name. DB2's LIKE facility is used to search the database and an array of matching customer names, together with their number, is returned. Data is loaded into memory with the findNumber method only when a customer from the result array is selected.

6. All updates to the data are performed first in memory and then immediately thereafter in DB2 with the persistentInsert, persistentUpdate, and persistentDelete methods. The DB2 database is therefore always up to date.

Source Code for DB2 Class Implementation

The source code for the DB2 classes is listed in “Persistence in DB2” on page 269.

The table definitions are listed in “DB2 Setup” on page 333.

The load program is listed in “Command File to Load DB2 Tables” on page 339.

Chapter 8. Using Advanced DB2/2 Facilities

In this chapter we exploit some of the more advanced features of DB2/2 delivered in Version 2 of the product. We make use of DB2′s BLOBs to store multimedia data.

Multimedia in DB2 BLOBs

“I hope things go well today when you call on Classy Cars, Steve!” called out Hanna. “We need you to bring back a signed contract.”

“I′ll do my best,” replied Steve. “Classy Cars is really keen on our car dealer package. I′m just a bit worried about delivering the multimedia function that we′ve promised to give them. Time′s getting short.”

“Is multimedia really necessary, Steve?” Hanna asked. “Wouldn′t it be simpler to install the application without it, and then come back to it later if they really want it?”

“They *do* really want it, Hanna,” Steve replied. “As I′ve mentioned, they make more money from selling cars than servicing them. They want to boost their sales, and they believe that the multimedia facilities I described and demoed to them will be a big help. Where they really hope to score is by exchanging information between different branches about cars they have for sale. So if a customer expresses interest in some type of car that the branch doesn′t have, they can quickly search the records of cars for sale at the other branches. If they find the car, they can use multimedia to show it to the customer. If the customer likes it, they will arrange to transfer the car to the most convenient branch for the customer. Classy cars is convinced that their sales will skyrocket.”

“That sounds very ingenious,” said Hanna. “But how are they going to capture multimedia images of the cars they have in stock? I know that you can take color pictures and have a print shop scan it and turn it into an image file, but that′s slow and quite expensive.”

Steve grinned. “Ah! I haven′t shown you my latest toy,” he said. He zipped open his bag and pulled out a black object that looked a bit like a camera. “Here we have a camera that captures image files directly. The lens focuses the image onto a charge-coupled device array (CCD) instead of conventional film, and the camera copies that into its own RAM storage in compressed format. It can hold up to 48 high-quality images. The camera comes with a cable to plug it into a PC′s serial port, and software to download the images.”

“Wow!” said Curt. “I bet that cost plenty.”

“About the same as a conventional camera,” Steve replied, “And the really good news is—you never have to buy film for it! That′s a saving.”

Curt shook his head. “You can see who′s the bachelor around here,” he said.

“Marry in haste, repent at leisure,” said Steve.

“Well, show us what it can do, Steve,” said Hanna.

Steve looked around for a suitable subject and then said, “Look, there′s Boxie.” The cat from the neighboring house often visited for the saucer of milk and tidbits she knew she could wheedle from Hanna. At the moment, Boxie was doing her best to melt into a wooden bench in the morning sunshine. She looked up sleepily as Steve approached her with the camera.

“Got it!” said Steve. He connected the camera to the serial port of his ThinkPad with a thin cable and brought up the camera software. Then he started to download the image. “This will go fast. I′ve only got one image in the camera,” Steve said. A series of small frames was presented on the screen. Only one contained an image, and when Steve double-clicked on it, up came an image of Boxie. Steve zoomed in (see Figure 32).

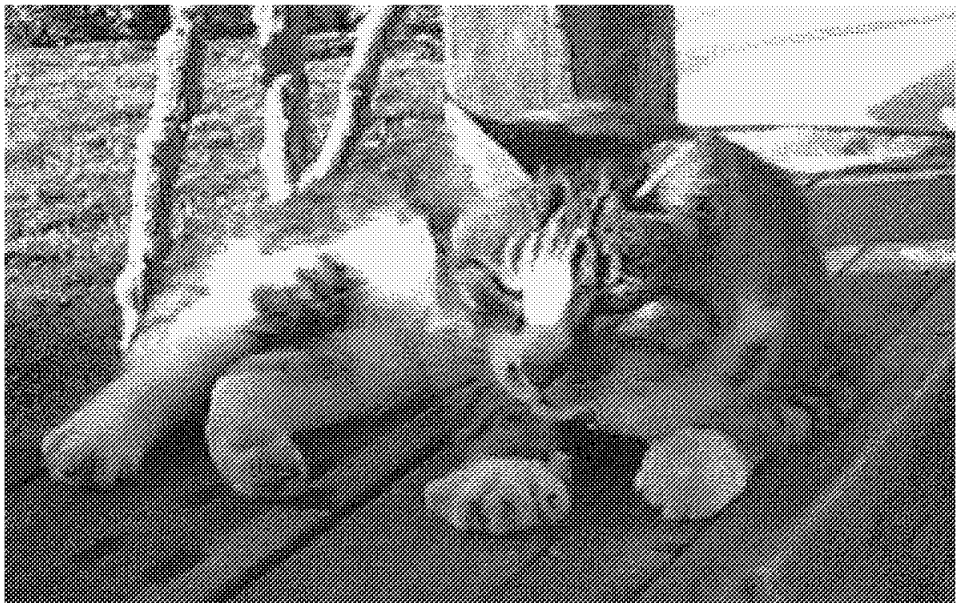


Figure 32. Boxie the Cat. The real picture is in full color!

“Oh, that′s lovely!” said Hanna. “I′ve often wanted a picture of Boxie, but I′ve never gotten around to bringing in my camera. Could you print that, Steve?”

“Sure thing,” said Steve. He selected the print menu, chose the color printer, and clicked on the OK button. A short while later the printer oozed out a picture. They picked it up and inspected it.

“This is pretty good, Steve,” said Hanna.

“Yes, and you can do a lot with the image before you print or store it,” Steve responded. “You can rotate it and crop it. You can edit the color tones too, very simply. This picture has come out a bit blue. It would be easy to warm it up by emphasizing the red tones. Anyhow, I′m taking this camera out to Classy Cars to show them how they could capture multimedia images. I′m sure they′ll be excited. Which brings me back to the question of how we′re going to build the code.”

“Maybe Curt could look at that while you′re busy,” said Hanna. “If you swap ThinkPads with him, he can get on with it while you′re out visiting Classy Cars′ branches.”

“Oh—aren′t you still busy with Trusty Trucks, Curt?” asked Steve.

“Not unless something breaks,” answered Curt. “If you′ll let me have your multimedia ThinkPad, I′ll give it a whirl. You keep on telling us how easy it is to handle multimedia in

REXX. And the BLOB support in DB2 Version 2 should make it easy to store and fetch multimedia data."

"OK," Steve agreed somewhat reluctantly. "I'll have to transfer the files I need this week onto your ThinkPad. I'll upload them onto the server." Steve sat down again, powered on, and plugged his PC into the LAN. Curt likewise started uploading files from his PC onto the server.

"Wait a minute," said Steve. "I've built up a whole set of folders with special icons for the Classy Cars project and I don't want to have to rebuild them all on your PC, Curt."

"No problem, Steve," responded Curt. "Just drag them and drop them on the server directory icon. So long as you keep the *Ctrl* key pressed, OS/2 will copy the whole structure for you. Then you can drag the icon off the Server and drop it onto my PC's desktop."

"Of course!" said Steve. "Great system, OS/2."

They swapped ThinkPads and downloaded their files from the server. Steve powered off Curt's PC, put it in his bag, and left to accompany the Classy Cars IT Manager on a series of visits to their bigger remote branches.

Curt opened the folders that Steve had defined for the Classy Cars project and tried running the multimedia demo. He was able to display images and play audio and video clips. He opened the settings notebooks of the various icons to find out what REXX commands they used, and opened these commands in the editor. "This does look quite straightforward," he said. "Now I'll need to dig into the DB2/2 manuals and find out how BLOBs work."

"Let me know when you find out," said Hanna, looking up from her work. "I'd like to understand more about BLOBs too."

Using DB2 BLOBs from Object REXX

Curt spent the next several hours reading the DB2/2 manuals and building small pieces of code to try out the BLOB features. By midafternoon he was ready to share with Hanna something of what he had learned.

"The DB2 developers have done a great job with BLOBs," said Curt. "I've managed to get some things working without any trouble at all."

Hanna closed her ThinkPad's lid and came over to see what Curt had built.

"For starters," said Curt, "they have defined three different types of BLOBs. Well, LOBs, actually—large objects, they call them. Binary LOBs are just one of these three types. They have also defined Character LOBs (CLOBs) and Double Byte Character LOBs (DBCLOBs) too."

"If we're storing images and audio and video clips, we'll need just plain BLOBs, right?" asked Hanna.

"Yes," said Curt. "We can define multiple LOBs in a single row, and each LOB can be up to 2 GB big."

"That's huge!" gasped Hanna. "How do you go about loading LOB data into a DB2 column?"

"Well, you can assemble the LOB data into a host variable and then put that into a DB2 column with a normal SQL insert or update statement," Curt answered. "Or if the LOB data is in a disk file, you can simply give DB2 a host variable that contains the name of the file that contains the LOB data on disk. That way the application program doesn't need to read the entire LOB into storage. DB2 copies the LOB data straight from its source disk file into a DB2 column."

“That’s a nice option,” said Hanna.

“Yes,” agreed Curt. “I’ve defined a simple DB2 table and written a load program in Object REXX that loads a BLOB into it. I just pass DB2 the name of the file that contains the BLOB. Look, here it is.”

Curt showed Hanna the code (see Figure 33). “See,” he explained, “I need to tell DB2 that my host variable is a locator and contains a file name. I declare it with the `language type blob file` options. If I were coding this in C, COBOL, or Fortran, I would have to build a structure containing information about the file—its name, length, and whether I wanted to read it or write it. The REXX interface is much simpler. My locator host variable is actually the name of a REXX stem variable. I store the name of the file in a compound variable, using the stem with the `name` tail and store the file read/write options using the `file_options` tail. This is the code I wrote to declare the file locator and the update statement that transfers the media file into the DB2 *picture* column,” said Curt.

```
1  call sqlexec 'declare :media language type blob file'
2  media.name = 'd:\cardeal\media\boxie.bmp'
3  media.file_options = 'read'
4  stmt = 'update myTable set myBLOB = cast(:media as blob(4M))'
5  call sqlexec 'prepare s1 from :stmt'
6  call sqlexec 'execute s1'
7  call sqlexec 'clear sql variable declarations'
```

Figure 33. Using REXX to Update a DB2 BLOB

“Look,” said Curt, ″to update the DB2 BLOB:

1. “I declare a file locator variable called `media`.
2. I put the name of a bitmap image file into the `media.name` variable, and
3. I put the file options into `media.file_options`.”

“OK so far,” responded Hanna. Curt continued, “Then

4. I build an SQL statement to update `myBLOB`—the column that contains the BLOB—and next
5. I prepare it,
6. I execute it, and
7. I clear the SQL variable declarations.”

“Hold on,” said Hanna. “What’s the `cast(:media as blob(4M))` in (4) for?”

“Cast is new in Version 2,” replied Curt. “I used it here to tell DB2 that my BLOB file locator host variable media will be used to store a BLOB no bigger than 4 MB.”

“And the `clear SQL variable declarations` in (7)?” asked Hanna.

“BLOB file locator host variables don’t get released until the process that created them terminates,” said Curt. “Since they’re potentially very big, it’s good practice to release them as soon as possible. That’s what this new clear command does.”

“Well that took some explaining, but you managed to get the job done with very little code,” said Hanna. “Is it just as easy to get the BLOB back out of DB2?”

“It sure is,” replied Curt. “This is the code I developed to do the job” (see Figure 34 on page 97).

```
1    call sqlexec 'declare :media language type blob file'
2    media.name = 'media.bmp'
3    media.file_options = 'overwrite'
4    stmt = 'select myLOB from myTable'
5    call sqlexec 'prepare s2 from :stmt'
6    call sqlexec 'declare c2 cursor for s2'
7    call sqlexec 'open c2'
8    call sqlexec 'fetch c2 into :media :mediaInd'
9    call sqlexec 'close c2'
10   call sqlexec 'clear sql variable declarations'
```

Figure 34. Using REXX to Fetch a DB2 BLOB

"First,

1. I declare the media file locator variable. Then
2. I put the name of a bitmap image file into the `media.name` variable, and next
3. I put my `overwrite` file option into `media.file_options`."

"This looks familiar," responded Hanna. "Yes, I was able to copy some of this code from the update program," Curt agreed.

4. "This is the SQL select statement. Very simple! I have only one BLOB loaded, so I don't even need to specify which row. Of course the code I develop for Classy Cars would specify a vehicle in this select statement. Next
5. I prepare the SQL select statement,
6. I declare a cursor on it,
7. I open the cursor and
8. I fetch the BLOB into the file.
9. I close the cursor and
10. I clear the SQL variable declarations."

"And then?" asked Hanna

"And then it's ready to display," answered Curt. "Like so." He opened the OS/2 Drives folder, found the image file that DB2 had just created, and copied it into the OS2\Bitmap directory. Then he dragged a new folder from Templates, opened its settings, and changed its background to the bitmap that he had just copied into the OS2\Bitmap directory. A picture of Boxie appeared in the folder.

"That's great, Curt!" said Hanna. "And it didn't take you long at all. What more do you have to build?"

"I need to change the Classy Cars database definitions," said Curt. "Apart from adding a new column to the vehicle table, I have to define a separate DB2 table space to store the multimedia data. Then when I define the new vehicle table, I'll specify that DB2 should perform no logging on the column that holds the multimedia data. Otherwise it would waste log space (see Figure 35 on page 98). Then of course I have to generalize this code to support multiple media files per vehicle, and also different media types. Currently I'm handling only images, but audio and video will be almost identical. I guess I should have something working by the end of the week."

"Wonderful!" said Hanna. "Steve will be back in the office on Monday and then we can all look at it together."

```
CREATE REGULAR TABLESPACE VEHICLESPACE          -- table space for non multimedia
     MANAGED BY DATABASE                        -- columns of the vehicle table
     USING ( FILE 'vehiclea' 300);              -- 300 blocks of 4K

CREATE LONG TABLESPACE VEHICLESLOB              -- table space for long (BLOB)
     MANAGED BY DATABASE                        -- columns of the vehicle table
     USING ( FILE 'vehicleb' 2000);             -- 2000 blocks of 4K = 8 MB

CREATE TABLE CARDEAL.VEHICLE                    -- Vehicle table
    (SERIALNUM          INTEGER   NOT NULL,
     CUSTNUM            SMALLINT  NOT NULL,
     MAKE               CHAR(12)  NOT NULL,
     MODEL              CHAR(10)  NOT NULL,
     YEAR               SMALLINT  NOT NULL,
     PICTURES           BLOB(4M)  NOT LOGGED )  -- BLOB column, up to 4 MB
  IN VEHICLESPACE                               -- assignment for normal columns
  LONG IN VEHICLESLOB;                          -- assignment for long (BLOB) column
```

Figure 35. DB2 Definition for the Vehicle Table with Multimedia

Multiple Multimedia Files in BLOBs

"If you're planning to store images and audio clips jumbled together in one BLOB, how on earth will you ever unscramble them?" asked Steve. It was Monday, Steve's first morning back at the office in a week.

"No problem!" said Curt with a smile. "DB2 provides facilities to break BLOBs into pieces, and handle one piece at a time. The really neat thing about this is, DB2 doesn't even have to read the whole BLOB into its own buffers to give you access to the part you need. That's very important. The images and audio clips may range from 100 to 500 KB each, but if we include video clips ..."

"Are video clips for real, Steve?" interrupted Hanna.

"Sure!" replied Steve. "We can only do limited video on this ThinkPad, but the latest home PCs from IBM include a chip that can display full-screen, full-motion video. And of course the IBM PowerPC is so powerful that it can deliver full video without needing any hardware assist. It does the whole job in software."

"Wow!" said Hanna.

"It's true," agreed Curt, "and I've heard that the Intel Pentium Pro processor has the same kind of capability."

"Yes," said Steve, "and it would be silly for us to ignore that kind of capability, since it's almost here now. And our car dealer application is going to be around for a *long time*, isn't it team?"

"Right!" chorused Hanna and Curt.

"So it won't hurt to make sure that our multimedia design can handle video when our customers ask for it," continued Curt. "OS/2's multimedia capabilities make it very easy to handle video. It uses the same commands as audio. And it sure makes for a powerful demo when you're trying to close a sale!"

"That sounds great, Curt," said Steve, "but you haven't answered my original question. How are you going to separate out all this multimedia data if you jumble it together in one big BLOB? Wouldn't it be better to store each piece of multimedia data as a separate BLOB?

You could add three new columns to the vehicle table—one for the image, one for the audio, and one for the video,"

"DB2 would allow us to do that," replied Curt, "although some other database managers wouldn't. But Classy Cars wants to be able to store several pictures of some of their cars—front view, side view, and so forth."

"Oh, yes," said Steve. "Well, it's obviously a repeating group, so why don't you normalize the data? Create a new DB2 table called *VehicleMedia,* key it on the vehicle's serial number and a multimedia sequence number, give it a BLOB column, and put the multimedia descriptive data in there. That way each vehicle could have as many or as few associated multimedia files as you want."

Curt looked thoughtful. "That approach could also work, Steve," he said, "but if you'd just listen for a moment, I'll tell you how I'm handling it."

"OK," said Steve, resolving to be patient.

"I've written code to put all the multimedia data for a given car into one BLOB. I also embed control information in the BLOB. I use the first 3 bytes of each BLOB to store a counter that tells me how many multimedia files it contains. It's in character format, so that allows me up to 999 multimedia files per vehicle."

"OK so far," said Hanna, "tell us more."

"Following the 3-byte counter," Curt continued, "I've got a 30-byte string of control information for each multimedia file in the BLOB. It contains a 20-byte title for the multimedia data, and its length. I strip these out using the DB2 substring function and pass them to the GUI code, which inserts the titles into a list box. This shows the user what multimedia files are available for playing. I use the relative position of the title within the list, and the sizes of the multimedia files that come before it, to calculate its position within the BLOB. Then I use the DB2 substring function to pull just the bytes we need out of the BLOB. So when the user clicks on a particular title and asks to play it, it's very efficient."

"Does DB2 read the multimedia data into one of your program variables?" asked Hanna.

"It could," answered Curt, "but I'm exploiting DB2's ability to transfer the data directly from the BLOB to a file on disk. My program never even sees the data. Once DB2 has copied it to disk, I issue a multimedia *play* command and the rest happens automatically."

"How do you load multiple multimedia files into one DB2 BLOB column, Curt?" asked Steve. "Do you read each file into a separate REXX variable, concatenate them together in storage, and then insert that data into the DB2 column?"

"I thought of doing it that way," answered Curt, "but then I found an easier way. This is how I build the SQL that I need." Curt showed them the piece of code in Figure 36 on page 100.

```
1     hostvar = ':ctlinfo'
2     ctlinfo = right(numpic,3)':'
3     stmt = 'update cardeal.vehicle set pictures = cast(? as blob(1K))'
4     do i=1 to numpic
5        piclength  = stream(picfile.i,'c','query size')
6        ctlinfo = ctlinfo''left(pictitle.i,20)','right(piclength,8)';'
7        call sqlexec 'declare :vpic'i 'language type blob file'
8        hostvar = hostvar', :vpic'i
9        call value 'vpic'i'.name', picfile.i
10       call value 'vpic'i'.file_options', 'READ'
11       stmt = stmt '|| cast(? as blob(4M))'
12    end
13    ctlinfo = "BIN'"ctlinfo"@@'"
14    stmt = stmt 'where  serialnum =' oldserial
15    call sqlexec 'prepare s1 from :stmt'
16    call sqlexec 'execute s1 using' hostvars
```

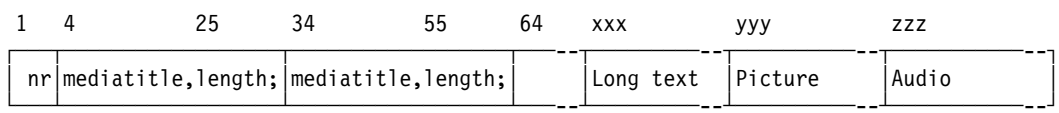
Figure 36. Using Object REXX to Build and Store a DB2 BLOB

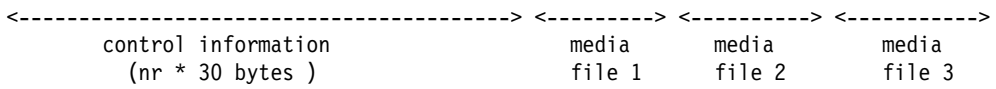
Curt explained his logic. "To begin,

1. I start the list of host variables with the control information variable.
2. I initialize this variable with the number of media files.
3. I code the beginning of the SQL update statement.
4. I loop as many times as there are media files to be inserted into DB2. Each time
5. I get the length of the media file, and
6. I concatenate the title and length to the control information.
7. I declare a new DB2 locator file host variable and
8. I concatenate its name to the list of host variables.
9. I set the locator variable's file name and
10. I also set its file options.
11. I concatenate another place-marker to the SQL update statement.
12. Once out of the loop,
13. I mark the control information host variable as binary, and
14. I complete the SQL update statement.
15. I prepare it and
16. I execute it using the list of host variables that I built up.

DB2 concatenates all the multimedia files together to form a single BLOB field, and I never even touch them in my Object REXX code. Pretty neat, hey?"

Layout of the self-defining BLOB and SQL statement to build and store the BLOB






```
SQL:     update cardeal.vehicle
         set pictures = cast(? as blob(1K)) || cast(? as blob(4M)) ||
                        cast(? as blob(4M)) || cast(? as blob(4M))
         where serialnum = 123456

HOSTVAR: :ctlinfo, :vpic1, :vpic2, :vpic3

         ctlinfo = "BIN'003Fact sheet...,146;Side view...,67118,Audio...,294956;@@'

         vpic1.name = 'd:\cardeal\media\auditext.fac'   /* fact sheet text */
         vpic1.file_options = 'READ'

         vpic2.name = 'd:\cardeal\media\audiside.bmp'   /* picture bitmap  */
         vpic2.file_options = 'READ'

         vpic3.name = 'd:\cardeal\media\audi.wav'       /* audio wave file */
         vpic3.file_options = 'READ'
```

"Wow! I never realized how powerful DB2's BLOB handling capabilities are," said Hanna. "And you're making full use of them, Curt."

Curt smiled. "Thanks, Hanna. Want to hear it play?"

"Yes please," said Hanna.

Curt started up the application using the Dr. Dialog interface that Steve had developed. "I've added the logic for the button called **Media,** under the vehicles list box," he said. "You select a vehicle, then click on the **Media** button. The application opens a new window, which shows a list of the multimedia files available for the currently selected vehicle, if any." Curt opened the Vehicle Multimedia window as he spoke (see Figure 37 on page 102).

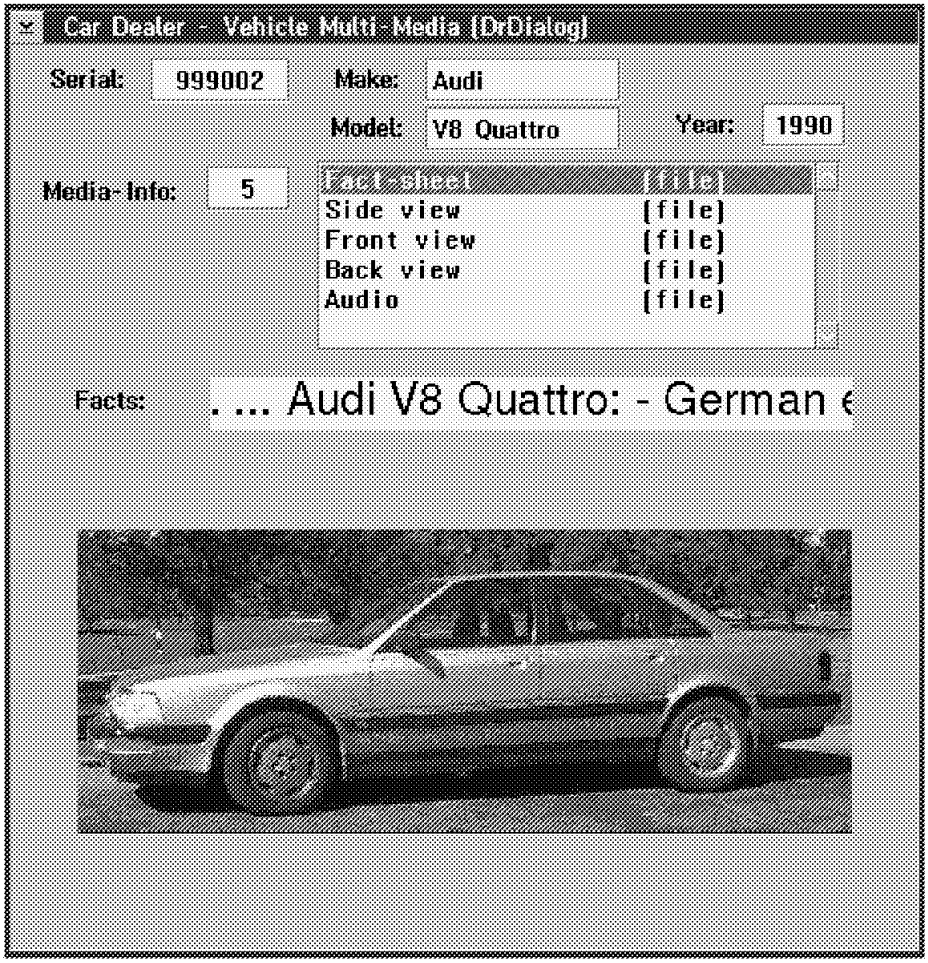


Figure 37. Vehicle Multimedia Window of Dr. Dialog GUI Application

"Then you just click on the multimedia file you want!" Curt did this. A line of text in large bold letters scrolled smoothly from right to left across a yellow area in the Media window. It carried a description of a car. "And since Object REXX supports concurrent processing," continued Curt, "I can kick off something else while the text display is still rolling." He clicked on a multimedia line describing a bit map picture, and a picture of a car appeared in another area of the window. Then Curt selected a sound bite and they heard a recording of his voice describing the car that he had selected.

"Classy Cars will be really impressed when they see what you've developed," said Hanna. "It will give them a wonderful marketing aid. I know they were thinking of using it for their marketing staff, but it's so impressive I think they could also show it directly to prospective car buyers. What do you think, Steve?"

All this time Steve had been watching Curt's demo silently. "Yes, it is impressive," he answered Hanna.

"But?" prompted Hanna. She could see that Steve wasn't completely happy.

"I'm worried about storing multiple multimedia files and the catalog of multimedia information in the BLOB itself," Steve answered. "We may need to add more control information later on, and this approach is limiting."

"There's no limit," said Curt. "I can easily increase the size of the control field if we need to."

“Well,” responded Steve, “if you had created a new vehicle multimedia table and stored one multimedia file per BLOB, we could add new columns to that table any time we needed to by using the DB2 `ALTER TABLE` command. We wouldn’t have to unload the existing data and reformat it, or even change existing applications. They would keep on working, while new applications made use of the new columns.”

“What new columns?” asked Curt. “Are you changing the application specs while I’m still writing the code?”

“I was talking with the consultant that Classy Cars has engaged to help them develop an IT architecture,” answered Steve. “He isn’t happy with our proposal that Classy Cars install a separate database manager in each of their branches.”

“Why not?” asked Hanna. “We’ve costed it out, and it’s a good, economic solution. DB2 is inexpensive, and they won’t have to get into the complexities and costs that networking their branches into a central database manager would entail. And Classy Cars told us right from the beginning that each branch runs as an autonomous unit. They don’t have any need to share data.”

“That *is* what they told us,” agreed Steve. “Of course their head office does want sales and service revenue figures on a weekly basis...”

“We agreed with them their head office would get that data by dialing into the distributed DB2 databases each week,” interrupted Curt.

“Right,” agreed Steve. “But the consultant has uncovered something that Classy Cars didn’t tell us. They deal with several large companies all over the country. Currently, each branch of Classy Cars deals with the branches of these large companies in isolation. Many of these companies are unhappy with this situation. They want a single, consolidated bill from Classy Cars each month, and they want a single national phone number where they can talk to one person about all their dealings with Classy Cars. The consultant says the best way of achieving this would be to have a single central database manager, with all the branches hooked into it.”

“That sounds like a big change, Steve,” said Hanna. “I don’t know if we can support that approach. What are the implications for our design and the code we have already written?”

“No problem!” interjected Curt. “DB2/2 can support a distributed operation over a wide area SNA or TCP/IP network, and the program code doesn’t have to change a bit. All we have to do is install the DB2 OS/2 client package on each remote PC, and point them to the central server.”

“That’s true,” agreed Steve. “DB2 gives us a great deal of flexibility in that area. But I’m worried about the implications of shipping multimedia files over the wide area network every time a dealer wants to display a picture or play a sound clip. It would overload their network and kill their response times.”

“Well for Pete’s sake!” said Curt, his anger boiling up. “It was *your* idea to add multimedia to this application. Classy Cars never even dreamed of doing it till you talked them into it. And now it turns out to be unaffordable, and they’ll probably decide to can the whole car dealer application. When will you learn to be sensible and do what the customer asks for, instead of getting so smart you can’t deliver what you promise?”

Steve was about to respond angrily, but Hanna stepped between the two of them. “Hold on there, guys,” she said. “Let’s make sure that we understand how big a problem this is before we start shouting at each other.” She held her ground until Curt and Steve backed off.

“It’s clearly late in the day for Classy Cars to decide that they want to run on a centralized database,” she said. “They’ve already signed off our design, and that specified one database per branch. If they want to change their minds, we will have to assess the impact of that change and tell them what it will cost, in terms of network bandwidth, extra coding, or

whatever. What would the impact be if we ran the multimedia off ASCII files on the users′ PCs instead of using DB2 to store them?" she asked Steve.

"That would work fine," he said, "except there wouldn′t be any easy way to distribute new multimedia files when new models come out. If we store all the multimedia files in DB2, it′s easy to make sure every user has the most recent multimedia information, whether they′re local or remote users."

"You can′t have it both ways," said Curt. "You can′t plan to use DB2 to distribute multimedia files and then complain that it will use too much bandwidth."

"Maybe we can," said Steve. "Supposing we use DB2 to distribute the multimedia data, but keep copies on the users′ PCs and reuse them as long as they′re still current."

"How would you know if a user′s copy is still current?" Curt asked.

"By putting extra columns into the vehicle table," Steve answered. "If we put the multimedia file′s time and date stamp in there, our multimedia playing logic could fetch those columns from DB2 and check if the user has a current copy of the multimedia file on the PC. If not, we ask DB2 to give us a copy, play it to the user, but also keep it for next time. But the way you′re handling the multimedia control information, there′s no way to do that."

"I could easily extend my control information to handle file date and time stamps," retorted Curt.

"Sure!" said Steve sarcastically. "But what about the next change that we need?"

"Steve, you′re coming up with a whole lot of new requirements and criticizing Curt because his code can′t handle them," said Hanna. "Now, let′s think this through together. We have already agreed with Classy Cars that we′ll implement our application as a pilot in their San Jose branch next month. That′s going to be six PCs on a LAN with a stand-alone database, right?"

"Yes," agreed Steve.

"Fine," said Hanna. "Curt′s multimedia code would work perfectly in that environment, wouldn′t it?"

"Yes," said Steve again.

"The pilot is due to run for a month," continued Hanna. "That will give Classy Cars time to think through whether they really need a centralized database, and us time to think through the implications of making such a change. Right?"

Steve looked relieved. "You′re right, Hanna," he said. "I guess I don′t have to start panicking yet. There′s still a fair amount of time before they go live across multiple branches. And if the pilot is successful, their first payment is due. At least we′ll be able to eat while we′re working out what to do next."

"Now you′re talking, Steve," said Hanna. "Curt has put together some really smart code, and it seems to work well. We′ve still got time to put it through acceptance testing with the users and implement it as part of the pilot installation. That way, we′ll be delivering it before the date we committed to. I′m sure that Classy Cars will be happy."

"I sure hope so," said Curt.

"I′m due back at Classy Cars tomorrow to start working out the implementation plan once the pilot has proved successful," said Steve. "During the pilot, I′ll talk to them about the approach we want to take for distributed databases."

"Let us know what happens," said Hanna.

Implementing the DB2 Multimedia Support

Here are the steps required to implement multimedia in DB2/2 Version 2:

1. Define two DB2 table spaces for the vehicle table, to separate the normal data from the large multimedia data (BLOBs).

2. Define the vehicle table so that the BLOB column is stored in the special table space for such columns (`long in` keyword).

These two steps are shown in Figure 35 on page 98.

3. Write a DB2 program, `load-mm.cmd`, to update the vehicle table with the multimedia files in the BLOB column. An extract of the program with the SQL statements is shown in Figure 36 on page 100.

   - We described all the multimedia files in a specification file named MEDIA.DAT:

```
/* serial, title of file       , filename    */
   999001, Fact-sheet          , ford.fac
   999001, Side view           , fordsid.bmp
   999001, Front view          , fordfrt.bmp
   999001, Back view           , fordbck.bmp
   999001, Angle view          , fordang.bmp
   999001, Audio               , ford.wav
   999002, Fact-sheet          , audi.fac
   999002, Side view           , audisid.bmp
   999002, Front view          , audifrt.bmp
   999002, Back view           , audibck.bmp
   999002, Audio               , audi.wav
   ...
   end
```

   - The multimedia update program reads this file and updates the vehicle table with multimedia BLOBs.

4. Write three new methods for the vehicle class to retrieve the multimedia data:

   - Retrieve and return the number of media files of a vehicle:

```
::method getmedianumber
   expose medianumber mediacontrol
   if symbol("medianumber") = 'VAR' then return medianumber
   medianumber = 0
   mediacontrol = ''
   stmt = 'select substr(v.pictures,1,3)' ,
          '  from cardeal.vehicle v  where v.serialnum =' self~serial
   call sqlexec 'PREPARE s2 FROM :stmt'
   if sqlca.sqlcode \= 0 then return 0
   vpicind = -1
   call sqlexec 'DECLARE c2 CURSOR FOR s2'
   call sqlexec 'OPEN c2'
      call sqlexec 'FETCH c2 INTO :vpic :vpicind'
   call sqlexec 'CLOSE c2'
   if vpicind >=0 then medianumber = vpic
   return medianumber
```

- Retrieve the control information of multimedia files for a vehicle:

```
::method getmediacontrol
   expose medianumber mediacontrol
   if symbol("medianumber") = 'LIT' then return ''
   if medianumber <= 0 then return ''
   stmt = 'select substr(v.pictures,5,30*'medianumber')' ,
          '  from cardeal.vehicle v  where v.serialnum =' self~serial
   call sqlexec 'PREPARE s2 FROM :stmt'
   call sqlexec 'DECLARE c2 CURSOR FOR s2'
   call sqlexec 'OPEN c2'
      call sqlexec 'FETCH c2 INTO :vpic :vpicind'
      rcv = sqlca.sqlcode
   call sqlexec 'CLOSE c2'
   if rcv = 0 & vpicind >= 0 then mediacontrol = vpic
   return mediacontrol
```

- Retrieve one multimedia file from the BLOB of a vehicle:

```
::method getmediainfo
   expose medianumber mediacontrol
   if symbol("medianumber") = 'LIT' then return ''
   if mediacontrol = '' then selfgetmediacontrol
   arg medianum
   if medianumber = 0 | medianum > medianumber | medianum <= 0 | ,
      mediacontrol = '' then return ''
   mediatitle  = substr(mediacontrol,medianum*30-29,20)
   medialength = substr(mediacontrol,medianum*30- 8, 8)
   mediastart = 7 + 30 * medianumber
   do i=1 to medianum -1
      blg = substr(mediacontrol,i*30-8,8)
      mediastart = mediastart + blg
   end
   call sqlexec 'CLEAR SQL VARIABLE DECLARATIONS'
   call sqlexec 'DECLARE :vpic3 LANGUAGE TYPE BLOB FILE'
   vpic3.file_options = 'OVERWRITE'
   select
     when mediatitle = 'Fact-sheet' then vpic3.name = ''
     when mediatitle = 'Audio'      then vpic3.name = 'temp.WAV'
     when mediatitle = 'Video'      then vpic3.name = 'temp.AVI'
     otherwise                           vpic3.name = 'temp'medianum'.BMP'
   end
   vfacts = vpic3.name
   stmt = 'select substr(v.pictures,'mediastart','medialength')' ,
          '  from cardeal.vehicle v  where v.serialnum =' selfserial
   call sqlexec 'PREPARE s2 FROM :stmt'
   call sqlexec 'DECLARE c2 CURSOR FOR s2'
   call sqlexec 'OPEN c2'
      if vfacts = '' then call sqlexec 'FETCH c2 INTO :vfacts'
                     else call sqlexec 'FETCH c2 INTO :vpic3 :vpicind3'
      if sqlca.sqlcode \= 0 then vfacts = ''
   call sqlexec 'CLOSE c2'
   call sqlexec 'CLEAR SQL VARIABLE DECLARATIONS'
   return mediatitle'::'vfacts
```

The fact sheet is retrieved directly into a variable, whereas pictures (.bmp), audio (.wav), and video (.avi) are retrieved into temporary files, and the file name is returned to the caller.

5. Write the code to play audio and video multimedia files. Sample code to play an audio file:

```
::method playaudio class
   arg filename
   call mciRxSendString 'open waveaudio alias audio shareable wait', 'RetSt', '0', '0'
   call mciRxSendString 'load audio' filename 'wait', 'RetSt', '0', '0'
   call mciRxSendString 'set audio time format ms', 'RetSt', '0', '0'
   call mciRxSendString 'play audio wait', 'RetSt', '0', '0'
   call mciRxSendString 'close audio wait', 'RetSt', '0', '0'
   call mciRxExit
```

   The code for video is similar, with `waveaudio` replaced by `digitalvideo` and the `audio` keyword replaced by `video`.

6. Pictures are displayed using PM controls provided by the visual builders.

Implementation Notes

1. The DB2 table spaces and the vehicle table are set up by the installation program. All tables are loaded as well, including the multimedia data. We have provided the programs runsql.cmd, load-db2.cmd, and load-mm.cmd; similar code is embedded in the installation program.

2. Multimedia data cannot be loaded for DB2 Version 1. The rest of the application is fully functional, however. It is still possible to see multimedia in action because we added this support to the FAT implementation as well (see below).

3. We retrofitted multimedia support into the FAT implementation. The FAT vehicle class was enhanced by the same three methods (getmedianumber, getmediacontrol, getmediainfo) and the respective multimedia files are passed to the code directly from the distributed data files.

   This allows the GUI applications to be run with FAT persistence support and multimedia data.

4. Multimedia data is available for customers *New and used cars*, *Furukawa*, *Griborn*, *Turton*, and *Wahli*.

Source Code for DB2 Multimedia Implementation

The source code for the DB2 Vehicle class is listed in “DB2 Vehicle Class” on page 271.

Table definitions are listed in “DB2 Setup” on page 333.

The multimedia descriptive file is listed in “Multimedia Data Definition File” on page 245.

The multimedia load program is listed in “Command File to Load Multimedia Data” on page 341.

Audio and video play methods are part of the car dealer class, which is introduced in “Overall Car Dealer File Structure” on page 124, and the source code is listed in “Base Cardeal Class” on page 262.

Chapter 9. Data Security with Object REXX and DB2

In this chapter we exploit DB2 stored procedures to solve a common security problem when using dynamic SQL.

The Security Problem

Next day Hanna and Curt were working quietly in the office when the phone rang. Hanna answered it.

“Hello, Hacurs Software Systems,” she said. “Oh hello, Steve. We were wondering how your morning went with Classy Cars. What? What’s the problem? They don’t like our data security? No ... wait ... hold on, Steve! I think that you’re overreacting. Come into the office straight away and tell us what happened. I’m sure we’ll be able to sort something out.”

“That sounded like trouble,” observed Curt.

“Steve’s very upset,” said Hanna. “He said that the IT consultant Classy Cars has engaged has persuaded them that there’s a major security exposure in our system. Steve said he couldn’t talk them out of it; they’re saying they can’t implement the system as it is.”

“We’ve invested a lot of effort in Classy Cars, and so far we’ve had nothing but problems with them,” said Curt. “I think we should cut our losses. There are lots of other car dealers around. We’re sure to sell our system with less time and trouble than we’re having.”

“We’ve invested too much time and effort in Classy Cars to just walk away,” Hanna responded. “Let’s wait and see what the problem is, Curt. I’ve got a lot of faith in you and Steve. I’m sure you’ll be able to handle it.”

Curt didn’t look convinced. They both tried to keep working at their tasks while waiting for Steve. At last they heard the crunch of his car tires outside the office. He came in moments later, slamming the door.

“That confounded consultant is really making things hard for us,” Steve said.

“What is it now, Steve?” asked Hanna.

“Well, he’s still going on about the need for a centralized database manager,” said Steve, “and he seems to have convinced Classy Cars that that’s the way they must go. I explained to them that they have already signed off our design based on a separate database per branch, and that’s the way we’ll have to install the pilot. It’s too late to change without impacting the schedule. They agreed to that. We’ll investigate the impact of changing to a distributed system later on.”

“What else, Steve?” asked Hanna.

“The consultant has been reviewing our design in detail,” Steve responded. “He’s come to the conclusion that its security is weak, and that this will be a problem particularly for their customer data.”

“Why does he say that?” asked Hanna.

“Mainly because we’re using dynamic SQL in all our applications,” answered Steve. “The implication is that we will have to authorize the end users to access the DB2 tables directly. So long as they use our programs, we can control what data they can see. But they could equally well use a package like Lotus 1-2-3 or Excel to access the tables, and then we can’t control what they do.”

“But isn’t access to DB2 password-protected, Steve,” asked Hanna.

“Yes,” replied Steve, “but the user is asked to perform the logon when our code first tries to access DB2. So users have to know their own logon ID and password. And once they’ve logged on to allow our application to run, they can start up other applications and access the database with them.”

“Hold on, Steve,” said Curt. “What you say is true for a user working on the database server itself. But someone using a client PC to access a DB2 server must issue a *connect* command to DB2 quoting a userid and password. That connect command must be embedded in the application program. And we’re not planning to allow users to run applications directly on the DB2 server machine.”

“I wish that I’d had you with me this morning, Curt,” said Steve. “But if the DB2 connect statement is in a REXX program, anyone can look at the source, and then they’ll see the userid and password, won’t they?”

“That used to be true, but not any more,” said Hanna. “Object REXX includes a new utility called REXXC. You can use this to read REXX source code and produce a new program that does what the original program does, but is unreadable, similar to compiling C or COBOL source, which produces unreadable object text.” (See “The REXXC Utility” on page 226 for more information.)

“That’s great,” said Steve, “but if a REXX program contains a user ID and password as plain text literals and it gets processed by the REXXC command, won’t the literals still be there in the file written by REXXC?”

“Let’s find out,” said Curt. He typed in a small REXX command file, processed it through REXXC, and looked at the output. “Hmm—yes, the literals are stored as plain text in the output file.”

“Hey!” said Steve. “Maybe we can write the logon data in an encrypted form in our programs, then include code to decrypt it before we pass it to DB2. The Object REXX translate or bitxor methods could do the trick. That way no one could see the logon information in our programs, because it wouldn’t be there—in readable form.”

“I’m impressed!” said Hanna. “You guys have thought of lots of ways to tackle this security issue, and it didn’t take you long at all.”

“I’m going straight back to Classy Cars,” said Steve. “I think we can overcome their concerns about security.”

“Let us know how it goes,” called out Hanna as Steve strode for the door.

Hanna and Curt settled down to their work again. It was mid-afternoon before they heard from Steve. He strode into the office with a troubled look on his face.

“Hi, Steve,” said Curt. “How did Classy Cars like our approach to ensuring the security of their data?”

“They were impressed,” Steve answered. “So was their IT consultant, except on one issue. They definitely want to move towards a single, centralized database. They accept that this

wasn′t in the original spec that they signed off, so they′re prepared to implement using separate databases in each branch and then to centralize over time. I′m sure we can work out an approach that will satisfy them."

"What′s the IT consultant′s concern?" asked Curt.

"He′s been helping Classy Cars plan how they will run in the future," Steve answered. "They want central control over their customer accounts. It turns out that lots of their customers have run up substantial debts, and some simply switched their business to another branch when the first branch refused to extend them any more credit. Their branches don′t exchange customer information. They really want to fix that. But they′re pretty worried, because the accounting data they want to store will be very sensitive. They want a guarantee that unauthorized personnel can′t read it—and even more important, alter it."

"I don′t understand the problem, Steve," said Hanna. "DB2 has very good built-in facilities to restrict the people who can access a specific table."

"Yes," agreed Steve, "but every branch must have users authorized to capture and view accounting data for their own branch only, but not to update or delete it. I was trying to work out a way we could do this with the *check* option of the DB2 view facility, but their requirements as to who can see what and who can update what may be too complicated to handle this way. The consultant says that the best way to implement really tight security is to have the application code running on the server in a locked room, and not on a hundred plus PCs all around the country. He says if you can′t even keep games and viruses off users′ PCs, how can you hope to keep fraudulent code off?"

"So what′s wrong with the security schemes we came up with this morning?" asked Curt.

"Well, our schemes all depend upon the remote user having an access userid and password," said Steve. "We can do a lot to keep those hidden, but if there′s collusion and somehow an ID and password pass into the wrong hands, the security of their accounts data will be lost, and they won′t even know about it."

"Is this for real?" asked Curt. "Aren′t they being a bit paranoid?"

"I′m afraid not," answered Steve. "Last year they had to write off more than a quarter of a million dollars in bad debt. They suspect that there may have been some collusion between some customers and some of their staff. But there′s no way they can prove anything. They just don′t have the right controls in place. Our computer system could help them, but its security will have to be water-tight."

"Ouch!" said Curt. "It′s a tough world out there."

"I′ve got an idea that some of the new DB2/2 features may provide a solution in this area," said Hanna, "but I′m not sure if we can use them from Object REXX. I′ll take the manuals home tonight and check it out."

"Good hunting, Hanna," said Steve. "If you can come up with a really watertight solution to their problems, it would be worth a lot to them—and to us!"

Coding Stored Procedures with Object REXX

Next morning Hanna came in clutching the DB2 manuals and smiling. “I think I’ve got the answer, guys!” she said.

“Cut the suspense, Hanna!” said Steve. “Tell us what your approach is, please.”

“The consultant suggested that the code dealing with the most sensitive data should run on the central server only,” said Hanna. “Historically, that’s the way transaction programs have been handled on mainframes. Normally we build our REXX programs to run directly on the client PCs. Our challenge is to find a way to get some of the REXX code to run on the secure server, and still to be able to access it from the client PCs. The answer I thought of is to use DB2’s stored procedures facility. It’s often used to reduce network traffic and improve server performance by moving code that accesses the database heavily onto the database machine. But it can also be used to improve security. It would allow us to move key code off the client’s PCs, and to access secure DB2 tables, by using a special logon ID and password in code that runs on the server only.”

“Hanna,” said Curt, “I hate to puncture a great idea, but a client program must be connected to a DB2 database before it can invoke a DB2 stored procedure. Which means that it has already supplied a logon ID and password. The DB2 stored procedure isn’t allowed to issue another connect command, and so it has to operate under the client’s ID and password. Anything that the stored procedure can do in DB2, the client can do too. And since the client’s ID and password are embedded in code on the client PC, your proposal doesn’t sound any more secure than the approaches Classy Cars have already turned down.”

Hanna just smiled. Curt and Steve were really intrigued. What did she have up her sleeve? She moved to the whiteboard and picked up the pen.

“What you say is true, Curt,” she said. “I thought of that too. But I also thought, is there anything new in Object REXX that could help us in this situation? I did some reading about DB2 and Object REXX last night, and I came up with an idea. I wrote some code to check it out, and it looks like it will work. But I only had a single ThinkPad to test it on. We’ll have to try it out on a couple of PCs connected over our LAN.”

“Come on, Hanna, you’re driving us crazy!” exclaimed Steve. “What’s your idea?”

“It’s quite simple, really,” said Hanna. And for once, she actually drew something on the whiteboard. “This is the way that DB2 stored procedures are normally put together,” she said, drawing Figure 38.

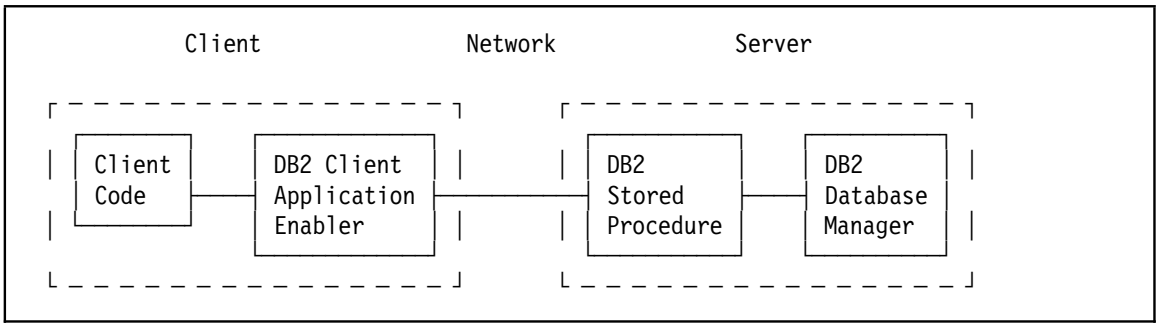


Figure 38. DB2 Stored Procedure

“The client code tells DB2 to call a stored procedure,” explained Hanna. “The Client Application Enabler package (CAE/OS2) on the client PC relays the request to the DB2 database manager on its server. DB2 schedules the stored procedure code, passing it the arguments on the original call command. The stored procedure runs, accessing DB2, and passes results back to DB2, which relays them back to the client code.”

Hanna continued. “We can write both the client code and the stored procedure in Object REXX. But as you pointed out, Curt, the stored procedure has to use the DB2 connect that the client code has already issued, and therefore has no more authority than the client. Now for the magic!” Hanna changed the figure, as shown in Figure 39 on page 113.

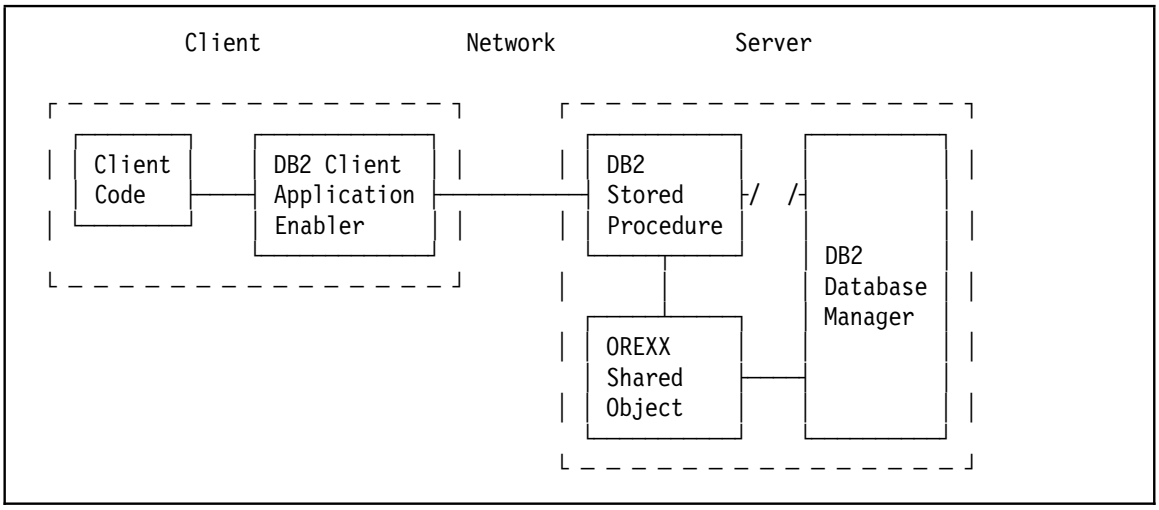


Figure 39. DB2 Stored Procedure with Object REXX Shared Objects

“The key thing here is that although the DB2 stored procedure has access to DB2 by virtue of the connect that the client PC issued, *it doesn′t use it*,” Hanna explained. “At least, not for accessing the really sensitive data, because the client doesn′t have authority to do that. Instead, we automatically start up a disconnected process each time the server boots up, running an Object REXX server command. This command issues its own connect to DB2 using a secure ID and password, creates a special shared Object REXX object, and stores its name in the *.environment* directory. Once it′s there, any Object REXX command that runs on the server can find it and use it. In particular, DB2 stored procedures written in Object REXX can find it and use it to relay requests to the Object REXX server command that created the object. The server command waits for requests, handles them, and sends responses back to the requester—all through the shared object and its methods.”

“This is brilliant, Hanna!” said Steve. “Show us your code.”

“This is the Object REXX server code,” said Hanna, bringing up the code shown in Figure 40 on page 114.

```
/****** server.cmd ******/
server = .DB2server~new                  /* make a DB2 server object */  1
.environment['CARDEAL.DB2SERVER'] = server                                2
'logon special /p=secret /L'             /* logon as special user    */  3
if RxFuncQuery('SQLEXEC') then
   call RxFuncAdd 'SQLEXEC', 'SQLAR', 'SQLEXEC'
call sqlexec "connect to dealerdb"
say "The OREXX server is active..."      /* server iis ready         */
do until input = '!'                                                      4
   input = server~Respond                /* process a client request */
end
say "The OREXX server is ending."
.environment['CARDEAL.DB2SERVER'] = .nil /* clean-up                 */
call sqlexec "connect reset"
exit

::class DB2server                        /* DB2 SERVER CLASS         */  5
::method init                            /* invoked by the server    */  6
  expose state
  state = 'Free'                         /* we're ready for a client */
  return
::method Respond unguarded               /* invoked by the server    */  7
  expose state input output
  guard on when state = 'Request'        /* wait for a client        */  8
  select
     when input~translate = 'CONNECT' then do       /*** CONNECT *****/  9
        stmt = "select user from sysibm.systables",
               "where name = 'SYSTABLES'"           /* return userid */
        call sqlexec "prepare s1 from :stmt"
        call sqlexec "declare c1 cursor for s1"
        call sqlexec "open c1"
        call sqlexec "fetch c1 into :output"
        call sqlexec "close c1"
        end
     when input~translate~word(1) = 'CUST' then do  /*** CUST xxx ****/  10
        custno = input~word(2)
        stmt = 'select * from cardeal.customer where custnum =' custno
        call sqlexec "prepare s2 from :stmt"
        call sqlexec "declare c2 cursor for s2"     /* return the    */
        call sqlexec "open c2"                      /* customer info */
        call sqlexec "fetch c2 into :custnx, :custname, :custaddr"
        if sqlca.sqlcode = 0 then
             output = custnx':' strip(custname) 'in' strip(custaddr)
        else output = custno':  not found'
        call sqlexec "close c2"
        end
     otherwise output = input~reverse    /* just to show we're here  */
  end
  state = 'Respond'                      /* signal client to proceed */  11
  return input
::method Request                         /* invoked by the client    */  12
  expose state input output
  use arg input
  state = 'Request'                      /* signal server to proceed */  13
  guard on when state = 'Respond'        /* wait for server          */  14
  state = 'Free'                         /* ready for next request   */  15
  return output                          /* give output to client    */  16
```

Figure 40. DB2 Stored Procedure with Object REXX Shared Objects: Server

“Now this isn′t production-strength code. There isn′t any error-checking in it,” explained Hanna. “I just did enough to make sure that it would work the way I thought it should. Let me step you through the main points:

1. This is the file that would run when the server boots up. It contains definitions for the DB2 server class and methods. I create a single object from this class.

2. I store the object′s name in the global .environment directory. (See ‘Communication among Classes’ on page 126 for more details on the global and local directories).

3. I issue an OS/2 logon using a special ID and password, then connect to DB2. This gives me the authority to anything the special ID can do.

4. I go into a loop sending the Respond message to the server object. Each time it waits for a client request, then processes it. I make this loop quit if the client sends an exclamation mark (!) character, just to ease debugging.

5. Here′s where I define the DB2 server class and its methods.

6. The init class method is invoked when I create a new object. I set the object′s state attribute to Free. The other values it can have are Request and Response. It controls access to the Object REXX DB2 server object.

7. The Object REXX DB2 server process invokes the Respond method to wait for a client request and then process it.

8. The Respond method is unguarded so it can run concurrently with client requests, but issues a guard command to wait for a client, which will change the state to Request. (See Chapter 13, ‘Object REXX and Concurrency’ on page 181 for details on GUARD).

9. There′s only token logic in the Request method. If the input transaction is a CONNECT request then I tell DB2 to select the special SQL value User, which is my DB2 connection ID, and return this to the client. That′s just enough logic to verify that I can access DB2 data and to make sure that I′m using the right DB2 connection.

10. If the input is a CUST request, I retrieve the customer from the database and return its information. Otherwise I simply reverse the input just so I can see that something happened.

11. The Respond method sets the object′s state to Respond once it has set up the required response in its output attribute. This signals the waiting Request method to finish processing the client′s request.

12. The Request method is invoked by the client, and runs under the client′s process. It′s guarded by default, so only one client at a time can run it.

13. The Request method sets the object′s input attribute to the request argument passed by the client, then changes the object′s state to Request to signal the server process to handle this new request.

14. Then the Request method waits until the server sets the state to Respond, by which time the required response is in the attribute output. (See Chapter 13, ‘Object REXX and Concurrency’ on page 181 for details on the *guard* instruction).

15. I set the object′s state to Free. We′re ready for the next client request.

16. I return the server′s response to the client.

And here's the DB2/2 stored procedure code," said Hanna, referring to Figure 41.

```
/****** gateway.cmd ******/

server = .environment['CARDEAL.DB2SERVER']                              1
sqlroda.1.sqldata = 'anything'    /* touch argument to make DB2 happy */
sqlroda.2.sqldata = server~request(sqlrida.1.sqldata)   /* set reply */  2
sqlca.sqlcode = 0                                                       3
```

Figure 41. DB2 Stored Procedure with Object REXX Shared Objects: Gateway

"You'll see that there really isn't much to it. It acts as a gateway between the remote client and the Object REXX server code.

1. I pick up a pointer to the Object REXX DB2 server object from the .environment directory.
2. The input transaction is passed to the stored procedure in the *sqlrida.1.sqldata* REXX variable. I pass this to the request method of the server object, and store the result that it gives back to me in *sqlroda.2.sqldata*. DB2 will pass this back to the remote client that called my procedure.
3. I set the *sqlcode* to zero to indicate that the call worked correctly."

"The gateway is tiny, Hanna," said Curt, "there are only four lines of code. Is this what they call middleware?"

"I guess so," Hanna replied.

"Where's the client code?" asked Curt.

"Here it is," said Hanna, bringing up the code shown in Figure 42. "I wrote this as a stand-alone command that I can invoke from the command line. You'll see that there really isn't much to the client code either."

```
/****** client.cmd ******/

'logon humble /p=user /L'               /* logon as normal user     */  1
call sqlexec "connect to dealerdb"
reply = " "~left(60)                    /* prime reply so DB2 knows */  2
proc = "gateway.cmd"                    /* gateway code on DB2server*/  3
say "The DB2 client is active; I'm going to use the DB2 server..."
do until reply = "!"                    /* ask for input            */  4
   say "Give me an argument (any, connect, cust xxx, ! to end)"
   parse pull argument
   call sqlexec "call :proc (:argument, :reply)"  /***** call proc ***/  5
   if sqlca.sqlcode = 0 then
      say "The reply is '"reply"'"
   else
      say "sqlcode =" sqlca.sqlcode", sqlerrmc =" sqlca.sqlerrmc
end
say "The DB2 client is terminating."    /* done                     */
call sqlexec "connect reset"
```

Figure 42. DB2 Stored Procedure with Object REXX Shared Objects: Client

"Let me step you through this code.

1. I log on to OS/2 using a low-security ID and password, then connect to DB2 with this ID and its authority. On a separate DB2 client PC, these two statements could be combined into one.

2. I′m going to use the SQL CALL command. I have to prepare the field in which the reply will come by assigning a representative value to it.

3. My DB2 stored procedure is called gateway.cmd.

4. The client loops, asking the user for input until the user keys in an exclamation mark (!).

5. This is the real meat of the code. The client calls the DB2 stored procedure, passing it the user′s input string in argument and the reply field for the reply. I check the SQL return code, and if it′s good I give the reply back to the user. Otherwise I display the SQL code and error message."

To show them how it worked, Hanna opened an OS/2 command line window and entered the `server` command. The server code displayed a message saying it was active and waiting for customers. Then she opened a second OS/2 command line window, and entered the `client` command. The client code also notified them that it was active, and asked for some input. Hanna typed in `Hello`! and back came `!olleH`. She did it again, and the same response came back instantly. Then she typed in `connect`, and back came the answer `SPECIAL`.

"That′s the server process′s logon ID, not the client′s," observed Hanna. Then she typed `CUST 106` and the response was the name and address of the customer Helvetia. Finally she typed ! into the client command line. Both the server and the client commands terminated in their respective windows.

"Hanna, this is brilliant," said Curt, "but the client, gateway and server code are all running on the same PC. How does this scale up?"

"DB2 stored procedures can be called by remote client PCs," Hanna answered. "The clients can be running under a variety of operating systems including OS/2, DOS, Windows, and AIX. DB2 supports connections over both LANs and WANs, and can handle SNA, TCP/IP, NetBIOS, and IPX/SPX communications protocols. It′s very flexible."

"Hanna, you′re a genius!" said Steve. "This approach will allow us to implement really tight control over Classy Cars′ sensitive data. I′m due to visit them later today, and I′d really like to take the code that you′ve developed, and to review your ideas and code with them. If they′re happy with it, and I′m sure they will be, we can start implementing their pilot branch while we build secure code to handle their accounts data."

"I′m glad you like it, Steve," Hanna replied. "This new version of REXX is so powerful, we′re all going to end up looking like heroes!"

"I love it," said Steve, "and I′m sure that Classy Cars will too, once I explain it to them. Let me copy the code you developed, and I′ll go there right away."

Later that day Hanna and Curt were in the office, waiting to hear from Steve how his visit to Classy Cars had gone. They had expected him to phone after his visit, but he hadn′t. There was an edge of nervousness in the office as Hanna and Curt tried to keep busy with things that needed doing. But the Classy Cars deal was so important to the future of their company that they found it hard to concentrate on anything else. Suddenly they heard Steve′s footsteps outside the door, and moments later he walked in with his ThinkPad slung over his shoulder and a large brown paper packet in his hands. As he put the bag down, it made a clinking sound.

"How did it go?" asked Hanna. She had a suspicion that the bag contained the answer to her question. Steve didn′t answer immediately. He took a bottle of sparkling wine from the bag and placed it on the desk, followed by three glasses.

"Cut the suspense, Steve," said Curt. "Tell us what happened."

"They signed."

“Congratulations,” said Hanna, giving him a hug. Curt got up and shook his hand vigorously, as if he had just announced his engagement.

“Thanks, Hanna. Thanks, Curt,” said Steve. “This has really been a team effort. We did it together. And Hanna, I want to thank you especially for helping us work as a team whenever Curt and I got bogged down in silly arguments.” Having said this, Steve reached once more into the brown paper bag and somewhat shamefacedly pulled out a beautiful, if slightly smashed, bunch of red roses, which he handed to Hanna. This gift was so unexpected that she blushed.

“Thanks, Steve,” said Hanna, “these are really lovely.” She put them into a vase and added water while Curt tried to get some more information out of Steve.

“What did they sign for?” asked Curt. “What do they want us to deliver? And when?”

“They want us to install the application we’ve already built and demonstrated to them,” Steve answered. “They want the GUI front-end. After all the trouble they put us to, they’ve decided to go with the Dr. Dialog interface after all! They realize that we really can convert our application to another GUI builder if they ever need us to in the future, and they like Dr. Dialog’s price. Oh, and they want the application to run against multiple distributed copies of DB2, one per branch, for the initial implementation. They want us to quote on extending the application to run off a single centralized copy of DB2 in about three months’ time. And most importantly, they wrote a check to cover our development effort to date. Here it is!”

Steve pulled out the check and showed it to the others. Hanna took it and said, “Well done, Steve! I’ll deposit that in our bank account later today. Our bank manager will be very happy to see it.”

“All this talking,” said Curt, “and you haven’t even offered us a drink.”

“You’re right,” Steve responded, “what am I thinking of?” He loosened the cork, filled the three glasses, and passed them around. “I propose a toast to Hacurs—may it prosper and grow.”

“To Hacurs,” said Hanna and Curt in agreement.

Demonstration notes

- The code for the three commands is in the *StorProc* subdirectory of the car dealer application.
- Before running these commands, define the two userids, `SPECIAL` as local administrator with password `SECRET`, and `HUMBLE` as regular user with password `USER`.
- Make sure DB2 is started.
- Open two OS/2 windows and make the StorProc subdirectory the current directory in both windows.
- Type `server` in one window, and wait for the ready message.
- Type `client` in the other window, and then enter any text, or the special keywords `CONNECT` or `CUST xxx`.
- The response of the `SPECIAL` userid when entering `CONNECT` is proof that the code on the server runs under the userid of the server.
- Type `!` to end both client and server.

Chapter 10. Configuration Management with Object REXX

In this chapter we discuss ways of managing an Object REXX application that is large and has different versions, all of which must be supported concurrently. We shall see how to use Object REXX classes with inheritance and polymorphism to help us achieve these goals. The grouping of related files into subdirectory structures can also help.

Most REXX programmers know that writing small, one-off applications is fun. It's quick to do, and the users are often grateful to get a fast response to their needs. But of course there is always the risk that after a while the application might become very popular with many users. Suddenly the code must run in environments never contemplated and therefore turned into a maintenance burden.

This is the kind of problem that a software company like Hacurs loves to have. One-off applications yield revenue once only. The real money-spinners are those applications that can be sold to a number of different customers. Inevitably the operating environment will be different in each location. There may be different database managers to interface with, and maybe different GUI packages as well.

When classic REXX was first designed, no one could ever have guessed how widely used it would become, or how big some REXX applications would grow. The base language has some facilities for managing large applications by separating called subroutines into separate files, but Object REXX brings a lot more to the table.

We've spoken about the benefits of classes, polymorphism, and inheritance. We've claimed that these make it easier to substitute parts without impact to the rest of the system. Now it's time to deliver. We must show practical ways to make these promises come true. In this chapter we talk about the problems that confront "successful" applications and show how the features of Object REXX can be used to ease the creation, distribution, implementation, and maintenance of such applications.

Breaking an Application into Multiple Files

Hanna was working alone in the Hacurs offices. Curt and Steve were out at Classy Cars, training more staff to use the pilot car dealer application that was now installed and running. Hanna was working through the various pieces of the car dealer application on the server. Although it had been Hacurs' goal to work off a common and shared set of class libraries, things had gotten a little out of control while Curt was struggling to meet deadlines at Trusty Trucks and Steve at Classy Cars. The time had now come to reconcile any differences there might be and consolidate both versions of the application into a single library.

Hanna knew that once a source file grows bigger than about 400 lines, it becomes hard to read and understand. It was time to break the source into a number of separate files. Each component file should deal with a separate part of the overall system, and ideally each part of the system should be dealt with only in one place. The Hacurs team had tried to follow this approach with classic REXX, but with limited success. While classic REXX enables the programmer to split procedures off into separate source files, the code in a separate file can see the data passed only as call arguments. This is good in terms of hiding data that the

called code should not see or change, but bad when the amount of data that must be shared with the called routine is large. The number of arguments needed on the call statement can become unmanageable, and getting the caller and callee's parameter lists to agree can be difficult.

With Object REXX, sets of related data can and should be grouped together into objects. When a procedure or routine in another file is called, only a short list of objects needs to be passed. When an object is passed to a subroutine, only a reference, not the object's data, is actually passed. Hanna was trying to work out the best way of applying Object REXX's new capabilities to segmenting the car dealer application code.

Curt and Steve came tramping into the office with a take-out lunch they had bought on the way. They offered Hanna a share.

"Thanks," said Hanna. "How did the training go?"

"No problems," answered Steve. "We agreed to do three more training sessions with them, and that should be all they need from us. How does the converged version of our application look?"

"Just a little chaotic," Hanna answered. "I'm surprised how many differences you and Curt managed to sneak into your code without consulting anyone. I've drawn up a list of them and shown what I think the converged version should look like. I'd like you two to go through this list and tell me if you agree or disagree."

Steve and Curt groaned but settled down at their desks and powered up their ThinkPads to review the list that Hanna had stored on the server. About half an hour later they had completed this task.

"Your suggestions all look good to me, Hanna," said Curt.

"Me too," agreed Steve. "It's mainly a question of making sure that each class definition includes all the methods and features that we need for both Trusty Trucks and Classy Cars. I think you've got it all sorted out."

"Thanks, guys," said Hanna. "I've also come up with an idea of how we can split the source code up into separate files. I'd like to review that with you. We've already moved the major class definitions into their own separate files. We had to write *::requires* directives in our source files so that the code in each file could see the other classes and methods that it needs." (See "The Requires Directive" on page 62.) Hanna produced a sketch from her files. "The work order class requires the vehicle class because it references the vehicle's serial number," she said, "and the vehicle requires the customer class because it references its owner's ID. The work order class also requires the service class, since each work order contains one or more services; and the services class references the parts required for a particular service." (See Figure 43 on page 121.)

"The work order class also references the customer class," chimed in Steve.

"That's right," agreed Hanna. "I'll show that with a dotted line. The work order file doesn't have to contain a requires directive because work order requires vehicle which in turn requires customer, so the customer class is visible to work order. Strictly speaking, we don't need the customer's ID in the work order object since we can get it from the vehicle object. But in theory a vehicle can change ownership while it's undergoing service, and there could be arguments about who's liable for the costs of the service."

"In practice, the dealer owns the database," said Steve, "and they would only register a change in vehicle ownership after they had made sure that the new owner would accept the service charges. But Trusty Trucks was worried about this part of the data model, and our zealous salesman bent over backwards to meet their needs, as usual."

"Some of the biggest sales in the history of our industry have been made by salesmen who showed they were keen to meet their customers' needs," responded Curt.

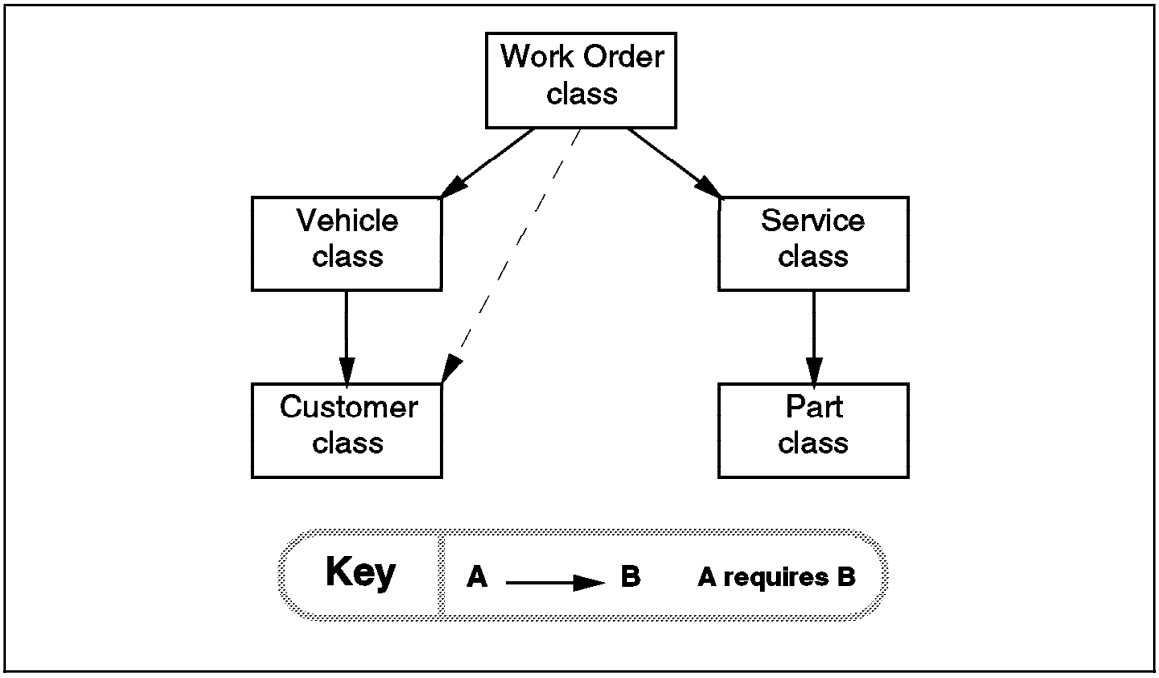


Figure 43. Car Dealer Data Class Relationships

Using Multiple Subdirectories

"The way it works out, a lot of the class and method definitions are (or should be) the same across both versions of our application," she continued. "But some of the method definitions are different depending on whether it's the FAT or DB2 version. I wanted to get some uniformity in the file-naming conventions, so I've used the same file name for the common or base class definitions, the FAT ones, and the DB2 ones. All customer class definitions are stored in files called `carcust.cls`, for example."

"Now hold on, Hanna," said Curt. "If the base, FAT, and DB2 class definition files all have the same name, they'll wipe each other out when you copy them into the common directory."

"I thought of that, Curt," said Hanna, "and decided that the cleanest approach is to create separate subdirectories for the common base class definitions, and likewise for the FAT and DB2 ones. I store the class definitions each in its own subdirectory, so there are no name conflicts. It could look something like this," said Hanna, pulling another sketch from her file (see Figure 44).

```
Common
  ├─ Base
  ├─ FAT
  ├─ DB2
  ├─ RAM
  ├─ AUI
  ├─ DrDialCD
  ├─ VisProCD
  └─ VxRexxCD
```

Figure 44. Directory Structure for Car Dealer Application

"Why so many subdirectories?" asked Steve.

"I've got a list here," Hanna replied, producing yet another piece of paper:

Common	files common to all configurations
Base	base object management classes
FAT	persistent storage in disk files
DB2	persistent storage in DB2 tables
RAM	initialization of objects in memory
AUI	the ASCII user interface
DrDialCD	the Dr. Dialog GUI builder
VisProCD	the VisPro/REXX GUI builder
VxRexxCD	the Watcom VX·REXX GUI builder

"What's the RAM subdirectory for?" asked Curt.

"We did our initial development without any persistent storage—remember? I think we can keep that version alive with almost no effort, using the same techniques that we need to separate the FAT version from the DB2 version. I plan to put that code into the RAM subdirectory."

Controlling Which Files Are Used

"This all looks wonderfully neat and tidy, Hanna," said Steve, "but how on earth will Object REXX know where to find the files that you've hidden in those subdirectories when it runs the application? It will never see them, unless all the subdirectories are in the OS/2 PATH environment variable. And if they are, it will always pick the files it needs from the first subdirectory that appears in the PATH variable."

"I thought of that too, Steve," said Hanna with a smile, "and I built a sample configuration file to try out an idea." Hanna opened an editor window to reveal the code in Figure 45.

```
::requires 'DB2\carcust.cls'
::requires 'DB2\carvehi.cls'
::requires 'DB2\carpart.cls'
::requires 'DB2\carserv.cls'
::requires 'DB2\carwork.cls'

::requires 'Base\cardeal.cls'
```

Figure 45. DB2 Configuration Command File

"As you can see, I included the relative subdirectory name as part of each `::requires` command," said Hanna, "and Object REXX was able to find all of the files with no trouble, so long as the common directory was the current directory when I invoked the configuration command file that contains all these statements."

"That's pretty neat," said Steve,"but what happens if the common directory *isn't* the current directory when you issue the configuration command?"

"It works fine provided that the common directory is in the OS/2 PATH variable," Hanna responded. "Which is what we would need even if all our files were merged into a single subdirectory."

"That sounds great," chimed in Curt, "but you've got the relative subdirectory hard-coded into the configuration command file. What will you do when you need to include the class definition files from the FAT subdirectory instead of DB2?"

"I guess we'll have to have a different configuration file for each different configuration of files we need to use," Hanna answered. "It's sort of like the make file you build to tell the C compiler where all the source files are for a particular project, except the make file gets

used at compile and link time, while my configuration would be used by Object REXX at run time. In fact, I started out by thinking of all the configurations that we may have to support, and that's what got me to develop a tidy way of handling them all. This is the sketch I made," said Hanna, scratching through her papers. She produced the figure shown in Figure 46.

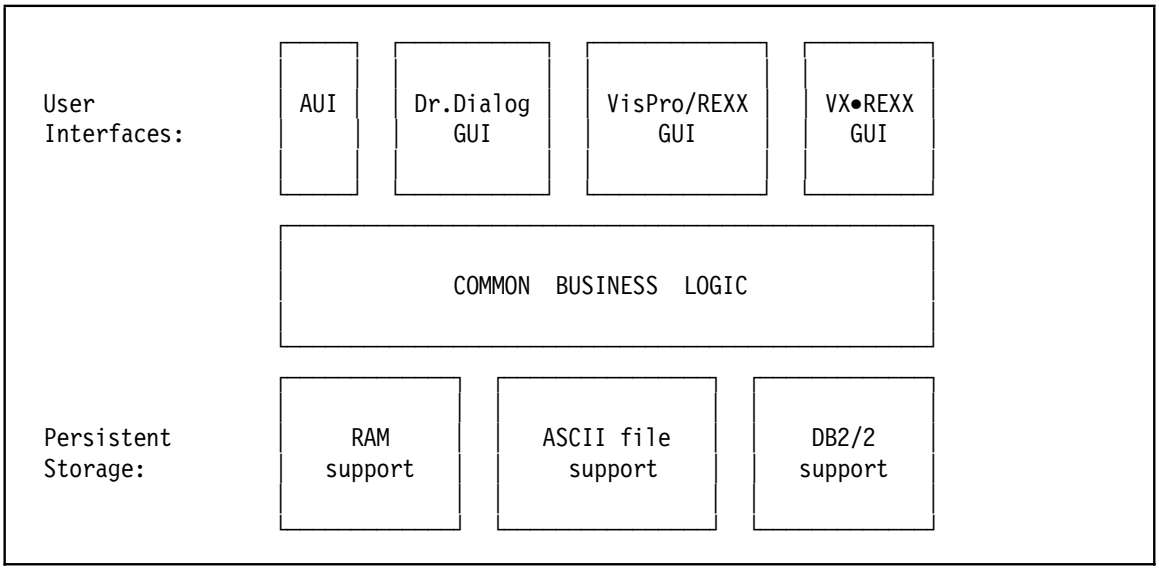


Figure 46. Car Dealer Application Configurations

"I've included the storage-based version we started out with for completeness," said Hanna. "I called it the RAM version. So we currently have four different front-ends and three different persistent storage systems. In theory we could support 12 different configurations. And if we succeed in selling our application to other customers, the list of persistent storage systems could grow. We need a way of managing this complexity."

"This is very ingenious," said Steve, "but wouldn't it be simpler just to give every class definition file a different name and put them all into a single, common subdirectory? Suppose you give all the FAT class definitions a file extension of .FAT and all the DB2 definitions a file extension of .DB2. That would resolve the conflict."

"Yes, that would do the trick," said Hanna. "But would it also work when we have to merge the subdirectories that contain the Dr. Dialog, VisPro/REXX, and Watcom VX·REXX projects? We can't necessarily control the names and extensions of all the files those packages produce. And when we come to write the car dealer installation program, I'm sure that it would be easier if all the files we need for DB2 support are in one subdirectory, all the files for FAT in another, and so on. Then the installation program won't need to know which files are required for each type of support; it will just copy complete subdirectories."

"All this comes from having an obsessively tidy mind," said Curt, "but I can see that it would lead to a tightly controlled system and reduce the number of surprises when we need to implement major new versions of the application. For example, I was talking to an outfit called Value Vans the other day, and they are very interested in our application. But they already have several Oracle-based packages running, and we would have to port our code to Oracle before they would even look at it. With this approach, we would create a new subdirectory called Oracle and develop the new code we needed in there."

"It also allows us to put fences around portions of the code," said Hanna. "If we get contractors in to develop the Oracle code, for example, we could direct the server to give them read/write access to the Oracle subdirectory and read-only access to the others. That way they couldn't accidentally break the FAT or DB2 code while they were building the Oracle code."

"That's a good idea," said Steve, "and maybe not just for contractors! I accidentally saved one of my DB2 class definition files on top of Curt's FAT version the other day, and I had to recover his code from the backup tape. I might make fewer mistakes if my default server profile gave me read-only access to the FAT subdirectory. I could always request the server to give me read/write access if I needed it."

"Thanks for your help, guys," said Hanna. "I still need to think this problem through some more. I'll take it home with me. Maybe we can look at it together again tomorrow."

"That's fine by me," said Steve, and Curt grunted agreement too.

Overall Car Dealer File Structure

Next morning Hanna was already in when Curt and Steve reached the office.

"Hi, Hanna," they called out as they entered.

"I've got a question," said Steve. "I copied the files you were working with yesterday from the server. When I looked at the end of your configuration file (see Figure 45 on page 122) I noticed a new class called `cardeal.cls`. What is it?"

"I found that we need a place to put initialization code for all the other classes," Hanna explained. "Every class needs to fetch its initial objects, for example. There didn't seem to be a good place to put it so I made the car dealer class. It will be responsible for initializing the application and terminating it properly as well—for example, to disconnect from DB2."

Hanna dug a sketch from her bag. "I was working on the overall structure of our application last night, and it looks like this," she said (see Figure 47 on page 125).

"This shows all the files we need for the various configurations we have to support," Hanna explained. "Each file is shown as a box in the sketch. There were so many, I've simplified it by showing boxes stacked on one another. There are customer, vehicle, work order, service, and parts classes all hiding behind the box I labelled Base classes, for example, and likewise for the boxes labelled FAT, DB2, and RAM data classes. Each different configuration we need to support will have its own configuration file. I've shown them as a stack labelled Config file."

"This looks complicated," exclaimed Steve. "Do we really need all these files?"

"I think so, Steve," answered Hanna. "Most of them already exist today for the systems that we've developed for Trusty Trucks and Classy Cars. We just haven't put all of them together on one piece of paper before. For example, the `car-aui.cmd`, `caraui.cls`, and `carmenu.cls` files are all used to drive the AUI interface for the Trusty Trucks version of our application. And the various GUI packages that you and Curt used to build front-ends for the system are hiding under the label `car-gui` packages, like spiders under a rock. Those packages actually generate lots of files; I simply haven't shown them."

"Yeah - I guess you're right," said Steve as he stared at the sketch.

"I've shown that there's more than one configuration file," said Hanna. "When a user installs our application onto a PC, the install program will list the various options available, and then copy in the configuration file that implements the options chosen. This file will contain `::requires` directives for either the FAT or the DB2 data handling classes. When we need to switch between different configurations, we can edit our own configuration file, or copy one of a set of standard configurations into our working directory."

"Now that I can see it all mapped out like this, I realize that we've built quite a complex system," said Steve.

"Have we?" asked Curt. "Or have we built two simple systems, and made life difficult for ourselves by trying to share code between them? This looks like a lot of work to me. We aren't a research lab, we're a small software development company. We have to meet

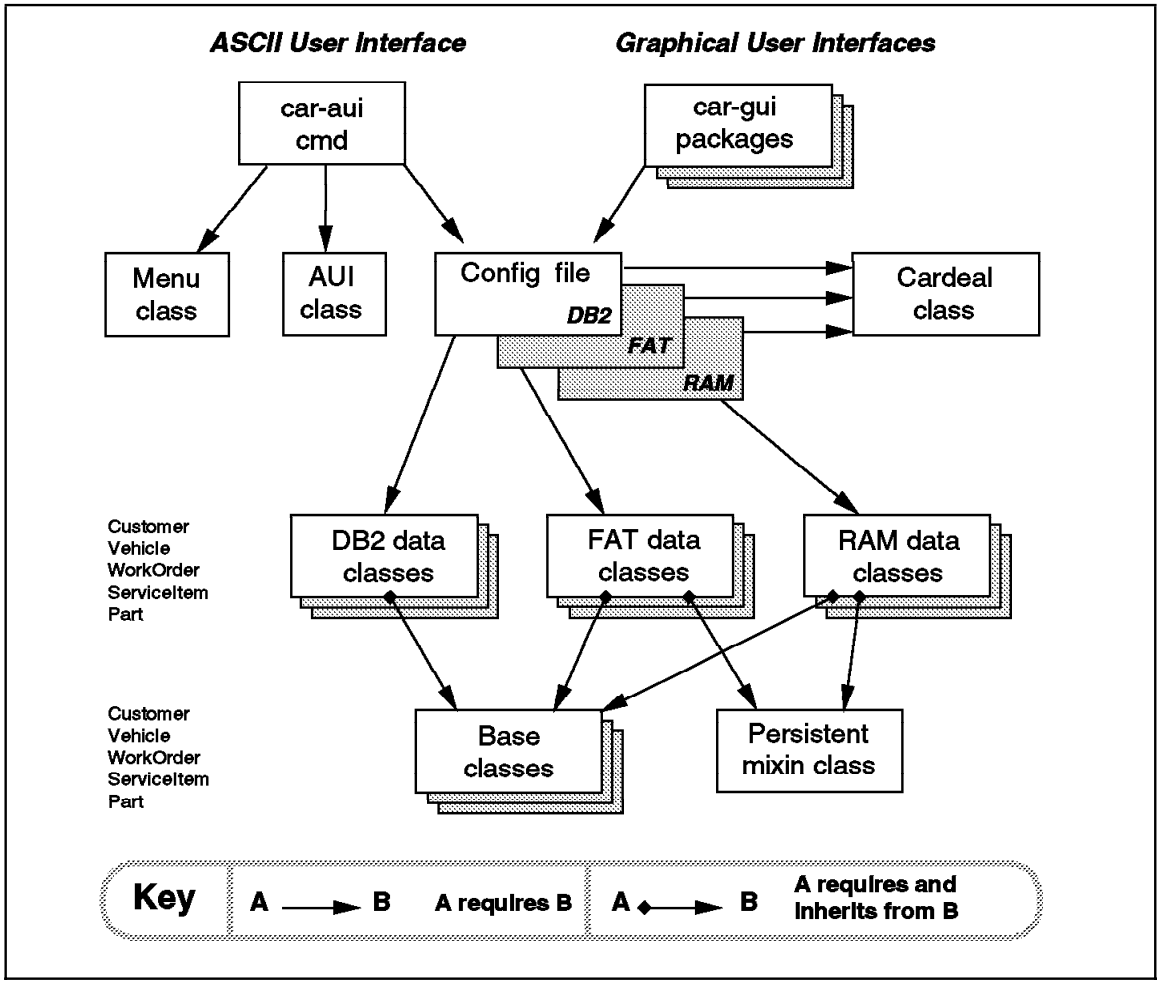


Figure 47. Car Dealer Application Overall Class Relationships

customer needs fast, or we'll go out of business. We don't have time to mess around with complicated schemes like this one."

Steve squared up to reply, but before he did so Hanna intervened by saying "You're absolutely right, Curt. We need to be able to respond to our customers quickly. And we all know that we can't do that with our old invoicing application. We've installed five—no, six different versions of it for different customers. They all started out the same, but today they're all different. Maintaining that code is chewing up a lot of our time. And yet all the different versions do much the same thing. We need to be smarter with the car dealer application. You're doing a great job finding prospects for the product. We need to make sure that we can deliver all they need, without creating a monster maintenance problem."

Turning back to her sketch, Hanna said "As I said before, most of the files shown in this sketch already exist. We just need to tidy them up so they can reside in the subdirectory structure we looked at yesterday. What do you think, Curt?"

Communication among Classes

Curt pondered for a while, then said, “well for starters, we’ll have a problem that one class will not know about other classes. How can a method in the customer class access a method in the vehicle class?” he asked. “Shouldn’t every application class have access to all the other application classes, in case we decide to enhance the system?”

Steve had a concerned look on his face, but then he lightened up and shouted “We could use the Object REXX local directory for this!” He continued, “If every class puts itself into the local directory, then all classes will have access to each other.”

The Local Directory

Steve brought up two editor windows with the Vehicle and Customer classes and changed the source code to make use of the local directory (see Figure 48).

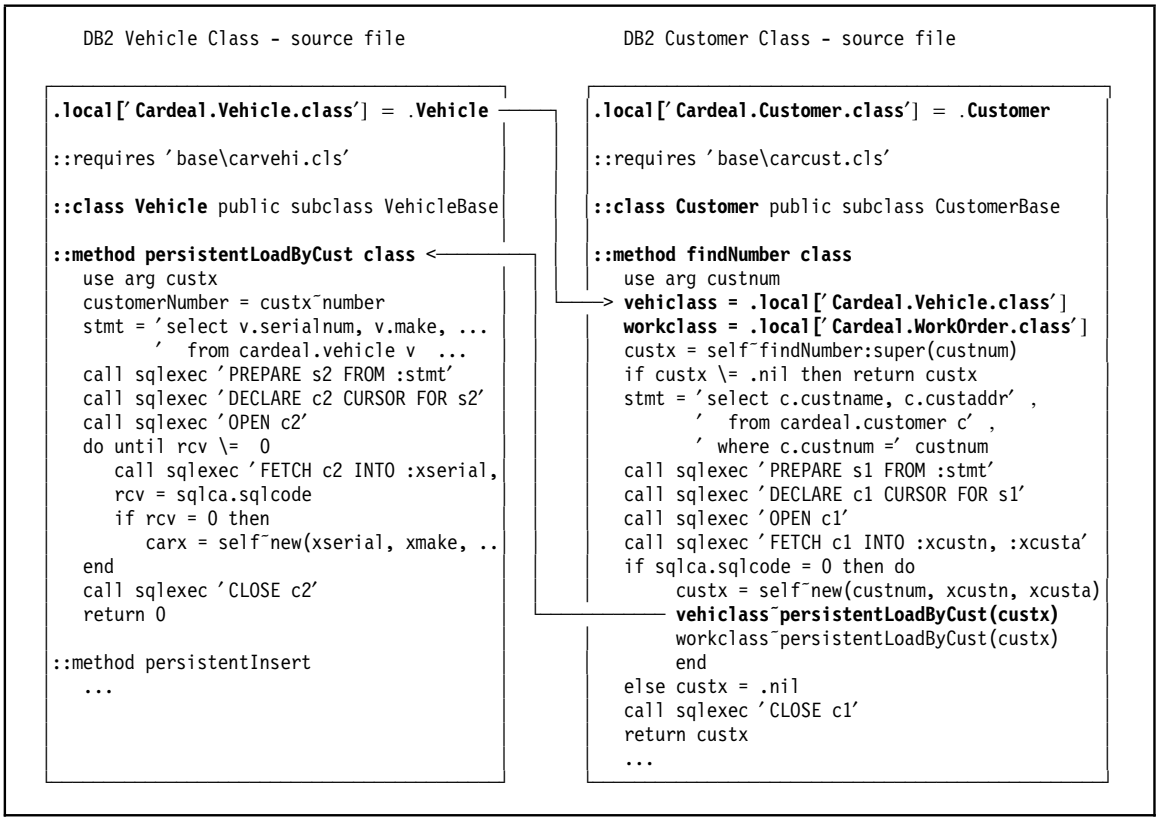


Figure 48. Using the Local Directory

“That’s cool,” said Curt, “I can use the same technique between the Menu and the AUI class. When the *aui* object is created I store it in the local directory. This way I don’t need to pass the aui object to the menu methods.”

Curt thought a few seconds, then said, “Lets keep our copies of the code that’s currently running at Trusty Trucks and Classy Cars untouched in their respective directories on our server. We can start restructuring the code along these lines, but I would like to be able to show Value Vans that we can meet their requirements as soon as possible. So we can’t afford to get bogged down for weeks in a big restructuring exercise that prevents us from building and running demos.”

“That’s reasonable,” said Hanna. “The question is, how long will it take us to restructure the code along these lines?”

“If we all work at it, I think we could have it done in two or three days,” replied Steve. “Then we’ll have to test it out, of course.”

“Sounds good to me,” said Hanna. “Let’s do it!”

Using the local directory

The local directory (`.local`) is available to all Object REXX programs running in one OS/2 process.

For the car dealer application we used the local directory to record:

- Each class as .local[’Cardeal.*classname*.class’]
- The relationship between work orders and service items as .local[’Cardeal.WorkServRel’]
- The ASCII window interface object (aui) as .local[’Cardeal.aui.object’]
- The active persistent storage as .local[’Cardeal.Data.Type’], either FAT, DB2, or RAM
- The directory of the FAT data files as .local[’Cardeal.Data.dir’]
- The directory of the multimedia files as .local[’Cardeal.Media.dir’]

The Global Directory

Object REXX also provides a global directory (`.environment`) that is available to all Object REXX programs running on the same machine. The global directory can be used to communicate between processes, as illustrated in Figure 40 on page 114 in “Coding Stored Procedures with Object REXX.”

Using the global directory

A small example shows that one process can set up a class and an entry in the global directory, and then a second process can use that class through the global directory, and, even when the first process ends, the global object will still be there.

eater.cmd (OS/2 window 1)

```
call RxFuncAdd 'SysSleep','RexxUtil','SysSleep'
eater = .eat~new('Peter')
.environment~my.eater = eater    /* global */
say 'The eater is active'
say 'I''m going to sleep now...'
call SysSleep 20       /* sleep 20 seconds */
.environmentmy.eater = .nil
exit

::class eat
::method init
   expose name
   use arg name
::method feed  /* invoked by other process */
   expose name
   use arg food
   say '===>Eater' name 'got:' food
::method uninit
  expose name
  say '***> Eater' name 'is terminating!'
```

feeder.cmd (OS/2 window 2)

```
eater = .environment~my.eater
do 10
   say 'Give me a line for the eater'
   say '... or null to end:'
  parse pull line
   if line == '' then exit
   eater~feed(line)
end
exit
```

First start the eater in one OS/2 window, then the feeder in another OS/2 window.

Installation Program Considerations

Three days later the Hacurs team met to review progress.

"I've got my Watcom VX·REXX front-end working with the new class structure," said Curt.

"I've got my VisPro/REXX front-end working with it too," said Steve.

"And I've got the old Dr. Dialog front-end working with it," said Hanna with a smile. "Sounds like it's time for a shoot-out."

The threesome put their ThinkPads side by side and went through their standard demo process in parallel. Everything seemed to work perfectly.

"Great work, team!" said Hanna. "The class conversion work wasn't hard at all. Are you running against FAT files or DB2, by the way?"

"FAT files," said Curt. "DB2," said Steve simultaneously.

The two looked at each other. "There's actually no easy way to tell, short of looking to see which configuration file is currently active," said Steve.

"I guess that proves something," said Hanna. "How easy is it to switch from DB2 to FAT?"

"We'll have to develop an installation program," said Steve.

"No, it's simpler than that," said Curt. He clicked on the directory structure to open the DB2 subdirectory, and drag-copied the configuration file within it back into its parent directory. After confirming the overwrite, he restarted his application. It ran as before, but this time using the DB2 configuration file.

“Well that′s a handy way for programmers to do it,” said Steve, “but our users will still need an installation program. Come on, it won′t take long to build. The way Hanna parcelled everything out into separate directories, it should be a snap.”

“Count me out,” said Curt. “I′ve got an appointment to see Value Vans, and I don′t want to be late. See you later.” Curt left with a wave.

“OK,” said Hanna, “I′ll work with you. Should we use a GUI builder tool?”

“Absolutely!” answered Steve. “We want everything about this application to look professional. There, I′ve created a new Dr. Dialog resource file; let′s open it and edit it ... right, I′ve got an empty form. What should I put in it?”

“The target disk and path for our installation,” Hanna answered.

“OK,” said Steve. “I′ll provide an entry field for that.”

“Fine,” said Hanna. “Now we need to offer the user a choice of persistent storage techniques—ASCII disk files or DB2 database.”

“Hmm,” said Steve, “I′ll build a group box labelled *Persistent storage option* and put some radio buttons into it with the two storage options available. I′ll add the RAM option too—let′s call it *Objects in memory.*”

“Now we need to offer the user a choice of user interfaces—the ASCII character, or the Dr. Dialog, VisPro/REXX, or Watcom VX·REXX GUIs,” said Hanna.

“OK,” said Steve, “I′ll copy the storage options group box to make the *User interface option* box. I need an extra radio button, and I must change the text to show the interface options that we have available.”

“And then we need an OK button,” said Hanna, as Steve finished this task.

“I′ll put in an OK button and a Cancel button,” said Steve. “Some folk get a little nervous if they can′t see a Cancel button. There, that does it. Now let′s just neaten this up a bit.” Steve used Dr. Dialog′s group menu buttons to standardize the alignments and sizes of the controls he had built.

“I′ve put hardly any logic behind the controls, but let′s see how it looks,” said Steve. He clicked on the tools run icon and started the application.

“That looks really professional, Steve,” commented Hanna as the panel shown in Figure 49 on page 130 appeared on the screen. “Now I′ve got to add the logic,” said Steve, “but that really shouldn′t be hard, thanks to the directory structure you set up.”

“OK, I′ll leave you to it,” said Hanna, getting up.

“Just a moment, Hanna,” said Steve, rising too. “There′s something I need to tell you.” Steve suddenly looked serious, and rather strained. “I′ve been thinking about this for a while, maybe it′s time I settled down and sorted out my life. We′ve been so busy getting our company going, I haven′t had time to think about myself. But now that we′ve got our first big application installed with two customers and the money is starting to come in ...” Steve′s voice trailed off.

Hanna felt uneasiness, almost panic. Did Steve want to leave? Their little company had only just started to find its feet, and every member of the team was vital to its continued existence. If Steve left at this stage, Hacurs company would never survive. And what did he mean by “settle down and sort out his life?” Was there a woman in his life? Where had he found time? They had all been so busy getting the company going. Hanna′s heart started to pound.

“So ... what I mean is,” Steve struggled on, “do you want to see the ball game on Saturday?”

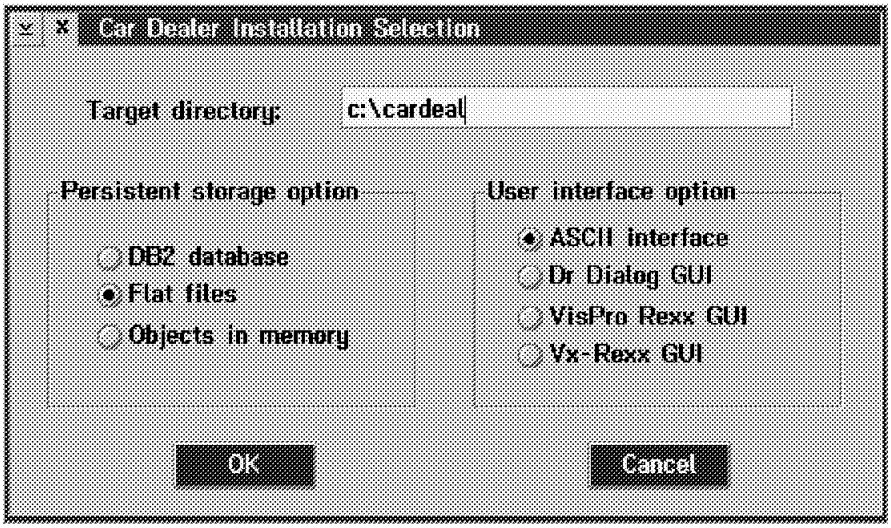


Figure 49. Simple Car Dealer Installation Program

A flood of relief swept through Hanna. She laughed involuntarily, and Steve was startled and might have taken offense, but Hanna's broad smile and shining eyes reassured him that she would very much like to see the ball game on Saturday.

Implementation of Configuration Files

All configuration files are named `carmodel.cfg`. There is one for FAT persistence, one for DB2 persistence, and one for objects in memory (RAM). Each file is in the subdirectory of its respective implementation.

Object REXX executes any REXX code placed at the beginning of a file required by other programs that use the `::requires` directive. This feature allowed us to place entries in the local directory, load REXX function packages, and then connect to DB2.

Figure 50 shows the configuration file for FAT; Figure 51 on page 131 shows the configuration file for DB2.

```
Parse source . . me .
maindir = me~left(me~lastpos('\')-1)     /* main cardeal directory */

.local['Cardeal.Data.type'] = 'FAT'             /* Data in Files   */
.local['Cardeal.Data.dir']  = maindir'\FAT\Data'/* Data directory  */
.local['Cardeal.Media.dir'] = maindir'\Media'   /* Media directory */

::requires 'base\cardeal.cls'

::requires 'fat\carcust.cls'
::requires 'fat\carvehi.cls'
::requires 'fat\carpart.cls'
::requires 'fat\carserv.cls'
::requires 'fat\carwork.cls'
```

Figure 50. Configuration File for FAT Persistence

```
if RxFuncQuery('SQLDBS') then
   call RxFuncAdd 'SQLDBS', 'SQLAR', 'SQLDBS'
if RxFuncQuery('SQLEXEC') then
   call RxFuncAdd 'SQLEXEC', 'SQLAR', 'SQLEXEC'
call sqlexec "CONNECT RESET"
call sqlexec "CONNECT TO DEALERDB"
if sqlca.sqlcode \= 0 then do; say 'Cannot connect to DEALERDB'
                               exit 16;  end

.local['Cardeal.Data.type'] = 'DB2'             /* Data in DB2     */
.local['Cardeal.Data.dir']  = '-none-'          /* Data in DB2     */
.local['Cardeal.Media.dir'] = '-none-'          /* Media in DB2    */

::requires 'base\cardeal.cls'

::requires 'db2\carcust.cls'
::requires 'db2\carvehi.cls'
::requires 'db2\carpart.cls'
::requires 'db2\carserv.cls'
::requires 'db2\carwork.cls'
```

Figure 51. Configuration File for DB2 Persistence. Placing the SQL CONNECT call into the configuration file completely relieves the ASCII interface and the GUIs from dealing with DB2.

Using the Configuration File

There are two ways of using the configuration file:

- Put a *::requires* directive at the end of the source program to embed the configuration file:

  ```
  ::requires carmodel.cfg
  ```

- Alternatively, *call* the configuration file:

  ```
  CALL carmodel.cfg
  ```

  This must be done at the very beginning of the program.

The configuration file must either be located in the current directory or found through the OS/2 PATH variable. In our application, we copy one of the three configuration files into the main car dealer directory to make it *active*. Object REXX finds the currently active configuration file—DB2, FAT or RAM. The application has no knowledge of which persistent storage method was selected. This technique is valid for both the OS/2 window application (AUI) and the three GUI versions. See “How to Include Directives in GUI Builders” on page 74 for detailed instructions.

Configuration File for List Routines

We use an additional configuration file, `carlist.cfg`, to select the correct routines to list customers and work orders for the ASCII user interface according to file or DB2 persistence.

This configuration file is copied from FAT or DB2 subdirectories to the AUI subdirectory automatically according to the configuration set for persistence.

Implementation of the Car Dealer Class

The car dealer class is responsible for initialization and termination of the environment. It is also a good place to hold the methods for multimedia—that is, playaudio and playvideo.

An extract of the class is shown in Figure 52.

```
.local['Cardeal.Cardeal.class'] = .Cardeal
::class Cardeal public
::method initialize class
   self~mciRxInit                                /* initialize multimedia */
   .local['Cardeal.Part.class']~initialize       /* let each class        */
   .local['Cardeal.ServiceItem.class']~initialize /* initialize itself    */
   .local['Cardeal.Customer.class']~initialize   /* and load objects      */
   .local['Cardeal.Vehicle.class']~initialize
   .local['Cardeal.WorkOrder.class']~initialize
   return 0
::method terminate class
   if .local['Cardeal.Data.type'] = 'DB2' then   /* disconnect from DB2   */
      call sqlexec "CONNECT RESET"
::method playaudio class
   ...
::method playvideo class
   ...
::method mciRxInit class private
   ... load multimedia function package
```

Figure 52. The Car Dealer Class

Using the Car Dealer Class

Each version of the car dealer application has to make one call, `.Cardeal~initialize`, at the beginning of the program to initialize the application, and one call, `.Cardeal~terminate`, at the end of the program to terminate the application.

Source Code for Configuration Management

The source code for the configuration files is with the DB2, FAT, or RAM implementation.

The source code for the car dealer class is with the base classes (“Base Cardeal Class” on page 262).

Chapter 11. Object REXX, SOM, and Workplace Shell

In this chapter we extend the car dealer application using some of the facilities that Object REXX provides for interacting with SOM. SOM is a standard component of OS/2, AIX, MVS, and OS/400 that enables objects to interact with other objects by exchanging messages with them, even when the other objects are parts of different applications, written in different languages, and running on different, distributed computers. It provides a very powerful but easy-to-use way of developing client/server applications.

SOM conforms to the CORBA standard, by far the most advanced and widely implemented standard for interobject communication available today. Objects that can communicate with SOM can also interact with objects running under any other CORBA-compliant broker.

In this chapter we also make use of Object REXX′s SOM facilities to access the OS/2 Workplace Shell.

Using SOM in the Car Dealer Application

Curt came clattering into the office wielding a huge umbrella, which was shedding water copiously. “Wow! It′s raining cats and dogs out there,” he said, laying down the umbrella and brushing water from his jacket. “Hi Hanna,” he added, “Where′s Steve?”

“Hi Curt,” Hanna responded. “You′re right about the rain. I′ve been watching people struggle past my window. Just about 20 minutes ago the gutters were so full they ran over onto the sidewalks. Steve′s still busy with Classy Cars. They′re working out an implementation schedule for centralizing their data onto a single, secure server. How did your call on Value Vans go, by the way?”

“Very well,” said Curt. “They loved the demonstration, and we went through all their requirements this morning. Our application can meet almost all of them as it stands.”

“That sounds encouraging!” said Hanna. “What sort of things do they need beyond what we can currently do?”

“They want to do a lot more in the area of accounts analysis,” said Curt. “I told them that if they store their data in DB2, they′ll be able to access it using any of a number of shrink-wrap PC packages with analysis facilities. Since DB2 provides support for the ODBC API and most PC data analysis packages can make use of it, we have lots of choice in this area. They make extensive use of Lotus 1-2-3 already, so I thought we could help them access their data in DB2 from Lotus 1-2-3. If we set up the ODBC interfaces for them and code-up a few sample spreadsheets and macros, we can get them off to a flying start.”

“Good thinking, Curt,” said Hanna. “Maybe we should code-up some examples and store them on our ThinkPads. That way we could show our prospects how our approach would work.”

“You′re right, of course,” Curt agreed. “I′ll try my hand at doing that. Oh, and there was one other thing that Value Vans asked about. They′re in the process of installing a client/server stores management system. It′ll help them manage stock levels and

procurement. This system will manage the parts they use when they service vehicles, so they want us to interface our car dealer application to it. We'll have to get all our parts information from this system."

"Hmm—I wonder how easy that will be," said Hanna. "Will the stores system be running on the same processor as our application?"

"The client code will run on the same PCs as our application's clients do," Curt replied, "but their server code needs to run on an AIX machine."

"Oops!" said Hanna, "Our server code was specifically designed to run under OS/2, so we won't be able to run it on the stores server. What database manager does the stores system use? Maybe we can use remote data access to get hold of the parts."

"The stores system uses flat files," Curt replied. "But don't worry. I found out that this system is being developed in C++, and the clients will make use of SOM to communicate with the server. Since Object REXX allows access to SOM objects, I'm sure we can adapt our system to work against their parts."

"I like your confident approach, Curt," said Hanna. "I'm sure that's why you've been so successful in selling our products. But we'll have to research this situation quite carefully. At this stage, Object REXX allows us to access SOM objects built in other languages, but we can't create SOM objects in Object REXX."

"Well I happen to know that both AIX and OS/2 support SOMobjects, and that they can communicate with one another," said Curt. "The stores system implements parts along with other stock items as a SOM object, so we should be able to get hold of it from Object REXX."

"That's true, Curt," Hanna agreed "but we need to know more about the way they've implemented their stock item. Does it contain all the information our application needs, for example? Tell you what, if you can get the IDL—that's Interface Definition Language—that defines their stock item and its behavior, then we can work out how difficult it would be to use it. This may not be quite so easy as the other installations we've done."

"OK," Curt agreed, "I'll get a copy of the IDL for their stock items. Is there anything else we need?"

"Well," Hanna replied, "we will need to get access to their stores server from our development machines here so we can make use of their stock-item SOM object."

"I'll check it out," said Curt, "I'm sure there won't be a problem."

Hacurs Builds a SOM Object

The next morning when Curt came in, both Hanna and Steve were in the office.

"Hi guys," Curt called out, "I've got the IDL for the stock-item SOM object. It's only a small file; I'm sure this is going to be easy." Curt unpacked his ThinkPad and plugged it in. While it powered up, he continued: "I asked about getting access to their stores server, and there's no problem. We can use a SLIP connection to a dial port on their server. We can use the TCP/IP that ships as a standard component of the Warp Bonuspack."

"Well, there's a bit more to it than that," said Hanna. "Thanks for bringing in the IDL, Curt, but I'm quite worried about this project. None of us has used SOM or distributed SOM (DSOM) before, and we're bound to hit some problems. And learning how to use DSOM with a SLIP connection to a remote server that we can't see—it's going to be very difficult to know what's going wrong where, when things don't work."

"Come on, Hanna!" said Curt in exasperation. "We're all ace programmers, aren't we? DSOM is supposed to make it very easy to implement distributed objects. Sure, we'll have to learn things as we go along, but we've done that before."

“Yes,” Steve agreed, “but we′ll be going through the DSOM learning curve on your customer′s server. They′ll be able to see every mistake we make. We could blow our credibility before we′re able to finish implementing the system and show them how well it works.”

“Oh—well maybe we can get their stores system to run on our OS/2 server here,” suggested Curt. “Then we can cut our teeth on SOM while no one′s looking over our shoulder.”

Hanna and Steve looked at each other. “That′s a good idea, Curt, but I doubt if their stores system will run under OS/2. Since they′ve coded it in C++, they′ve probably made direct calls to AIX for the resources they need. And the AIX APIs are different from the OS/2 ones.”

“But this is C++ code, Hanna,” said Curt. “C++ comes with a very comprehensive class library. I′m sure that it provides all the resource management their programs need, so they won′t have to use AIX APIs. And the C++ class library is compatible between AIX and OS/2. That means their code should be portable too.”

“Maybe so,” said Steve, “but I wouldn′t count on it. There are a lot of unreconstructed C programmers out there. And anyhow,” he continued, “would they be prepared to give us their source code? They probably regard us as competitors.”

“Well there′s no point in us sitting around here trying to second-guess what they have done and what they will do,” said Curt. “I′ve met with the suppliers of the stores system, and I′ve got their phone number. I′ll call them and ask if we can have their source code for the stock item, and whether we can port it to OS/2.”

While Curt made the call, Steve had a look at the stock-item IDL file. Curt′s conversation was rather short, and he was scowling when he put the phone down.

“The project leader thinks they have made some use of AIX APIs,” he said. “And he says it isn′t possible to separate out just the stock-item SOM object and run it on its own. It interacts with all the other SOM objects in their system.”

“Well, is he prepared to give us the source for the whole system?” asked Hanna.

“Not at this stage,” Curt answered. “Seems like their system is only 90% complete, and they aren′t prepared to start handing it out yet.”

“Oh, oh!” said Hanna.

“What′s with the ‘Oh, oh,’ Hanna?” asked Steve. “Do you mean OO?”

“Uh-uh!” said Hanna, shaking her head in disagreement. “Not this time. This is the other ‘Oh, oh’ that′s been around the IT industry a lot longer—the one no one likes to talk about. You used the ‘90% complete’ phrase. In the company we used to work for, that meant the project was in trouble. Tell me Curt, when is the stock system due to be installed?”

“Four weeks from now,” Curt replied.

“And when would they install our car dealer system, if they went for it?” asked Hanna.

“Only afterwards,” Curt replied. “They don′t want to install two systems at the same time—it would be too disruptive.”

“That makes sense,” said Hanna. “But what will happen if the stores system goes in late?”

“Then our implementation would slip too,” Curt answered.

“If the stores system does go in late, would they consider implementing our car dealer system as-is, and changing it later to work with the stores system when it gets implemented?” asked Steve.

“Now hold on!” said Curt. “Value Vans have had a lot of their people working on the stores system for the last three months. I′ve only been talking to them for about one month. If I

suggest to them that they′re going to be late and we′ll be ready before they are, they′ll throw me out of their offices."

"I guess you′re right," said Hanna, "but I think we need to keep a fall-back implementation plan up our sleeves, just in case the stores system isn′t there when we need it. We′re getting good revenue from Trusty Trucks and Classy Cars, but if we get stuck with a two-month or longer hold-up at Value Vans through no fault of our own ..."

There was a glum silence while the Hacurs team contemplated this possibility. Then Steve piped up: "I′ve got an idea. I′ve had a quick look at the IDL for the stock item, and it looks pretty simple. Even if the suppliers don′t give us the source, I reckon that I could knock together a SOM object in C++ that implements the behavior we need pretty quickly."

"Really, Steve?" asked Hanna. "Let′s have a look at the IDL." They all turned to look.

"We don′t need many instance methods for the part object," said Steve.

"That′s true," agreed Curt, "and the ones we do need are pretty simple."

"But what about the persistent storage methods?" asked Hanna. "I don′t see any in the IDL. Maybe they′re hidden inside the create, update, and delete instance methods?"

"I guess they must be," Steve agreed.

"Well how would you handle it?" Hanna asked. "Do you want to code persistence methods in C++? And which would you code—the FAT ones or the DB2 ones?"

Steve shook his head. "I don′t want to code either of those in C++," he answered. "Hmm. Maybe we can subclass the SOM objects class in Object REXX and add our existing persistent storage methods to the new subclass. Then the rest of our car dealer system can use the Object REXX subclass for parts, and I won′t have to code the persistence methods in C++."

"Have you got time to build it, Steve?" asked Hanna.

"Yes," Steve answered. "The plans I worked out with Classy Cars leave me a few days free now. I can build the C++ code, but you or Curt will have to write the Object REXX code."

A slow smile crept across Hanna′s face. "Don′t you love it when a plan comes together?" she said. "I think we can make this work. If Steve builds an OS/2 version of the stock-item SOM object, we can do our car dealer customization and testing in our own office and only implement at Value Vans when our code is solid. If the stores system goes in on time, we use it. Our code will be enabled to work with a stock-item SOM object already, so it shouldn′t take long to sort out the connection. And if the stores system is late, we use our own stock-item SOM object as a stop-gap measure and we′re still able to implement on schedule. Either way, we come out smelling like roses."

Steve had risen to go to his desk. As he passed behind Hanna, he sniffed loudly and appreciatively at her hair. "Hmm, I love that rose scent!" he said. Hanna crumpled up a piece of paper and threw it at him, but he ducked out of the way and went to his desk to start building the stock-item SOM object.

How the SOM Object Was Implemented

Two days later Steve announced that his stock-item SOM object was ready for testing. Hanna and Curt pulled their chairs around his desk to see.

"Let's have a look at the IDL you built for your stock item first," said Hanna. Steve brought up his IDL in an editor window.

"I called it part rather than stock item, but that's no problem, it's easy to change," Steve said. "Now don't get picky about this, it's throw-away code, remember. It's here to help us do our own development and testing, and maybe as a stop-gap solution if the stores system is late, but after that we don't need it. So I made things as easy as possible for myself."

Hanna and Curt said nothing, but exchanged smiles. Steve was a perfectionist, and embarrassed to show them code that was anything less than a masterpiece.

"We can't define both class and instance methods in a single SOM class," Steve continued, "so I've defined two separate but related SOM classes. I built a SOM Object called *Part* for the instance methods, and a SOM Class called *PartMeta* for the class methods. I told SOM to give Part the class methods from PartMeta. Let's look at Part first" (see Figure 53).

```
#include <somobj.idl>                                                    1
#include <somcls.idl>
#include "partmeta.idl"                                                  2

    interface Part : SOMObject                                           3
    {
      attribute  short   pid;           // part number                   4
      attribute  short   pprice;        // part price
      attribute  short   pstock;        // part stock
      attribute  string  pdesc;         // part description

      short   number();                 // get number                    5
      short   price();                  // get price
      short   stock();                  // get stock
      string  description();            // get description
      string  detail();                 // make a detail line
      void    display();                // display to standard out

#ifdef __SOMIDL__
      implementation {                                                   6
         releaseorder: _get_pid, _set_pid, _get_pprice, _set_pprice,
                       _get_pstock, _set_pstock, _get_pdesc, _set_pdesc,
                       number, price, stock, description, detail, display;
         metaclass = PartMeta;                                           7
         majorversion = 0;
         minorversion = 0;
         dllname      = "part.dll";                                      8
         //# Method Modifiers
         somInit: override;                                              9
         somUninit: override;
      };
#endif /* __SOMIDL__ */
    };
```

Figure 53. IDL for the SOM Object Part

"Let me walk you through this," said Steve. "From the top,

1. I start with some standard includes for the SOM header files.

2. I include the PartMeta IDL as well. We'll look at that later.

3. This is where the interface definition starts. I tell SOM that Part inherits from SOMObject, the root of all SOM classes.

4. The attribute tags identify instance variables, and also automatically create get and set methods for each. Since it's C++, these methods start with an underscore character. So the methods for pprice are _get_pprice and _set_pprice, for example. We won't be using these methods because their names are different from those we've already coded in Object REXX. Notice that I had to put an extra p in front of each instance variable. SOM doesn't allow me to have an attribute name that is the same as a method name.

5. This is where I define the methods we use in our Object REXX code.

6. This is where the Part's implementation definition starts. I have to specify the order in which its methods are released.

7. Here's where I tell SOM that PartMeta is Part's meta class. Part gets PartMeta's methods as its class methods.

8. My compiled and linked code is stored in part.dll.

9. I tell SOM that we need to override the SOM init and uninit methods so we can keep track of our objects in persistent storage."

Steve continued, "Now let's look at the PartMeta IDL" (see Figure 54).

```
#include <somobj.idl>                                                    1
#include <somcls.idl>

    interface Part;              // forward declare                     2

    interface PartMeta : SOMClass                                        3
    {
      attribute       sequence<Part>   pextent;    // extent of instances

      void            add(in Part partx);          // add part to extent
      void            remove(in Part partx);       // remove part from ...
      sequence<Part>  extent();                    // retrieve extent
      Part            findNumber(in short pnum);   // find part by number
      string          heading();                   // list heading

#ifdef __SOMIDL__
      implementation {                                                   4
         releaseorder: _get_pextent, _set_pextent,
                       add, remove, extent, findNumber, heading;
         majorversion = 0;
         minorversion = 0;
         dllname      = "part.dll";
         //# Method Modifiers                                           5
         somInit: override;
         somUninit: override;
      };
#endif /* __SOMIDL__ */
    {;
```

Figure 54. IDL for the SOM Class PartMeta

"From the top,

1. I start with the same standard SOM includes.

2. PartMeta refers to Part, so I need a forward declaration.

3. Here's the interface definition. I tell SOM that PartMeta inherits from SOMClass, so its methods will be class methods. Part has only one class attribute, and that's the extent. I implement that as a sequence of Parts in my SOM code. Then I identify the class methods our Object REXX code needs: add, remove, extent, findNumber, and heading.

4. Here's the implementation definition, where I specify the order in which its methods are released.

5. I tell SOM that we need to override the SOM init and uninit class methods."

"So that's the IDL you had to write," said Curt thoughtfully. "There isn't a lot of it, but—rather you than me!"

"Rather the compiler than me, next time," said Steve with a smile. "The VisualAge C++ product compiler can generate IDL automatically from the class and method definitions you write in the C++ code."

"This is great, Steve," said Hanna. "What do we need to code in Object REXX to make use of this?"

Steve looked sheepish. "Hey, I couldn't give you this code without testing it, could I?" he asked. "So I just wrote a little Object REXX code to make sure it works OK. Here it is," he said, opening a new editor window (see Figure 55).

```
::class SOMPart   EXTERNAL 'SOM Part'              1

::class PartBase public subclass SOMPart           2

::method initialize class                          3
   self~persistentLoad

::method init                                      4
   use arg partid, description, price, stock
   self~_set_pid(partid)
   self~_set_pprice(price)
   self~_set_pstock(stock)
   self~_set_pdesc(description)
   self~class~add(self)
   if arg() = 5 then self~persistentInsert

::method increaseStock
   parse arg stockchange
   self~_set_pstock(self~stock + stockchange)
   return self~persistentUpdate

...
```

Figure 55. Object REXX PartBase Class for SOM. An extract of the beginning of the file is shown.

"I took the base class definition for Part and modified it to work against my SOM Part object," Steve continued. "I won't go through all the detailed changes, but I want to point out a few things:

1. This is how we import the SOM Part class and its associated meta class PartMeta. Object REXX reads the SOM interface repository and builds an Object REXX class called SOMPart, which gets all the instance methods of the Part SOM object and all the class methods of the PartMeta SOMClass.

2. I could have defined PartBase on the first line, but we need to add some extra class and instance methods that we have already coded in Object REXX. So instead I defined

PartBase as a subclass of SOMPart. It inherits all of SOMPart's class and instance methods.

3. The class and instance method definitions that we need to add follow immediately after Step 2, as usual. I copied them from the original PartBase and modified them as needed to invoke the SOM set methods.

4. For example, I coded the *init* and *increaseStock* methods."

"This looks really simple, Steve," said Hanna. "I was afraid we'd get bogged down in a long coding exercise."

"Object REXX's support for SOM makes it simple," Steve replied. "Mind you, I haven't put in all the changes that will be required to the base class to support the Part SOM object. I thought you and Curt might like to do that. It's mainly a case of using the _set and _get methods that SOM generated to set and get the part's attributes."

"This is great, Steve," said Curt. "You've got us off to a flying start. It shouldn't be too hard to finish the job."

Implementation Steps

A number of steps are needed to make the SOM Object Part operational from IDL . The CSet++ compiler and the SOM Toolkit are prerequisites. (See Figure 56.)

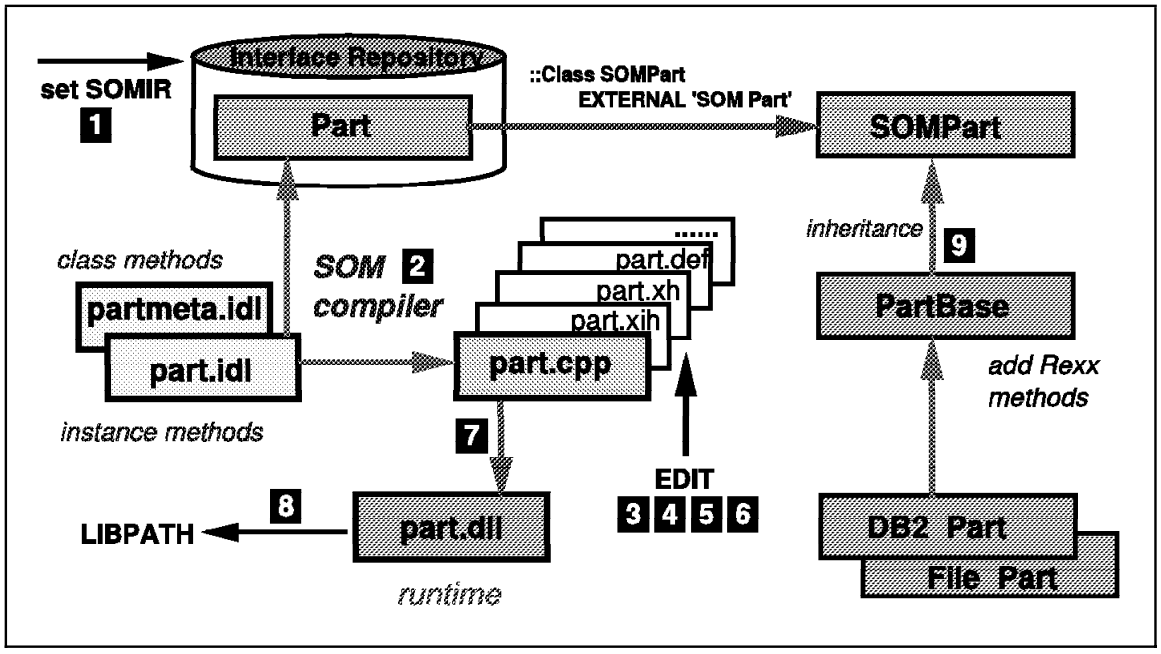


Figure 56. Implementation Steps for SOM Object Part

1. Check the SET SOMIR statement in config.sys. Any SOM compiles use the last SOM interface repository in that concatenation. It may be desirable to define a separate SOM.IR file in the car dealer directory.

2. Run the SOM compiler against part.idl and partmeta.idl:

```
                                    /* config.sys overwrites */
SET SMADDSTAR=1                     /* pointer notation      */
SET SMEMIT=xh;xih;xc;def            /* c++ and def emitters  */

SC.EXE -u part.idl                  /* compile the IDL files */
SC.EXE -u partmeta.idl
```

This generates .xh, .xih, .cpp, and .def files.

3. Replace the _set_pdesc method in part.xih. The SOM-generated code does not handle strings properly.

```
SOM_Scope void  SOMLINK _set_pdesc(Part *somSelf, Environment *ev,
         string pdesc){
    PartData *somThis = PartGetData(somSelf);
    PartMethodDebug("Part","_set_pdesc");
    SOM_IgnoreWarning(ev);
 /* somThis->pdesc = pdesc; ***************** eliminated ******/
    /************************************** replacement *****/
    if (somThis->pdesc)
        SOMFree(somThis->pdesc);
    somThis->pdesc = (string) SOMMalloc(strlen(pdesc) + 1);
    strcpy(somThis->pdesc, pdesc);
}
```

4. Add method code to part.cpp for the number, price, stock, description, detail, display, somInit, and somUninit methods.

5. Add method code to partmeta.cpp for the add, remove, extent, findNumber, heading, somInit, and somUninit methods.

6. Combine part.def and partmeta.def into one parttot.def by concatenating the export entries.

7. Compile part.cpp and partmeta.cpp, and link them into part.dll:

```
ICC -I. -I%SOMBASE%\include  -Q+ -W3 -Gd- -Ge- -c  part.cpp
ICC -I. -I%SOMBASE%\include  -Q+ -W3 -Gd- -Ge- -c  partmeta.cpp

ILINK /packd /packc /exepack /align:16 /noi /nol /De /PM:VIO /Freeformat
      part.obj partmeta.obj /OUT:part.dll somtk.lib os2386.lib parttot.def
```

8. Copy part.dll into a LIBPATH directory.

9. Implement the Object REXX PartBase class as shown in Figure 55 on page 139.

Running the Application with the SOM Part

The prerequisites for running the car dealer application with the SOM Part class are:

- Copy the part.dll file into a LIBPATH directory.
- Make sure that the SOM.IR file of the car dealer directory is in the concatenation in SET SOMIR in config.sys.
- Replace carpart.cls in the Base subdirectory with the SOM version of the Part class (part.som).

Implementation Notes

1. We added our own get methods to the SOM IDL to make it consistent with our Object REXX class. These methods are duplicates of the SOM-generated _get methods.
2. We implemented persistence outside the SOM class to enable persistence in files or DB2.
3. We used a SOM sequence attribute in partmeta.idl to keep track of up to 30 part objects (in partmeta.cpp).

Source Code for SOM Implementation

The source code for the SOM implementation is listed in “Implementing Parts in SOM” on page 292.

Object REXX and the OS/2 Workplace Shell

One morning about a week later, Hanna was already in the office when Curt and Steve came in. She looked up from her work and greeted them. “How′s Classy Cars doing, Steve?” she asked.

“Very well,” Steve replied, “and I′ve got a lot of the development done in preparation for their centralization in a month′s time. How are things progressing at Value Vans, Curt?”

“They′re getting more and more worried about getting their stores system in on schedule,” Curt answered. “On the other hand, they′re really delighted with the demo I gave them of our car dealer application running against a SOM Parts object. I′ve started talking to them about contingency plans to get our car dealer system in on schedule if stores happens to be late, and they′re listening.”

“That sounds great, Curt,” said Hanna.

“And what have you been doing back in the office while we′ve been slaving away with our customers, Hanna?” asked Curt.

“I′ve been looking at Object REXX′s new Workplace Shell (WPS) facilities,” Hanna answered. “I′ve finished all the coding you two asked me to do,” she continued a little defensively, “so I felt I could invest some time in doing a little research.”

“Hmm—research, hey?” said Curt with a solemn look. “I wonder if we could apply to the government for a research grant...”

“Oh don′t be silly!” said Hanna, slightly flustered. “Anyhow, look at what I′ve got going here. It might come in handy one day.”

Steve and Curt drew their chairs up to her desk.

“Classic REXX has always had functions that allow REXX commands to access and manipulate the Workplace Shell,” said Hanna. “Object REXX has the same functions,” she continued, “but also offers the programmer more direct and powerful means of doing this job. The OS/2 WPS is an object-oriented system in its own right, and it′s SOM-enabled. Object REXX′s SOM support can access and manipulate WPS objects directly. Any WPS class may be imported into Object REXX in exactly the same way as any other SOM class.” (These new facilities are described in the publications listed in “Related Publications” on page xxiv, and there are some good examples of their use in the Object REXX samples subdirectory.)

Car Dealer Data in the Workplace Shell

“I cannibalized a copy of the car-aui.cmd to build this little demo,” said Hanna.

“The new command is called carshow.cmd. It invokes the initialize method of the car dealer class to get all of our car dealer objects loaded into storage, and then displays them and their relationships in a WPS folder. I put my command in a subdirectory called WPS, so if I just type in `wps\carshow` at the command line—there we go.”

Hanna′s new command created a new icon called Car Dealer Show on the desktop and opened it to reveal a folder with a Customer View icon and several template icons inside it (see Figure 57 on page 144).

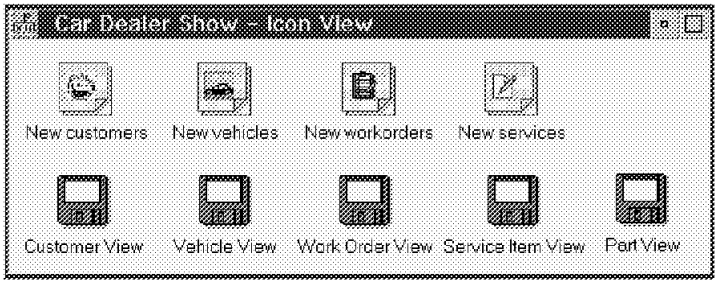


Figure 57. Car Dealer Show WPS Folder

Hanna's PC kept cranking away for a little while longer.

"What's happening, Hanna?" asked Steve.

"It's populating the Customer View folder, but I'll show you in a minute," Hanna replied. "Let's just have a look at the rest of the folder that my command opened. There are templates for new customers, vehicles, work orders and service items. Now let's look at the Customer View." Hanna selected the Customer View folder. It was populated with an icon for each of the customers in the sample database, each tagged with the customer's number and name (see Figure 58).

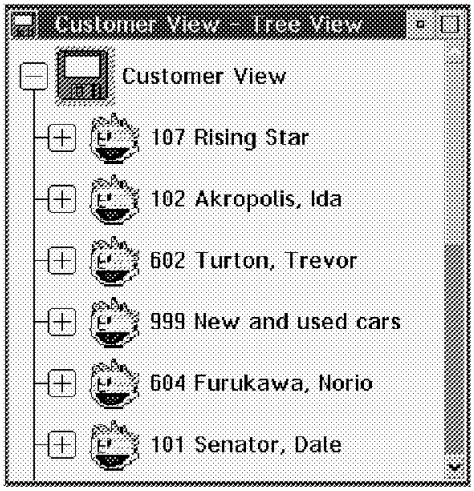


Figure 58. Car Dealer Customer View Folder

"Hey, that's cute!" said Steve.

"It gets cuter," said Hanna. She clicked on the plus sign in front of Rising Star, and the folder expanded to show an icon for Rising Star's car—an Acura-Legend. (See Figure 59 on page 145 for this and the subsequent expansion steps.)

"Neat," said Curt.

"It gets neater," said Hanna. She clicked on the plus sign in front of the car icon, and a work order icon appeared below it. She expanded the work order, and a service item appeared. She clicked on the service item, and three parts icons filled in below it.

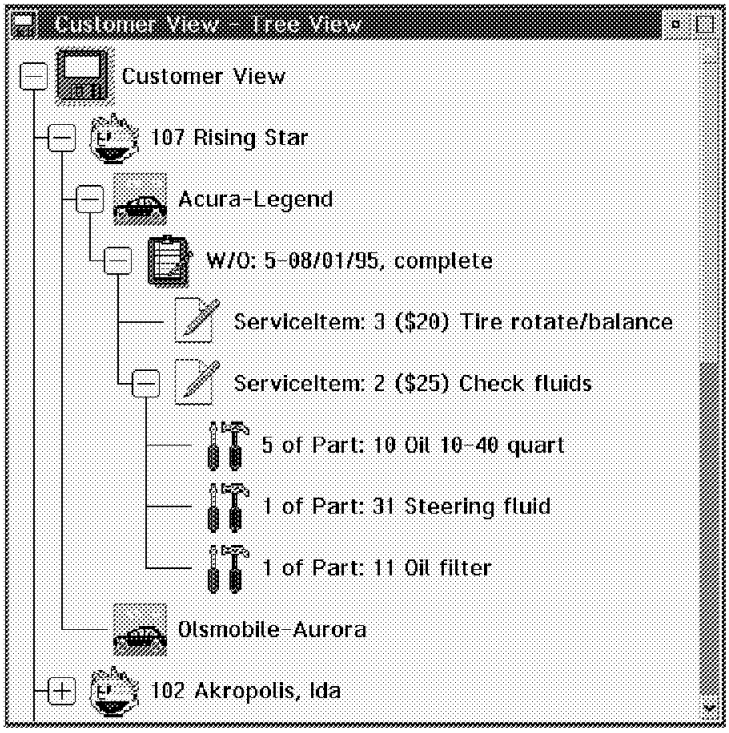


Figure 59. Car Dealer Customer View Folder, Expanded

"Wow!" said Steve and Curt.

Hanna then collapsed the complete Rising Star branch by clicking on the minus sign before the customer's icon. Next she expanded a few other customer icons. "As you can see, the whole sample database has been expanded into this folder in the form of icons," Hanna said. "This representation could be used to give a customer-centered view of the data to the car dealer staff who deal with customers. The program goes on and builds similar representations that are rooted on vehicles, work orders, service items, or even parts." (See Figure 60.)

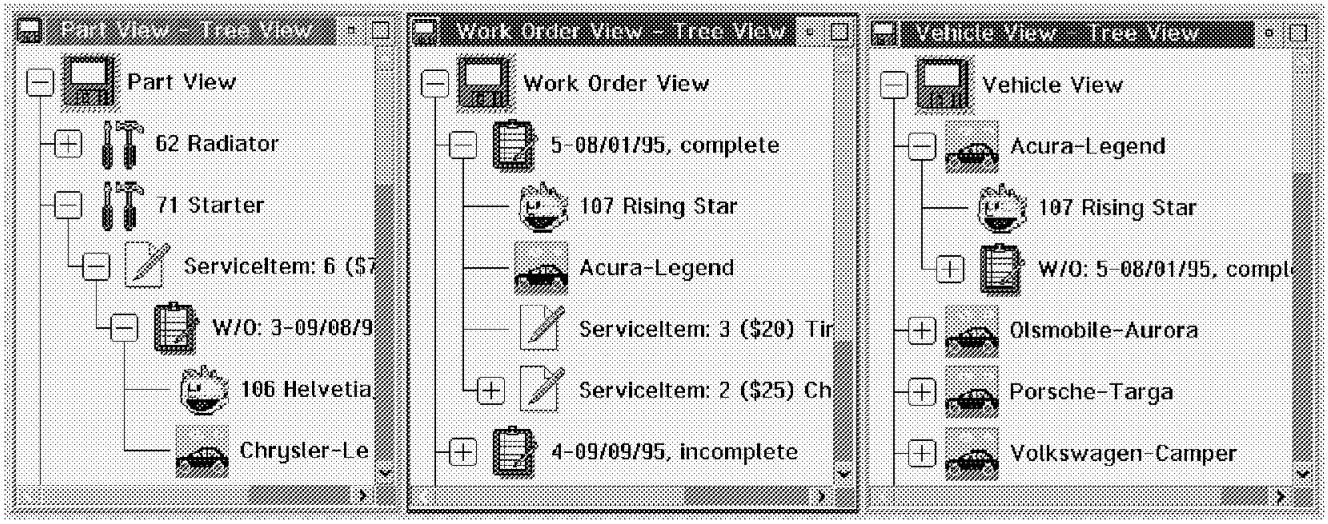


Figure 60. Car Dealer Views

“That’s a pretty compact way of putting a lot of data up on the screen,” Curt mused. “The user can drill down into any area of interest.”

“What about the first folder you opened, Hanna—the one with the templates in it?” Steve asked.

Hanna smiled. “So far all I’ve shown you is a way to present information to the user,” she said. “I was wondering if this approach could be extended to allow the user to manipulate data. So I defined these templates. Let me show you what I can do with them.”

Hanna dragged the New vehicles template and dropped it onto the Ida Acropolis customer icon. A new car joined the other two below. Hanna then dragged the New work orders template, dropped it onto the new vehicle, and then dropped a New services template onto the work order (see Figure 61).

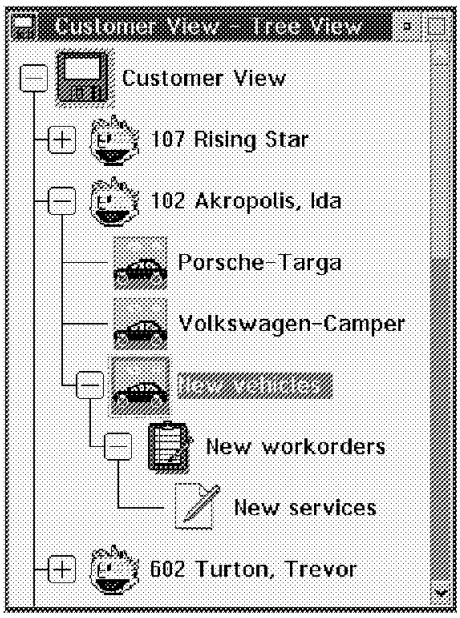


Figure 61. Customer View Folder Populated by Drag and Drop

“What I was playing with here is a way of allowing the user to update the system using mainly drag and drop,” said Hanna. “It’s a very simple and intuitive interface.”

“This all looks amazing, Hanna,” said Steve, “but how do you specify the details of the customers, cars, and services that you drop? So far you’ve left them all with default values.”

“At this stage, I can’t handle updates, only data presentation,” Hanna answered. “I can import all the SOM classes that define the WPS into my application, and invoke their methods to create new WPS objects and manipulate them. But I don’t get any notification from WPS when the user manipulates the icons I create.”

“Is there any way of getting that feedback?” Curt asked.

“Not as Object REXX stands today,” Hanna answered. “I can’t subclass the WPS classes that I import. If this were possible, I could write methods for my subclasses that would trap the WPS messages associated with opening, dragging, and dropping WPS objects. So if the user dropped a new car onto a customer, I could open up a GUI panel to allow the user to capture the new vehicle’s details. I would of course forward the drop message to my superclass, which would invoke standard WPS processing.”

“What happens if you do stupid drags and drops?” Steve asked. “Say, for example, you pick up an existing customer in your database view and drop it onto an existing service item?”

"The WPS will do exactly as I tell it to do," Hanna answered. "If I could subclass the WPS class and write my own drag and drop methods for the objects that I put up on the screen, I could decide which drop targets were meaningful and outlaw all the rest. The user would get the normal no-entry sign unless the icon were hovering over a legal drop target."

Implementation Notes

1. The WPSINST command must have been run in the Object REXX directory.

2. First steps in the program are to initialize the Cardeal class, import the wpAbstract class, and call the wpconst command provided by Object REXX.

```
.Cardeal~initialize
wpAbstract = .wps~import('WPAbstract')
call wpconst  /* define WorkPlace Shell constants */
```

3. The program basically reads through all of the objects and creates a folder for each one encountered. The basic Object REXX code to create the Customer View folder is very simple:

```
dealer = addFolder('Car Dealer Show', dealicon, .wpdesktop)
custView = addFolder('Customer View', dataicon, dealer)
do custn over .Customer~findName('')  /* get all customers  */
   customer = .Customer~findNumber(custn~left(3))
   custFolder = addFolder(customer~makestring~substr(11), custicon, custView)
   do car over customer~getVehicles
      carFolder = addFolder(car~makemodel, caricon, custFolder)
      ...
   end
end

addFolder: procedure
   use arg name, iconFile, parent
   folder = .wpfolder~new(name~makestring, '', parent, 1)
   folder~wpsetup('NODELETE=NO;ICONFILE='iconFile)
   folder~wpSetDefaultView(.wpconst·OPEN_TREE‟)
   return folder
```

Source Code

The source code for the WPS demo is listed in "Workplace Shell (WPS) Demonstration" on page 300.

Applications Assembled from Components

Steve and Curt looked at Hanna′s little demo thoughtfully. With only about 200 lines of code, Hanna had put a whole new slant on the car dealer application.

“I wonder if this is the way we′ll be developing applications in the future?” Steve mused. “It strikes me that a lot of the objects that our programs deal with could be presented in this way. It would give the users a simple and uniform way of seeing and changing the relationships between different objects. By the way, why did you use the WPS to display application data?”

“Ah—I guess I could quote Sir Edmund Hillary,” said Hanna. “When asked why he had climbed Mount Everest, he said, ‘Because it′s there!’ I wanted to add some new function to the car dealer installation program we developed,” Hanna answered, “so I started finding out what I could do with WPS from Object REXX. I shouldn′t be pumping application data into the user′s desktop. Ideally I should build a GUI application that opens its own window, and then populate that with the car dealer data. The problem is, Object REXX doesn′t have a built-in GUI builder, and I′m not sure which of the GUI builders could handle tree-structured views of icons in a container. The WPS can do those things, so I used it.”

“Yeah, it′s a real pity about the lack of a built-in Object REXX GUI builder.” Curt agreed.

“I used to think so too, but I′m not so sure anymore,” said Steve. “I started reading a really great book last night. It′s called *The Essential Distributed Objects Survival Guide*.” (See reference in “Related Publications” on page xxiv.)

“Oh no, not another book!” Curt interjected.

“Relax, Curt,” said Steve. “This one is by Bob Orfali and Dan Harkey—you know, the guys who wrote *Client/Server Programming with OS/2 2.1*.”

“Oh yeah—well that one′s OK; it′s got lots of sample code,” Curt admitted.

“So you don′t mind books so long as they have lots of pictures,” Steve sniped.

“I′ll say it′s OK!” said Hanna. “That book has been our bible for coding OS/2 client/server applications over the last two years.”

“Right,” said Steve. “Well, in this new book about distributed objects, they paint a very different picture of how applications will be built in the future. They point out that with the availability of products like SOM, which allow separately built objects to talk to each other, it′s possible to build complete applications just by collecting a whole lot of smart objects and wiring them together, in the same way that hardware designers can buy standard electronics components and wire them together to build appliances. They call these smart objects *components*, and they predict that in the near future most application developers will be building smart components that can be reused in many different applications.”

“What does ‘wiring objects together’ mean, Steve?” asked Hanna.

“Well with SOM, any object written in any language can send messages to any other object written in any other language,” Steve explained. “And SOM provides bridges between computers, so the objects can talk to each other even if they′re running on machines with different operating systems in different locations. And it goes further than that. SOM is just IBM′s implementation of the CORBA standard. Lots of other vendors have built their own implementations of this standard, so SOM objects can talk to objects built using other vendors′ software. It′s the closest thing to universal middleware that there′s ever been.”

“Wonderful,” said Curt, “but what′s the connection with GUI builders?”

“Well—suppose we were in the business of developing world-class GUI builders for programmers,” said Steve. “Our biggest problem would be deciding which development

language to support. There are GUI builders for C, C++, Smalltalk, Basic, Pascal, COBOL, PL/I, ..."

"OK, OK, there are lots of languages," Curt interrupted, "so we'd have lots of choices. What's the problem?"

"If we wanted to build the best GUI builder in the world and sell it to everyone, which language would we support?" Steve asked. "The market is hopelessly divided among all the languages that programmers use today. Pick any one language and you automatically exclude 80% of the potential market. Pick the top five languages and you might get 60% market coverage, but at the cost of supporting five versions of your GUI builder. And that's really expensive."

"Yeah," said Curt, "but that's just the way things are. There's no way round it."

"Until today," Steve countered. "Suppose we built a GUI builder that is language neutral. The programmers would use it to build all the panels and controls they need. But then instead of writing code *inside* the GUI builder, they hit the generate button and the GUI builder turns their design into a SOM object, which programs written in *any* language can drive, providing they have SOM support."

"I get it," said Hanna. "So the GUI object that you build isn't tied to only one language. It would be just like the OS/2 WPS. You can drive it with scripts written in any language, or even a mixture of different languages if that's what's needed."

"Exactly!" beamed Steve.

"That's pretty flexible," said Curt, "but it wouldn't sell. The real advantage of using a language-specific GUI builder like Dr. Dialog is that when a programmer builds a GUI control and he or she wants to link some code with it, all that has to be done is to double-click on the control and a REXX language editor window will open up. That makes it really easy to tie the code to the control that needs it. Your approach would take us back to the bad old days when all the code was dumped into one big bucket, and the programmer had to search through it to find which piece of logic related to which control."

"Not necessarily," was Steve's reply. "Suppose we had an application development framework..."

"What's a framework?" asked Curt.

"You should read the book—it's all in there," Steve answered. "But for simplicity, let's say a framework is a big component that has slots into which you can plug smaller components. An application development framework wouldn't have any built-in GUI builder or language editor or compiler or linker. It might just have a toolbar, and it would allow you to pick the components you want (like GUI builders) and drop them into its toolbar. When you want to build a GUI panel, the framework will launch the GUI builder you chose. And once you've edited a GUI control and you double-click on it, the GUI builder will send a message back to the framework, together with context information, to say what you clicked on. Then the framework will send the message on to the language editor that you chose, and it will open an edit window and show you the code that's currently linked to the control you clicked, if any, or else an empty panel. So far as the programmer is concerned, it all looks like one integrated application, but the integration only takes place on the glass. Behind the glass you've got a bunch of separate objects exchanging SOM messages with each other."

A look of excitement had come to Hanna's face. "And the people who build those smart objects no longer have to do the whole development job," she said. "They can just concentrate on building an object that does one thing, and does it really well."

"That's right," Steve agreed. "Programmers will be able to shop around for the components that best meet their particular needs, and then plug and play the mix of components they've chosen. They'll all work together within a common framework."

"Where does Object REXX feature in this picture, if at all?" asked Curt.

“Anywhere!” said Steve. “Nobody will know or care what language the components are written in. Any language that can talk SOM is a first-class citizen in the new world of component architecture. One of the biggest strengths of REXX has always been its ability to act as glue. You can use it almost anywhere, anytime, to get different things working together. You don’t need a compiler or an elaborate programmer’s workbench. I think that Object REXX is going to turn in a star performance in pulling other components together to get the job done fast.”

“So maybe we backed the right horse when we pinned our company’s future on Object REXX,” said Hanna. “Steve, this is awesome! Is all this in the book you spoke about? The one about distributed objects?”

“Part one of the book talks about this kind of approach in general terms,” said Steve. “It doesn’t deal with application development or any other application area in particular. The subsequent parts talk about the standards and products that will be used to make it happen. Things like SOM and OpenDoc and CORBA and OLE and COM.”

“So did you work out this wonderful approach to application building just from the principles they describe?” asked Hanna. “That’s pretty smart!”

“Oh, well, they did all the hard work and spelled out the basic ideas,” said Steve, trying unsuccessfully to look modestly heroic. “I just extended those ideas to cover the area of most interest to us—application development.”

“Hmph!” said Hanna, a small smile curving her lips. “Next you’ll be quoting Isaac Newton and saying, ‘If I have been able to see a little further than other men, it is only because I stood on the shoulders of giants.’”

“Not quite his style,” said Curt with a chuckle. “He’s more likely to say, ‘If I have been able to see a little further than other men, it is only because I stood on the toes of pygmies!’”

Curt and Hanna doubled up in laughter. Steve was torn between laughter and pique, but Hanna reached an arm around his shoulder and drew him close into the circle of mirth. All his resentment melted away and he joined in the laughter, which continued for some time. Their company had faced many dangers in its short life, often being close to failure. Their decision to use first REXX and now Object REXX was really starting to pay off. They could feel the old tensions fading away, and a new sense of security replacing them. There also seemed to be the promise of exciting new things to come. At least for now, life was good.

Chapter 12. Object REXX and the World Wide Web

The World Wide Web (Web) on the Internet is fast becoming the platform of choice for advertising applications. Therefore, in this chapter let's rewrite the car dealer application to run on a Web Server and use any Web browser as the GUI.

With minimal effort we can port the car dealer application to run under the control of a Web server, using DB2 as the database. We can redesign the user interface, using the Hypertext Markup Language (HTML). The car dealer application creates most of the HTML documents from the data stored in DB2, using Common Gateway Interface (CGI) programs written in Object REXX.

Hacurs Connects to the Internet

It was after the long Labor Day weekend when Steve walked into the office with an unhappy expression on his face, seemingly carrying the weight of the world on his shoulders.

"What's going on with you?" asked Hanna, concerned.

"Now that we've implemented the application for both Classy Cars and Value Vans, we are simply not busy enough" Steve replied. "We need to advertise our skills and our beautiful application, so that we get more companies interested in our services. I just have not figured out a good way of doing it."

Curt, who had listened half-heartedly to the conversation, suddenly got up from his chair and shouted "The Internet!"

"The Internet?" asked Steve.

"Yes, the Internet," reiterated Curt. "I visited the Computer Software Exposition at the Convention Center over the weekend, and lots of companies advertised their services and applications using one of those Web browsers connecting to their main home site."

Hanna was silent for a moment, reflecting on what she had just heard. Then she said, "I think that's a great idea, Curt. I have read so many articles lately about the Internet and the World Wide Web; we need to get our act together and become part of this exciting new technology."

"What does it all take, Curt?" Steve asked a little shyly. He felt badly that he did not really know much about the Web.

"Let's sit down and make a list" suggested Hanna. "Curt, you lead the discussion; of the three of us you know most about the Web."

Hacurs Makes a Plan for the Web

Curt got up from his chair, grabbed a marker pen, and marched to the flipchart stand. “Let’s see,” he began. “There are several things we have to do.”

1. “First, we must physically connect our server to the Internet. That’s usually done through a high-speed leased phone line provided by the phone company. Then we need a modem at our end of line. We connect TCP/IP to the modem and line, using the Serial Line Internet Protocol (SLIP) or Point-to-Point Protocol (PPP).”

   “Our line traffic will not be very big, I guess?” asked Hanna.

   “True” replied Curt. “We can get by with a medium-speed phone line for quite a while.”

   “Luckily we’ve already configured our LAN with TCP/IP” said Steve. “It should be a breeze to connect our desktop machines and the ThinkPads to the Internet through our LAN server.”

   “There you go, Steve” laughed Curt.

2. “Second, we have to install an Internet server program on our LAN server. Many server products are on the market, but for our OS/2 system I think the best server is the IBM Internet Connection Server for OS/2. I saw a demonstration at the exposition in the IBM booth. IBM currently has a promotion, and it only takes a few minutes to download the server for free from an IBM site.”

   “Is that server hard to install?” asked Steve.

   “It looks very easy,” replied Curt. “There is only one configuration file to be updated with our installation-specific information, and the product even provides a Web browser dialog to do most of the tailoring.”

   “I guess we have to install one of those Web browsers” added Hanna.

3. “You’re right, Hanna” responded Curt. “That is the third point: a Web browser on every machine. And for our OS/2 machines, the best browser is the IBM WebExplorer.”

   “I have read so much about that other browser, but I don’t recall its name” said Hanna. “Aren’t the other browsers better?”

   “Not for OS/2!” Curt shouted a little angrily. “The other browsers mostly run under Windows. They can be run in an WINOS2 session, but then they run in 16-bit mode, whereas the WebExplorer is a 32-bit application for OS/2.”

   “Great,” intervened Steve. “We’ll stick with OS/2; it’s been a wonderful product for our needs. What else do we need, Curt?”

   “What does a user see when he connects to our server?” asked Hanna.

4. “That’s item number four: a home page,” Curt said. “The home page is the first thing you see when you point your browser to a Web server. Our home page must make a statement about our company that entices people to want more information about us. It has to be attractive and lure users into our net—the car dealer application.”

   “I’ll help you design the home page,” said Hanna. “We can use our logo, add some information about ourselves, and then do directly into advertising the car dealer application.”

   “That sounds wonderful, Hanna,” Curt agreed.

   “By the way, how is a home page designed?” asked Steve.

   Curt explained: “All Web pages are written as a file with the Hypertext Markup Language, or HTML for short. It’s a tag language, similar to some word processors. There are many tools on the market to design Web pages interactively in WYSIWYG mode and then generate the HTML file. Our home page is probably simple enough to just code in HTML directly.”

"Don't we have to create the Web pages for the car dealer application from the data stored in DB2?" asked Steve. He was now very interested in understanding and learning more about Web technology.

5. "Yes," said Curt. "And this leads directly to the fifth item: the car dealer application. We have to design the flow of how a user can look at the car dealer data. Then we design each of the pages individually and write an Object REXX program to generate the page."

   "How are these programs invoked?" asked Steve.

   "Most Web servers support the Common Gateway Interface, or CGI for short," replied Curt. "In the configuration file, you specify which requests should be handled by a program, as opposed to just returning a predefined HTML file. The program can create the HTML file on disk and tell the server about it, or, for better performance, it can pass the lines of the generated HTML page directly to the server. Most servers pick up the output by rerouting standard output, so we just use the Object REXX *say* instruction to prepare the pages."

   "That sounds easy enough for me," Steve added. "I'll work on that because I understand the DB2 database the most. The hard part will be to learn the syntax of HTML. I better go to the bookstore to buy a manual."

   "I bet you will find a great way to generate those pages from DB2," Hanna joked. "Maybe you'll even define an Object REXX class to handle the HTML easily!"

   "Hmm, not a bad idea from a young kid like you!" Steve replied, and he started to leave.

6. "Don't run away yet!" said Curt, holding Steve back by the arm. "We have to decide on an Internet name for our server and register it with the gods of the Internet."

   "What does an Internet name look like?" Hanna asked.

   "Well, it's something like 'www.ibm.com,' so I suggest we name our Internet server 'www.hacurs.com,' and our machines could then have the names 'steve@hacurs.com' and so forth."

   "I like it!" Steve exclaimed, and Hanna agreed as well after deeply pondering her new name.

"OK Curt, you and I can install the Internet server and WebExplorer this afternoon," she said. "We can work with them on our existing LAN without the leased line for now. Then we'll meet tomorrow morning to work on the home page. Steve, you can go to the bookstore and get us some manuals about HTML and the CGI way of invoking programs. I think we're on a roll!"

Hanna was happy to see that Steve was excited about the World Wide Web. He had been morose for quite some time, but now his face was lit up, and he was ready to tackle any problems that might arise. Indeed, everything looked bright again.

Hacurs Designs a Home Page

Next morning, Hanna and Curt worked together to design the home page. Both were eager to get it done quickly.

"We don't have to design the *ultimate* home page" Hanna reasoned. "It should be simple, not too long, and provide the essential information about our company. What information do we need on it?"

"Let's make a list," suggested Curt.

They brainstormed for 15 minutes and came up with the following topics.

- Company logo
- People (Hanna, Curt, Steve) with some personal details
- Services offered
- Introduction to the car dealer application

"The company logo we can enter as is, because Web browsers handle all kind of graphic files," Curt explained. "For the people we use a table with our names and personal details. Then we list our services in boldface, and for the car dealer we could use some of the cute little icons we developed for the Workplace Shell application. One of these icons will start the application."

"We could make the table a little more interesting by adding a picture of our car to each row. I mean, we do have that neat camera to take electronic pictures!" Hanna suggested.

"That's a good start; let's go to work," said Curt, who was getting eager as well, and the HTML manuals Steve bought from the bookstore were all ready to get dirty.

The Home Page

Within a few hours Hanna and Curt managed to get the home page coded in HTML. The table of the people was a little tricky, but after some trials the home page (Figure 62 on page 155 and Figure 63 on page 156) saw the light of the day on Curt's ThinkPad.

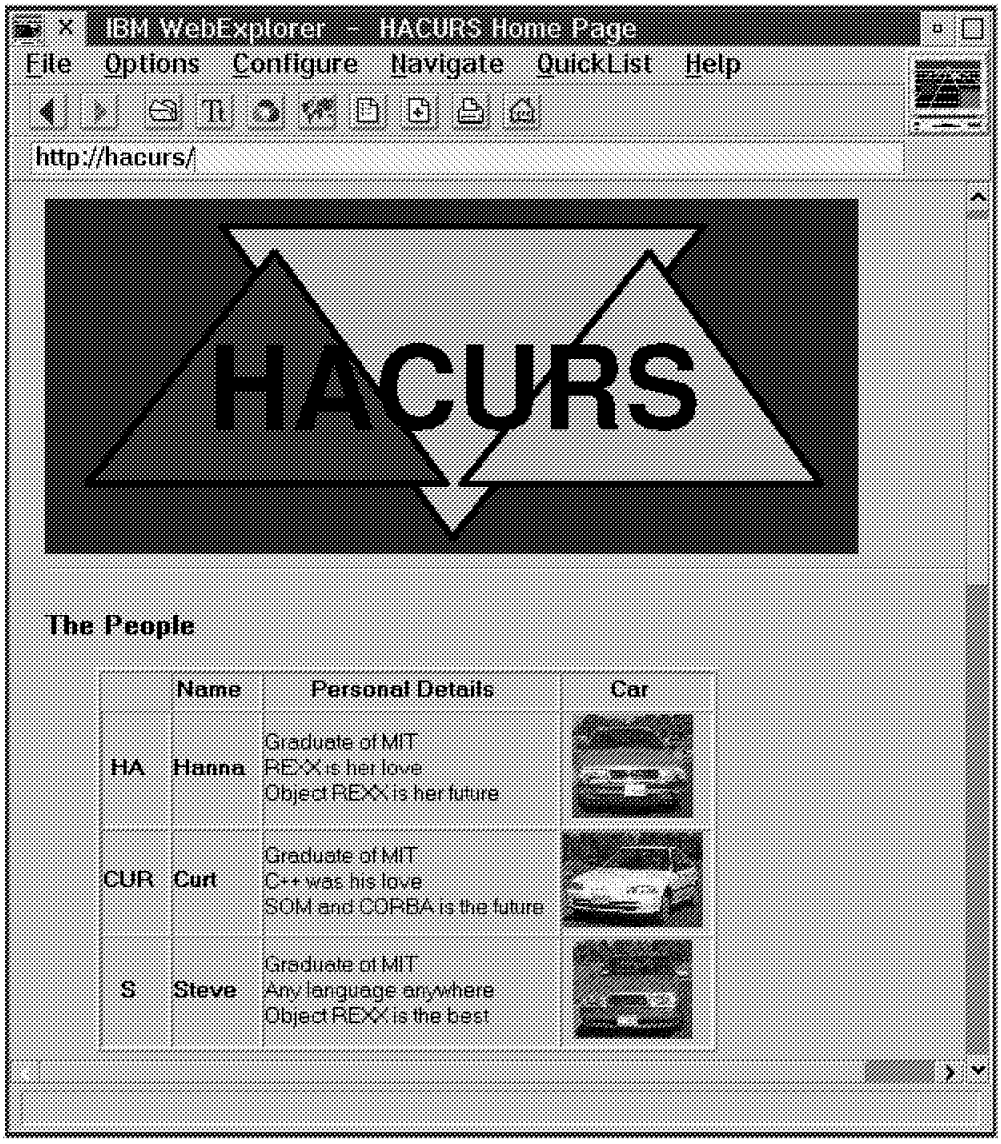


Figure 62. Hacurs Home Page: Top Half

Notes:

To connect to the home page of the Hacurs company with a Web browser, you would enter:

```
http://www.hacurs.com/
  or
http://www.hacurs.com/Hacurs.htm
```

We used the TCP/IP *HOSTS* file to make a short-hand entry, *hacurs*, to point to the OS/2 machine with the Internet connection Server.

```
129.33.160.207  www.hacurs.com  hacurs
```

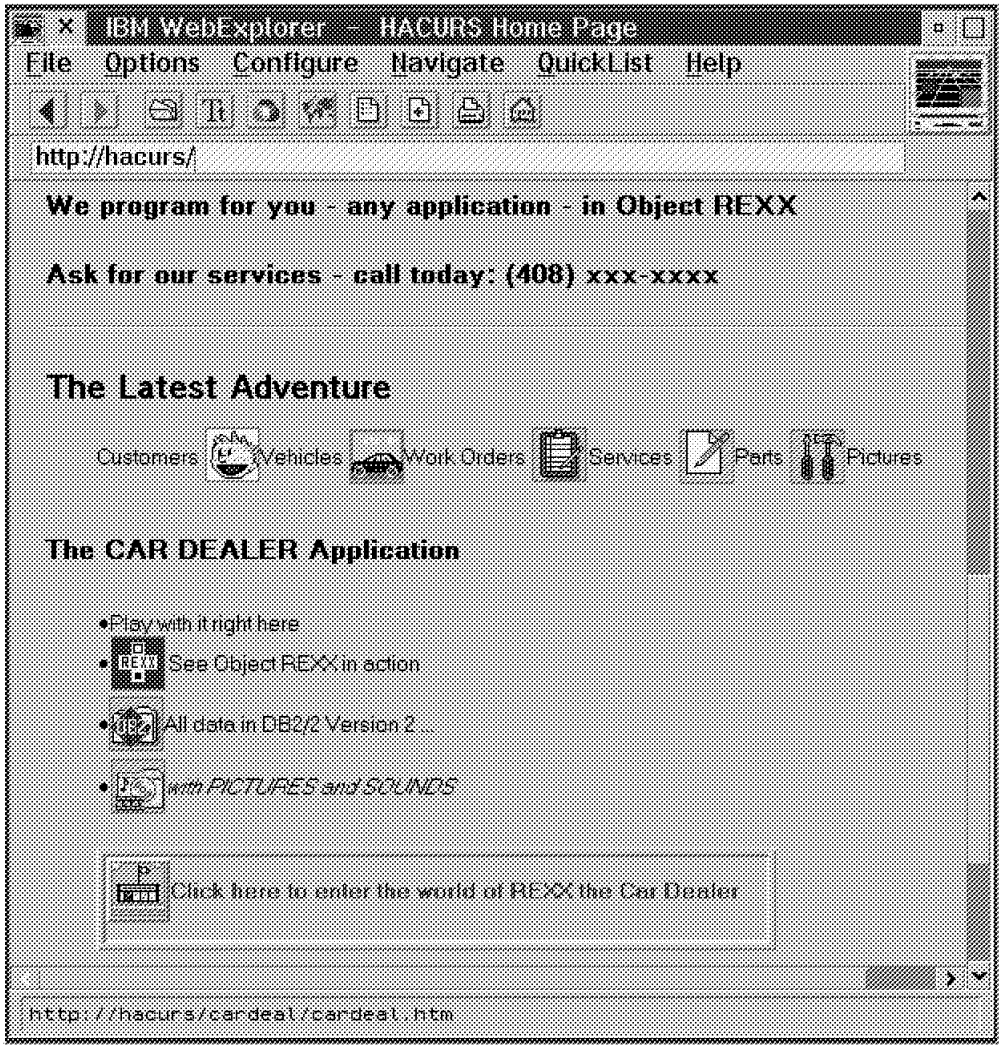


Figure 63. Hacurs Home Page: Bottom Half

Those readers, who want to know what the Hacurs home page looks like in HTML can see the actual coding in Figure 64. The home page is stored in the HTML directory of the Web server.

```
<!------------------------------------------------------------------------>
<! WWW\Hacurs.htm        CarDealer - Web - Hacurs Home Page  ITSO-SJC ->
<!------------------------------------------------------------------------>

<html> <head> <title> HACURS Home Page </title> </head>
<body>
<img align=top src="hacurs.gif">
<hr>
<h3> The People </h3>
<dir>
```

Figure 64 (Part 1 of 2). Hacurs Home Page HTML Code

```
  <table border=2 cellpadding=0>
  <tr>
  <th> </th> <th> Name </th> <th> Personal Details </th> <th> Car </th>
  <tr>
  <td align=center> <b> HA </b> </td> <td align=left  > <b> Hanna </b> </td>
  <td align=left  > <br> Graduate of MIT     <br> REXX is her love
                    <br> Object REXX is her future                    </td>
  <td align=center> <img align=middle src="carhanna.gif"> </td>
  <tr>
  <td align=center> <b> CUR </b> </td> <td align=left  > <b> Curt </b> </td>
  <td align=left  > <br> Graduate of MIT     <br> C++ was his love
                    <br> SOM and CORBA is the future                  </td>
  <td align=center> <img align=middle src="carcurt.gif"> </td>
  <tr>
  <td align=center> <b> S </b> </td> <td align=left  > <b> Steve </b>  </td>
  <td align=left  > <br> Graduate of MIT     <br> Any language anywhere
                    <br> Object REXX is the best                      </td>
  <td align=center> <img align=middle src="carsteve.gif"> </td>
  <tr>
  </table>
</dir>
<p>
<hr> <h3> We program for you - any application - in Object REXX </h3>
     <h3> Ask for our services - call today:  (408) xxx-xxxx    </h3>
<hr>
<h1> The Latest Adventure </h1>
<dir>  <p> Customers   <img align=middle src="customer.gif">
           Vehicles    <img align=middle src="vehicle.gif">
           Work Orders <img align=middle src="workordr.gif">
           Services    <img align=middle src="service.gif">
           Parts       <img align=middle src="parts.gif">
           Pictures                                          <p>
</dir>
<h3> The CAR DEALER Application </h3>
<ul>
  <li> Play with it right here
  <li> <img align=middle src="myorexx.gif"> See Object REXX in action
  <li> <img align=middle src="db2.gif">     All data in DB2/2 Version 2 ...
  <li> <img align=middle src="media.gif">   <em> with PICTURES and SOUNDS </em>
</ul>
<dir>
  <table border=4 cellpadding=0> <br>
  <a href="/cardeal/cardeal.htm">
      <img align=middle src="cardeal.gif">
      <strong> Click here to enter the world of REXX the Car Dealer </strong> </a>
  </table>
</dir>
<hr> <b> HACURS </b>
     <address> swiss@hacurs.com   <br> (408) xxx-xxxx </address>
     <p>
     <b> Ulrich (Ueli) Wahli - IBM ITSO San Jose </b>
     <address> wahli@vnet.im.com </address>
<hr>
</body></html>
```

Figure 64 (Part 2 of 2). Hacurs Home Page HTML Code

Note: Web browsers compress multiple blanks to single blanks, and lines are concatenated unless a tag forces a new line.

Web Car Dealer Application

In the meantime Steve had designed the car dealer application for the Internet. On a few sheets of paper he sketched out the different formats for presenting the car dealer data in Web browser pages. He called Curt and Hanna over to his desk and showed them his inital design (see Figure 65).

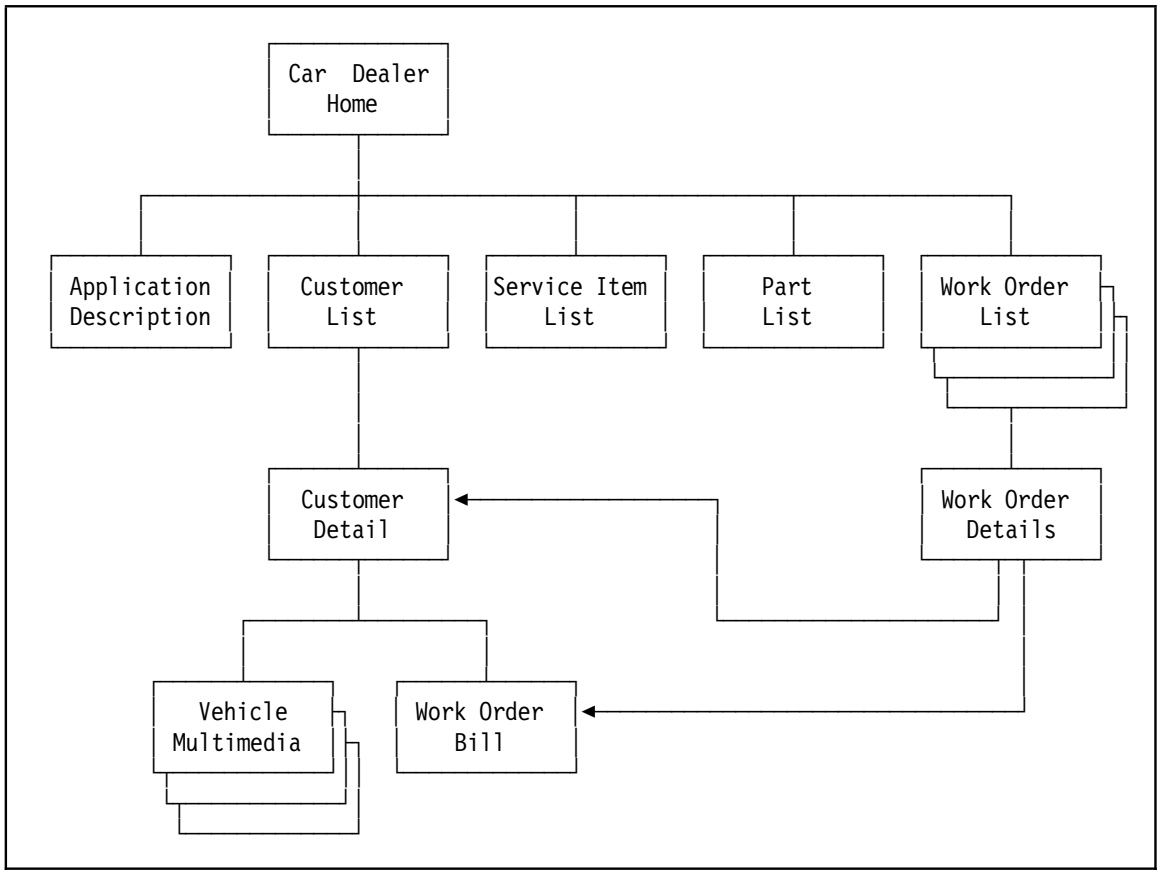


Figure 65. Initial Design for the Car Dealer Application on the Web

Steve explained: "I start with a home page from where we can invoke the different paths. The path most used will be the customer lookup. We provide a customer search facility by partial name, as we did in the GUI applications." (see Figure 13 on page 66).

"Customer search presents a list of matching customers, from where we can invoke the details of one customer. The details will include all the cars of the customer, the work orders for each car, including the list of services and parts of the work order," Steve continued.

"And then you can invoke the bill for a selected work order," said Hanna.

"That's right," Steve responded. "And for our multimedia *new and used cars* customer we can display the pictures or play the sounds and videos. I represented that with the three stacked boxes. The other paths are to list all service items, parts, or work orders, and I think we should also have a short application description."

"Why do you show three stacked boxes for Work Order List?" asked Curt.

"Ah, yes, I forgot to mention that," said Steve. "I designed it so that we can list incomplete work orders, complete work orders, or all work orders. Remember we have that search facility implemented in the work order class. When a work order is selected, I will show the

details, including the service items with parts, and the customer and vehicle. From there the user can get the customer details, or the bill."

"That looks all very good," said Curt. "When can we see it running?" he asked, smirking.

"I will start coding a simple page first, such as the Part List. Once I get familiar with the CGI technique of invoking an Object REXX program, it should be a breeze to get the other pages done. Remember, the object model is working and stable. Retrieving the data from DB2 is simple; we already have all the methods. It is just a matter of accepting the parameters from the Web browser and creating the HTML output."

"Show us your first page tomorrow—I have lots of confidence in you," said Hanna smiling and she left. Steve just stood there, but what Hanna just said filled him with pride. He would have something running by the morning.

Web Common Gateway Interface

Steve studied the documentation of the Internet Connection Server carefully. He found that the way to invoke a CGI program was by entering the Web browser request as:

```
http://hacurs/cgi-bin/progname?parms
```

This would invoke the program *progname* in the CGI-BIN subdirectory of the server (d:\WWW\CGI-BIN). The program could be either an EXE or CMD file. The parameters would not be passed directly to the program. They would be stored as OS/2 environment variables, together with other useful information about the request (see Figure 66).

```
REMOTE_ADDR        TCP/IP address of the requester (xxx.xxx.xxx.xxx)
SCRIPT_NAME        Request string before the ? (/cgi-bin/progname)
QUERY_STRING       Parameters following the ? in the request (parms)
                   (blanks are replaced by + signs)
...
```

Figure 66. CGI Environment Variables (Extract)

Steve proceeded to write the first program to list all parts in the database. All he had to do was to initialize the application, output the top part of the HTML file, iterate through all the parts and output each part in HTML, conclude the HTML file, and close the application. He decided to use an HTML table to display the part list (see Figure 67 on page 160).

```
/*--------------------------------------------------------------------*/
/* WWW\partall1.cmd      CarDealer - Web - Part list 1       ITSO-SJC */
/*--------------------------------------------------------------------*/

   .Cardeal~initialize
   partclass = .local['Cardeal.Part.class']
   say 'Content-Type: text/html'
   say ''
   say '<html>'
   say '<head><title>Object REXX Car Dealer Application</title></head>'
   say '<body>'
   say '<H2>Part List</H2>'
   say '<table border=2 cellpadding=0>'
   say '<tr>'
   say '<th>Number</th> <th>Description</th> <th>Price</th> <th>Stock</th>'
   say '<tr>'
   do part over partclass~extent
      say '<td>' part~number '</td>'
      say '<td>' part~description '</td>'
      say '<td align=right>' part~price '</td>'
      say '<td align=right>' part~stock '</td>'
      say '<tr>'
   end
   say '</table>'
   say '</body>'
   say '</html>'
   .Cardeal~terminate
   return

::requires carmodel.cfg         /* include the configuration file
```

Figure 67. CGI Program to List All Parts

Steve ran the program and was pleased with the output. He called Hanna and Curt and showed them how simple the program was.

"This looks really easy!" Curt said in astonishment. "But what are those first two say instructions?" he asked.

Steve explained: "A CGI program must first tell the server what kind of output is produced. The string `Content-Type: text/html` tells the server that a regular HTML file will be generated, and the second say instruction must be blank."

"I thought you were going to write an HTML class to simplify the coding of the generated HTML lines," Hanna interjected.

"That's true," said Steve. "But first I wanted to have a simple working example. Now I can design the HTML class to provide the functions that are used most."

"Show us the output in the browser," demanded Curt, who was excited and wanted to see the program in action.

"Here we go," said Steve as he started the WebExplorer and entered `http://hacurs/cgi-bin/partall1`. It took a while, but eventually the screen filled with the Part List (see Figure 68 on page 161).

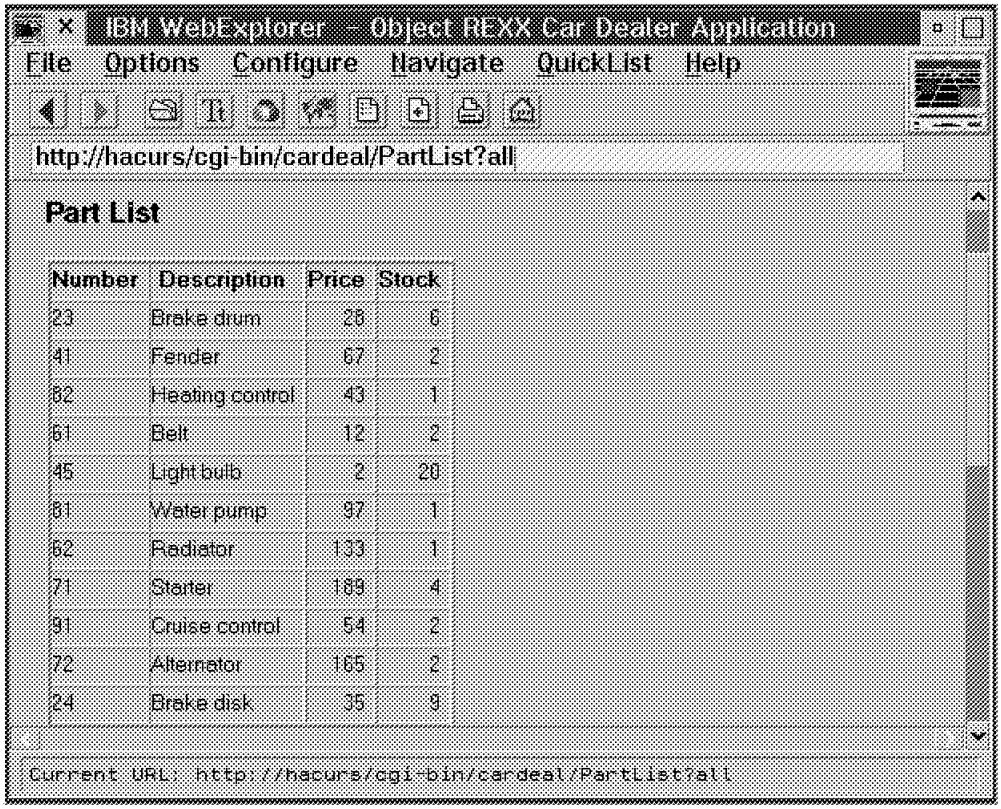


Figure 68. Car Dealer Part List in WebExplorer

HTML Class

After a nice lunch at the nearby Mexican cantina, Steve proceeded to rewrite the code using a new HTML class. He thought of the functions that are used most often and designed those as methods of the class.

He also decided that each car dealer output page should have a reference to the car dealer home page, and a common signature area at the bottom. The redesigned code looked definitively more object-oriented (see Figure 69 on page 162).

```
/*--------------------------------------------------------------------*/
/* WWW\partall2.cmd      CarDealer - Web - Part list 2       ITSO-SJC */
/*--------------------------------------------------------------------*/

   .Cardeal~initialize
   partclass = .local['Cardeal.Part.class']
   html = .HTML~new
   html~title('Object REXX Car Dealer Application')
   html~carhome                 /* reference to car dealer home page */
   html~h2('Part List')
   html~table('border=2 cellpadding=0')
   html~tr
   html~~th('Number')~~th('Description')~~th('Price')~~th('Stock')
   html~tr
   do part over partclass~extent
     html~~td(part~number)~~td(part~description)
     html~~td(part~price,'align=right')~~td(part~stock,'align=right')
     html~tr
   end
   html~etable
   html~~p~carhome              /* reference to car dealer home page */
   html~sign                    /* common signature at bottom        */
   html~send                    /* output all the accumulated lines  */
   .Cardeal~terminate
   return

::requires html.frm
::requires carmodel.cfg
```

Figure 69. Object-Oriented CGI Program to List All Parts

The HTML class allocates an array of lines. Each method basically adds a line to the array in the proper HTML format. Some of the methods produce matching start-and-end tags with the argument passed as the text between the tags. For example:

```
html~h2('Part List')  ==>  <H2>Part List</H2>
```

Other HTML tags are produced by individual start-and-end methods:

```
html~table('border=2 cellpadding=0')  ==>  <table border=2 cellpadding=0>
html~etable                           ==>  </etable>
```

The *title* method produces all of the required HTML tags at the start of the document:

```
html~title('xxxxxx')  ==>  <html> <head> <title>xxxxxx </head> <body>
```

The *carhome* method produces the reference to the car dealer home page, the *sign* method produces the common ending, and the *send* method outputs the whole array as REXX say instructions.

Not every HTML tag has a matching method. Tgas without a method can be generated with generic methods where the name of the tag is passed as well. (See Figure 70 on page 163 for an extract of the HTML class.)

```
/* WWW\html.frm          CarDealer - Web - HTML Framework    ITSO-SJC */

::class HTML public subclass array

::method init                           /* initialize an html object         */
  expose array_index type               /* index into the array, docu type   */
  array_index = 1                       /* start at the first item           */
  type = 'text/html'                    /* default document type             */
  forward class (super)                 /* do superclass initialization      */
                                        /* Start the html array off          */
::method put                            /* over ride of the put method       */
  expose array_index                    /* get the current index             */
  parse arg text
  self~put:super(text, array_index)
  array_index = array_index + 1
::method title                          /* title tag                         */
  parse arg text
  self~put('<html><head><title>'text'</title></head><body>')
::method h1                             /* header 1 tag                      */
  parse arg text
  self~put('<H1>'text'</H1>')
::method tag                            /* generate any tag                  */
  parse arg name, text
  self~put('<'name'>'text)
::method text                           /* add raw text to the stream        */
  parse arg text
  self~put(text)
::method p                              /* paragraph tag                     */
  parse arg text
  self~put('<p>'text)
::method ul                             /* ul tag                            */
  self~put('<ul>')
::method li                             /* li tag                            */
  parse arg text
  self~put('<li>'text)
::method table                          /* table tag                         */
  parse arg options
  self~put('<table' options'>')
::method td                             /* td tag                            */
  parse arg text, options
  if text = '' then self~put('<td' options'>')
  else              self~put('<td' options'>'text'</td>')
::method sign                           /* signature/end                     */
  self~~hr~b('Hacurs - Car Dealer Application')
  self~br('Ulrich (Ueli) Wahli - IBM ITSO San Jose')
  self~address('wahli@vnet.im.com')
  self~~hr~~etag('body')~~etag('html')
::method send                           /* send the HTML from the array      */
  expose type
  crlf = '0d0a'x
  say 'Content-Type:' type
  say ''
  say '<!doctype html public "html2.0">'
  do line over self                     /* loop over the array               */
    say line                            /* send out the next line            */
  end
```

Figure 70. HTML Class for CGI Programs (Extract)

Customer Search Form

The next morning Steve showed the HTML class to Hanna and Curt. “This will make future coding much easier,” he explained.

“That’s true,” said Hanna. “But how are you going to implement the customer search facility. Can you put a push button into an HTML page?”

“I already investigated that last night,” Steve said. “HTML provides the form facility with entry fields, radio buttons and check boxes, and a submit button to pass the values of the form to the next CGI program. The extract of the customer home page for customer search looks like this.” (See Figure 71.)

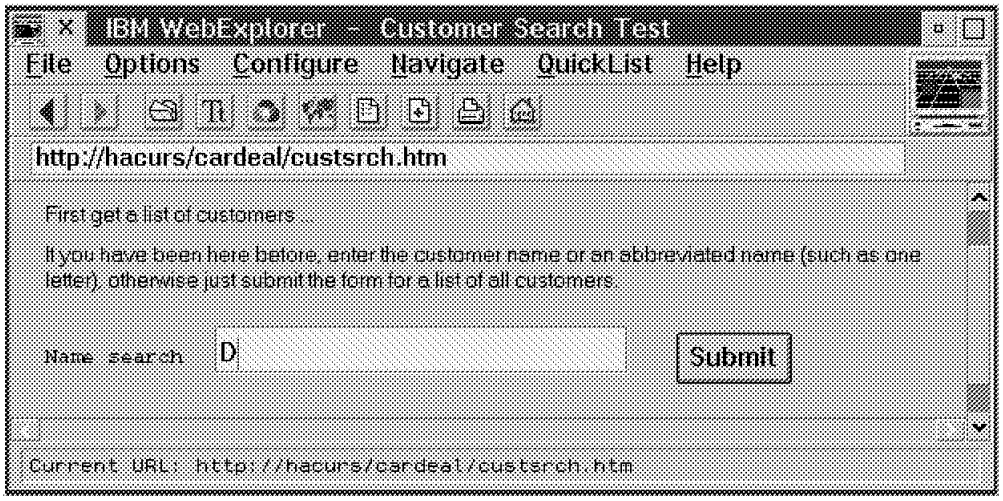


Figure 71. Customer Search Form

“Explain this one to me, please,” said Curt.

“Sure, I can do that,” Steve answered. “Just look at the HTML code that creates this form.” (See Figure 72.)

```
<html> <head> <title> Customer Search Test </title> </head> <body>
<form method="GET" action="/cgi-bin/CustList">
 <p> First get a list of customers ...
 <p> If you have been here before, enter the customer name or
     an abbreviated name (such as one letter),
     otherwise just submit the form for a list of all customers.
 <p> <pre>Name search   <input name="name" type="text" size="20">    <input type="submit">
     </pre>
</form>
</body> </html>
```

Figure 72. HTML for Customer Search Form

“The form tag defines the method of passing data and the program, CustList, that is invoked. The *get* method passes all data in the request string, whereas the *post* method tells the program to retrieve the data from the browser once it has been invoked. I specified the get method because the amount of data is small.”

“The input tags specify the different fields and buttons of the form. Here I only used one input field *name* of 20 bytes, and one **Submit** button. The *<pre>* tag specifies that this line

is preformatted, with blanks between the text label, the input field, and the **Submit** button. Normally Web browsers reduce all blanks to a single blank," Steve concluded.

"What does the program get passed when I click on the **Submit** button?" asked Hanna.

"The browser builds a query string from all of the fields of the form. Each field is passed in the format `fieldname=value`, separated by an ampersand. In our simple form with one field

```
http://hacurs/cgi-bin/CustList?name=D
```

would be the request string if you enter D in the search field. If the form had a name and an address field, the request string would include both fields, separated by an ampersand."

"Come see me after lunch, and I'll show you the customer search in action," said Steve, who was confident that it would be fairly easy to write the second program, using the form and his new HTML class.

After lunch he showed the customer list output to Hanna and Curt. He had designed a table to hold the customer data. He made the customer names active, so that clicking on a name would invoke the next program, CustDetail, to generate the customer detail page. (See Figure 73.)

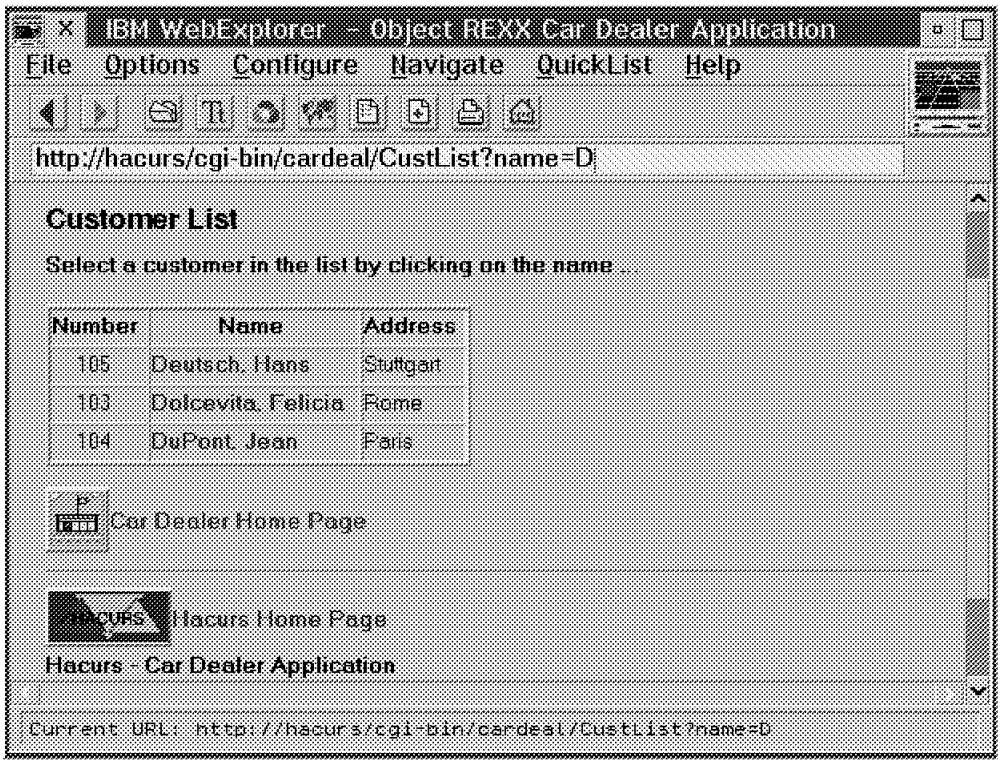


Figure 73. Customer List in WebExplorer

"Wow, you really did a lot of work!" exclaimed Hanna, who was very pleased with the progress Steve had made. The other pages would be fairly easy to add. The work on the object model and the configuration paid off with every new application based on that model.

"Have you tried to run the application with persistent storage in files?" asked Curt.

"No problem," replied Steve. "I am doing most of the test with the file system because it is faster than the DB2-based application. I just switch the configuration file (carmodel.cfg), using our car-run program. But when we make the Web application available to outside users, it is better for advertising if it runs on DB2."

Steve had another ace up his sleeve. He clicked on a customer name in the list, and the details of the customer showed up in the WebExplorer. (See Figure 74 on page 166.)

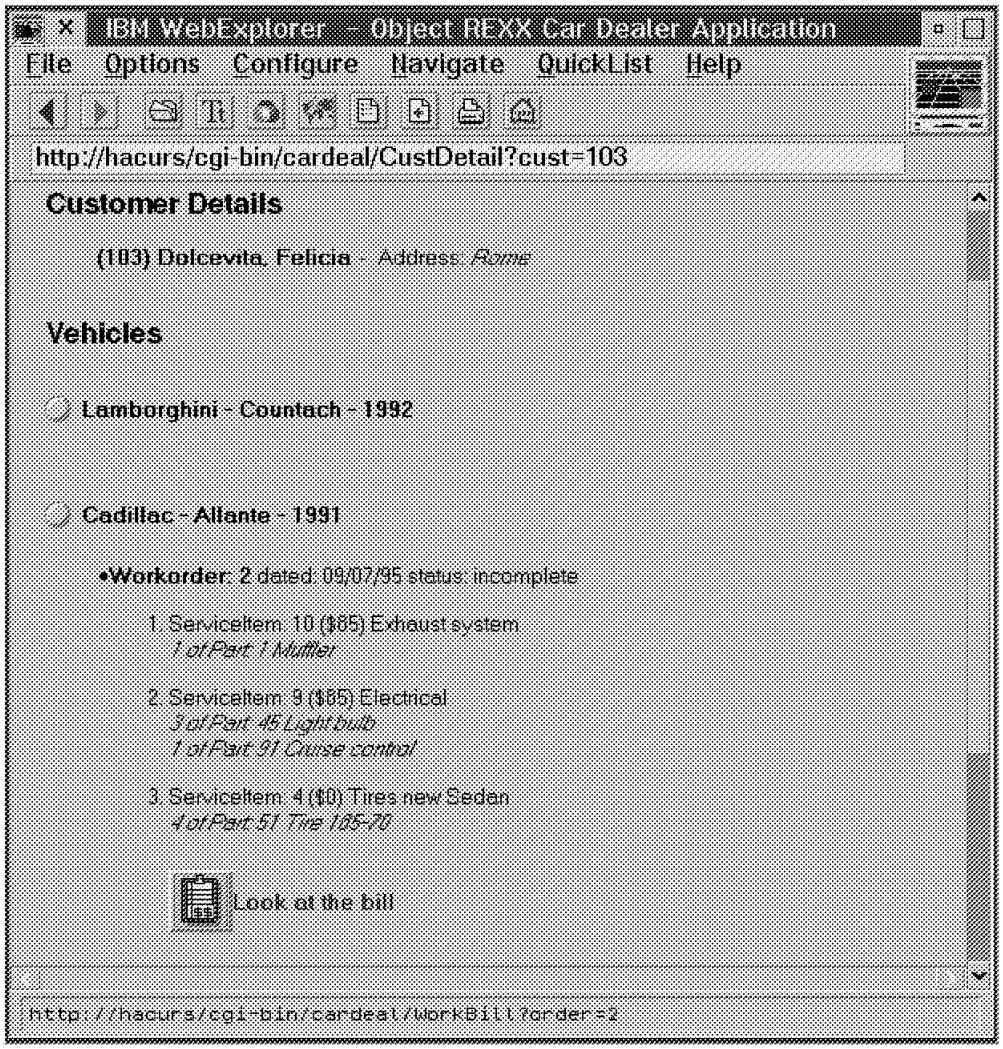


Figure 74. Customer Details in WebExplorer

“What else is there to do?” asked Curt. “Just a few more programs generating the other Web pages.”

“I think there are a few more items on my list,” Steve replied.

Program Organization and Performance

“The car dealer is just the first application we put on the Internet. In the future we might add other applications. I have to organize my files better, so that future applications do not interfere with the car dealer,” Steve continued.

“Steve, that’s good thinking ahead,” said Hanna. “The Internet could be useful for many things we do over the next few months. We better start organizing all the programs and HTML files we produce for the car dealer application.”

"There is another thing that bugs me," Steve added. "In every CGI program I have to initialize the application and terminate it afterward. That adds a lot of overhead and makes the application look slow. I must find a way at keeping the object classes in memory, so that each CGI program can immediately access them. I have an idea, but I have to run a few tests to make sure that the design holds."

Customizing the File Organization on the Web Server

Steve decided to put all the car dealer HTML files and programs into a separate subdirectory. At first he considered using a subdirectory within the Internet Connection Server directory structure, but, after studying the documentation on server administration he decided to use a subdirectory within the existing car dealer directory:

```
d:\CARDEAL\WWW
```

He then tailored the server administration file to point to the new directory. The `httpd.cnf` administration file is stored in the ETC directory of TCP/IP.

Note: Issue the `SET ETC` command to find the ETC directory. It is usually called either d:\MPTN\ETC or d:\TCPIP\ETC.

Figure 75 shows an extract of the tailored administration file.

```
       #       Sample configuration file for Web Server for OS/2
       #
       ......
       ......
       # added for car dealer application (next 2 lines)
  1    Welcome    Hacurs.htm
  2    Welcome    cardeal.htm
       Welcome    Welcome.html
       Welcome    welcome.html
       Welcome    index.html
       Welcome    Frntpage.html
       ......
       ......
       # added for car dealer application (next 4 lines)
  3    Exec    /cgi-bin/cardeal/*         D:\CARDEAL\WWW\CGIREXX.CMD
  4    Pass    /cardeal/media/*           D:\CARDEAL\Media\*
  5    Pass    /cardeal/*                 D:\CARDEAL\WWW\*
  6    Pass    /tmp/*                     E:\TMP\*

       Exec    /admin-bin/*  E:\WWW\ADMIN\*
       Exec    /cgi-bin/*  E:\WWW\CGI-BIN\*
       Pass    /Docs/*   E:\WWW\DOCS\*
       Pass    /httpd-internal-icons/*  E:\WWW\ICONS\*
       Pass    /icons/*  E:\WWW\ICONS\*
       Pass    /Admin/*   E:\WWW\ADMIN\*
       Pass    /*   E:\WWW\HTML\*
       ......
```

Figure 75. Tailored Web Server Administration File. Extract of the HTTPD.CNF file in the ETC directory.

"Why are you making these changes, Steve?" asked Hanna, glancing over Steve's shoulder. She had just returned with a coffee from the machine and wondered why Steve was so engrossed in his work.

It was like Steve had just woken up. He had not realized that Hanna was standing right behind him. He started to apologize for not noticing her, but then he just shrugged and explained:

1. "The first Welcome line directs the server to display the Hacurs home page":

   ```
   http://www.hacurs.com                    ==>  d:\WWW\HTML\Hacurs.htm
   http://www.hacurs.com/Hacurs.htm         ==>  same
   ```

2. "The second Welcome line directs the server to display the car dealer home page if the car dealer directory is selected":

   ```
   http://www.hacurs.com/cardeal            ==>  d:\CARDEAL\WWW\cardeal.htm
   http://www.hacurs.com/cardeal/cardeal.htm  ==>  same
   ```

   Note: Point 5 directs any requests starting with `/cardeal` to the d:\CARDEAL\WWW subdirectory.

3. "The Exec line invokes the `CGIREXX.CMD` program for every CGI request starting with `/cgi-bin/cardeal`":

   ```
   /cgi-bin/cardeal/progname?parms
   ```

   "I plan to write one interface program that handles the environment variables and some housekeeping before invoking the individual function programs."

   "I guess that putting common code into one CGI program will make the individual programs a little simpler," remarked Hanna. Steve nodded and continued:

4. "The first Pass line directs the server to the Media subdirectory for any `/cardeal/media` requests. We will need that to display the car pictures if we run with file persistence."

5. "The second Pass line directs any car dealer request to the WWW subdirectory."

6. "The last Pass line directs any requests for `/tmp` to the temporary directory (as set in SET TMP in the CONFIG.SYS file). That's where the pictures are extracted to when we run with DB2."

"I am impressed!" gasped Hanna. "You have thought of everything. This keeps all the car dealer files nicely separated from the normal Web server files.

Have you thought about performance yet?" she added. "How can you keep all of the class objects in memory?"

Optimizing Performance

"Here's my idea," Steve answered. "For every client program request the server starts a thread. That's where I initialize the car dealer application, generate the HTML file, and terminate the application. What I would like to do is initialize the application outside of the Web server, and then just use the classes in memory from the Web programs."

"I see your problem," said Hanna. "Our application stores information in the local environment (see 'Implementation of the Car Dealer Class' on page 132), and every class stores itself too. These local variables are not available in another process."

"What I have to do is write a small program that starts the application and stores the necessary information in the global environment (see 'The Global Directory' on page 127). Then I have direct access to all of the class information from my CGI programs," Steve pondered.

"Good idea," said Hanna. "And since you have already decided to have one main CGI program, CGIREXX, you can pick up the global information in that program and convert it to the local variables needed by the car dealer application."

"I can also check whether the application is running and produce a nice error message if it is not," added Steve.

"There you go, but it's not an error message, it's another Web page saying, 'Sorry, the application is not running at this time.' That is much nicer than an unfriendly error message," said Hanna. "I'll prepare that page for you, busy guy. I'll name it cardealN.htm."

Car Dealer Start Program for the Web

Steve quickly wrote the program to start the car dealer application (see Figure 76). He would enhance it later to provide more function and make it usable from a Web browser as well.

```
/*     carstart.cmd      CarDealer - Web - Start Application          */

 parse upper source env . me .
 maindir = me~left(me~lastpos('\WWW\')-1)
 curdir = directory()
 x = directory(maindir)
 call carmodel.cfg                /* configuration file */
 .Cardeal~initialize
 .environment['Cardeal.Data.type']         = .local['Cardeal.Data.type']
 .environment['Cardeal.Data.dir']          = .local['Cardeal.Data.dir']
 .environment['Cardeal.Media.dir']         = .local['Cardeal.Media.dir']
 .environment['Cardeal.Customer.class']    = .local['Cardeal.Customer.class']
 .environment['Cardeal.Vehicle.class']     = .local['Cardeal.Vehicle.class']
 .environment['Cardeal.WorkOrder.class']   = .local['Cardeal.WorkOrder.class']
 .environment['Cardeal.ServiceItem.class'] = .local['Cardeal.ServiceItem.class']
 .environment['Cardeal.Part.class']        = .local['Cardeal.Part.class']
 .environment['Cardeal.WorkServRel']       = .local['Cardeal.WorkServRel']
 say
 say 'Waiting for you to....'
 say 'Press enter to stop Car Dealer Application'
 pull ans
 .Cardeal~terminate
 .environment['Cardeal.Data.type'] = .nil
 /* other variables similar */
 x = directory(curdir)
 return
```

Figure 76. Car Dealer Start Program for the Web. This is an abbreviated version of the program. The real program (carstart.cmd) uses a class with start, display, and stop methods.

Car Dealer Common Interface Program

Next Steve attacked the common interface program, CGIREXX. He had to implement a number of common functions:

- Pick up the environment variables holding the request and the parameters from the Web server.
- Check whether the car dealer application is running. Return the Web page Hanna designed if the application was not available; otherwise prepare the .local variables.

- Invoke the individual program to handle the request. He decided to pass the same Web server environment variables to all programs even if they were not needed.

The task was not too difficult, and soon Steve tested the new interface program shown in Figure 77.

```
/* WWW\cgirexx.cmd       CarDealer - Web - CGI Rexx Interface        */

parse source env . me .
envir = 'OS2ENVIRONMENT'
sourcedir = me~left(me~lastpos('\')-1)
script = value('SCRIPT_NAME',,envir)       /* Web server variables  */
who    = value('REMOTE_ADDR',,envir)
list   = value('QUERY_STRING',,envir)
parse var script '/cgi-bin/' type          /* extract request type  */
list=translate(list, ' ', '+'||'090a0d'x)  /* Whitespace, etc.      */
ddir   = sourcedir                         /* CARDEAL\WWW directory */
x = directory(ddir)
sqlca.sqlcode = 0                          /* init DB2 return code  */

.local['Cardeal.Data.type']         = .environment['Cardeal.Data.type']
.local['Cardeal.Data.dir']          = .environment['Cardeal.Data.dir']
.local['Cardeal.Media.dir']         = .environment['Cardeal.Media.dir']
.local['Cardeal.Customer.class']    = .environment['Cardeal.Customer.class']
.local['Cardeal.Vehicle.class']     = .environment['Cardeal.Vehicle.class']
.local['Cardeal.WorkOrder.class']   = .environment['Cardeal.WorkOrder.class']
.local['Cardeal.ServiceItem.class'] = .environment['Cardeal.ServiceItem.class']
.local['Cardeal.Part.class']        = .environment['Cardeal.Part.class']
.local['Cardeal.WorkServRel']       = .environment['Cardeal.WorkServRel']
if .local['Cardeal.Data.type'] = 'DB2' then do
   if RxFuncQuery('SQLDBS') then            /* DB2 Rexx functions     */
      call RxFuncAdd 'SQLDBS', 'SQLAR', 'SQLDBS'
   if RxFuncQuery('SQLEXEC') then
      call RxFuncAdd 'SQLEXEC', 'SQLAR', 'SQLEXEC'
   call sqlexec "CONNECT RESET"             /* just to be sure        */
   call sqlexec "CONNECT TO DEALERDB"       /* connect to database    */
end
select
   when .environment['Cardeal.Data.type'] = .nil then
        call returnfile ddir'\cardealN.htm' /* CAR DEALER NOT RUNNING */
   when sqlca.sqlcode \= 0 then
        call returnfile ddir'\cardealN.htm' /* DB2 DB CONNECT FAILED  */
   when type='cardeal/cardeal' then
        call returnfile ddir'\cardeal.htm'  /* cardeal home page      */
   when type='cardeal/CustList' then
        call custlist file, type, list, who
   when type='cardeal/CustDetail' then
        call custdeta file, type, list, who

   /* others similar ...... */

   otherwise
        call error    /* not shown, returns an HTML error page */
end
return
```

Figure 77 (Part 1 of 2). Car Dealer Common Interface Program

```
/*----------------- return a precoded HTML file ----------------------*/
RETURNFILE:
    parse arg resultfile
    say 'Location:' '/cardeal'translate(substr(resultfile,length(ddir)+1),'/','\')
    say ''
    return
```

Figure 77 (Part 2 of 2). Car Dealer Common Interface Program

Multimedia on the Web

Working late that day, Steve implemented a few more of the individual CGI programs. The next morning he called Hanna and Curt over to his desk and showed them the latest additions.

"Look," he said. "When you display the multimedia customer (new and used cars), you get the list of pictures, audio sounds, and videos." (See Figure 78.)

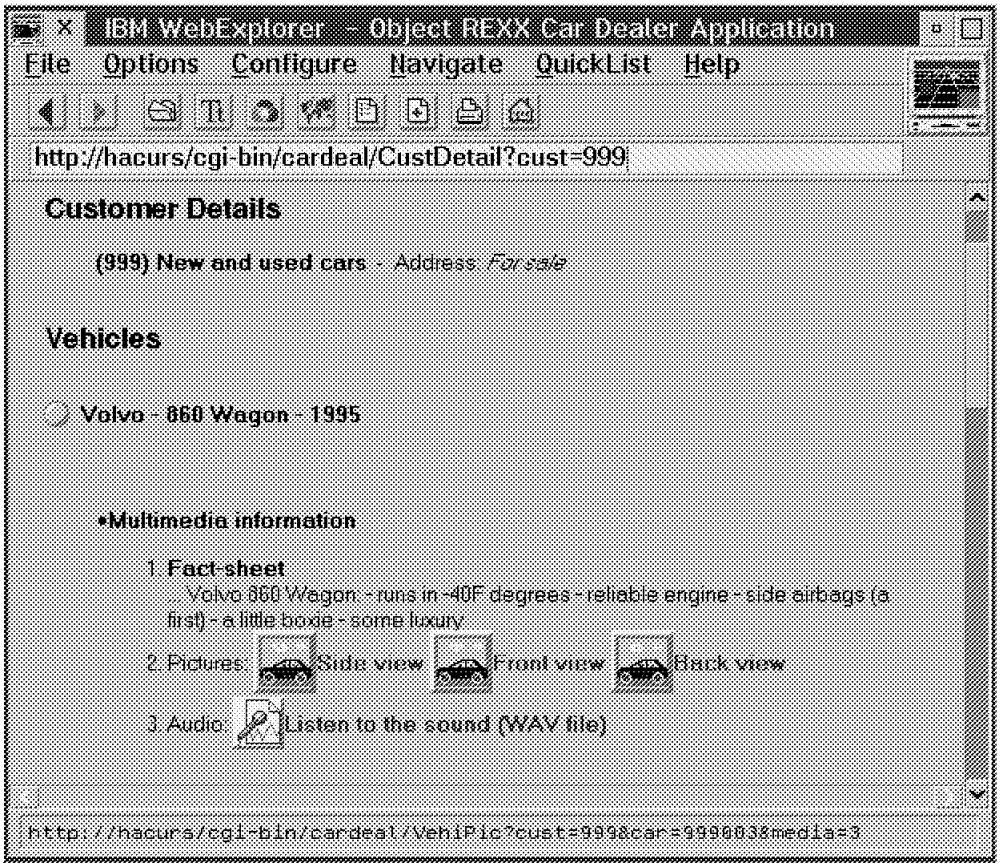


Figure 78. New and Used Car List

"Can you click on one of these to see the picture?" asked Curt.

"Yes, these are active links, and when you click on one of them you get a new page that includes the picture of the car. Most Web browsers handle many picture formats, including BMP, GIF, and JPEG.

When I click on the Volvo, the picture is displayed." (See Figure 79 on page 172.)

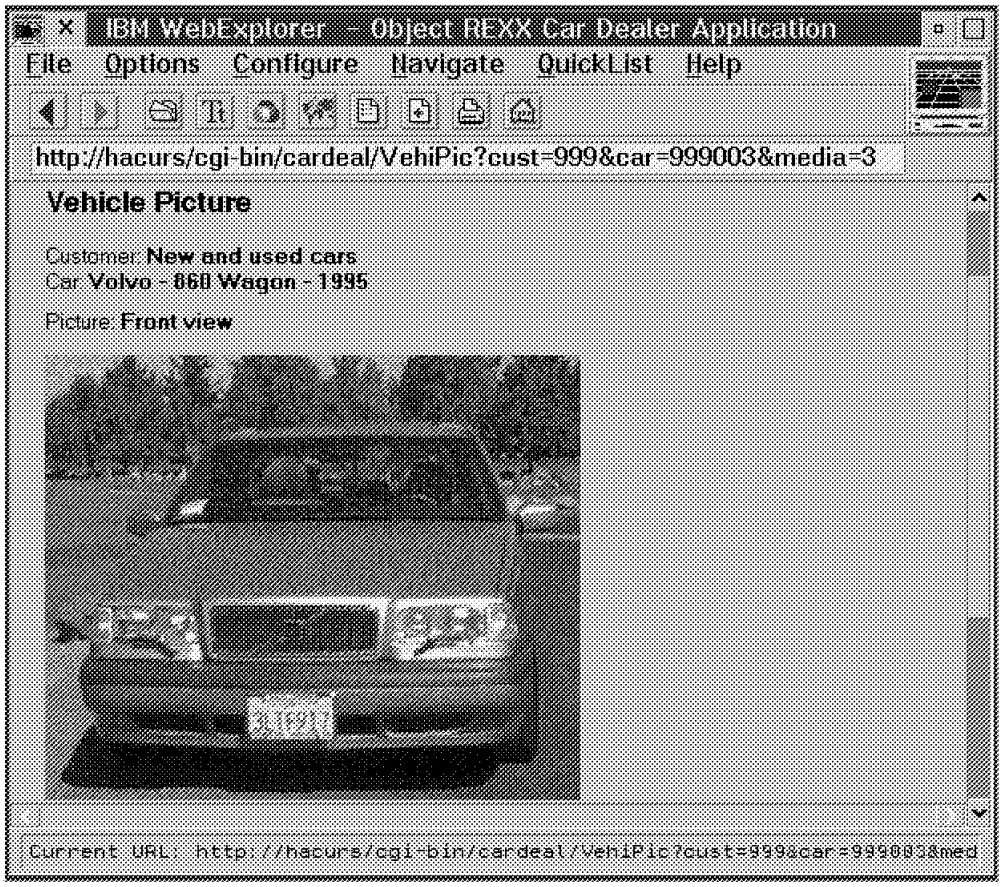


Figure 79. Web Browser Vehicle Picture

"I am surprised at how fast the pictures appear," said Curt, after Steve clicked on a few more picture lines.

"Remember we are on a local network," replied Steve. "For users on the real Internet, the pictures will appear more slowly because our BMPs are not compressed. Pictures in GIF or JPEG format are smaller than BMP, but the GUI builders do not display those formats in the GUI applications.

Try out one of the audio sounds now," he commanded Curt.

Curt clicked on an audio sound, and soon a familiar voice advertised the features of the Volvo wagon. And clicking on the simple demonstration video played the movie nicely in the multimedia TV window.

"Does every Web browser support audio files?" asked Hanna.

"Most browsers can be configured to invoke the operating system's multimedia function," Curt answered, before Steve even had a chance to explain how he managed to play the audio file on his ThinkPad.

Interacting with Web Users

One morning Hanna arrived at the office with a new idea. She immediately called Curt and Steve over to explain her idea.

“I had a dream last night,” she said. “We must involve the Web user in the application. What I want is thus: The user enters his or her name and address and information about a car. We enter this new customer and vehicle data into the database, and then we let the user create a work order, select the services to be performed, and finally look at the bill for the job.”

“That′s an amazing idea,” Curt shouted. “The user will come back to our home page several times to check whether the information is still there. That will prove how reliable the DB2 database is.”

“What about security?” asked Steve. “The user could pretend to be somebody else when visiting our home page and create many new customers and add work orders to any of our demonstration customers. We need some control so that each Web user can only add one car and not modify any of our own customers in the database.”

“That′s a real concern, Steve, you are right,” said Hanna. “Maybe we can use the address field of the customer and store the Web user′s TCP/IP address as a reference. Remember, the Web server passes the address in an environment variable to the CGI program,” she added.

“That′s a neat solution,” said Steve. “Nobody will be able to touch our existing customers. But we have to extend the DB2 object model to include a method to search the customer table by address. That would enable us to check whether a customer already exists for a given TCP/IP address.”

“And since we generate the resulting HTML file by the CGI program, we can include the active link to create a work order only for the customer entry of the current Web user.” Curt was thinking quickly as well.

“There is just one problem,” he added. “Clever Web users can fake TCP/IP addresses and change customer records of other Web users. It′s only a small problem, however, because our existing customer records cannot be touched.”

“I think that′s good enough for a start,” said Hanna. “Our prospects are hardly of the hacker kind. Let′s go to work. I will design the layout of the interactive form where a Web user can add a customer and a vehicle. It will be a static HTML file, and I can do that!”

“Curt, you work on the program to create a new work order. You have to know how to code a CGI program; we cannot depend on Steve alone,” she said, turning to Steve and smiling.

“And you Steve, you modify the existing customer display program to add an active link to create a new work order if the customer matches the TCP/IP address. And while we are at it, we can also allow Web users to delete the work order and the customer if they so choose.” she concluded.

Hanna felt good, she was in charge. It had been *her* dream, and nobody could away *her* idea.

Adding a Web Customer

Hanna quickly designed the form for a new customer and car. She deliberately added a field for the TCP/IP address, which could then be compared with the address passed by the Web server, thus eliminating a few cases of users trying to fool the system. (See Figure 80.)

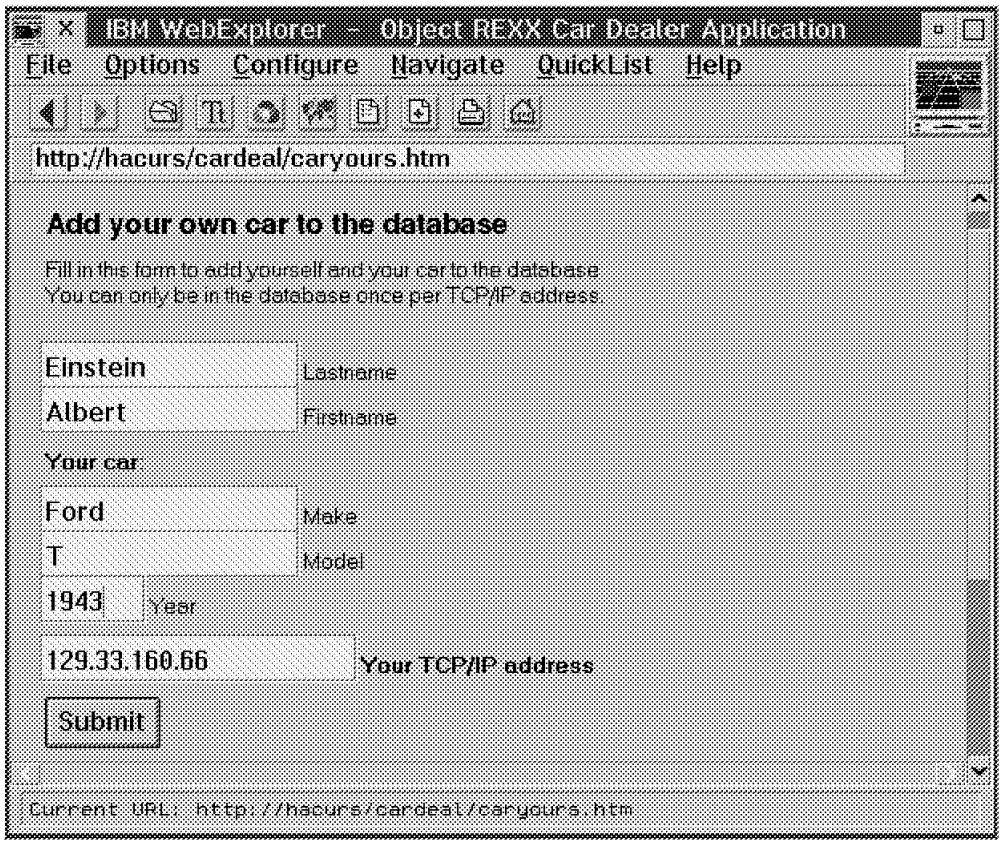


Figure 80. HTML Form for a New Customer and Car

In the meantime Steve added a *findAddress* method to the customer class for both file and DB2 persistence. The new code could be tested with the file system first before running on the DB2 database. Implementing the method for both types of persistence also kept the object model in sync.

Steve then modified the customer detail page to show an active link to delete the customer and create a new work order, if the address matched the TCP/IP address passed by the Web server. The additional code was simple:

```
parse arg file, type, list, who
parse var list 'cust=' custnum '?'
...
customer = custclass~findNumber(custnum)
...
if customer~address = who then
   html~~br~href('CDDelete?cust='customer~number, '==> Click here to delete the customer')
...
if customer~address = who then
   html~~li~href('NewWork?cust='custnum'&car='car~serial, '==> Click here for new workorder')
```

He could always replace the active text link with a nice, small picture icon later. For now, it was important to get his code working before Curt was ready with the customer delete and the create new work order routines.

Curt implemented the delete routine with a little pain. It was his first attempt at CGI programming, and it took a few trials to get the parameters right, delete the information in the object model, and generate a suitable HTML reply.

Then he tackled the new work order program. Creating a work order was simple, it just needed a customer and a vehicle; all other attributes were generated by the model. The hard part was designing the addition of service items to the work order. He decided to use an HTML form, display all the service items as check boxes, and let the user select any number of them before sending the form by using the **Submit** button. (See Figure 81.)

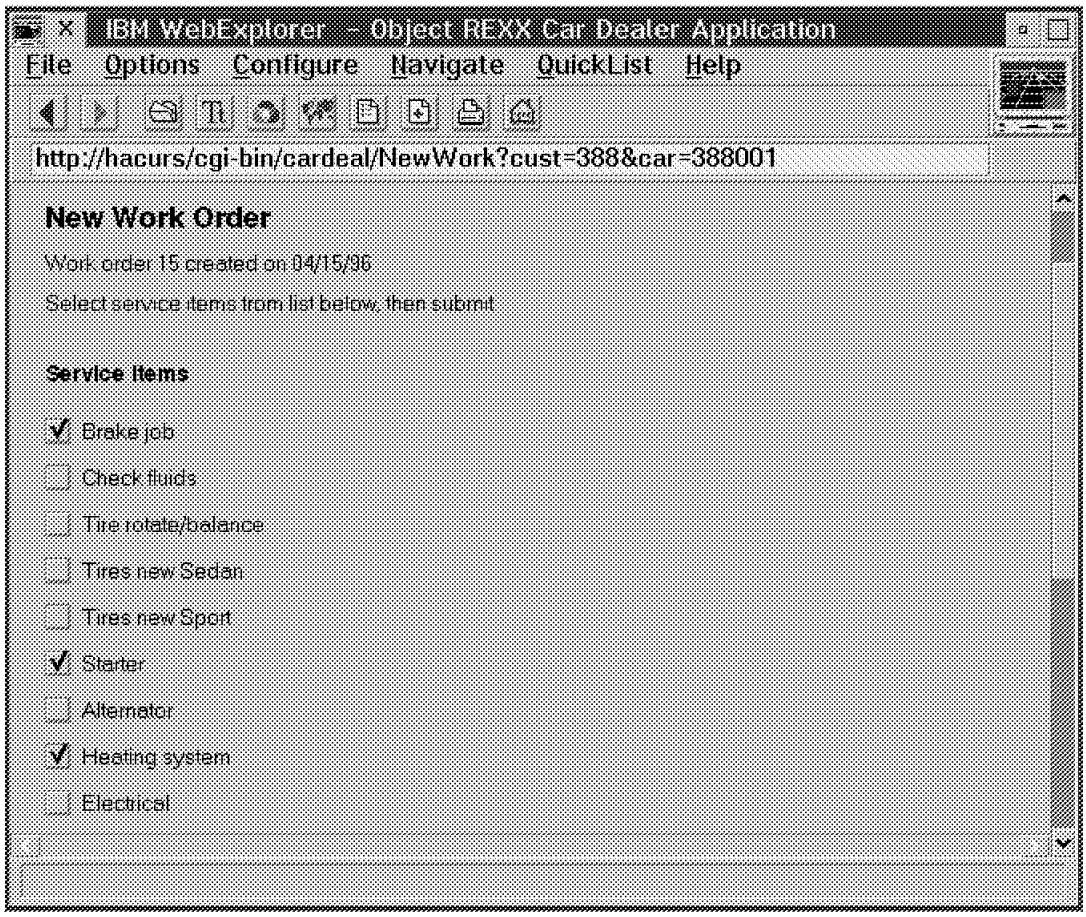


Figure 81. HTML Form for a New Work Order. There is a Submit button at the bottom of the form.

Curt decided that the resulting Web page would be the existing customer detail display that Steve had done previously. Figure 82 on page 176 shows the final application flow diagram.

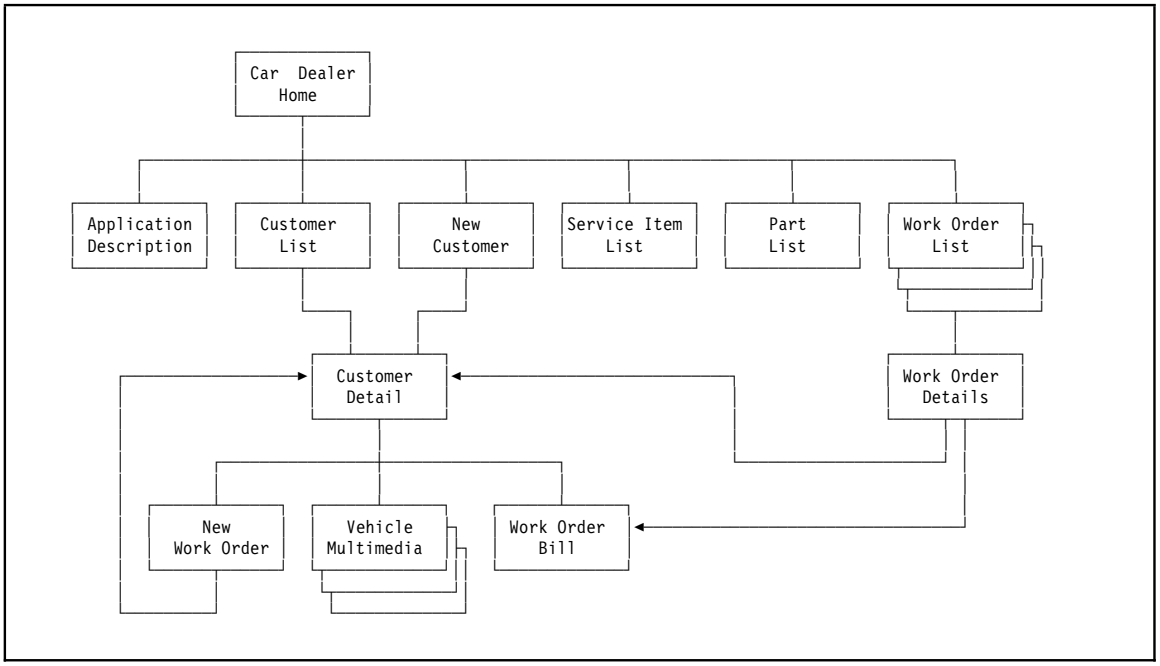


Figure 82. Final Design for Car Dealer Application on the Web

Car Dealer Home Page

Hanna thought about a few other pages that would enhance the function of the application, but time was running out. The leased phone line was installed and they had to get the application out in the market.

There would be another day to make further changes. The Web was an active place, and enhancements could be added any time. Their object model and Steve's CGI program design would make it easy to maintain the attractiveness of the application and its currency in the face of the ever-changing Web technology.

Hanna completed the car dealer home page with the new function of user interaction and tested it herself. Then she called Steve and Curt over and proudly presented the Hacurs car dealer home page (see Figure 83 on page 177).

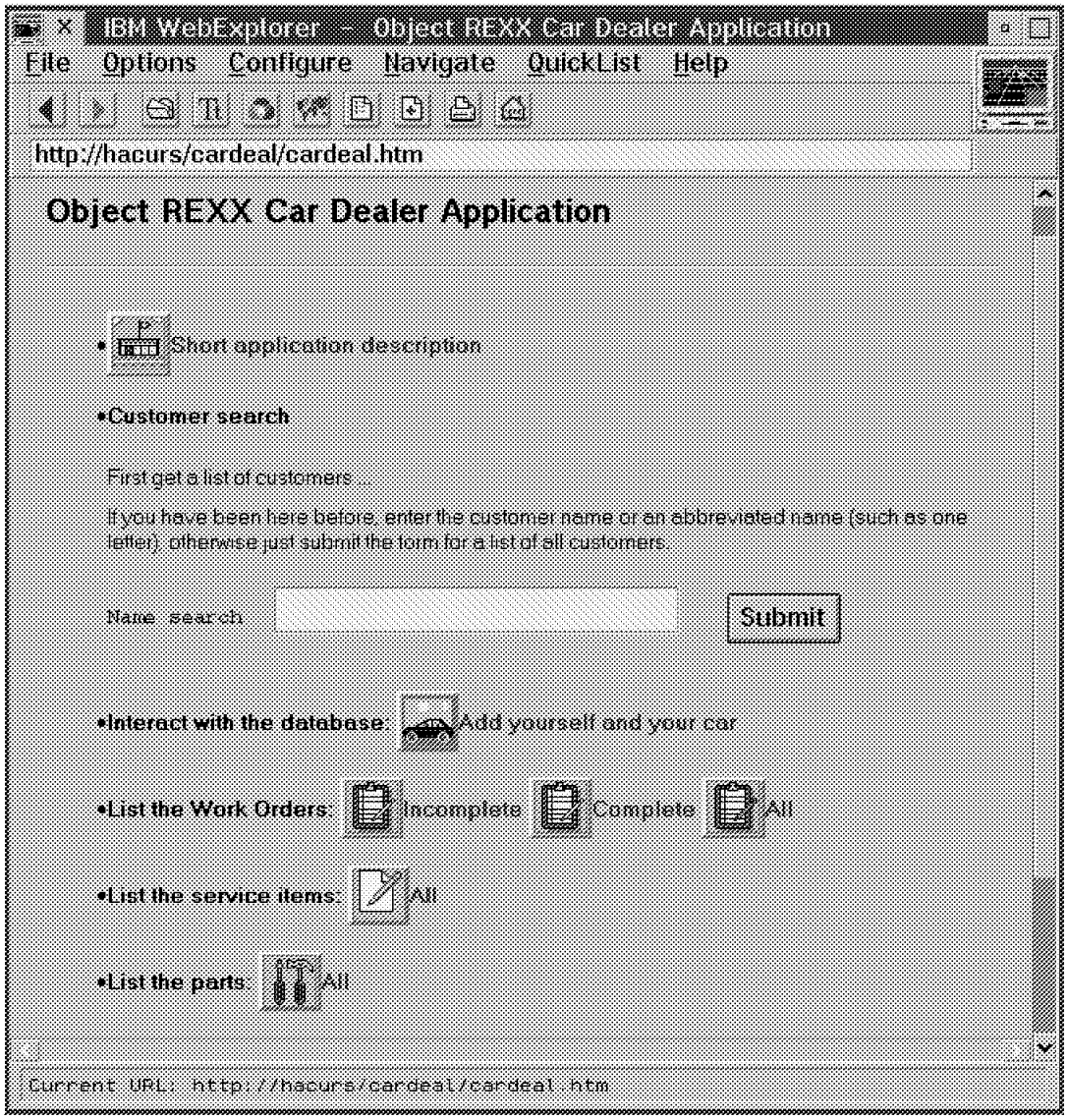


Figure 83. Web Car Dealer Application Home Page

"I think that's a start," said Curt, and Steve added "You cleverly used our icons as active links to the different programs. Let's put it out on the external Internet Connection Server"

"Let the world enjoy Object REXX and the car dealer on the Web!" Hanna exclaimed as she pushed the button to activate the external connection to their server.

Implementation Notes

Further tests showed that the car dealer application could also be started from the Web browser by invoking the `carstart` program. The CGIREXX interface program was enhanced with these functions:

cardeal/start?db2 Run the start program for DB2 persistence without waiting for an answer. Display the status in the Web browser.

cardeal/start?file Run the start program for file persistence without waiting for an answer. Display the status in the Web browser.

cardeal/status Display the status of the application in the browser.

cardeal/stop Stop the car dealer application. Display the status in the Web browser.

These functions were implemented as methods of a class in the `carstart` program. The start method for DB2 persistence performs a logon, starts DB2, starts the application, and displays the status.

Source Code

The source code for the car dealer on the World Wide Web is listed in “Car Dealer on the World Wide Web” on page 310.

Part 3. Object REXX and Concurrency

Chapter 13. Object REXX and Concurrency

In this chapter we experiment with the concurrency facilities of Object REXX. Object REXX provides both inter- and intraobject concurrency.

Interobject concurrency enables us to run a method against each of several different objects concurrently. Intraobject concurrency enables us to run multiple methods concurrently against a single object.

There is a detailed description of Object REXX concurrency in *Object REXX Reference for OS/2*.

Object-Based Concurrency

Every Object REXX object contains its own encapsulated method variables. It is given the processing power needed to run its methods and to exchange messages with other objects. Each object is a totally self-contained entity, and any number of objects can be active at the same time. This is defined as *interobject concurrency*. There is no danger of multiple updates to the same object variable because each object variable is owned by only one object, and each object runs only one method at a time.

Object REXX also supports another type of concurrency, where more than one method can run against the same object at the same time. This is defined as *intraobject concurrency*. Careful planning and synchronization are needed to ensure that the variables shared between methods are updated by only one method at a time. Object REXX provides facilities to manage these aspects.

The Object REXX Concurrency Facilities

The facilities provided by Object REXX to manage concurrency are early reply, message objects, unguarded methods, and the guard instruction.

Early Reply

A method can send an early reply to its caller using the *reply* statement and then continue running. The calling routine will be able to resume its own work while the called method continues to execute (see Figure 84 on page 182).

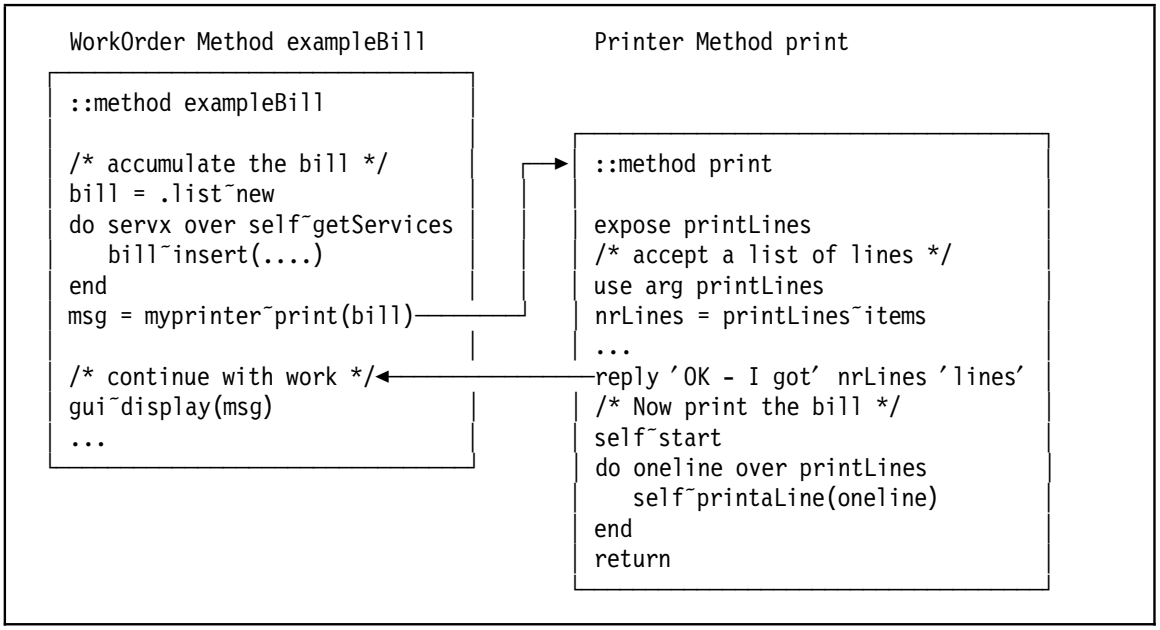


Figure 84. Concurrency with Early Reply

Message Objects

Message objects enable an Object REXX program to *start* a method executing in parallel with itself. The caller continues executing and can later ask the intermediate message object for the results of the call (see Figure 85).

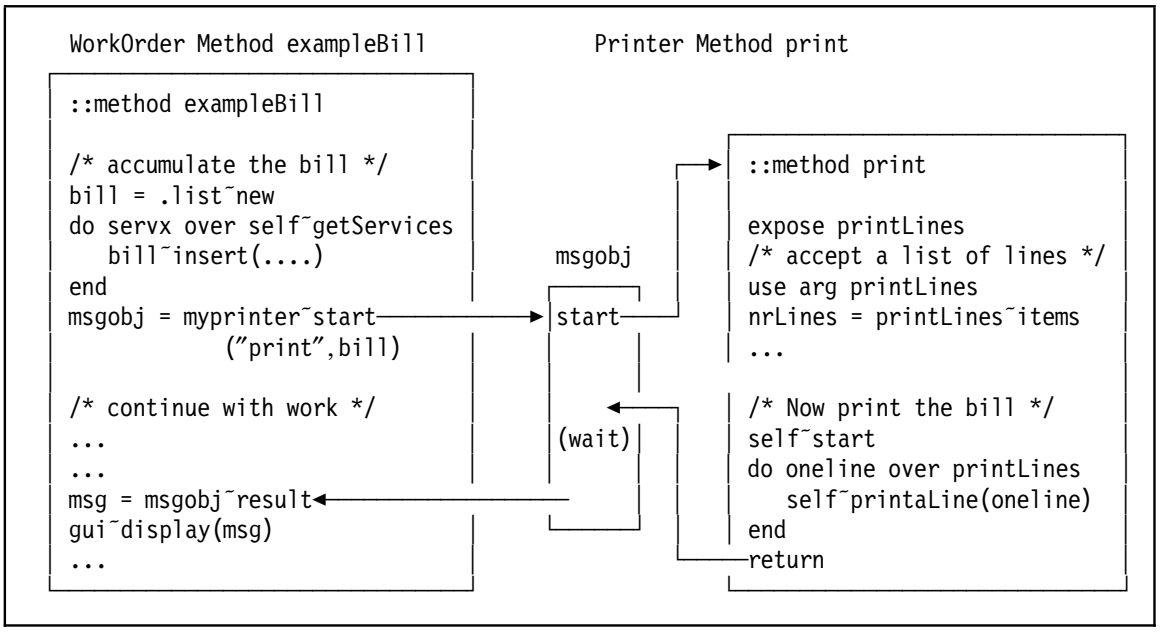


Figure 85. Concurrency with Message Objects

Note: When the caller asks the message object for the results, Object REXX makes it wait if the invoked method has not yet completed.

Unguarded Methods

A method can be declared *unguarded*:

```
::method getnumber unguarded
```

An unguarded method will run even if another method is already active for the same object. This enables intraobject concurrency. It is usually quite safe to make read-only methods unguarded because they do not modify the shared variable pool. It is, however, possible that some of the variables in the pool will be inconsistent with others in the same pool. Suppose, for example, that an object's methods maintain a list of numbers and the sum of all the numbers in this list within the object's variable pool. If an unguarded method reads the numbers in this list and compares their sum to the sum maintained by the other methods, the sums may differ if another method just happens to be updating the list at the time it is read.

Unguarded methods are needed in recursive situations. For example, the *init* method for a vehicle invokes the *addVehicle* method of the customer, which in turn invokes the *getOwner* method of the vehicle to check whether the vehicle is already owned. The *getOwner* method must be declared as unguarded so that it can run in parallel with the *init* method that is already active for the vehicle in question.

The Guard Instruction

The *guard* instruction acquires or releases exclusive control of an object's variable pool. This allows a method to alternate between exclusive access to all variables and parallel execution with other methods (see Figure 86).

```
/* method code */
...
guard on                    /* acquire exclusive control */
                            /* wait if another method has exclusive control */
...
x = x + 1                   /* process variables */
...
guard off                   /* release exclusive control, allow others */
...
guard on when z > 0         /* acquire exclusive control when
                               variable z is greater than zero */
...                         /* ===> wait until z changes to positive */
```

Figure 86. Concurrency with Guard

For examples of the usage of `guard on when` see "Coding Stored Procedures with Object REXX" on page 112 and "Philosophers' Forks" on page 186.

Examples of Early Reply with Unguarded and Guarded Methods

The example that follows shows what happens when early reply is used to achieve intraobject concurrency. We start with completely unguarded methods, which utilize full intraobject concurrency (see Figure 87).

```
/* xmpreply.cmd          Early reply example - OS/2 window           */

   repetitions = 3                                 /* may change       */
   call RxFuncAdd 'SysSleep', 'RexxUtil', 'SysSleep'
   lvar = '(Main)'                                 /* init variables   */
   cvar = 'Main'
   cobj = .example~new                             /* allocate object  */
   say lvar cobj~repeat1(repetitions, cvar)        /* - invoke repeat1 */
   call SysSleep 1
   say lvar 'Var =' cvar
   return

   ::class example

   ::method repeat1 unguarded                      /* repeat1 method   */
     expose reps cvar
     use arg reps, cvar
     lvar = '(R1)'
     say lvar self~repeat2                         /* - invoke repeat2 */
     reply 'Reply from' lvar                       /* - early reply    */
     do reps                                       /* - loop           */
        say lvar '- Var =' cvar
        cvar = 'R1'
     end

   ::method repeat2 unguarded                      /* repeat2 method   */
     expose reps cvar
     lvar = '(R2)'
     say lvar self~repeat3                         /* - invoke repeat3 */
     reply 'Reply from' lvar                       /* - early reply    */
     do reps                                       /* - loop           */
        say lvar '- Var =' cvar
        cvar = 'R2'
     end

   ::method repeat3 unguarded                      /* repeat3 method   */
     expose reps cvar
     lvar = '(R3)'
     reply 'Reply from' lvar                       /* - early reply    */
     do reps                                       /* - loop           */
        say lvar '- Var =' cvar
        cvar = 'R3'
     end
```

Figure 87. Example of Early Reply with Unguarded and Guarded Methods

The program contains a main routine that creates an object and sends a *repeat1* message to it. The expected result (a string) is displayed with *say*. The main routine sleeps for one second and then displays the variable *cvar*.

If we look at the object class *example* and the three methods *repeat1, repeat2,* and *repeat3*, we see they are all unguarded. Thus all three can run concurrently on the same object. The object's variables *reps* and *cvar* are concurrently available to all three methods.

The first method, *repeat1*, initializes the variable subpool with the arguments from the main routine. It immediately calls the *repeat2* method for the same object and waits.

The *repeat2* method calls the *repeat3* method for the same object and waits. We now have four invocations stacked on the activity chain (the main routine, repeat1, repeat2, and repeat3). When the *repeat3* method issues a *reply*, a new activity chain (thread) is started for the *repeat3* method, and control goes back to the next instruction in method *repeat2* (the one following the invocation of method *repeat3*). Similarly, *repeat2* uses an early reply to *repeat1*, and *repeat1* uses an early reply to the main routine.

Running the program produces the kind of output shown in Figure 88. In the first run (left column) we leave all methods unguarded; in the middle column, all methods are guarded (remove the keyword unguarded from the source code); and in the right column, we use a mix of guarded and unguarded methods.

Methods:	**UNGUARDED**	**GUARDED**	**MIXED**
repeat1:	unguarded	guarded	unguarded
repeat2:	unguarded	guarded	guarded
repeat3:	unguarded	guarded	guarded

output:			
	(R2) Reply from (R3)	(R2) Reply from (R3)	(R2) Reply from (R3)
	(R3) - Var = Main	(R1) Reply from (R2)	(R1) Reply from (R2)
	(R1) Reply from (R2)	(Main) Reply from (R1)	(R2) - Var = Main
	(R3) - Var = R3	(R1) - Var = Main	(Main) Reply from (R1)
	(R2) - Var = R3	(R1) - Var = R1	(R2) - Var = R2
	(Main) Reply from (R1)	(R1) - Var = R1	(R1) - Var = R2
	(R3) - Var = R3	(R3) - Var = R1	(R2) - Var = R2
	(R1) - Var = R3	(R3) - Var = R3	(R1) - Var = R1
	(R2) - Var = R2	(R3) - Var = R3	(R3) - Var = R2
	(R1) - Var = R1	(R2) - Var = R3	(R1) - Var = R1
	(R2) - Var = R2	(R2) - Var = R2	(R3) - Var = R3
	(R1) - Var = R1	(R2) - Var = R2	(R3) - Var = R3
	(Main) Var = Main	(Main) Var = Main	(Main) Var = Main

Notes:	(1)	(2)	(3)

Figure 88. Sample Output of Early Reply with Unguarded and Guarded Methods

Notes:

1. The sequence in which this output appears will change each time the program is run. The three methods run in parallel and compete for processor time. Which runs when is up to the OS/2 scheduler.
2. Once a method gets control, it will run to completion. Only after this, can another one continue. R1 gets control first from the reply of R2, and finishes its work.
3. Because method *repeat1* is unguarded, it can run in parallel with *repeat2*, whereas *repeat3* must wait until *repeat2* is finished.

Other combinations of guarded and unguarded methods can be tried.

Philosophers′ Forks

Let′s join our Hacurs team again to see a visual demonstration of Object REXX′s concurrency capabilities.

On the Monday morning after a rainy weekend in October, Hanna came into the office beaming.

“Hi Hanna, why the big smile?” called out Steve. “Are you up to something?”

“I spent the weekend playing with Object REXX′s concurrency facilities. Let me show you what I built. Do you know the philosophers′ forks problem?” she asked.

“Hmm,” said Curt, “isn′t that the one with five philosophers sitting around a table trying to grab forks and eat in turn?”

“Yes, that′s the one,” replied Hanna with a smile.

The philosophers′ forks

- Five philosophers sit around a table. Each one goes through a cycle of sleeping and eating.
- There is a fork between each philosopher, so there are five forks as well.
- To eat, a philosopher has to grab the forks on both sides. If a fork has already been taken by the philosopher on the other side of the fork, the philosopher must wait until that fork is free.
- The philosophers reach for forks in no particular order, and wait even if the first fork they try to grab is not available.
- When they have finished eating, the philosophers put down both forks and go back to sleep.
- The times they sleep and eat vary randomly around given values.

Philosophers′ Forks in an OS/2 Window

“I wasted my weekend watching the fifth game of the World Series,” said Steve. “It didn′t produce a winner, and then I missed the final game because I had to go to a cousin′s wedding. So how did you implement the philosophers′ forks, Hanna?” he asked.

“I developed a main program to control the operation, and two classes—one for philosophers and one for forks,” said Hanna. She opened her ThinkPad and fired it up. Steve and Curt gathered round her desk.

“The main program sets the parameters, creates the forks and philosophers, and then runs all philosophers concurrently using the *start* method,” Hanna explained (see Figure 89 on page 187). “Then it just waits for everything to finish.”

```
arg parms                                       /* parameters default values: */
if parms = ''  then parms = '8 6 any 2'         /* - sleep = 8 sec, eat = 6   */
parse var parms psleep peat side repeats        /* - grab forks from ANY side */
T.eat = peat                                    /* - run 2 cycles             */
T.sleep = psleep
T.veat = trunc(peat / 2)                        /* random variations          */
T.vsleep = trunc(psleep / 2)                    /* - for eat and sleep times  */
if      side = 'L' then side = 100  /*left*/   /* fork side can be Left,     */
else if side = 'R' then side = 0    /*right*/  /* - Right, or Any (random)   */
                   else side = 50   /*random*/
f1 = .fork~new(1)                               /* allocate 5 forks           */
f2 = .fork~new(2)
f3 = .fork~new(3)
f4 = .fork~new(4)
f5 = .fork~new(5)
p1 = .phil~new(1,f5,f1)                         /* allocate 5 philosophers    */
p2 = .phil~new(2,f1,f2)
p3 = .phil~new(3,f2,f3)                         /* tell them which forks      */
p4 = .phil~new(4,f3,f4)                         /* they must use              */
p5 = .phil~new(5,f4,f5)
m1 = p1~start("run",T.,side,repeats)            /* start the 5 philosophers   */
m2 = p2~start("run",T.,side,repeats)            /* concurrently               */
m3 = p3~start("run",T.,side,repeats)
m4 = p4~start("run",T.,side,repeats)
m5 = p5~start("run",T.,side,repeats)
m1~result                                       /* wait for the 5 message     */
m2~result                                       /* objects to complete        */
m3~result
m4~result
m5~result
return 0
```

Figure 89. Philosophers' Forks: Main Program

"I'm surprised how straightforward it looks, Hanna," said Steve.

"The philosopher class is also quite simple," said Hanna (see Figure 90 on page 188). "The *init* method stores references to the fork objects and prepares an output string for indentation. The *run* method loops through sleeping and eating, picking up the forks, and laying them down again."

```
::class phil

::method init                                   /* initialization             */
   expose num rfork lfork out                   /* store fork objects         */
   use arg num, rfork, lfork
   out = ' '~copies(15*num-14)                  /* prepare output indentation */

::method run                                    /* run through the cycle      */
   expose num rfork lfork out
   use arg T., side, repeats
   x =  random(1,100,time('S')*num)
   say out 'Philosopher-'num                    /* announce who you are       */
   do i=1 to repeats
      stime = random(T.sleep-T.vsleep,T.sleep+T.vsleep)
      say out 'Sleep-'stime                     /* announce you are sleeping  */
      rc=SysSleep(stime)                        /* sleep some random seconds  */
      say out 'Wait'                            /* announce wait for forks    */
      if random(1,100) < side then do           /* which fork first ?         */
         lfork~pickup(1,'left',num)             /*  - pick up left fork       */
         rfork~pickup(2,'right',num)            /*    then    right           */
         end
      else do
         rfork~pickup(1,'right',num)            /*  - pick up right fork      */
         lfork~pickup(2,'left',num)             /*    then    left            */
      end
      etime = random(T.eat-T.veat,T.eat+T.veat)
      say out 'Eat-'etime                       /* announce you are eating    */
      rc=SysSleep(etime)                        /* eat some random seconds    */
      lfork~laydown(num)                        /* lay down both forks        */
      rfork~laydown(num)
   end
   say out 'Done'                               /* announce you are done      */
   return 1
```

Figure 90. Philosophers' Forks: Philosopher Class

"It may look simple to you, Hanna," said Curt, "but that's because you wrote it. Still, it is pretty short. Where's the magic?"

"My secrets are hidden in the fork class," said Hanna. "That's where the concurrency and synchronization are managed, but Object REXX makes it pretty easy to do" (see Figure 91).

```
::class fork

::method init                                   /* initialization             */
   expose used
   used = 0                                     /* initialize "used" flag     */

::method pickup                                 /* pick up the fork          */
   expose used
   guard on when used = 0                       /* WAIT until "used" flag = 0 */
   used = 1                                     /* set "used" flag "occupied" */

::method laydown unguarded                      /* pay down the fork          */
   expose used
   used = 0                                     /* set "used" flag to "free"  */
```

Figure 91. Philosophers' Forks: Fork Class

“Ah,” said Steve, “now it starts to get interesting. Walk us through this code, Hanna.”

“The fork’s *used* variable is the key,” Hanna explained. “It’s initially set to zero, indicating that the fork is free. The *pickup* method changes it to 1, but it contains a *guard* instruction which forces it wait until the fork is free, which happens in the *laydown* method.”

“Sounds good,” said Curt, “but let’s see it in action!”

Hanna started the program, and soon the window was filled with announcements of the philosophers’ activities (see Figure 92).

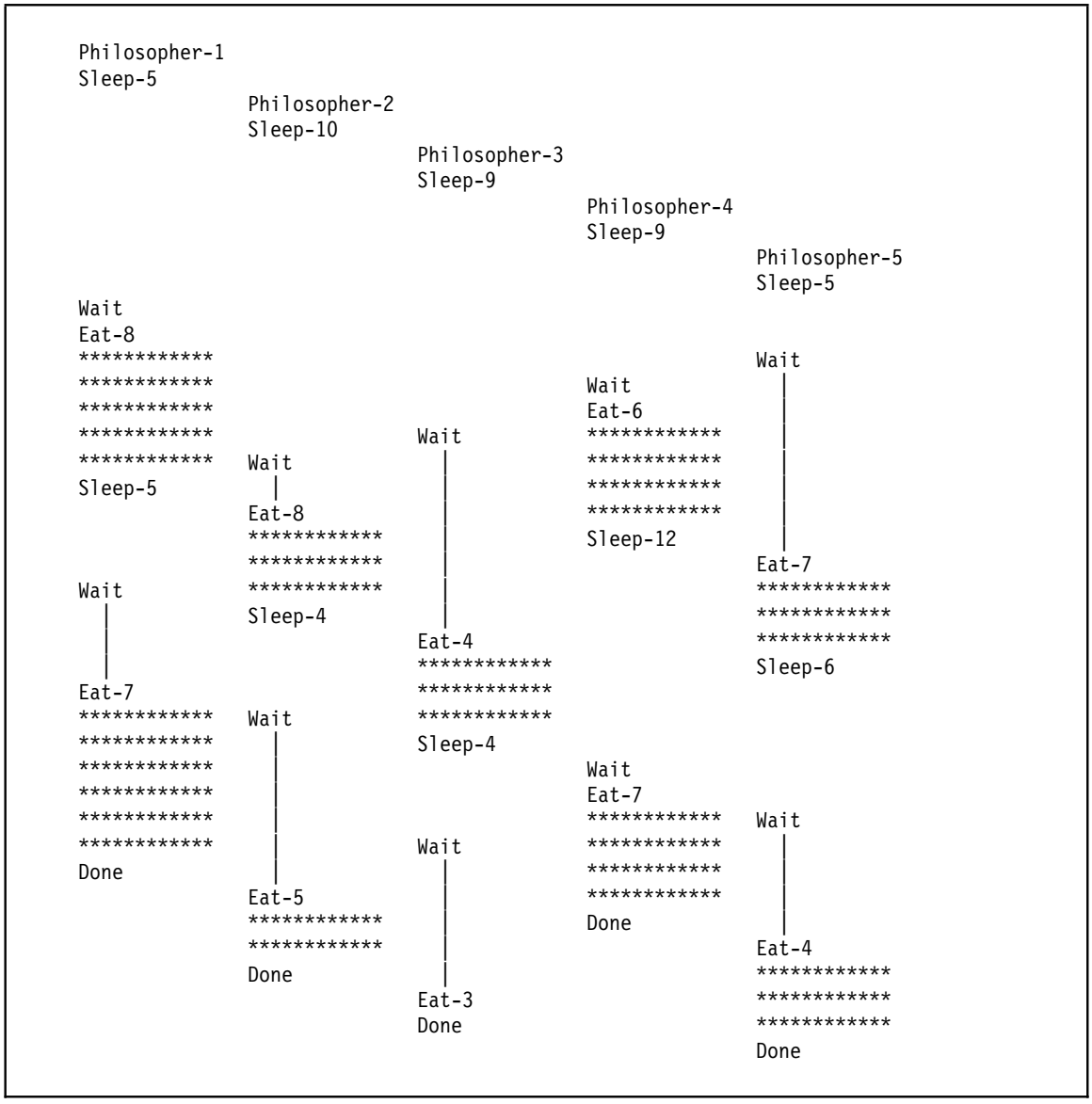


Figure 92. Philosophers’ Forks: Sample Output. The output has been enhanced with blocks of asterisks (*) to indicate eating and vertical lines to indicate waiting. No more than two philosophers can eat at the same time because of the shared forks.

“Cool!” said Steve. “I wonder if we could use a GUI builder to make this look a bit more snazzy.”

“Sounds like a great idea, Steve,” said Hanna. “Why don’t you try? You’ve got Classy Cars running so smoothly you probably don’t have anything better to do this week.”

“Me and my big mouth!” said Steve with a rueful smile. “I guess I walked straight into that one. You knew that I would, didn’t you. You were just waiting for me to make that suggestion!” he accused Hanna. Her smile broadened, but she said nothing.

Visualizing Philosophers’ Forks with a GUI

The next day Steve came to the office late but looking rather smug. He called Hanna and Curt over to his desk to show off the colorful GUI version of the philosophers’ forks. He started his ThinkPad and clicked on an icon to launch the application. A window opened and displayed Steve’s inventive representation of the classical philosophers’ forks problem (see Figure 93).

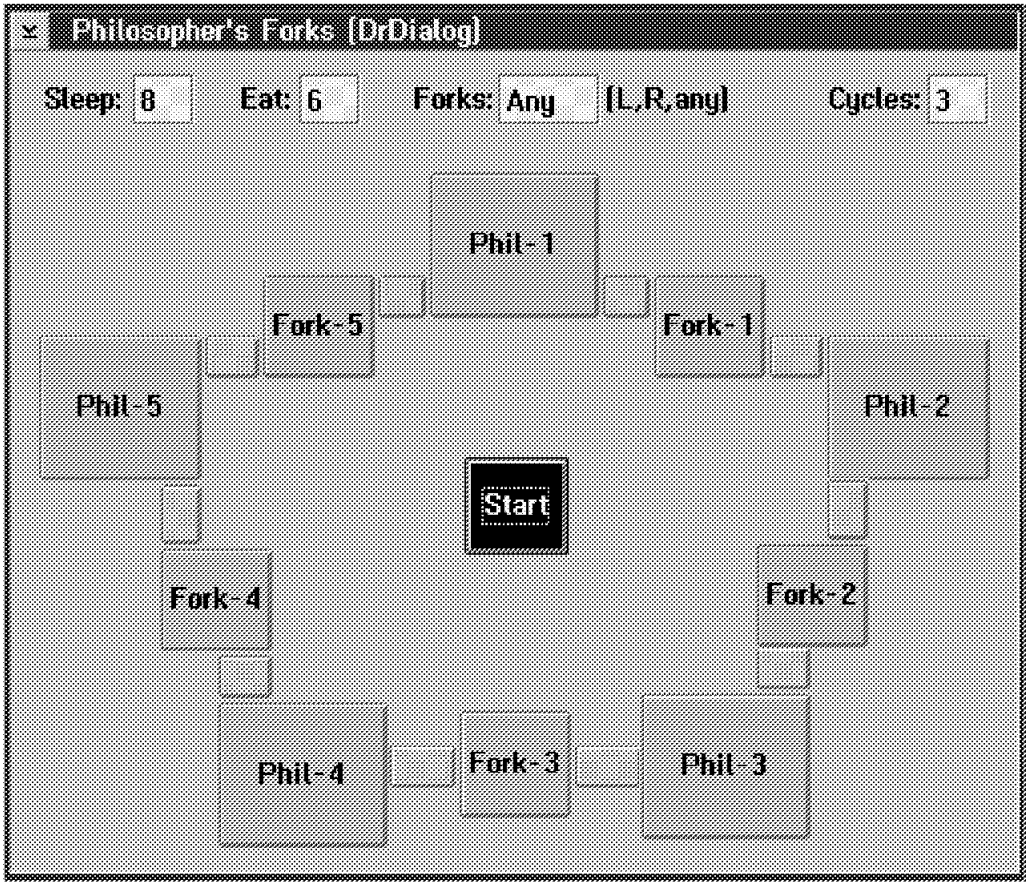


Figure 93. Philosophers’ Forks: GUI Layout

“I implemented philosophers and forks as push buttons, and even drew little buttons between the philosophers and the forks to indicate their arms grabbing the forks,” said Steve.

“That looks great, but what happens when you run it?” asked Hanna.

Steve clicked on the **Start** button, and suddenly the colors and text on the push buttons started changing. Hanna and Curt watched the unfolding story in admiration (see Figure 94 on page 191).

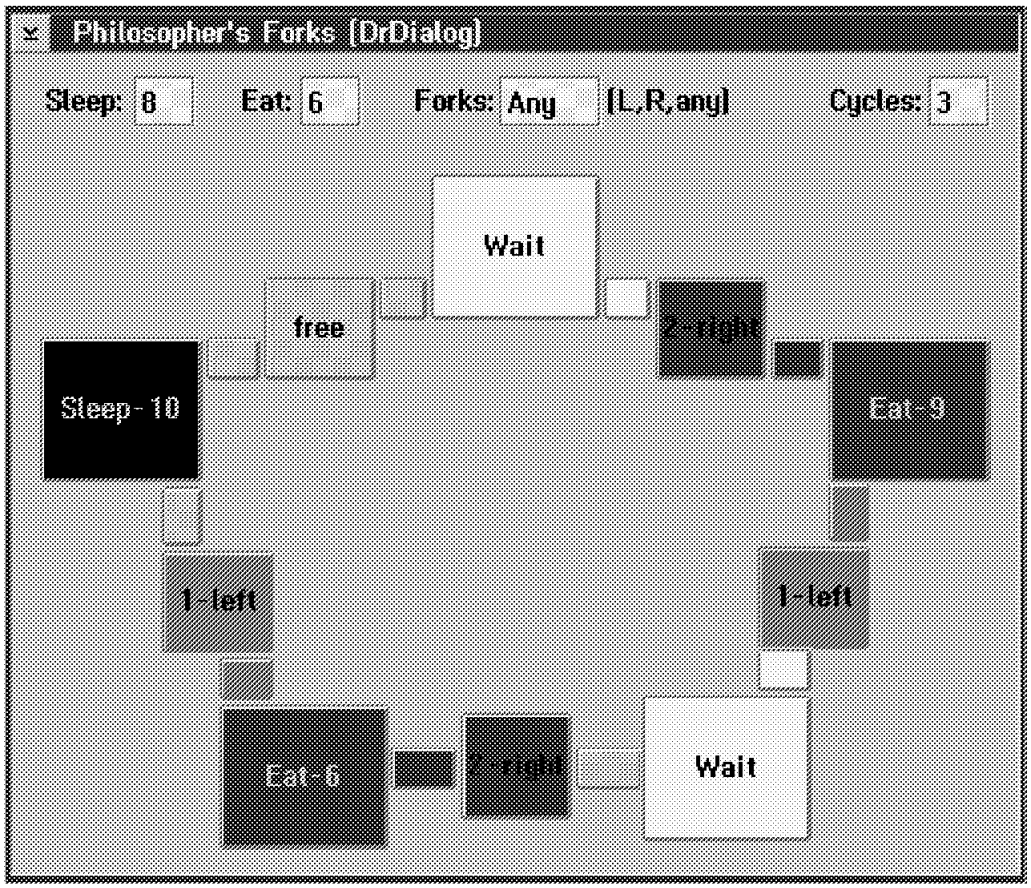


Figure 94. Philosophers′ Forks: GUI Run

“The philosophers are black while sleeping,” Steve explained.

“They turn white while waiting for a fork,” said Hanna.

“And they turn red while eating,” remarked Curt. “The food must be very spicy!”

“The forks also change colors,” added Steve. “They turn green or blue, depending on whether they are used as a left or right fork. They turn grey when they′re not in use.”

As the philosophers completed their specified number of sleeping and eating cycles, they disappeared from the screen one by one. But when all had finished, the screen was reset with all the philosophers and forks back in their initial colors.

“Marvelous,” exclaimed Hanna, “that looks much better than my OS/2 window version.”

“Can it run any faster?” asked Curt.

“No problem,” replied Steve, “I′ll set the sleep and eat times to 1 second each, and set it going again.”

Steve did so. The buttons changed color now much faster than before, and the three cycles completed in less than 15 seconds.

“Now let’s really soup this up,” said Steve. He set the times to 0 seconds and started again. Colors and text flashed rapidly across the buttons, and in just about 5 seconds it was all over.

Steve then set the number of cycles to 30 and started the application. Nothing happened. Steve turned white, as white as the five philosophers who were all waiting for a fork.

“What’s happening?” asked Curt.

“It’s a deadlock!” exclaimed Hanna. “Look, all the forks are green. All the philosophers happened to grab their left forks at the same time, and now they’re all waiting for their right forks. How do you get out of this mess, Steve?”

Steve closed the window while he searched for a solution. “I’ll have to add an interrupt button to take away the forks from the philosophers and end the deadlock,” he said.

“That should do the trick,” said Hanna, “and it will also allow you to interrupt the program while it’s running.”

“That won’t take long to do,” said Steve.

The three members of the Hacurs team enjoyed a hot, spicy lunch at a little Mexican restaurant near their office. Shortly after returning to his desk, Steve called Hanna and Curt over and showed them the upgraded application.

“How do you interrupt the application?” asked Hanna.

Steve just smiled and clicked on the **Start** button. It disappeared, and a red **Interrupt** button appeared in its place as the application started running.

“Sneaky!” said Hanna.

“When I click on the **Interrupt** button, the philosophers quit their cycle at the end of their current sleep or eat phase, and that makes the application stop,” Steve explained, demonstrating this function as he spoke.

“Let’s see if you can break a deadlock,” said Curt. “Can you force one?”

“Sure,” Steve responded. “I’ll set the Forks field to L (left). This will make all philosophers grab the left fork and we’ll get a deadlock.”

Steve followed this procedure and was able to create a deadlock and then break it by using the **Interrupt** button.

The philosophers’ forks in pictures

After we finished writing this book, we created a funny version of the application, using bitmaps and pictures. The funny application is shipped with the other samples.

The funny application is stored in subdirectory `PHILFORK\ZdialFun`. It uses Dr. Dialog as the GUI, but instead of colored push buttons, bitmaps of faces, hands, and forks are shown. When the philosophers are eating, they become real people, and the cake in the middle slowly disappears.

GUI Design of the Philosophers' Forks with Dr. Dialog

"Were you able to reuse the logic I developed for the OS/2 window?" asked Hanna.

"Oh yes, almost all of it," replied Steve. "I needed new code to change the color and text of all the buttons. I wanted to put as little code in the GUI builder as possible, so I put your main logic into a *starter* class and all the GUI methods into a *GUI* class. I put the class definitions into an external file, using the same approach we took for the car dealer application."

Steve continued, "The GUI builder contains only three little pieces of code:

1. Initialization when the window is opened,
2. Clicking on the Start button, and
3. Clicking on the Interrupt button."

Steve opened the GUI builder and showed the code to Hanna and Curt (see Figure 95).

```
Window open:      address "NULL"
                  parms = '8 6 Any 3'                    /* default values         */
                  parse var parms sleep eat side repeats
                  teat.text(eat)                         /* set entry fields       */
                  tsleep.text(sleep)
                  trepeat.text(repeats)
                  tfork.text(side)

                  .gui~initialize                        /* initialize GUI class   */
                  startit = .starter~new                 /* prepare starter object */

Start button:     eat = teat.text()                      /* get entry fields       */
                  sleep = tsleep.text()
                  side = translate(left(tfork.text(),1))
                  repeats = trepeat.text()
                                                         /* run the starter object */
                  smsg = startit~start("runphils",eat,sleep,side,repeats)

Interrupt button: startit~interrupt                      /* interrupt method       */
```

Figure 95. Philosophers' Forks GUI: GUI Builder Logic

"The *starter* class comes from your old main program, Hanna," Steve continued. "I added an *interrupt* method to lay down all forks. I set a switch in the .local environment, and interrogate this switch in the interrupt method of the philosophers" (see Figure 96 on page 194).

```
::class starter

::method init                                          /* create philosophers and forks */
   expose f1 f2 f3 f4 f5 p1 p2 p3 p4 p5
   call RxFuncAdd 'SysSleep', 'RexxUtil', 'SysSleep'
   f1 = .fork~new(1)
   f2 = .fork~new(2)
   f3 = .fork~new(3)
   f4 = .fork~new(4)
   f5 = .fork~new(5)
   p1 = .phil~new(1,f5,f1)
   p2 = .phil~new(2,f1,f2)
   p3 = .phil~new(3,f2,f3)
   p4 = .phil~new(4,f3,f4)
   p5 = .phil~new(5,f4,f5)

::method runphils                                      /* start the 5 philosophers */
   expose p1 p2 p3 p4 p5
   use arg T.eat, T.sleep, side, repeats
   .gui~hideStart                                      /* hide the start button */
   T.veat = trunc(T.eat / 2)
   T.vsleep = trunc(T.sleep / 2)
   if      side = 'L' then side = 100  /*left*/
   else if side = 'R' then side = 0    /*right*/
                      else side = 50   /*random*/
   .local[INT.FLAG] = 0                                /* initialize interrupt flag */
   do i=1 to 5
      .gui~colorFork(i,'free','free')
   end
   m1 = p1~start("run",T.,side,repeats)                /* start them here */
   m2 = p2~start("run",T.,side,repeats)
   m3 = p3~start("run",T.,side,repeats)
   m4 = p4~start("run",T.,side,repeats)
   m5 = p5~start("run",T.,side,repeats)
   m1~result                                           /* wait for finish */
   m2~result
   m3~result
   m4~result
   m5~result
   do i=1 to 5
      .gui~colorPhil(i,'black','phil','Phil-'i,'show')
      .gui~colorFork(i,'fork','Fork-'i)
   end
   .gui~showStart                                      /* show start button */
   return 0

::method interrupt unguarded                           /* interrupt button clicked */
   expose f1 f2 f3 f4 f5
   .local[INT.FLAG] = 1                                /* set the interrupt flag */
   f1~laydown                                          /* lay down all forks */
   f2~laydown
   f3~laydown
   f4~laydown
   f5~laydown
```

Figure 96. Philosophers' Forks GUI: Starter Class

“I took your philosopher class and added calls to the GUI class to manage the color and text of all the buttons,” said Steve. “I also added an interrupt method that is invoked after both eating and sleeping, to check whether the user has clicked on the Interrupt button” (see Figure 97).

```
::class phil

::method init
   expose num rfork lfork
   use arg num, rfork, lfork

::method run
   expose num rfork lfork
   use arg T., side, repeats
   x =  random(1,100,time('S')*num)
   do i=1 to repeats
      stime = random(T.sleep-T.vsleep,T.sleep+T.vsleep)
      .gui~colorPhil(num,'yellow','sleep','Sleep-'stime)
      rc=SysSleep(stime)
      if self~interrupt then return 0
      .gui~colorPhil(num,'black','wait','Wait')
      if random(1,100) < side then do
         lfork~pickup(1,'left',num)
         rfork~pickup(2,'right',num)
      end
      else do
         rfork~pickup(1,'right',num)
         lfork~pickup(2,'left',num)
      end
      if self~interrupt then return 0
      etime = random(T.eat-T.veat,T.eat+T.veat)
      .gui~colorPhil(num,'yellow','eat','Eat-'etime)
      rc=SysSleep(etime)
      lfork~laydown(num)
      rfork~laydown(num)
      if self~interrupt then return 0
   end
   .gui~colorPhil(num,'black','phil','Phil-'num,'hide')
   return 1

::method interrupt
   expose num rfork lfork
   if .local[INT.FLAG] = 0 then return 0        /*** check the interrupt flag ***/
   lfork~laydown(num)
   rfork~laydown(num)
   .gui~colorPhil(num,'yellow','sleep','Interrupt')
   return 1
```

Figure 97. Philosophers' Forks GUI: Philosopher Class

“I took your fork class and added a small amount of code to invoke the GUI class for color and text changes,” Steve continued (see Figure 98).

```
::class fork

::method init
   expose num used
   use arg num
   used = 0

::method pickup
   expose num used
   use arg seq, leftright, pnum
   .gui~colorLink(num,'wait',pnum)
   guard on when used = 0
   used = 1
   .gui~colorFork(num,leftright,seq'-'leftright)
   .gui~colorLink(num,leftright,pnum)

::method laydown unguarded
   expose num used
   use arg pnum
   .gui~colorFork(num,'free','free')
   if pnum \= '' then .gui~colorLink(num,'free',pnum)
   used = 0
```

Figure 98. Philosophers′ Forks GUI: Fork Class

“The GUI class handles all the changes in color and text, and also hides and shows the Start and Interrupt buttons when needed” (see Figure 99 on page 197).

“That′s a smart design, Steve,” said Hanna. “By separating all the GUI logic from the model, you′ve made it very easy to implement the application with VisPro/REXX or Watcom VX·REXX. The only changes would be in the GUI class and the three interactions in the GUI builder.”

“Hey that sounds like a great idea!” exclaimed Steve. “Why don′t you try it out, Hanna? As you say, it should be really easy. And you don′t have anything better to do this week, do you?”

Hanna tried to give Steve a hard glare, but her lips kept quivering into a smile. He was only returning the favor she had done him the day before.

“Well—I′m prepared to tackle VisPro/REXX if Curt will do Watcom VX·REXX,” said Hanna. She and Steve turned to look expectantly at Curt.

“Hey, why drag me into this fight,” he said, “you two are doing so well on your own.” But their gazes did not waver from his face, and after a while he said, “Look, I can′t promise anything. Unlike you two loafers, I′ve got to chase around the marketplace and find new business opportunities. But I′ll have a look at it. Just tell me what server subdirectory you′ve put this stuff into.”

This offer was met by cheers from Hanna and Steve, and the team settled down to work.

```
::class gui

::method initialize class
   expose color.
   color.black  = '#0 0 0'       /* - Black fg */
   color.yellow = '#255 255 0'   /* - Yellow fg */
   color.sleep  = '#0 0 0'       /* - Black     */
   color.wait   = '#255 255 255' /* - White     */
   color.eat    = '#255 0 0'     /* - Red       */
   color.free   = '#200 200 200' /* - Gray      */
   color.left   = '#0 255 0'     /* - Green     */
   color.right  = '#0 0 255'     /* - Blue      */
   color.phil   = '#0 255 255'   /* - Turqoise  */
   color.fork   = '#255 255 0'   /* - Yellow    */

::method colorPhil class
   expose color.
   use arg num, fcol, bcol, text, hid
   address "NULL"
   interpret "phil"num".color('+',value('color.'fcol))"
   interpret "phil"num".color('-',value('color.'bcol))"
   interpret "phil"num".text(text)"
   if hid = 'hide' then interpret "phil"num".hide()"
   if hid = 'show' then interpret "phil"num".show()"

::method colorFork class
   expose color.
   use arg num, col, text
   address "NULL"
   interpret "fork"num".color('-',value('color.'col))"
   interpret "fork"num".text(text)"

::method colorLink class
   expose color.
   use arg num, col, pnum
   address "NULL"
   if pnum = num
      then PBid = word('pf11 pf22 pf33 pf44 pf55',num)
      else PBid = word('pf21 pf32 pf43 pf54 pf15',num)
   interpret PBid".color('-',value('color.'col))"

::method showStart class
   address "NULL" interrupt.hide()
   address "NULL" start.show()

::method hideStart class
   address "NULL" start.hide()
   address "NULL" interrupt.show()
```

Figure 99. Philosophers' Forks GUI: GUI Class for Dr. Dialog

GUI Design of the Philosophers′ Forks with VisPro/REXX

The next morning Curt came in very late, looking tired. Hanna was able to show Steve and Curt the philosophers′ forks application running with a VisPro/REXX GUI. It looked identical to the Dr. Dialog version and appeared to behave exactly the same way too.

"I have to invoke the GUI initialize method with the current *window* variable," Hanna explained. "I need the window identification in the class to set color and text. And that′s all there is to it. As you can see, it follows pretty much the same pattern as your Dr. Dialog logic, Steve" (see Figure 100).

"It looks great, Hanna," Steve replied. He turned to Curt. "So, Mr. Ace Salesman, did you bring in any new business last night, or did you get a chance to look at the Watcom VX·REXX version of this application?"

"As it happened, my daughter woke us at 3 a.m. last night and I couldn′t get back to sleep," said Curt. "I had a stab at porting the code to Watcom VX·REXX, and this is how it turned out."

```
::class gui

::method initialize class
   expose color. window
   use arg window
   color.black  = 'BLACK'                /* - Black foreground       */
   color.yellow = 'YELLOW'               /* - Yellow foreground      */
   color.sleep  = 0                      /* #0   0   0   - Black     */
   color.wait   = 255*65536+255*256+255  /* #255 255 255 - White     */
   color.eat    = 255*65536              /* #255 0   0   - Red       */
   color.free   = 200*65536+200*256+200  /* #200 200 200 - Gray      */
   color.left   = 255*256                /* #0   255 0   - Green     */
   color.right  = 255                    /* #0   0   255 - Blue      */
   color.phil   = 255*256+255            /* #0   255 255 - Turqoise  */
   color.fork   = 255*65536+255*256      /* #255 255 0   - Yellow    */

::method colorPhil class
   expose color. window
   use arg num, fcol, bcol, text, hid
   Call VpItem window,'PHIL'||num,'FORECOLOR',value('color.'fcol)
   Call VpItem window,'PHIL'||num,'BACKCOLORRGB',value('color.'bcol)
   Call VpSetItemValue window,'PHIL'||num,text
   if hid = 'hide' then Call VpItem window,'PHIL'||num,'HIDE'
   if hid = 'show' then Call VpItem window,'PHIL'||num,'SHOW'

::method colorFork class
   expose color. window
   use arg num, col, text
   Call VpItem window,'FORK'||num,'BACKCOLORRGB',value('color.'col)
   Call VpSetItemValue window,'FORK'||num,text

::method colorLink class
   expose color. window
   use arg num, col, pnum
   if pnum = num
      then PBid = word('PF11 PF22 PF33 PF44 PF55',num)
      else PBid = word('PF21 PF32 PF43 PF54 PF15',num)
   Call VpItem window, PBid, 'BACKCOLORRGB',  value('color.'col)
```

Figure 100 (Part 1 of 2). Philosophers′ Forks GUI: GUI Class for VisPro/REXX

```
::method showStart class
   expose window
   Call VpItem window, 'INTERRUPT', 'HIDE'
   Call VpItem window, 'START', 'SHOW'

::method hideStart class
   expose window
   Call VpItem window, 'START', 'HIDE'
   Call VpItem window, 'INTERRUPT', 'SHOW'
```

Figure 100 (Part 2 of 2). Philosophers' Forks GUI: GUI Class for VisPro/REXX

GUI Design of the Philosophers' Forks with Watcom VX·REXX

Curt flipped open his ThinkPad and snapped it out of its hibernation. He clicked on an icon, and the now-familiar image of the philosophers' forks GUI implementation opened on the screen. Curt took the application through its paces, and the philosophers dined and slept once again. Hanna and Steve placed their ThinkPads alongside Curt's. There were no visible differences between the three implementations of the application.

"Well done, Curt!" said Hanna. "Show us how you coded it."

Curt started up Watcom VX·REXX and opened the philosophers' forks project. "The basic logic turned out pretty much the same as yours, Steve," he said (see Figure 101 on page 200).

"But then I hit a snag," Curt continued. "Every object in Watcom VX·REXX has a *name* property, which is assigned a unique value when it's created. These object names are global within a file but are hidden between files, so it's impossible to use them between different Object REXX concurrent activities. But in addition to the name property, every object has a unique internal name assigned when it's created. This isn't available at design time because the internal name of an object is assigned only at run time. But the internal name can be obtained through the *self* property of the object. To be able to pick up the internal names and use them, I had to store all the GUI names into a stem (guiname.), which I passed to the GUI initialize method":

```
gui_names = .array~of(PB_11,PB_21,PB_22,PB_32,PB_33,PB_43,PB_44,PB_54,PB_55,PB_15, ,
                      PB_Phil1,PB_Phil2,PB_Phil3,PB_Phil4,PB_Phil5,PB_Interrupt, ,
                      PB_Fork1,PB_Fork2,PB_Fork3,PB_Fork4,PB_Fork5,PB_Start)
do iname over gui_names
   guiname.iname = VRGet(iname,"Self")
end
.gui~initialize(guiname.)
```

"Great job, Curt," said Steve. "If you'd been a bit quicker to volunteer, you might have had an easier job on your hands. But this implementation looks pretty neat to me."

"It looks like we've all come up with the goods," said Hanna. "As a reward, why don't we treat ourselves to a good lunch?"

"That's a great idea!" said Steve and Curt. They turned on the voice mail system, closed the office, and set out for their favorite restaurant.

```
::class gui

::method initialize class
   expose color. guiname.
   use arg guiname.
   color.black  = "(0,0,0)"             /* - Black fg  */
   color.yellow = "(255,255,0)"         /* - Yellow fg */
   color.sleep  = "(0,0,0)"             /* - Black     */
   color.wait   = "(255,255,255)"       /* - White     */
   color.eat    = "(255,0,0)"           /* - Red       */
   color.free   = "(200,200,200)"       /* - Gray      */
   color.left   = "(0,255,0)"           /* - Green     */
   color.right  = "(0,0,255)"           /* - Blue      */
   color.phil   = "(0,255,255)"         /* - Turqoise  */
   color.fork   = "(255,255,0)"         /* - Yellow    */

::method colorPhil class
   expose color. guiname.
   use arg num, fcol, bcol, text, hid
   Call VRSet value('guiname.PB_PHIL'num), "ForeColor", value('color.'fcol), ,
                                       "BackColor", value('color.'bcol), ,
                                       "Caption", text
   if hid = 'hide' then Call VRSet value('guiname.PB_PHIL'num), "Visible", 0
   if hid = 'show' then Call VRSet value('guiname.PB_PHIL'num), "Visible", 1

::method colorFork class
   expose color. guiname.
   use arg num, col, text
   Call VRSet value('guiname.PB_FORK'num), "BackColor", value('color.'col),  ,
                                       "Caption", text

::method colorLink class
   expose color. guiname.
   use arg num, col, pnum
   if pnum = num
      then PBid = word('PB_11 PB_22 PB_33 PB_44 PB_55',num)
      else PBid = word('PB_21 PB_32 PB_43 PB_54 PB_15',num)
   Call VRSet value('guiname.'PBid), "BackColor", value('color.'col)

::method showStart class
   expose guiname.
   Call VRSet value('guiname.'PB_INTERRUPT), "Visible", 0
   Call VRSet value('guiname.'PB_START), "Visible", 1

::method hideStart class
   expose guiname.
   Call VRSet value('guiname.'PB_START), "Visible", 0
   Call VRSet value('guiname.'PB_INTERRUPT), "Visible", 1
   return
```

Figure 101. Philosophers' Forks GUI: GUI Class for Watcom VX·REXX

Part 4. Installing the Sample Applications

Chapter 14. Installing and Running the Sample Applications

In this chapter, we discuss the installation of Object REXX and how to install and run the sample applications of this redbook.

Content of the CD

The CD distributed with this redbook contains:

- Object REXX, for installation on your machine
- The sample applications, ready to run from the CD
- The sample applications, for installation on your machine

Installation of Object REXX

Object REXX must be installed on your machine to run any of the sample applications. Run the *INSTALL* program in the CD directory OBJREXX and follow the instructions of the installation program.

Make Object REXX the default REXX by rebooting the machine, then proceed with the sample applications.

Object REXX provides the *SWITCHRX* command to switch between classic REXX and Object REXX. Reboot is necessary after each switch.

Running the Sample Applications from the CD

The CD directories CARDEAL and PHILFORK contain an executable version of the sample applications.

Use the *CAR-RUN* command in the CARDEAL directory to start any of the car dealer applications, or run the *PHILFORK* programs in any of the subdirectories of PHILFORK.

Alternatively, start the *RED-RUN* program in the CARDEAL directory, then play with the sample applications as described in “Running the Sample Applications” on page 213.

Note: You can run the car dealer application only with FAT persistence and without the SOM Part class. We strongly recommend to install the sample applications on your machine and experiment with the DB2 version of the car dealer application.

Installing the Sample Applications

The sample applications are delivered on the CD in the CAR-INST directory as five .ZIP files and an installation program:

- CARDEAL.ZIP - car dealer base application
- CARMED1.ZIP - multimedia data (factsheets, video)
- CARMED2.ZIP - multimedia data (bitmaps)
- CARMED3.ZIP - multimedia data (audio)
- PHILFORK.ZIP - philosophers' forks application
- INSTALL.CMD - installation command—start here
- RED_INST.EXE - installation program
- UNZIP32.EXE - unzip program
- READ.ME - latest information and pointers to the Internet
- VROBJ.DLL - needed to run VX·REXX applications

Prerequisites

The sample program requires the following:

- The system must run under OS/2 WARP.
- Object REXX must be installed and run as the default REXX.
- DB2/2 Version 2 must be installed to use the BLOBs for multimedia data.
- DB2/2 Version 1 must be minimally installed to run the application with DB2.
- OS/2 Multimedia support must be installed for audio and video play; without it, only the color pictures of the cars can be seen.
- Dr. Dialog must be installed to modify or test the Dr. Dialog applications; it is not needed for execution only.
- VisPro/REXX Version 2.1 or 3.0 must be installed to modify or test the VisPro/REXX applications; it is not needed for execution only.
- Watcom VX·REXX Version 2.1 must be installed to modify or test the Watcom VX·REXX applications; for execution only the vrobj.dll file from the installation directory is needed.
- SOM Toolkit 2.1 must be installed to run the SOM compiler for the part class in SOM; it is not needed for execution only.
- CSet++ or VisualAge C++ is required to compile the SOM part class; it is not needed for execution only.

Installation Program

Start the installation using the *INSTALL* command.

The installation program preforms a number of pre-installation tasks on your system:

- Log on to the system, by default as user userid
- Interrogate the OS2.INI file for a previous installation of the sample application
- Check Object REXX WPS registration, run *WPSINST* if needed
- Check whether the redbook WPS folder already exists
- Check whether DB2/2 is installed on your system and which Version it is (only Version 2 can store BLOBs)
- Start DB2/2 and check whether the *DEALERDB* database exists

Finally, the installation menu is displayed with check marks for items that have not yet been done (see Figure 102).

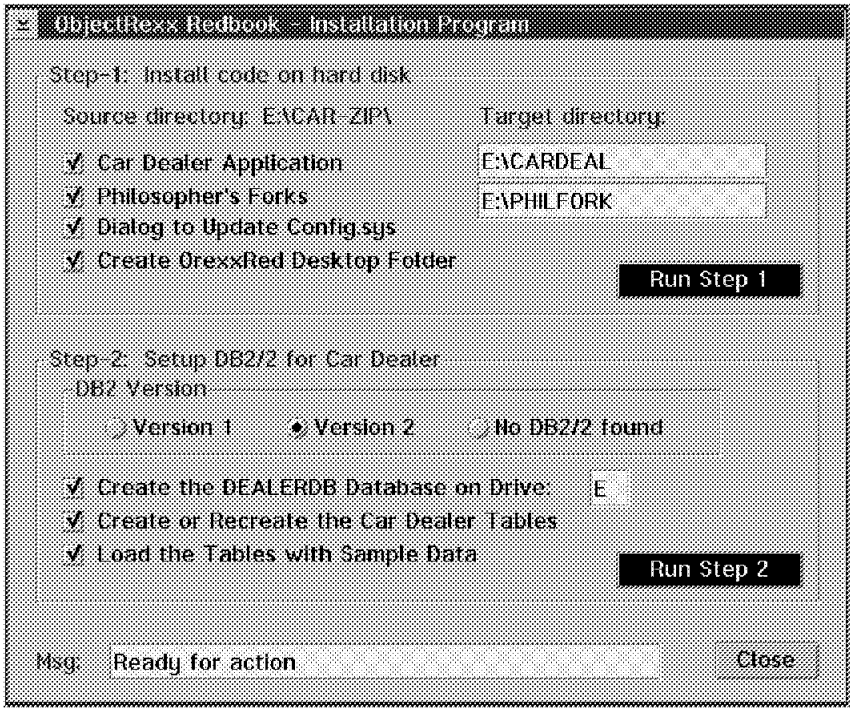


Figure 102. Installation Program: User Interface

The installation program delivered with the code consists of two distinct steps:

1. Installation of the code, including update of the environment and preparation of a folder
2. Setup of DB2 for persistent storage

Choose the target directories for the two applications. Use the check buttons to run only selected portions of the install program. When ready, click on the **Run Step1** push button.

The target directories are recorded in OS2.INI as application *OREXXRED* and redisplayed automatically when the install program is restarted. A command file, `sysini.cmd`, is provided in the Install subdirectory to display and delete this information.

Installation of the Code

Step 1 of the installation consists of:

- Installation of the car dealer application
- Installation of the philosophers′ forks application
- Updating of config.sys
- Creation of a folder with icons for all applications

Installing the Car Dealer and Philosophers′ Forks Applications

The code is delivered as ZIP files, which are unzipped into the target directories in the first two steps. A progress panel is shown while unzipping the code (see Figure 103).

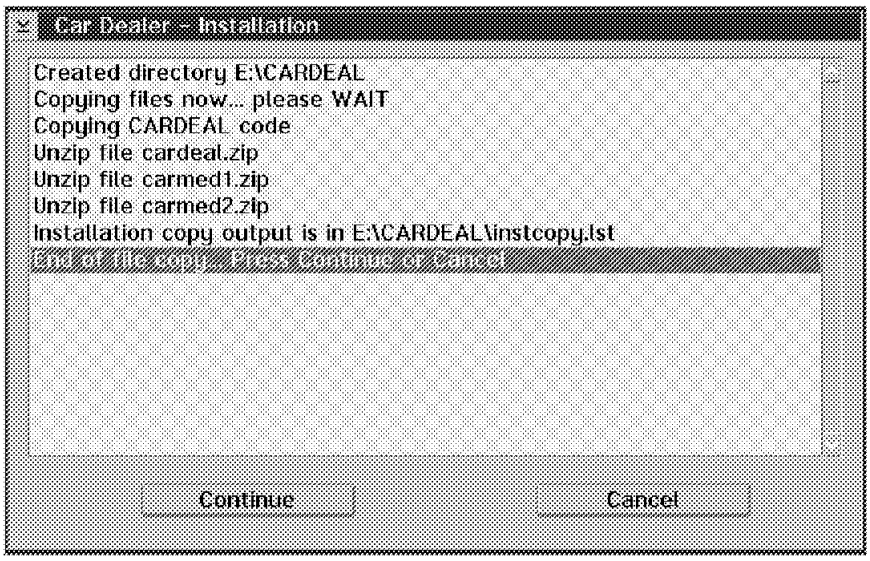


Figure 103. Installation Program : Progress Window

A similar progress window is displayed when installing the philosophers′ forks application.

Update of Config.sys

Config.sys will be updated by the installation program, affecting two lines:

- SET PATH has the CARDEAL directory added. This is necessary so that Object REXX finds the code when testing from a GUI builder.
- SET SOMIR has the SOM.IR file of the CARDEAL directory added. This is necessary when running the application with the SOM part class.

Reboot is necessary only before running the car dealer application from a directory other than the CARDEAL directory—for example, when testing with a GUI builder.

The changes to config.sys are shown in Figure 104.

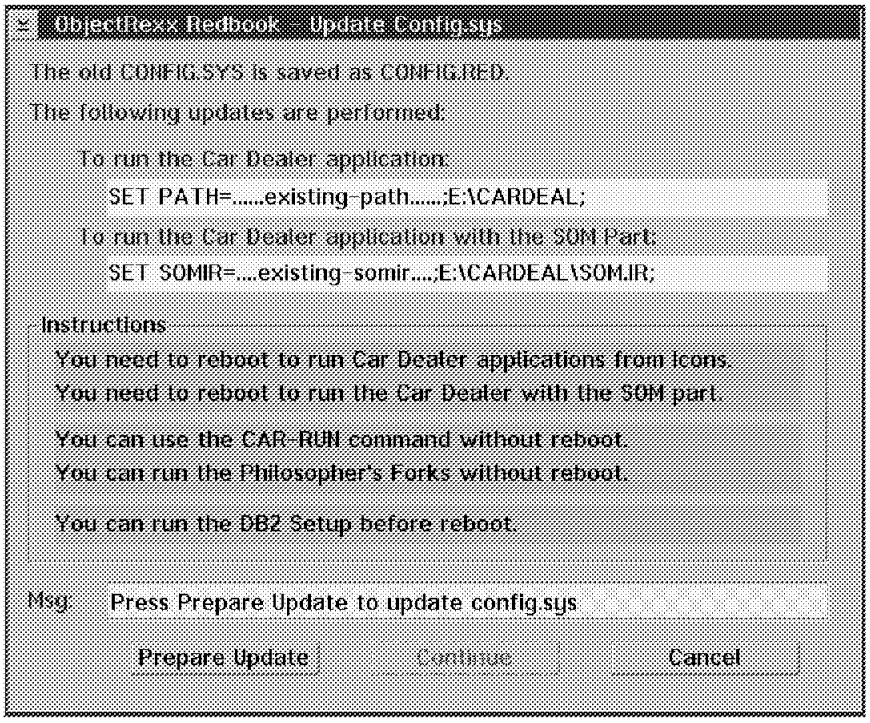


Figure 104. Installation Program: Config.sys Update

Click on the **Prepare Update** push button and the changed config.sys will be displayed in a window. The actual update on the hard disk must be confirmed.

Create the ObjectRexx Redbook Folder

The last step of Phase 1 creates a nice ObjectRexx Redbook folder with icons for all applications and setup programs. While the folder is being created, a progress window is shown (see Figure 105 on page 208).

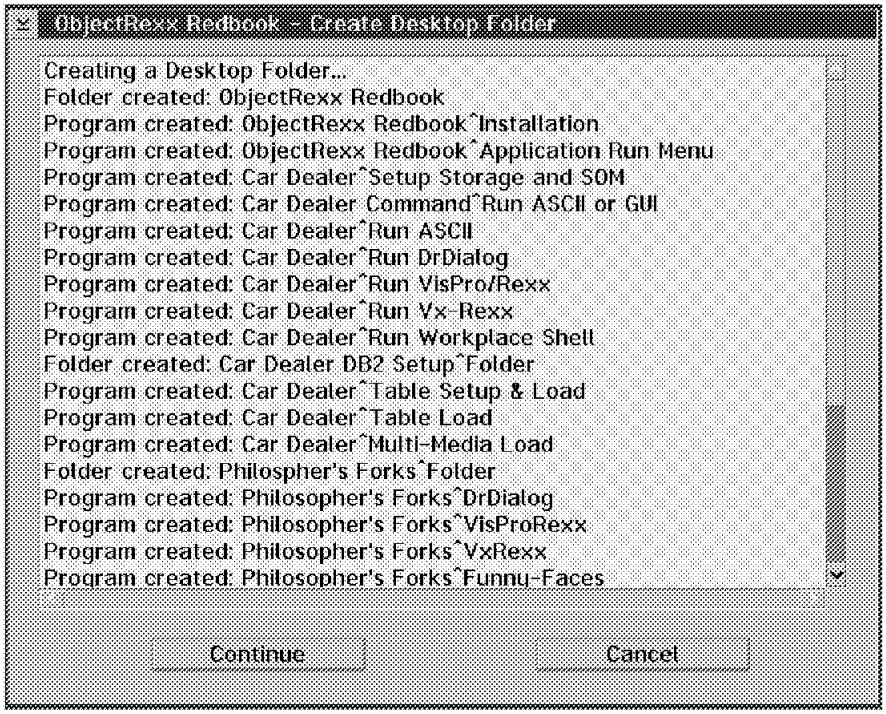


Figure 105. Installation Program: Folder Creation

Figure 106 shows the *ObjectRexx Redbook* folder as installed, and Figure 107 on page 209 shows the Philosophers' Forks folder when opened.

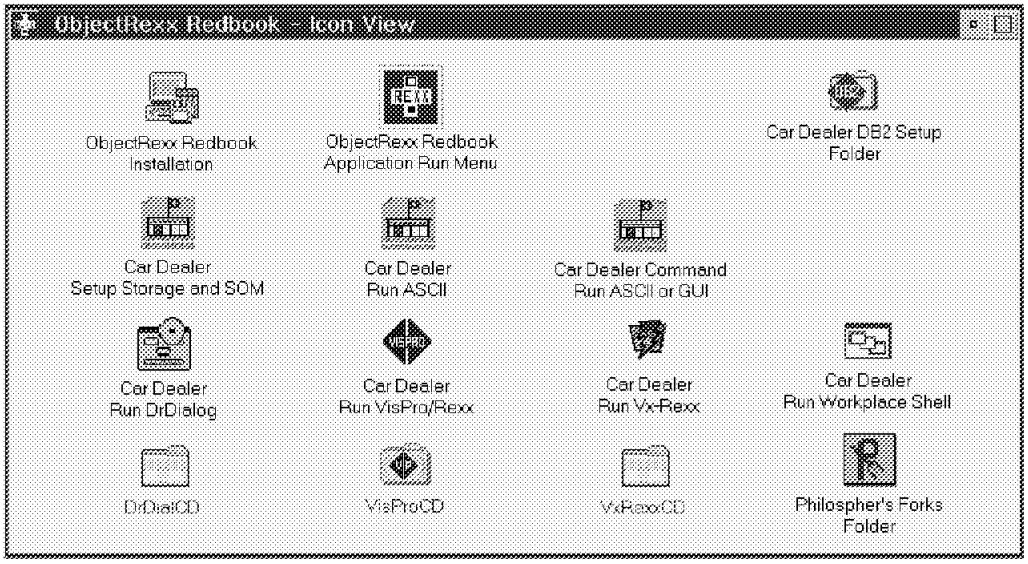


Figure 106. ObjectRexx Redbook Folder

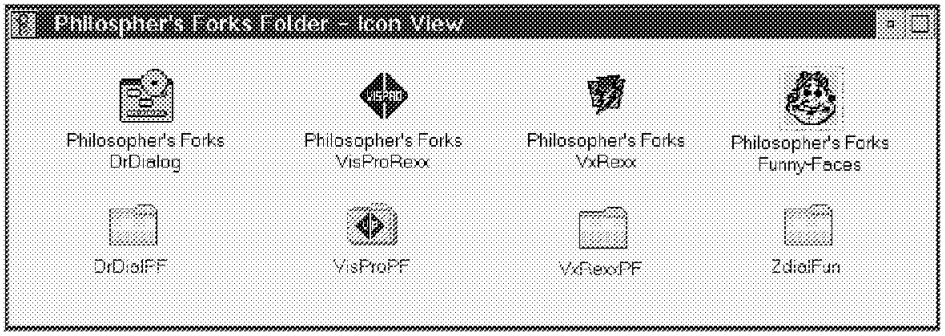


Figure 107. Philosophers′ Forks Folder

Table 18 shows icons that are available in the two folders.

Table 18 (Page 1 of 2). Icons of the ObjectRexx Redbook Folder	
Icon	**Description**
ObjectRexx Redbook Installation	ObjectRexx Redbook Installation program. Use this icon to redo certain steps of the installation, such as recreating the folder and redefining and reloading the DB2 tables.
ObjectRexx Redbook Application Run Menu	ObjectRexx Redbook Application Run Menu (see Figure 110 on page 214). This icon permits access to all the sample programs.
Car Dealer DB2 Setup Folder	Car Dealer DB2 Setup Folder with icons to rerun table definition and load programs. The DB2 implementation programs can run outside the installation program using the icons in this folder.
Car Dealer Setup Storage and SOM	Car Dealer Setup Storage and SOM. Use this icon to set up persistent storage for the car dealer application, and to choose whether the Part class should run from Object REXX or SOM. The option remains in effect until changed.
Car Dealer Run ASCII	Car Dealer Run ASCII Window Program (car-aui.cmd). Start the ASCII version in an OS/2 window.
Car Dealer Command Run ASCII or GUI	Car Dealer Run ASCII or GUI (car-run.cmd). Start any of the car dealer programs, ASCII or GUI.
Car Dealer Run DrDialog	Run Car Dealer Dr. Dialog GUI program.
Car Dealer Run VisPro/Rexx	Run Car Dealer VisPro/REXX GUI program.

Table 18 (Page 2 of 2). Icons of the ObjectRexx Redbook Folder	
Icon	**Description**
	Run Car Dealer Watcom VX·REXX GUI program.
	Run Car Dealer Workplace Shell Demonstration (carshow.cmd). Start the WPS program that visualizes all car dealer data as WPS folders. This program runs for quite a long time.
	Dr. Dialog Development Folder Shadow (Car Dealer). Access the Dr. Dialog development environment.
	VisPro/REXX Development Folder Shadow (Car Dealer). Access the VisPro/REXX development environment.
	Watcom VX·REXX Development Folder (Car Dealer). Access the Watcom VX·REXX development environment.
	Philosophers' forks Folder. This folder gives access to the philosophers' forks GUI applications.
	Run philosophers' forks Dr. Dialog.
	Run philosophers' forks VisPro/REXX.
	Run philosophers' forks Watcom VX·REXX.
	Run philosophers' forks funny-face application.
	Dr. Dialog Development Folder Shadow (philosophers' forks). Access the Dr. Dialog development environment.
	VisPro/REXX Development Folder Shadow (philosophers' forks). Access the VisPro/REXX development environment.
	Watcom VX·REXX Development Folder Shadow (philosophers' forks). Access the Watcom VX·REXX development environment.
	Development Folder Shadow for the funny-face application.

Note: The shadows of the GUI development folders give direct access to the appropriate development environment if that product is installed.

DB2 Setup

Step 2 of the application prepares an existing DB2/2 system for the car dealer application. This setup is optional; the car dealer application can run purely with file persistent storage. This step can be run immediately after Step 1, or at any time later. At initialization of the installation program, DB2/2 is started and checked for its Version (1 or 2).

Click on the **Step 2** push button to:

- Define the DB2 database
- Define the tables in the database
- Load the tables with sample data

Define the DB2 Database

The DB2 database has the name DEALERDB. The disk drive for the database can be selected in the entry field. Be patient while DB2 performs this step; a progress panel is not displayed.

Define the DB2 Tables

The data is stored in seven tables, one for each of the five classes and two for the m:m relationships between the classes.

If DB2/2 Version 2 is installed, the vehicle table contains the extra BLOB column for multimedia data, and two table spaces are defined to separate the basic vehicle data from the BLOB data.

With DB2/2 Version 1, only basic data can be stored in DB2. The multimedia application is still available, running from the file system.

The DDL statements are shown in a progress window while they are executed (see Figure 108 on page 212).

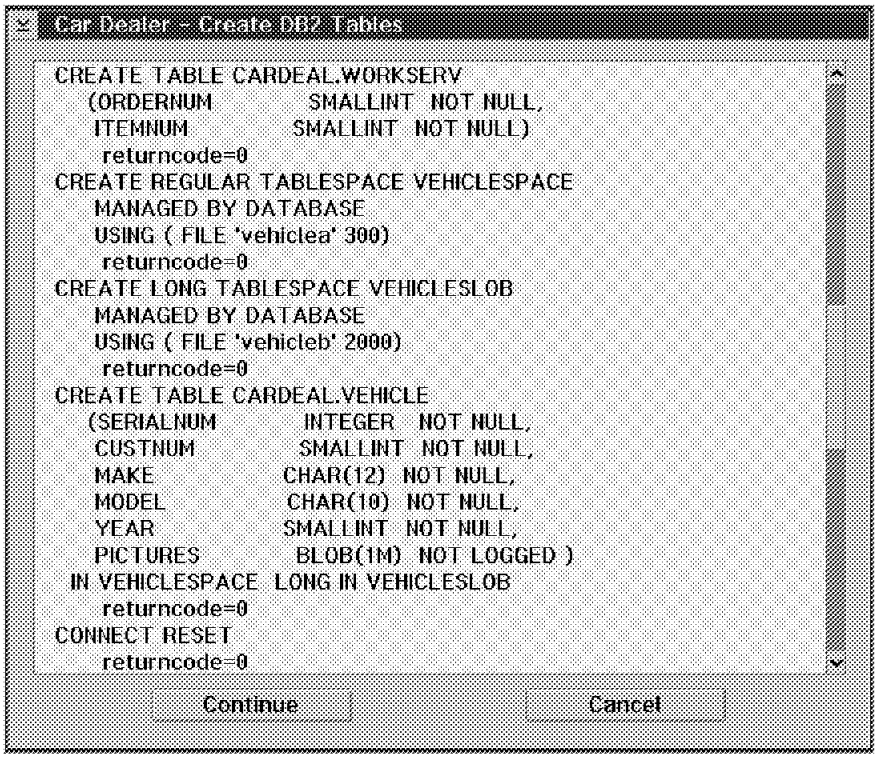


Figure 108. Installation Program: DB2 Table Definition

This step can be rerun at any time to redefine the tables—for example, when upgrading DB2 to version 2.

Load the DB2 Tables

The tables are loaded using a load program that reads the sample data provided in the SampData directory. For DB2/2 Version 2, multimedia data is loaded in addition into the BLOB column. A progress window is shown while loading the tables (see Figure 109 on page 213).

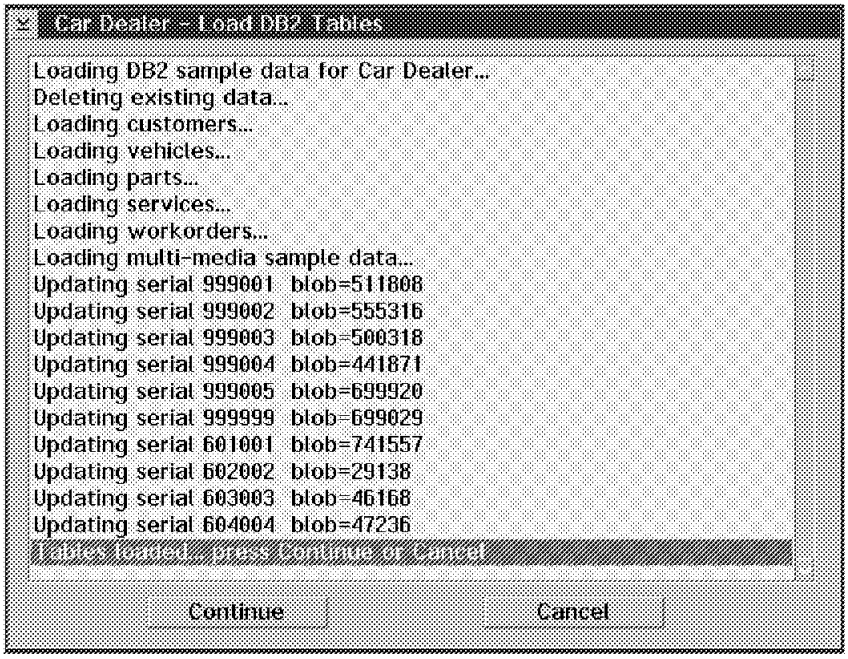


Figure 109. Installation Program: DB2 Table Load

This step can be rerun at any time to reinitialize the tables with the original data.

Running the Sample Applications

A menu program to run the sample applications is distributed with the code (icon ObjectRexx Redbook Run). When the program is started, the window shown in Figure 110 on page 214 is displayed.

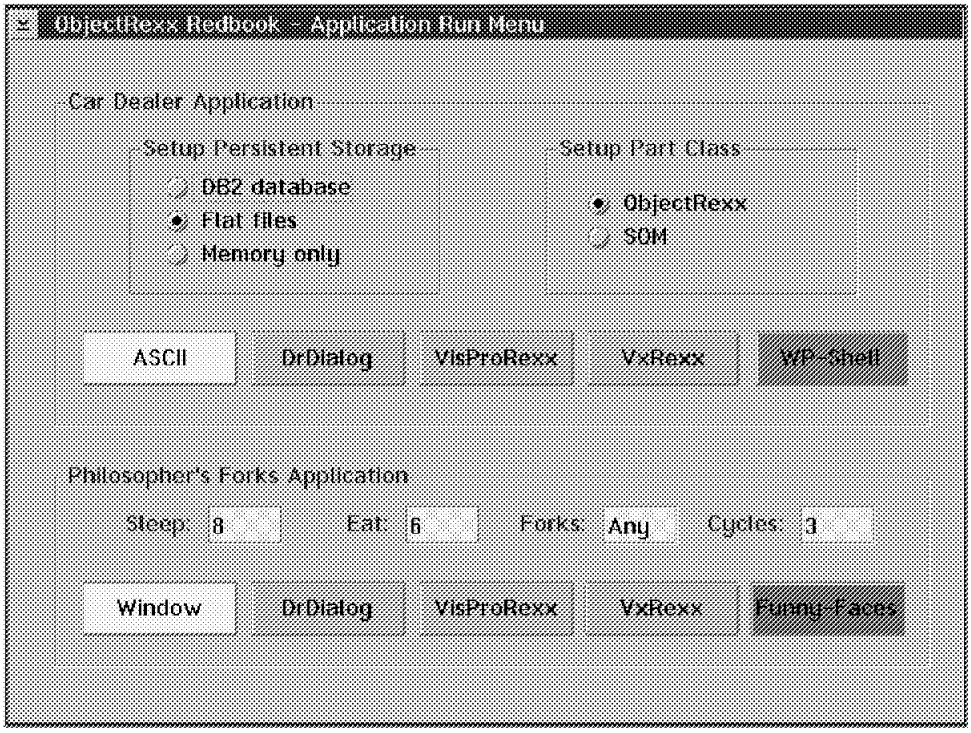


Figure 110. Running the Sample Applications

From this menu, all four versions of the car dealer application, the sample Workplace Shell folder demonstration program, and all four versions of the philosophers′ forks can be run.

For the car dealer application, select the persistent storage and optionally the SOM part class.

For the philosophers′ forks, select the initial values of the sleep and eat times, forks sequence, and number of cycles, and then invoke any one of the programs with those values.

Have fun exploring the variations of the two applications.

Running the Car Dealer Application on the World Wide Web

To run the car dealer application on the Web:

- Install the IBM Internet Connection Server on a machine with access to the CARDEAL directory.
- Tailor the configuration file (httpd.cnf) as described in “Customizing the File Organization on the Web Server” on page 167. The configuration must point to the CARDEAL\WWW subdirectory for HTML files and CGI programs.
- Start the car dealer application on the server in a window:

```
d:\CARDEAL\WWW\carstart db2 wait
  or
d:\CARDEAL\WWW\carstart file wait
```

- Use a Web browser, for example the IBM WebExplorer, and point to the server:

```
http://hostname/cardeal/hacurs.htm
```

- Use the hot links to invoke difference pieces of the application.
- When done, stop the car dealer application (press enter in the window where you started it) and the server.

Installed Sample Applications

The distributed code is installed in two main directories, one for the car dealer application, and one for the philosophers' forks. By default, these directories are named CARDEAL and PHILFORK, but any name can be given.

Car Dealer Directory

Within the CARDEAL directory the code is structured into many subdirectories, as shown in Tables 19 – 34.

Table 19. Files of the CARDEAL Directory. Master directory of car dealer application.

Filename	Description
red-run.exe	Runtime menu for applications
car-run.cmd	Command file to run with FAT, DB2 or RAM
rxfctsql.cmd	Command file to load REXX-DB2 functions
carerror.cmd	Command file to check for proper directory
carmodel.cfg	Active configuration (copy of either FAT, DB2, or RAM)
som.ir	SOM interface repository for the car dealer application
install.cmd	Install command file for recreate DB or folder
red-inst.exe	GUI installation program

Table 20. Files of the Base Subdirectory. Base class definitions for objects in storage.

Filename	Description
carcust.cls	Base class definition for customers
carvehi.cls	Base class definition for vehicles
carwork.cls	Base class definition for work orders
carserv.cls	Base class definition for service items
carpart.cls	Base class definition for parts, a copy of either part.ori or part.som
part.ori	Base class definition for parts in Object REXX
part.som	Base class definition for parts in SOM
cardeal.cls	Car dealer class for initialization and termination
persist.cls	Class for definition of persistent methods

Table 21. Files of the FAT Subdirectory. Class definitions for persistent objects in files.	
Filename	**Description**
carcust.cls	FAT class definition for customers
carvehi.cls	FAT class definition for vehicles
carwork.cls	FAT class definition for work orders
carserv.cls	FAT class definition for service items
carpart.cls	FAT class definition for parts
carmodel.cfg	Configuration file for persistence in files
carlist.cfg	Configuration file for carlist.rtn (file persistence)
carlist.rtn	Additional routines for list on standard output
Data	Subdirectory with persistent file storage. Initially this is a copy of the SampData subdirectory (see Table 22). The files have the same names as in the SampData subdirectory. Running the car dealer application updates the files in this directory. The original state can always be restored by copying the files from the SampData directory.

Table 22. Files of the Sampdata Subdirectory. Master files with sample data. Used as initial state for FAT persistent storage and to load the sample data into DB2 tables.	
Filename	**Description**
customer.dat	Master file with sample customer data
vehicle.dat	Master file with sample vehicle data
workord.dat	Master file with sample work order data
service.dat	Master file with sample service item data
part.dat	Master file with sample part data

Table 23. Files of the DB2 Subdirectory. Class definitions for persistent objects in DB2. Initially DB2 is loaded with data from the SampData subdirectory.	
Filename	**Description**
carcust.cls	DB2 class definition for customers
carvehi.cls	DB2 class definition for vehicles
carwork.cls	DB2 class definition for work orders
carserv.cls	DB2 class definition for service items
carpart.cls	DB2 class definition for parts
carmodel.cfg	Configuration file for persistence in DB2
carlist.cfg	Configuration file for carlist.rtn (DB2 persistence)
carlist.rtn	Additional routines for list on standard output (DB2)

Table 24 (Page 1 of 2). Files of the RAM Subdirectory. Class definitions for objects in RAM. Sample data is loaded into memory using REXX statements.	
Filename	**Description**
carcust.cls	RAM class definition for customers
carvehi.cls	RAM class definition for vehicles

Table 24 (Page 2 of 2). Files of the RAM Subdirectory. Class definitions for objects in RAM. Sample data is loaded into memory using REXX statements.	
Filename	**Description**
carwork.cls	RAM class definition for work orders
carserv.cls	RAM class definition for service items
carpart.cls	RAM class definition for parts
carmodel.cfg	Configuration file for persistence in RAM
carlist.cfg	Configuration file for carlist.rtn (RAM, same as FAT)

Table 25. Files of the AUI Subdirectory. Class definitions for ASCII interface and menus and basic list routines for displaying the class contents on standard output.	
Filename	**Description**
caraui.cls	AUI class with methods for window interactions
carmenu.cls	Menu class for menu display and run
menu.dat	Menu definition file
carlist.cfg	Configuration file for list on standard output; copy of same-named file from either FAT or DB2
carlist.rtn	Basic list routines
car-aui.cmd	Command file to run ASCII window

Table 26. Files of the DrDialCD Subdirectory. GUI definitions and generated executable for Dr. Dialog.	
Filename	**Description**
car-gui.res	GUI definition file for Dr.Dialog
car-gui.rex	External routines for GUI (::requires carmodel.cfg)
car-gui.rxx	Generated REXX code of GUI (for listing)
car-gui.exe	Generated executable from Dr. Dialog GUI

Table 27. Files of the VisProCD Subdirectory. GUI definitions and generated executable for VisPro/REXX.	
Filename	**Description**
car-gui.exe	Generated executable from VisPro/REXX GUI
Main	Main GUI window subdirectory
CarXxxxx	Subdirectory for subwindow of main; one for each window
SubProcs	Subdirectory for external procedures; with configuration file zCargui.cvp (::requires carmodel.cfg)

Table 28 (Page 1 of 2). Files of the VxRexxCD Subdirectory. GUI definitions and generated executable for Watcom VX·REXX.	
Filename	**Description**
car-gui.exe	Generated executable from Watcom VX·REXX GUI
car-gui.cvx	External procedure (::requires carmodel.cfg)
Project.VRP	Project definition file (all windows)

Table 28 (Page 2 of 2). Files of the VxRexxCD Subdirectory. GUI definitions and generated executable for Watcom VX·REXX.	
Filename	**Description**
Window1.*	Generated REXX code (.VRM,.VRW,.VRX,.VRY)

Table 29. Files of the SOM Subdirectory. Interface definition language files to implement the part class in SOM, and all files generated by the SOM and C++ compilers.	
Filename	**Description**
part.idl	Interface definition file for part
part.xh	Generated header file
part.xih	Generated header file (updated with special code)
setpdesc.xih	File with instructions on updating part.xih
part.cpp	Generated source file (updated with own methods)
part.def	Generated DEF file for linkage editor
partmeta.idl	Interface definition file for partmeta (class methods)
partmeta.xxx	Similar to part (.xh, .xih, .cpp, .def)
parttot.def	Constructed DEF file from other DEF files
somcomp.cmd	Command file for SOM compiler
complink.cmd	Compile and link using C++
part.dll	Resulting DLL for LIBPATH

Table 30. Files of the WPS Subdirectory. Sample commands to visualize car dealer data in WPS folders.	
Filename	**Description**
carshow.cmd	Command file to load sample data into WPS folders
foldfind.cmd	Subroutine to search for folder
genfold.cmd	Command file to create one WPS folder
icons	Subdirectory with all kind of icons

Table 31. Files of the StorProc Subdirectory. Sample commands to use stored procedures in a client/server environment for DB2 security purposes.	
Filename	**Description**
server.cmd	Command file to start server for stored procedures
gateway.cmd	Command file for gateway between client and stored procedures in server
client.cmd	Command file for client (user of stored procedure)
read.me	A description and instructions

Table 32 (Page 1 of 2). Files of the Xamples Subdirectory. Additional small examples of the redbook.	
Filename	**Description**
eater.cmd	Command file for eater of global object demo
feeder.cmd	Command file for feeder of global object demo

Table 32 (Page 2 of 2). Files of the Xamples Subdirectory. Additional small examples of the redbook.	
Filename	**Description**
rexxcx.cmd	Command file to invoke the REXXC utility
browser.cmd	Experimental Object REXX class browser in a window
browser.exe	Experimental Object REXX GUI class browser

Table 33. Files of the WWW Subdirectory. Car Dealer on the World Wide Web (Internet)	
Filename	**Description**
Hacurs.htm	Hacurs home page
cardeal.htm	Car dealer main page
cardealN.htm	Car dealer application not running page
caryours.htm	Add your own car page
cardesc.htm	Short application description page
html.frm	HTML class definition
carstart.cmd	Start car dealer application (global environment)
CGIREXX.CMD	Common Gateway Interface REXX program
partall*.cmd	Part list test programs 1 and 2
*.cmd	Individual CGI programs
hacurs.gif	Hacurs logo
car*.gif	Car pictures (Hanna, Curt, Steve)
*.gif	Small icon pictures for active links
http.cnf	Tailored Web server administration file (sample)

Table 34 (Page 1 of 2). Files of the Install Subdirectory. Installation program source and executable, and DB2 setup programs.	
Filename	**Description**
red-inst.res	Dr. Dialog GUI definition file for installation program
red-run.res	Dr. Dialog GUI definition file to run sample programs
db2setup.cmd	Set up and load of DB2 tables for car dealer application
load-db2.cmd	Load program for DB2 tables, uses SampData directory
load-mm.cmd	Load program for multimedia data, uses menu.dat
runsql.cmd	Command file to run SQL DDL through DB2 command
db2xmit.cmd	Command file to submit a command to DB2 from the online install program
sysini.cmd	Command file to display and reset OS2.INI information of Car Dealer
createdb.ddl	DDL to create database DEALERDB
createtb.ddl	DDL to create tables for DB2 Version 2
createt1.ddl	DDL to create tables for DB2 Version 1
createix.ddl	DDL to create indexes on tables
droptb.ddl	DDL to drop tables for DB2 Version 2

Table 34 (Page 2 of 2). Files of the Install Subdirectory. Installation program source and executable, and DB2 setup programs.	
Filename	**Description**
dropt1.ddl	DDL to drop tables for DB2 Version 1

Philosophers′ Forks Directory

Within the PHILFORK directory, the code is structured into only a few subirectories, as shown in Table 35.

Table 35. Files of the PHILFORK Directory. Philosophers′ forks window and GUI programs, source and executables.	
Filename	**Description**
xmpreply.cmd	Sample command with early reply and unguarded methods
philfork.cmd	Philosophers′ forks in an OS/2 window
DrDialPF	Subdirectory for Dr. Dialog application
VisProPF	Subdirectory for VisPro/REXX application
VxRexxPF	Subdirectory for Watcom VX·REXX application
ZdialFun	Subdirectory for funny-faces application

Source Code for Installing and Running Sample Applications

The source code of the installation programs is listed in “Installation Programs” on page 332.

The source code of the car dealer run programs is listed in “Running the Car Dealer Programs” on page 344.

Removing the Sample Applications from Your System

To remove the sample applications from your system:

- Delete the Object REXX Redbook folder
- Run the Sysini program (in the CARDEAL\Install subdirectory) to remove the sample application from OS2.INI
- Delete the CARDEAL and PHILFORK directories
- Remove the CARDEAL directory from config.sys

Part 5. New Features and Syntax in Object REXX

Chapter 15. New Features in Object REXX and Migration

Object REXX is a superset of the previous OS/2 REXX. Therefore most programs will run unchanged using Object REXX. Some small incompatibilities that may arise when migrating existing programs are discussed at the end of this chapter in “Migration Considerations” on page 242.

Many enhancements have been built into Object REXX. The sample applications presented in this book demonstrate in detail the object-oriented support. In this chapter, we summarize the object-oriented support and discuss the other enhancements in detail.

Object REXX provides the following enhancements:

- A full set of object-oriented facilities
  - Classes and methods with inheritance and polymorphism
  - A new operator, ~, to invoke methods
  - Direct access to SOM objects and the Workplace Shell (WPS)
  - Concurrency—the ability to easily run code in parallel
  - New special variables (self, super)
  - Special and built-in objects
- A set of directives that permit
  - Definition of classes and methods (::class and ::method)
  - Embedding of source files (::requires)
  - Creation of improved subroutines with private variables (::routine)
- The REXXC utility, which can be used to distribute programs without source
- New and enhanced instructions
- New and enhanced built-in functions
- New condition traps
- New REXX utilities

Syntax diagrams are used extensively to describe the detailed parameters of the new and enhanced instructions. The structure of the syntax diagrams is explained in Appendix B, “Definition for Syntax-Diagram Structure” on page 351.

Object-Oriented Facilities

The set of object-oriented facilities is so large that we cannot describe them all in detail here. Our intention is to add a few concepts and facilities not described in the earlier chapters of this book. We encourage study of the chapters on OO facilities in the *Object REXX Reference for OS/2*.

New Special Variables

There are two new special variables:

self The object of the currently running method. Used to invoke other methods on the same object (`self~display`) or to pass as a parameter to a method of another object (`.Customer~addVehicle(self)`).

super The superclass (parent in inheritance hierarchy) of the current object. Used to invoke a method in the superclass, in many cases the method of the same name. For example, in the init method of a class it is common to invoke the init method of the parent (`self~init:super`).

Special and Built-In Objects

Object REXX provides a set of objects that are always available:

.environment The global environment object. It contains all predefined class objects (.Object, .String, ...) and some other objects (.true, .false, .nil). It can be used for communication among multiple processes (see “Communication among Classes” on page 126).

.nil The NIL object, an object that does not contain any data. It can be used to test for nonexisting data—for example, in an array (`if myarray[i] = .nil then ...`).

.local The local environment object. It contains default input/output streams (.input, .output, .error) and some SOM-related objects (.som, .somclass, ...). It can be used for communicating among parts of the application within one process (see “Communication among Classes” on page 126).

.methods A directory of methods defined in the current program using ::method directives without an associated class.

.rs The return code from any executed command, with values of -1 (failure), 1 (error), 0 (OK).

Directives

Object REXX provides four directives, two to define classes and methods, one to define external routines, and one to implement dependencies between source files.

Directives are nonexecutable and must be placed at the end of the source file. They are processed first to set up a program′s classes, methods, and routines.

Class Directive

The ::class directive defines a new class. Several options are available:

public Makes the class available in all programs that have a ::requires directive for this program

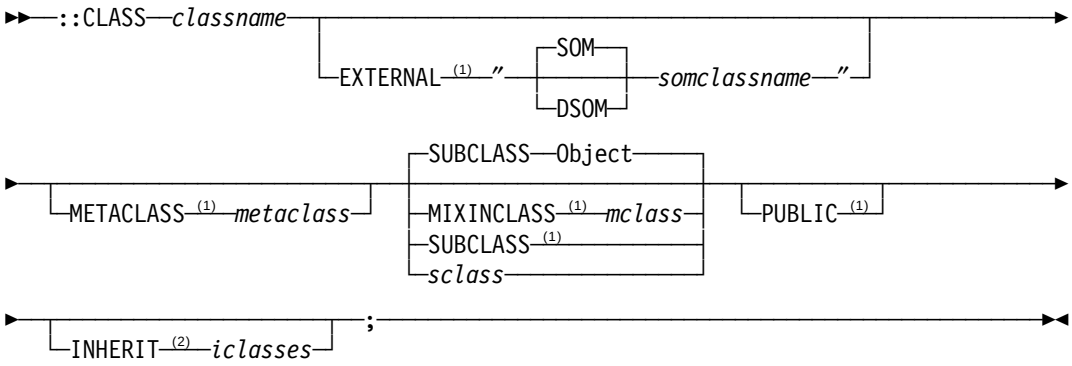
subclass Inherits from a parent class

inherit Inherits from other mixin classes

mixinclass Defines a mixin class for inheritance

metaclass Defines a meta class for additional class methods

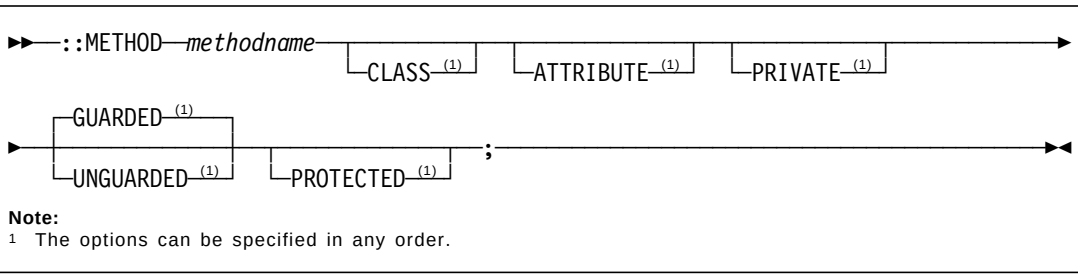
external Retrieves class from SOM interface repository



Notes:
1 These options can be specified in any order.
2 If INHERIT is specified, it must be the last option.

Method Directive

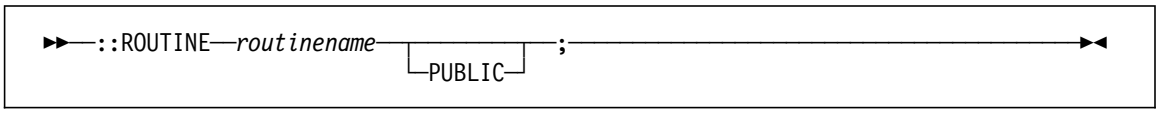
The ::method directive defines a method. Multiple method directives are usually placed directly after the class directive. All options except *protected* are described in this redbook. The protected option deals with the Security Manager, an Object REXX feature that has not been used in this redbook.



Note:
1 The options can be specified in any order.

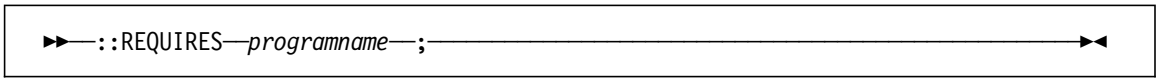
Routine Directive

The ::routine directive defines a callable subroutine. Such routines behave like external routines but are in the search order before external routines (after internal ones). The only option is *public*, which makes the routine available to all programs with a ::requires directive for this program.



Requires Directive

The ::requires directive specifies that a program requires access to another source program. In many cases the other program contains class definitions needed for execution. The ::requires directive allows the building of libraries of reusable code and the implementation of configuration management of REXX programs (see Chapter 10, “Configuration Management with Object REXX” on page 119). The ::requires directives must precede all other directives.



The REXXC Utility

The REXXC utility can be used to transform a source program into an executable image that can be distributed without the source code:

```
REXXC inputfile outputfile
```

When there are multiple programs that call each other, it is necessary to keep the same file names after transformation. There are basically two approaches:

- Use the same names for the output files but place them in a different matching directory structure.
- Transform the source into an output file and, when successful, save the source under a different name and rename the output to the name of the original source. (With HPFS drives, the source can be saved as *filename.ext.rxc*, for example, as implemented in the rexxcx.cmd in the Xamples subdirectory of the car dealer application).

New and Enhanced Instructions

The new instructions added to Object REXX are:

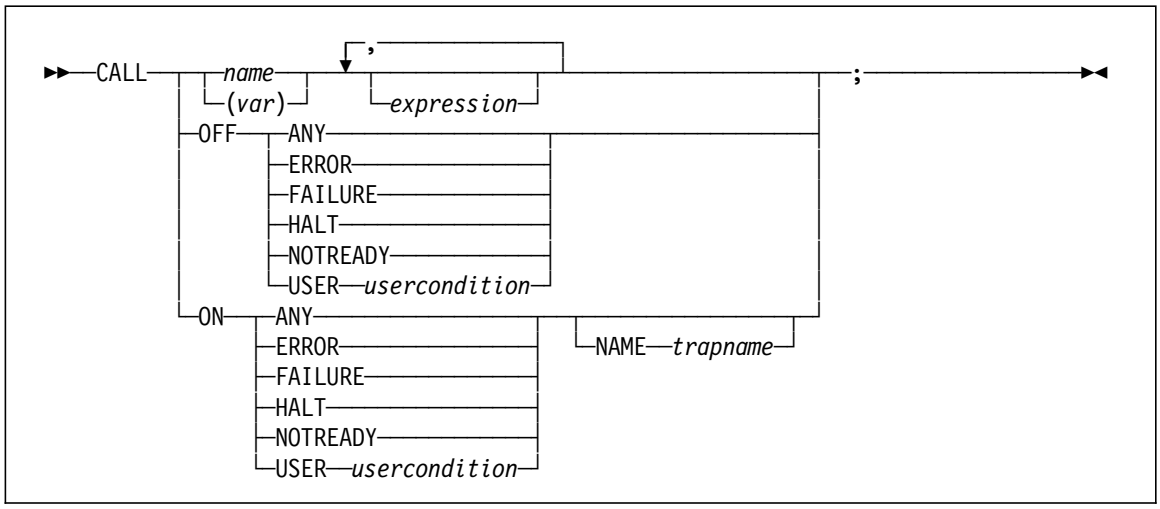
- EXPOSE
- FORWARD
- GUARD
- RAISE
- REPLY
- USE

The parameters for four old instructions have been enhanced:

- CALL
- DO
- PARSE
- SIGNAL

The new and changed instructions are discussed in alphabetical order.

CALL (Enhanced)



The first new feature on the CALL instruction is that now *(var)* can be used instead of *name* to specify the routine to be called. The variable is evaluated first, and the resulting value is used as the target of the CALL instruction. Observe that this value is not changed to uppercase, so it must exactly match the label to be called. In this small example there are three different ways of calling internal and external routines:

```
/* TstCALL.CMD - Test of "CALL (var)" instruction */
   Call label calldata       /* label is a symbol (constant) */
   label = 'label'
   Do 2
      Call (label) calldata  /* label is a variable */
      label = 'newlabel'     /* - that changes */
   End
   Call "label" calldata     /* label is a string */
   exit
label:
   Say "The first call was made to label - label:"
   return
```

```
"label":
   Say 'The second call was made to label - "label":'
   return
"newlabel":
   Say 'The third call was made to label - "newlabel":'
   return
```

The last call to "label" bypasses any search for an internal routine and calls an external command file named LABEL.CMD:

```
/* LABEL.CMD - test with external routine */
   Say 'The fourth call was made to external routine - LABEL.CMD'
   return
```

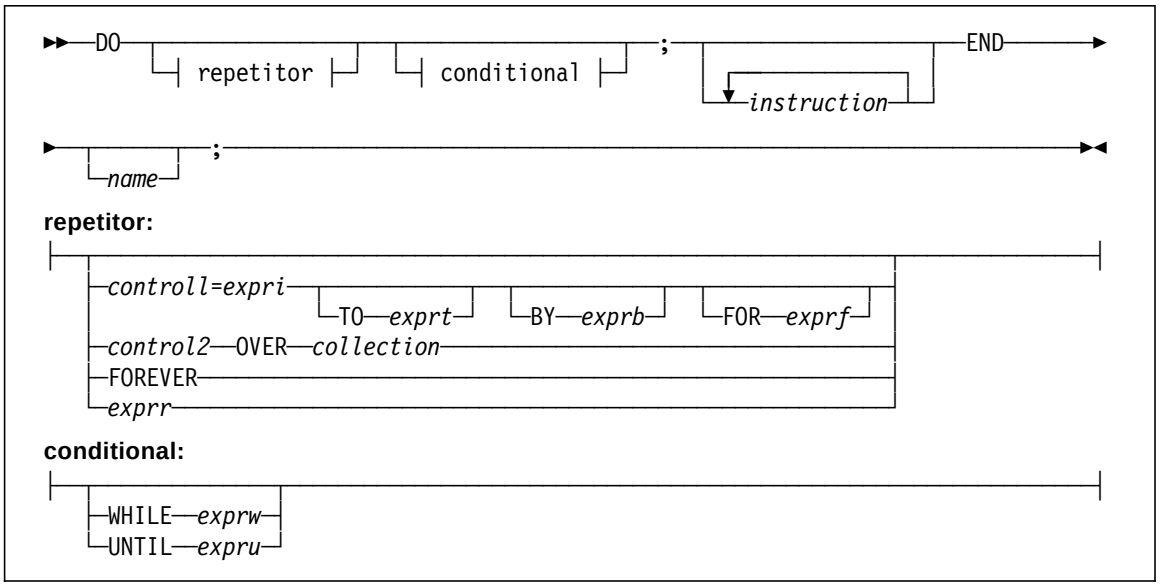
Running the TstCALL.CMD gave the expected result. The little do loop (Do 2) caused the same call statement to call two different routines. The variable *label* was evaluated correctly.

```
[C:]TstCALL
The first call was made to label -> label:
The second call was made to label -> "label":
The third call was made to label -> "newlabel":
The fourth call was made to external routine -> LABEL.CMD
```

Also, the CALL instruction has two new conditions, *ANY* and *USER*, added. They are explained in "SIGNAL (Enhanced)" on page 232 and we will come back to these in connection with the rest of the new condition traps in "New Condition Traps" on page 238.

DO (Enhanced)

The DO instruction has a new repetitor function added that will make it possible to loop through all values of a stem object or any other collection that provides a *makearray* method. The repetitor is coded as *control2* OVER *collection* in the syntax diagram below.



The *DO xvar OVER Stemx.* sets the variable *xvar* to each one of the member names of the *Stemx.* stem object. This is very useful because we no longer have to know the names of

the tails in a stem variable. The DO .. OVER gives all the tails, but in any order, so please do not rely on the order.

DO OVER works very well with the collection classes of Object REXX, such as lists, arrays, sets, tables, bags, and relations. The car dealer application uses it extensively.

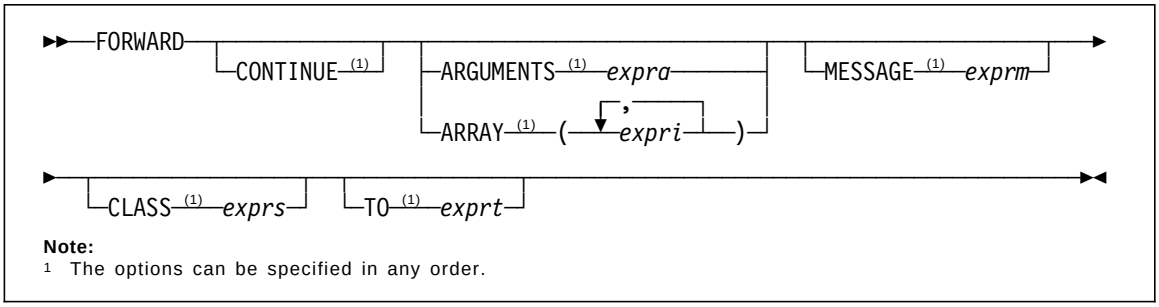
EXPOSE (New)

The EXPOSE instruction is new for Object REXX. Before, we had the EXPOSE option on the PROCEDURE instruction. The PROCEDURE instruction protected the variables of the calling routine. If the routine needed access to some of those variables, we used the EXPOSE option to make them available. The new EXPOSE instruction has a very similar function for the variables of an object. It is used to expose the instance or class variables of a method from the object's variable pool. The EXPOSE instruction can be used only in a method, and, if used, it must be the first instruction after the ::method directive.

FORWARD (New)

This new instruction is used to forward a message that caused the currently active method to start running. Parts of the forwarded message can be changed by the different options on the FORWARD instruction. Target object, arguments, and even the message name can be changed.

One use of FORWARD is to pass on a message to the superclass if the current method is overriding a method of that class but still wants that method to run. The CONTINUE option decides whether a return should be made to the forwarding method. It also decides how any result should be handled. The FORWARD instruction causes no concurrency—the forwarding method waits for the return (if CONTINUE is specified) or exits directly after forwarding the message.

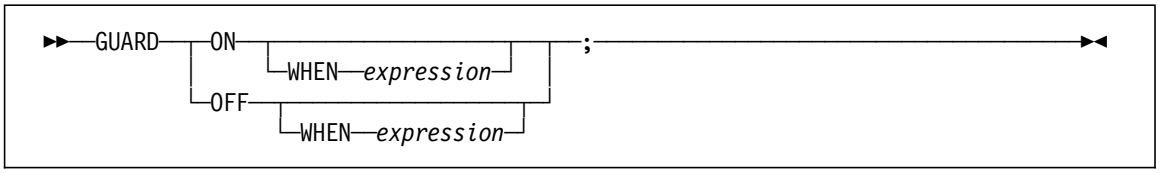


Note:
1 The options can be specified in any order.

GUARD (New)

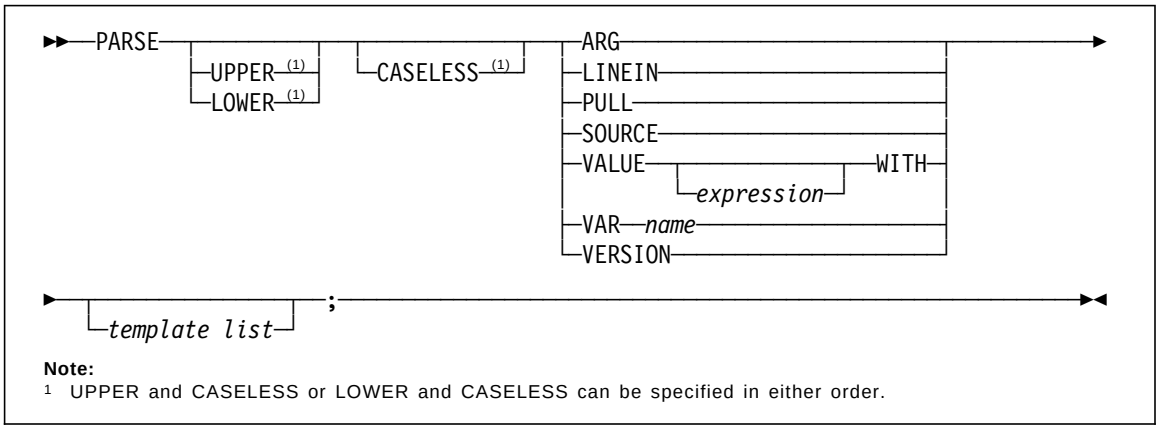
The GUARD instruction is used to control access to an object's variable pool. The normal state for an object is that it is guarded from concurrent use by different methods. Sometimes we want to let multiple methods share the use of one object's variable pool. This is then done by using either `methodname~ SETUNGUARDED` or `::method methodname UNGUARDED`. The GUARD instruction can now be used to temporarily lock out concurrent use of the object's variable pool. The option *WHEN expression* can make it conditional.

Examples of GUARD are used in “Coding Stored Procedures with Object REXX” on page 112 and in the fork class in the philosophers’ forks (see Figure 91 on page 188).



PARSE (Enhanced)

The PARSE instruction has two small enhancements. The UPPER option is now complemented with a LOWER option; thus any character string to be parsed is first translated to lowercase. The other new option—CASELESS—causes any matching done during parsing to be independent of case; a letter in uppercase is thus equal to the same letter in lowercase.



Note:
1 UPPER and CASELESS or LOWER and CASELESS can be specified in either order.

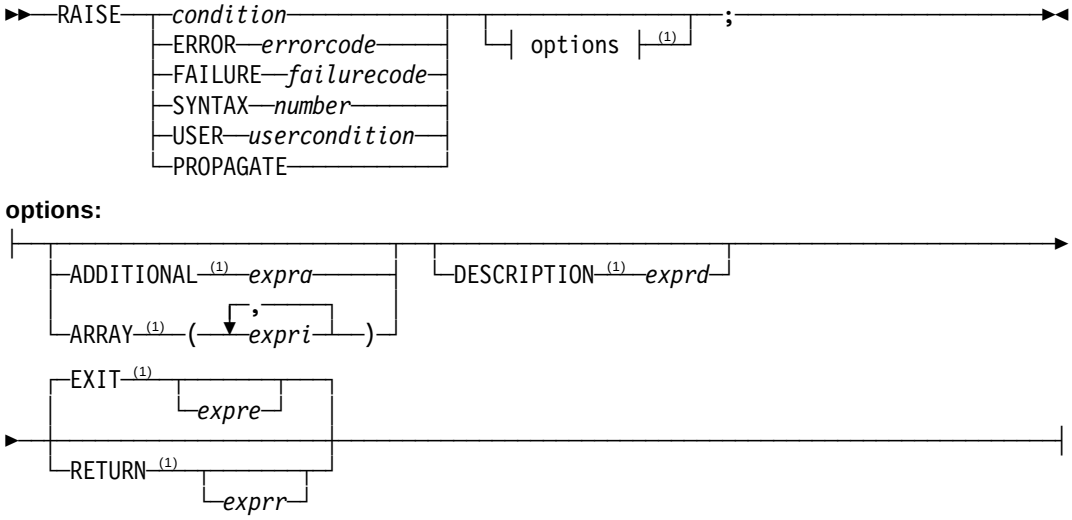
Examples:

```
parse value 'AbCdEfGhIjKlM' with p1 'FgH' p2
  ===> p1 = 'AbCdEfGhIjKlM', p2 = ''

parse caseless value 'AbCdEfGhIjKlM' with p1 'FgH' p2
  ===> p1 = 'AbCdE', p2 = 'IjKlM'
```

RAISE (New)

Traps are normally created totally involuntarily. RAISE is a new instruction that enables the programmer to create traps in a controlled way.



Note:
1 The options can be specified in any order except that if EXIT is specified without *expre* or RETURN without *exprr*, it must appear last.

One nice use of the RAISE instruction is to have a routine for catching condition traps for methods, without having to add a lot of code to each method.

The following is an example of *raise propagate*:

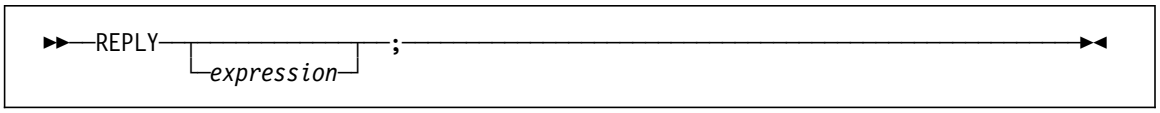
```
/* TstRaise.Cmd - Test the new RAISE instruction */
   signal on any
   tm = .myTest~new
   say tm~myMethod
   exit
any:
   signal off any
   if .local["M.SIGL"] <> .nil then do
      sigl = .local["M.SIGL"]
      .local["M.SIGL"] = .nil
      end
   if var('rc')
      then say 'REXX ['condition("C")'] error' rc 'in line' sigl':' ,
               "ERRORTEXT"(rc)
      else say 'REXX ['condition("C")'] error in line' sigl
   say 'The Source Line is:'"SOURCELINE"(sigl)
   exit

::class myTest
::method init
   return
::method myMethod
   signal on any
   a = 'xyz'
   c = a+2    /* This line causes SYNTAX error */
   return
any:
   .local["M.SIGL"] = sigl
   raise propagate

===> Result:
   REXX [SYNTAX] error 41 in line 25: Bad arithmetic conversion
   The Source Line is:   c = a+2
```

REPLY (New)

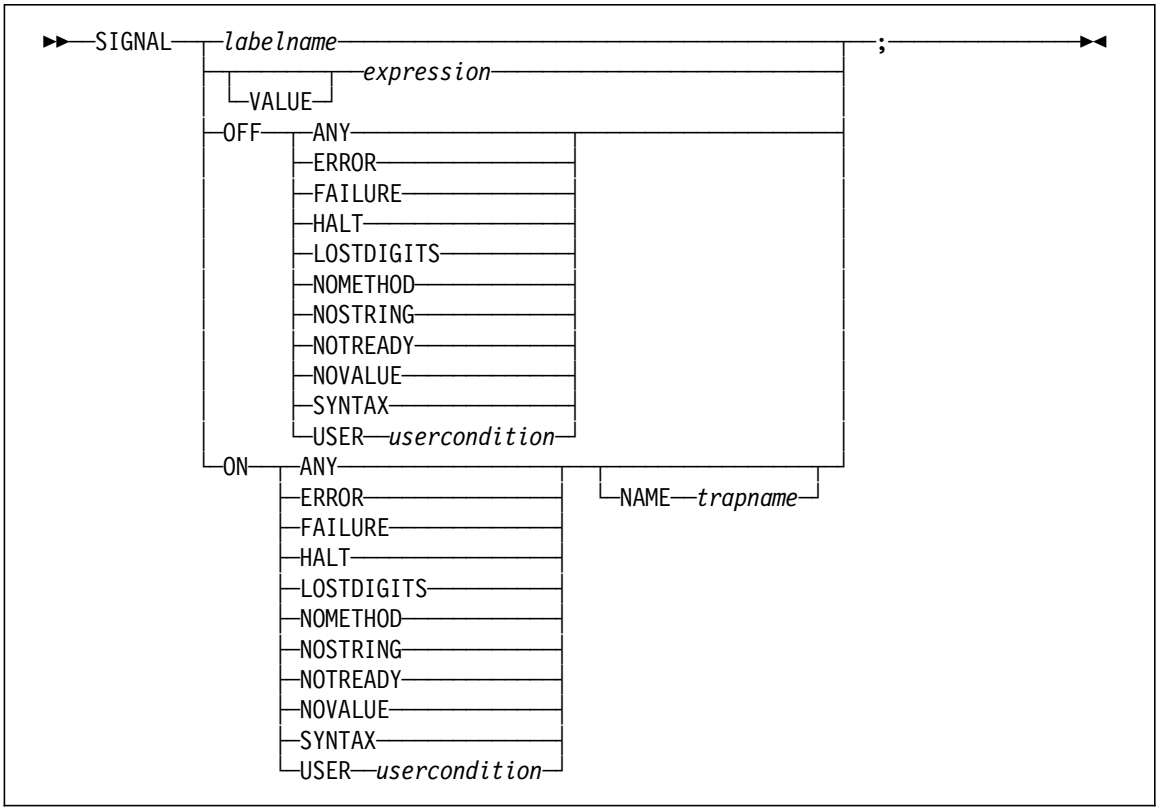
REPLY is used to send an *early reply* from a method to the caller, removing the method from the current activity stack and letting it run concurrently with the caller. This is one of the ways to cause concurrency under Object REXX. See “Examples of Early Reply with Unguarded and Guarded Methods” on page 184. Observe that REPLY can be used only within methods, and it can be executed only once within a method.



SIGNAL (Enhanced)

SIGNAL is used to cause an *abnormal* change in the flow of control, or, if ON or OFF is specified, it controls the trapping of specific conditions. In Object REXX, some new conditions have been added:

- ANY—traps any condition not specifically enabled by the other condition settings
- LOSTDIGITS—detects when a number in an arithmetic operation has more digits than the current setting of NUMERIC DIGITS
- NOMETHOD—detects when an object receives an unknown message and there is no UNKNOWN method to receive it
- NOSTRING—detects when a string value is required from an object and it is not supplied
- USER *usercondition*—allows the setup of user conditions invokable by the RAISE instruction that specifies the same *usercondition* name.



For more information on conditions and SIGNAL, see “CALL/SIGNAL (Enhanced)” on page 238.

USE (New)

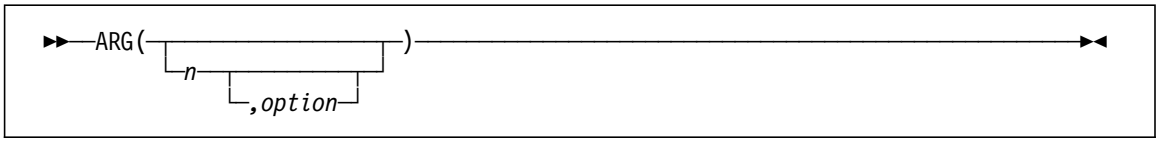
USE ARG retrieves the argument objects provided to a program, routine, function, or method. The objects are assigned into variables.

The difference between USE ARG and PARSE ARG is that PARSE ARG (and ARG) accesses and parses the string values of the arguments, but USE ARG allows nonstring arguments and does a one-to-one assignment of arguments to REXX variables. This is the way we pass objects (not only string objects) between routines.

New and Enhanced Built-In Functions

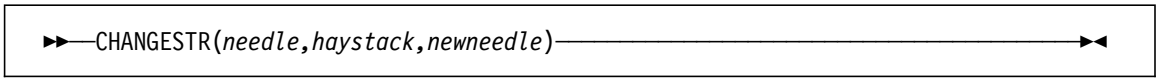
Object REXX has three new built-in functions and some changes to nine old ones.

ARG (Enhanced)



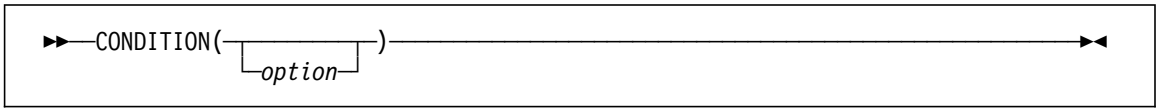
ARG has two new options. The first is *Array*, which returns the arguments in the form of an array object. The array index corresponds with the argument position. If the option *n* is used, the index starts at the specified position. If any argument is omitted, the corresponding index is absent. The second new option is *Normal*, which returns the nth argument, if it exists, or the null string otherwise.

CHANGESTR (New)



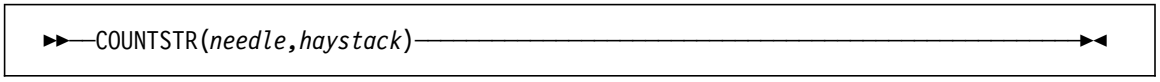
CHANGESTR returns a copy of *haystack*, in which *newneedle* replaces all occurrences of *needle*.

CONDITION (Enhanced)



CONDITION has two new options. The *Additional* option makes it possible to get some additional object information on certain conditions (NOMETHOD, NOSTRING, NOTREADY, SYNTAX, and USER). The second new option, *Object*, returns an object containing all the information about the current trapped condition. This can be used to create a generalized trap-and-debug routine, as described in “CALL/SIGNAL (Enhanced)” on page 238.

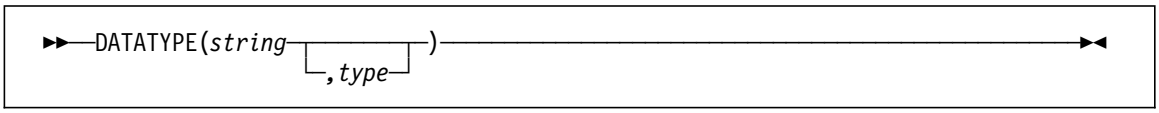
COUNTSTR (New)



COUNTSTR returns a count of the nonoverlapping occurrences of *needle* in *haystack*. Here is one example:

```
countstr('11','101111101110')   --> 3   /* observe - no overlap */
```

DATATYPE (Enhanced)

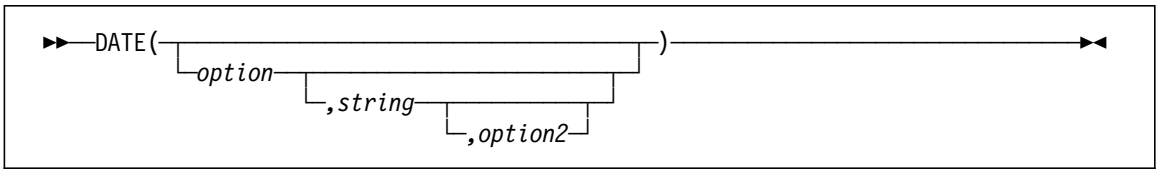


DATATYPE has two new types. The first one is *Variable*. As an example, `DATATYPE(xyz,'V')` would return 1 if "xyz" could be on the left-hand side of an assignment without causing a SYNTAX condition.

The second new type is *9 Digits*. The description specifies that this type returns 1 if `DATATYPE(string,'W')` would return 1 when NUMERIC DIGITS is set to 9. Thus if NUMERIC DIGITS is larger than 9, type *9* returns 0 for any whole number larger than 9 digits. Here is an example:

```
numeric digits 12
datatype('1234567890,'W')    --> 1    /* less than digits() */
datatype('1234567890,'9')    --> 0    /* more than 9 digits */
```

DATE (Enhanced)



DATE is now enhanced so that it is possible to work with a date other than the current one. The *string* allows input of a date to translate from one form to another. If the input string is not in the default format (*dd mon yyyy*), *option2* can be used to specify the format to Object REXX. For example, if you want to know how many days it is to your next birthday, enter the following statement in a REXXTRY window (96/mm/dd is your birthday):

```
say date('B','96/mm/dd','O') - date('B') 'days'
```

Two of the old options have different names. *Basedate* is now only *Base* and *Sorted* is changed to *Standard*.

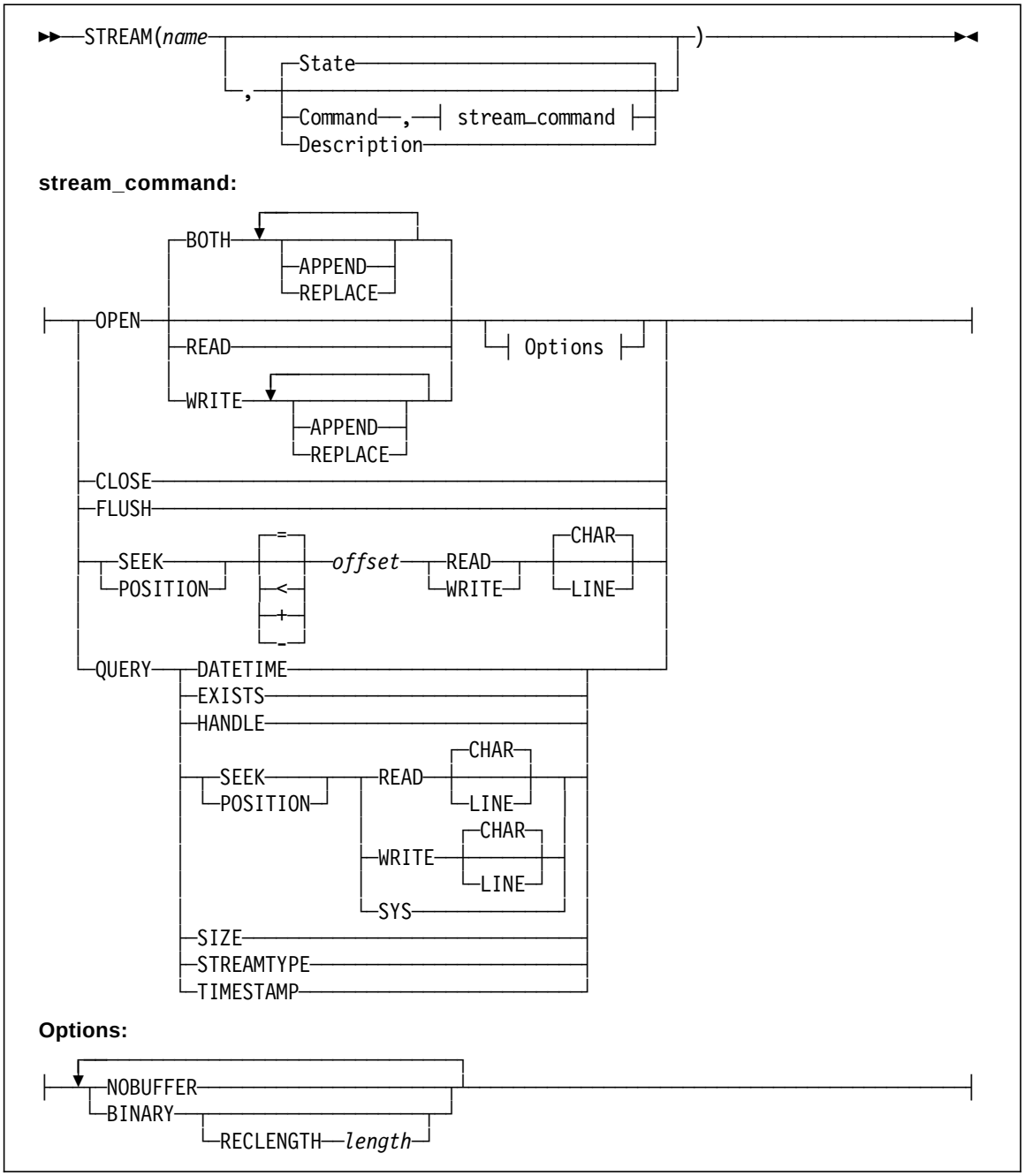
STREAM (Enhanced)

In Object REXX, input and output can be handled two ways. The old way is to use the built-in functions (STREAM, LINES, LINEIN, LINEOUT, CHARIN, and CHAROUT), which still works. STREAM has a lot of new command strings that we will look at, but we will not go through them all in detail. The new way is to use the new stream class (.Stream) in Object REXX, in which all of the built-in functions are available through methods.

Whichever we choose, we must remember not to mix the two ways for the same stream object. When we use the built-in I/O functions, the language processor creates a stream object and maintains it for us. If we use the *new* method to create a stream object, the object is returned to and maintained by our own program.

Because of this, when Object REXX stream methods and stream built-in functions refer to the same file from the same program, there are two separate stream objects with different read

and write pointers. This will cause unpredictable results if the stream is written to by using both methods and built-in functions.



So what are the changes to STREAM that both methods and functions can use:

1. OPEN has some new options. First, Object REXX now supports separate pointers for read and write. The default is to open for both read and write. That can also be specified by option BOTH, in case we want to point it out or add one of the new position options, APPEND or REPLACE. The position options are also valid if we open for WRITE.

   Option NOBUFFER turns off buffering of the stream. This forces all data written to the stream to be physically written immediately to the media.

BINARY makes it possible to handle data without regard to any line-end characters, and RECLENGTH makes it possible to define a fixed record length so that line operations can be used.

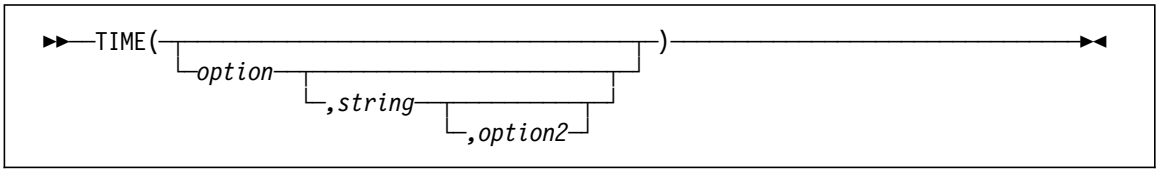
2. FLUSH is a new command that forces any data currently buffered for writing to be written to this stream.

3. SEEK now has a synonym called POSITION. Since we now have two pointers, we have to choose between the READ pointer (default) and the WRITE pointer. CHAR (default) specifies that we are seeking in terms of character position, and LINE in terms of lines.

4. QUERY is enhanced by four new options:

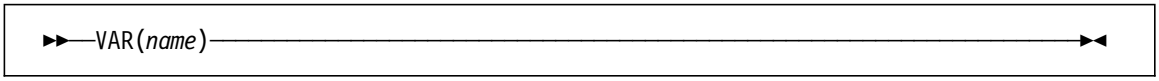
   - HANDLE—returns the handle associated with the open stream.
   - SEEK/POSITION—returns the current read or write position of the file as qualified by READ, WRITE, CHAR and LINE.
   - STREAMTYPE—returns the type of stream (PERSISTENT, TRANSIENT, or UNKNOWN).
   - TIMESTAMP—returns the date and time stamps of a stream in the form YYYY-MM-DD HH:MM:SS.

TIME (Enhanced)



TIME is now enhanced so that it is possible to work with a time other than the current one. The *string* allows input of a date to translate from one form to another. If the input string is not in the default format (*hh:mm:ss*), *option2* can be used to specify the format to Object REXX.

VAR (New)

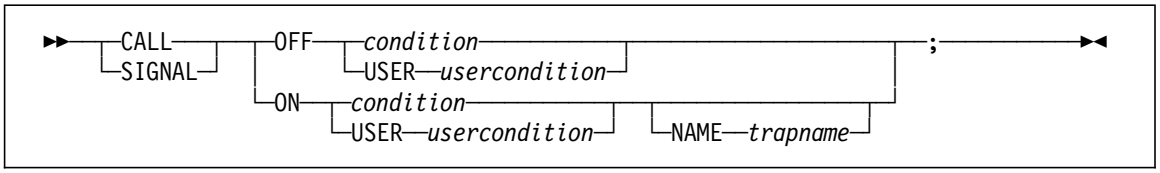


VAR is a new built-in function. It returns 1 if *name* is the name of a variable (that is, a symbol that has been assigned a value), or 0 otherwise.

New Condition Traps

New condition traps are implemented in both the CALL and SIGNAL instructions.

CALL/SIGNAL (Enhanced)



The new conditions are explained in “SIGNAL (Enhanced)” on page 232. Note that the *RAISE condition* does not trap on the level issued. It shows up as a trap on the calling statement in the parent routine.

The code examples below show the use of a generalized trap routine. A main program requires the class definition and a generalized trap routine. It creates an object and runs a method that causes a syntax error.

The main program:

```
/* TstRaise.Cmd - Test the new RAISE instruction */
   signal on any
   tm = .myTest~new
   say tm~myMethodA
   exit
   any: interpret .local["M.TRAPDSP"]

::requires 'TstRaise.CaM'      /* myTest class and methods */
::requires 'TrapDisp.Cmd'      /* generalized trap routine */
```

The program containing the Object REXX class and methods:

```
/* TstRaise.CaM - Class & Method directives for TstRaise.Cmd */
::class myTest public
::method init
   return
::method myMethodA
   signal on any
   x = self~myMethodB
   return x
   any: interpret .local["M.TRAPRTN"]
::method myMethodB
   signal on any
   a = 'xyz'
   c = a+2                  /* this line will cause SYNTAX error */
   return c
   any: interpret .local["M.TRAPRTN"]
```

The generalized trap routine:

```
/* TrapDisp.Cmd - Error condition trap and display routines */
.local["M.TRAPRTN"] = 'trace "o"; ',
   'if .local["M.SIGL"] = .nil then do; ',
   '   .local["M.SIGL"] = sigl; ',
   '   .local["M.COBJ"] = condition("O"); ',
   '   PARSE SOURCE with . sourceid; ',
```

```
   '    .local["M.COBJ"]["M.MODULE"] = sourceid; ',
   '    .local["M.COBJ"]["M.LINE"] = sourceline(sigl); ',
   'end; ',
   'raise propagate; '
.local["M.TRAPDSP"] = 'trace "o"; ',
   'signal off any; ',
   'if .local["M.SIGL"] <> .nil then do; ',
   '    sigl = .local["M.SIGL"]; ',
   '    .local["M.SIGL"] = .nil; ',
   '    CObj = .local["M.COBJ"]; ',
   'end; ',
   'else do; ',
   '    CObj = condition(o); ',
   '    CObj["M.MODULE"] = CObj["PROGRAM"]; ',
   '    CObj["M.LINE"] = sourceline(sigl); ',
   'end; ',
   'if var("rc"); ',
   '    then say "REXX ["CObj["CONDITION"]"] error" rc ',
   '              "in line" sigl":" "ERRORTEXT"(rc); ',
   '    else say "REXX ["CObj["CONDITION"]"] error in line" sigl; ',
   'say "The Source Module is: "CObj["M.MODULE"]; ',
   'say "Source line is:" CObj["M.LINE"]; ',
   'exit; '
```

Sample execution:

```
[C:]TstRaise
REXX [SYNTAX] error 41 in line 16: Bad arithmetic conversion
The Source Module is: C:\TstRaise.CaM
Source line is:    c = a+2    /* this line will cause SYNTAX error */
```

New REXX Utilities

A set of new REXX utilities has been added in Object REXX. These are described in detail in the Object REXX manuals; therefore we include only a short description here.

Utilities for WPS

SysOpenObject Opens a view of an existing WPS object and returns the WinOpenObject return codes; 1 (true) if the object was opened, or 0 (false) otherwise.

SysCopyObject Copies an existing WPS object to the specified destination folder and returns the WinCopyObject return codes: 1 (true) if the object was copied, or 0 (false) otherwise.

SysMoveObject Moves an existing WPS object to the specified destination folder and returns the WinMoveObject return codes: 1 (true) if the object was moved, or 0 (false) otherwise.

SysSaveObject Saves an existing WPS object. The WPS operates asynchronously. When one process updates an object, other processes may not see these updates until the WPS updates the object. You can use the SysSaveObject function synchronously to ensure that the WPS updates the object before continuing with other processing. SysSaveObject returns the WinSaveObject return codes: 1 (true) if the object was saved, or 0 (false) otherwise.

SysCreateShadow Shadows an existing WPS object to the specified destination folder and returns the WinCreateShadow return codes: 1 (true) if the object was shadowed, or 0 (false) otherwise.

Utilities or Semaphores

SysCreateEventSem Creates or opens an OS/2 event semaphore. Returns an event semaphore handle that can be used with the DosOpenEventSem, DosCloseEventSem, DosResetEventSem, DosPostEventSem, and DosWaitEventSem functions. Returns a null string if the semaphore cannot be created or opened.

SysOpenEventSem Opens an OS/2 event semaphore and returns the DosOpenEventSem return codes.

SysPostEventSem Posts an OS/2 event semaphore and returns the DosPostEventSem return codes.

SysWaitEventSem Waits on an OS/2 event semaphore and returns the DosWaitEventSem return codes.

SysResetEventSem Resets an OS/2 event semaphore and returns the DosResetEventSem return codes.

SysCloseEventSem Closes an OS/2 event semaphore and returns the DosCloseEventSem return codes.

SysCreateMutexSem Creates or opens an OS/2 mutex semaphore. Returns a mutex semaphore handle that can be used with the DosOpenMutexSem, DosCloseMutexSem, DosRequestMutexSem, and DosReleaseMutexSem functions. Returns a null string if the semaphore cannot be created or opened.

SysOpenMutexSem Opens an OS/2 mutex semaphore and returns the DosOpenMutexSem return codes.

SysRequestMutexSem Requests an OS/2 mutex semaphore and returns the DosRequestMutexSem return codes.

SysReleaseMutexSem Releases an OS/2 mutex semaphore and returns the DosReleaseMutexSem return codes.

SysCloseMutexSem Closes an OS/2 mutex semaphore and returns the DosCloseMutexSem return codes.

Utilities for REXX Macros

SysAddRexxMacro Adds a routine to the REXX macrospace and returns the RexxAddMacro return codes.

SysQueryRexxMacro Queries the existence of a macrospace function. Returns either the placement order of the macrospace function or a null string if the function does not exist in the macrospace.

SysReorderRexxMacro
Changes the search-order position of a loaded macrospace function. The new search-order position could be either before or after any registered functions and external REXX files. SysReorderRexxMacro returns the RexxReorderMacro return codes.

SysDropRexxMacro Removes a routine from the REXX macrospace and returns the RexxDropMacro return codes.

SysClearRexxMacroSpace
Removes all loaded routines from the REXX macrospace and returns the RexxClearMacro return codes.

SysLoadRexxMacroSpace
Loads all functions from a file created with the SysSaveRexxMacroSpace utility. If any of the functions already exists in the macrospace, the entire load request is discarded and the macrospace remains unchanged. SysLoadRexxMacroSpace returns the RexxLoadMacro return codes.

SysSaveRexxMacroSpace
Saves all REXX macrospace functions to a file. Observe that saved macrospaces can be loaded only with the same interpreter level that created the image. SysSaveRexxMacroSpace returns the RexxSaveMacro return codes.

Utilities for Files

SysAddFileHandle Adds to the number of file handles available to the current process and returns the number of file handles now available.

SysSetFileHandle Sets the maximum number of file handles available to the current process and returns the DosSetMaxFH return codes

Utilities for Code Pages

SysQueryProcessCodePage
Queries the current code page for the process. Returns the current code page the process is using.

SysSetProcessCodePage
Changes the current code page for the process. This change does not affect the display or keyboard code page. SysSetProcessCodePage returns the DosSetProcessCp return codes.

Utilities for OS/2 Systems

SysBootDrive Returns the drive used to boot OS/2, for example, 'C:'.

SysElapsedTime Returns a time in the format: sssssssss.uuuuuu. The number has no leading zeros or blanks. The fractional part always has six digits. This function uses the OS/2 high-frequency timer services. It has higher timer resolution than the REXX built-in TIME() function.

SysFileSystemType Returns the name of the file system for a drive (FAT, HPFS, LAN, ...). If the drive is not accessible, a null string is returned.

SysGetCollate Retrieves the country-specific collating table. Returns the 256-byte collating-sequence table for the indicated country and code-page combination.

SysLoadFuncs Loads all RexxUtil functions (or other packages). After a REXX program calls SysLoadFuncs, the RexxUtil functions are available in all OS/2 sessions:

```
call RxFuncAdd 'SysLoadFuncs', 'RexxUtil', 'SysLoadFuncs'
call SysLoadFuncs
```

SysMapCase Performs a national language uppercase mapping to a string. Returns the original string, case-mapped according to the country and code-page combination.

SysNationalLanguageCompare
Compares two character strings, using a country-specific collating table. The strings are compared for the length of the shorter string. Returns the comparison result as 0 (equal), 1 (first string longer or collating higher), -1 (first string shorter or collating lower).

SysProcessType Returns the type of process in which the REXX program is running. The return values are 0 (full screen), 1 (requires real mode), 2 (VIO windowable), 3 (Presentation Manager), 4 (detached process).

SysQueryEAList Retrieves the complete list of extended attribute names for a file or directory. Returns the names in a stem variable collection where the stem.0 entry contains the number of names.

SysSetPriority Changes the priority of the current process and returns the DosSetPriority return codes.

SysShutDownSystem Shuts down the OS/2 system. Returns 1 for a successful shutdown or 0 for an unsuccessful shutdown.

SysWildCard Produces an OS/2 edited file name using a source file name and a wildcard editing pattern. Returns the result of editing the source with the wildcard. The editing is performed using the DosEditName function.

Migration Considerations

Migration considerations are described in detail in *Object REXX Reference for OS/2*. Here we provide a short extract:

Stems Stems behave a little differently in Object REXX. The symbol functions return VAR (not LIT) because a stem object is automatically created the first time used, and a NOVALUE condition is never raised. Stems can be assigned to each other (a. = z.), and they point to the same object.

In many cases it may be desirable to use some of the new collections provided by Object REXX, instead of a stem variable.

Parse version Return n.nn, the current version.

Streams Avoid mixing methods (aStream~linein) and functions (linein(aStream)) because they work on different objects representing the same file. LINEIN, CHARIN, LINES, and CHARS return the null string for a nonexisting file, but they also create an empty file on the disk.

Earlier error detection
Before the program is started, Object REXX performs some syntax checking and the program might not get control ever. For example, missing END statements and missing parameters are detected before starting the program.

Appendix A. Car Dealer Source Code

Sample Data

Note: The not signs (¬) represent tab characters in the sample data listings below.

Sample Customer Data

```
/*--------------------------------------------------------------------*/
/* SampData\customer.dat CarDealer - Customer data file      ITSO-SJC */
/*--------------------------------------------------------------------*/
/*number name                  address                                */
/*--------------------------------------------------------------------*/
101¬Senator, Dale       ¬Washington
102¬Akropolis, Ida      ¬Athens
103¬Dolcevita, Felicia  ¬Rome
104¬DuPont, Jean        ¬Paris
105¬Deutsch, Hans       ¬Stuttgart
106¬Helvetia, Toni      ¬Zurich
107¬Rising Star         ¬Hollywood
108¬Zabrowski, Russkie  ¬Moscow
109¬Valencia, Maria de  ¬Barcelona
601¬Wahli, Ueli         ¬ITSO San Jose
602¬Turton, Trevor      ¬Johannesburg
603¬Griborn, Eddie      ¬Stockholm
604¬Furukawa, Norio     ¬Tokyo
/*--------------------------------------------------------------------*/
999¬New and used cars   ¬For sale
```

Figure 111. Sample Customer Data (SAMPDATA\CUSTOMER.DAT)

Sample Vehicle Data

```
/*--------------------------------------------------------------------*/
/* SampData\vehicle.dat  CarDealer - Vehicle data file       ITSO-SJC */
/*--------------------------------------------------------------------*/
/*serial make          model          year    customer              */
```

Figure 112 (Part 1 of 2). Sample Vehicle Data (SAMPDATA\VEHICLE.DAT)

```
/*-------------------------------------------------------------------*/
123456-Ford        -T         -1931-101
297465-Volkswagen  -Camper    -1971-102
111111-Porsche     -Targa     -1989-102
222222-Lamborghini -Countach  -1992-103
398674-Cadillac    -Allante   -1991-103
334455-Chevrolet   -Impala    -1985-104
456456-Toyota      -Camry     -1988-105
543543-Pontiac     -Firebird  -1979-106
911911-Chrysler    -Le Baron  -1982-106
298653-Mercury     -Sable     -1987-106
176549-Olsmobile   -Aurora    -1993-107
199999-Acura       -Legend    -1990-107
777777-Mercedes    -380S      -1990-108
666888-Lincoln     -Towncar   -1986-109
601001-Audi        -5000-Wagon-1984-601
602002-BMW         -735S      -1991-602
603003-Saab        -9000      -1992-603
604004-Nissan      -Altima    -1994-604
/*-----------------------------------------------new/used cars----*/
999001-Ford        -Windstar  -1995-999
999002-Audi        -V8 Quattro-1990-999
999003-Volvo       -860 Wagon -1995-999
999004-Honda       -Civic     -1994-999
999005-MixedStuff  -Fun       -1995-999
/*-----------------------------------------------not a car!-------*/
999666-ThinkPad    -701       -1995-999
999999-ORexxRedbook-Team      -1995-999
```

Figure 112 (Part 2 of 2). Sample Vehicle Data (SAMPDATA\VEHICLE.DAT)

Sample Work Order Data

```
/*-------------------------------------------------------------------*/
/* SampData\workord.dat  CarDealer - WorkOrder data file     ITSO-SJC */
/*-------------------------------------------------------------------*/
/*number date           cost  complete  custmr  serial  serv.items    */
/*-------------------------------------------------------------------*/
1-09/06/95--1-0-101-123456-1
2-09/07/95--1-0-103-398674-10-9-4
3-09/08/95--1-0-106-911911-7-6
4-09/09/95--1-0-108-777777-11
5-08/01/95-100-1-107-199999-2-3
```

Figure 113. Sample Work Order Data (SAMPDATA\WORKORD.DAT)

Sample Service Item Data

```
/*-------------------------------------------------------------------*/
/* SampData\service.dat  CarDealer - ServiceItem data file   ITSO-SJC */
/*-------------------------------------------------------------------*/
/*number description            labor   part    quant   part    quan  */
/*-------------------------------------------------------------------*/
1 -Brake job          -110-21-1-22-2-23-2-24-2
```

Figure 114 (Part 1 of 2). Sample Service Item Data (SAMPDATA\SERVICE.DAT)

```
2 -Check fluids        -25 -10-5-11-1-31-1
3 -Tire rotate/balance-20
4 -Tires new Sedan     -0  -51-4
5 -Tires new Sport     -10 -52-4
6 -Starter             -75 -71-1
7 -Alternator          -90 -72-1
8 -Heating system      -145-61-1-62-1-81-1-82-1
9 -Electrical          -85 -45-3-91-1
10-Exhaust system      -85 -1-1
11-Fenders             -45 -41-2
```

Figure 114 (Part 2 of 2). Sample Service Item Data (SAMPDATA\SERVICE.DAT)

Sample Part Data

```
/*-------------------------------------------------------------------*/
/* SampData\part.dat     CarDealer - Part data file          ITSO-SJC */
/*-------------------------------------------------------------------*/
/*number description    cost    stock                                */
/*-------------------------------------------------------------------*/
1-Muffler         -120-3
10-Oil 10-40 quart-5-30
11-Oil filter     -22-15
21-Brake cylinder -120-3
22-Brake fluid    -7-13
23-Brake drum     -28-6
24-Brake disk     -35-9
31-Steering fluid -8-40
41-Fender         -67-2
45-Light bulb     -2-20
51-Tire 185-70    -57-8
52-Tire 205-60    -73-12
61-Belt           -12-2
62-Radiator       -133-1
71-Starter        -189-4
72-Alternator     -165-2
81-Water pump     -97-1
82-Heating control-43-1
91-Cruise control -54-2
```

Figure 115. Sample Part Data (SAMPDATA\PART.DAT)

Multimedia Setup

Multimedia Data Definition File

```
/*-------------------------------------------------------------------*/
/* Media\media.dat       CarDealer - Multi-media definition  ITSO-SJC */
/*-------------------------------------------------------------------*/
/* serial, title of file       , filename                            */
```

Figure 116 (Part 1 of 2). Multimedia Data Definition File (MEDIA\MEDIA.DAT)

```
/*--------------------------------------------------------------------*/
   999001, Fact-sheet          , ford.fac
   999001, Side picture        , fordsid.bmp
   999001, Front picture       , fordfrt.bmp
   999001, Back picture        , fordbck.bmp
   999001, Angle picture       , fordang.bmp
   999001, Audio               , ford.wav
   999002, Fact-sheet          , audi.fac
   999002, Side picture        , audisid.bmp
   999002, Front picture       , audifrt.bmp
   999002, Back picture        , audibck.bmp
   999002, Audio               , audi.wav
   999003, Fact-sheet          , volvo.fac
   999003, Side picture        , volvosid.bmp
   999003, Front picture       , volvofrt.bmp
   999003, Back picture        , volvobck.bmp
   999003, Audio               , volvo.wav
   999004, Fact-sheet          , honda.fac
   999004, Side picture        , hondasid.bmp
   999004, Front picture       , hondafrt.bmp
   999004, Back picture        , hondabck.bmp
   999004, Audio               , honda.wav
   999005, Fact-sheet          , mixed.fac
   999005, Tow truck           , towtruck.bmp
   999005, Truck               , truck.bmp
   999005, Pickup              , pickup.bmp
   999005, Fire engine         , fireeng.bmp
   999005, Motor cycle         , motocycl.bmp
   999005, Audio               , mixed.wav
   999666, Fact-sheet          , ibm701i.fac
   999666, ThinkPad 701        , ibm701i.bmp
   999666, Video               , ibm701i.avi
   999999, Fact-sheet          , orexxred.fac
   999999, Team Photo          , orexteam.bmp
   999999, Ueli Wahli          , ueli.bmp
   999999, Trevor Turton       , trevor.bmp
   999999, Eddie Griborn       , eddie.bmp
   999999, Norio Furukawa      , norio.bmp
   999999, Audio               , orexxred.wav
   999999, Video               , macaw.avi
   601001, Fact-sheet          , wahli.fac
   601001, Ueli's Portrait     , ueli2.bmp
   601001, Ueli's car          , audi.bmp
   601001, License plates      , licenses.bmp
   601001, Cactus garden       , cactus.bmp
   601001, Family cat          , boxie.bmp
   601001, Cat in trouble      , cat.bmp
   601001, Audio               , wahli.wav
   602002, Trevor's Portrait   , trevor2.bmp
   603003, Eddie's Portrait    , eddie2.bmp
   604004, Norio's Portrait    , norio2.bmp
   end
```

Figure 116 (Part 2 of 2). Multimedia Data Definition File (MEDIA\MEDIA.DAT)

Classes and Methods

Base Classes

Base Customer Class

```
/*--------------------------------------------------------------------*/
/* Base\carcust.cls      CarDealer - Customer class (base)   ITSO-SJC */
/*--------------------------------------------------------------------*/

::class CustomerBase public

/*----- class methods ------------------------------------------------*/

::method initialize class                          /* preprare class          */
   expose extent
   extent = .set~new                               /* - keep track of cust.   */
   self~persistentLoad                             /* - and load into memory  */

::method add class                                 /* add new customer        */
   expose extent
   use arg custx
   if custx~class = self then do                   /* - check if already there*/
      do custo over extent
         if custo~number = custx~number then return
      end
      extent~put(custx)                            /* - add to extent         */
   end

::method remove class                              /* remove customer from    */
   expose extent                                   /*    extent               */
   use arg custx
   if custx~class = self then
      extent~remove(custx)

::method findNumber class                          /* find customer by number */
   expose extent
   parse arg custnum
   do custx over extent                            /* - search extent         */
      if custx~number = custnum then return custx /* - return when found     */
   end
   return .nil

::method findName class                            /* find customer by name   */
   arg custsearch
   custnames = .list~new                           /* - prepare result list   */
   do custx over self~extent                       /* - check extent          */
      if abbrev(translate(custx~name),custsearch) then do
         custstring = custx~number~right(3)|| ,
                      '-'custx~name'-'custx~address
         custnames~insert(custstring)              /* - add a match           */
      end
   end
   return custnames~makearray                      /* - return result array   */
```

Figure 117 (Part 1 of 4). Base Customer Class (BASE\CARCUST.CLS)

```
::method findAddress class                        /* find customer by address*/
   arg custsearch
   do custx over self~extent                      /* - check extent          */
      if custx~address = custsearch then
         return custx~number                      /* - return customer number*/
   end
   return ''                                      /* - return not found      */

::method extent class                             /* return extent of cust.  */
   expose extent
   return extent~makearray                        /* - as an array           */

::method heading class                            /* return a heading        */
      return 'Number      Name                    Address'

/*----- instance methods ---------------------------------------------*/

::method init                                     /* initialize new customer */
   expose customerNumber name address cars orders
   self~init:super                                /* - call parent           */
   use arg customerNumber, name, address
   cars = .set~new                                /* - prepare cars/orders   */
   orders = .set~new
   if arg() < 3 | arg() > 4 then return self~setnil
   if \datatype(customerNumber,'W') then return self~setnil
   if customerNumber<100 | customerNumber>999 then return self~setnil
   self~class~add(self)                           /* - add to extent         */
   if arg() = 4 then self~persistentInsert        /* - a real new customer   */

::method setnil private                           /* set customer data nil   */
   expose customerNumber name address cars orders
   self~class~remove(self)                        /* - remove from extent    */
   cars = .nil
   orders = .nil
   customerNumber = 0
   name = '-none-'
   address = '-none-'
   return .nil

::method delete                                   /* delete a customer       */
   expose cars orders
   do carx over cars                              /* - delete all cars       */
      carx~delete
   end
   do workx over orders                           /* - delete all workorders */
      workx~delete
   end
   self~class~remove(self)                        /* - remove from extent    */
   self~persistentDelete                          /* - delete permanent stor */
   self~setnil

::method number unguarded                         /*                         */
   expose customerNumber
   return customerNumber

::method name attribute                           /* customer's name         */

::method address attribute                        /* customer's address      */

::method update                                   /* update customer data    */
   expose name address
   if arg() = 2 then do
      use arg name, address
```

Figure 117 (Part 2 of 4). Base Customer Class (BASE\CARCUST.CLS)

```
      self~persistentUpdate                        /* - update persistent stor*/
   end

::method addVehicle                                /* add a vehicle           */
   expose cars
   use arg newcar
   owner = newcar~getowner                         /* - check its owner       */
   if owner = self | owner = .nil then do
      cars~put(newcar)                             /* - add if no owner       */
      if owner = .nil then
         newcar~setowner(self)                     /* - set new owner         */
      end
   else do                                         /* - error if other owner  */
      say 'Cannot add car' newcar~makemodel 'to customer' self~name
      say '  it belongs to' newcar~getowner~name
   end

::method removeVehicle                             /* remove vehicle from cust*/
   expose cars
   use arg oldcar
   oldcar~deleteOwner                              /* - delete owner          */
   cars~remove(oldcar)                             /* - remove from cars      */

::method checkVehicle                              /* check if car in set     */
   expose cars
   use arg somecar
   if cars~hasindex(somecar) then return 1         /* - yes it is             */
   else return 0

::method getVehicles                               /* return array of cars    */
   expose cars
   return cars~makearray

::method findVehicle                               /* find car by serial      */
   expose cars
   use arg serial
   do carx over cars                               /* - check all cars        */
      if carx~serial = serial then return carx
   end
   return .nil

::method addOrder                                  /* add order to customer   */
   expose orders
   use arg newwork
   orders~put(newwork)                             /* - add order to set      */

::method removeOrder                               /* remove order from cust. */
   expose orders
   use arg oldwork
   orders~remove(oldwork)                          /* - remove order from set */

::method getOrders                                 /* return all orders       */
   expose orders
   return orders~makearray                         /* - as an array           */

::method detail                                    /* return a detail line    */
   expose customerNumber name address
   return customerNumber~right(5) '     ' name~left(20) '  ' address~left(20)

::method makestring                                /* default string output   */
   expose customerNumber name
   return 'Customer:' customerNumber name

::method display                                   /* display customer data   */
```

Figure 117 (Part 3 of 4). Base Customer Class (BASE\CARCUST.CLS)

```
   expose customerNumber name address cars orders
   say '-'~copies(78)
   say self~class~heading
   say self~detail
   if cars~items > 0 then
      do carx over cars
         say '   Vehicle:' carx~detail
      end
   if orders~items > 0 then do
      do orderx over orders
         say ' WorkOrder:' orderx~detail
      end
   end
```

Figure 117 (Part 4 of 4). Base Customer Class (BASE\CARCUST.CLS)

Base Vehicle Class

```
/*--------------------------------------------------------------------*/
/* Base\carvehi.cls      CarDealer - Vehicle class (base)    ITSO-SJC */
/*--------------------------------------------------------------------*/

::class VehicleBase public

/*----- class methods ------------------------------------------------*/

::method initialize class                       /* prepare class          */
   self~persistentLoad                          /* - load into memory     */

/*----- instance methods ---------------------------------------------*/

::method init                                   /* initialize new vehicle  */
   expose serialNumber make model year owner
   self~init:super
   use arg serialNumber, make, model, year, owner
   if arg() < 5 | arg() > 6 then self~setnil
   if owner \= .nil then
      owner~addVehicle(self)                    /* - add car to customer   */
   if arg() = 6 then self~persistentInsert      /* - insert real new car   */

::method setnil private                         /* set vehicle data nil    */
   expose serialNumber make model year owner
   if owner \= .nil then
           owner~removeVehicle(self)            /* - remove from customer  */
   serialNumber = 0
   make = '-none-'
   model = '-none-'
   year = 0
   owner = .nil

::method delete                                 /* delete a vehicle        */
   expose serialNumber make model year owner
   self~persistentDelete                        /* - from permanent stor   */
   self~setnil

::method serial                                 /* return serial number    */
   expose serialNumber
   return serialNumber
```

Figure 118 (Part 1 of 2). Base Vehicle Class (BASE\CARVEHI.CLS)

```
::method make attribute                          /* vehicle's make          */

::method model attribute                         /* vehicle's model         */

::method year attribute                          /* vehicle's year          */

::method update                                  /* update vehicle data     */
   expose make model year
   if arg() = 3 then do
      use arg make, model, year
      self~persistentUpdate                      /* - in permanent storage  */
   end

::method makemodel unguarded                     /* return make and model   */
   expose make model
   return make~strip'-'model~strip               /* - as string             */

::method getOwner unguarded                      /* return owner (customer) */
   expose owner
   return owner

::method setOwner                                /* set a new owner (cust)  */
   expose owner
   use arg newowner
   if owner = .nil then
     if newowner~checkVehicle(self) then         /* - if its the proper one */
        use arg owner

::method deleteOwner                             /* delete the owner (cust) */
   expose owner
   owner = .nil

::method detail                                  /* return a detail line    */
   expose serialNumber make model year
   return serialNumber~right(8) '  ' make~left(12) '  ' model~left(10) ,
          '  ' year

::method makestring                              /* default string output   */
   expose serialNumber make model
   return 'Vehicle:' serialNumber make model

::method display                                 /* display vehicle data    */
   expose serialNumber make model year owner
   if owner = .nil then ownerst = '-no owner-'
                   else ownerst = owner~number
   say serialNumber~right(8) '  ' make~left(12) '  ' model~left(10) ,
       '  ' year '  ' ownerst
```

Figure 118 (Part 2 of 2). Base Vehicle Class (BASE\CARVEHI.CLS)

Base Work Order Class

```
/*-------------------------------------------------------------------*/
/* Base\carwork.cls      CarDealer - WorkOrder class (base)  ITSO-SJC */
/*-------------------------------------------------------------------*/
```

Figure 119 (Part 1 of 6). Base Work Order Class (BASE\CARWORK.CLS)

```
::class WorkOrderBase public

/*----- class methods ---------------------------------------------*/

::method initialize class                       /* prepare the class       */
   expose extent WorkServRel
   extent = .list~new                           /* - extent of work orders */
   if .local['Cardeal.WorkServRel'] = .nil then /* - prepare relation to   */
      .local['Cardeal.WorkServRel'] = .Relation~new
   WorkServRel = .local['Cardeal.WorkServRel']  /* - service items         */
   self~persistentLoad                          /* - load into memory      */

::method getWorkServRel class                   /* return the relation     */
   expose WorkServRel
   return WorkServRel

::method add class                              /* add workorder to extent */
   expose extent
   use arg workx
   if workx~class = self then do
      do worko over extent                      /* - check if already there*/
         if worko~number = workx~number then return worko~getindex
      end
      return extent~insert(workx, .nil)         /* - insert new at start   */
   end

::method remove class                           /* remove order from extent*/
   expose extent
   use arg indx, workx
   if extent~at(indx) = workx then              /* - ckeck and remove      */
      extent~remove(indx)

::method findNumber class                       /* find workorder by number*/
   expose extent
   use arg worknum
   do workx over extent                         /* - check the extent      */
      if workx~number = worknum then return workx
   end
   return .nil

::method findStatus class                       /* find workorder by status*/
   expose extent
   use arg xstatus
   worklist = .list~new                         /* - prepare result        */
   xstat1 = 0                                   /* - 0 is incomplete       */
   xstat2 = 1                                   /* - 1 is complete         */
   if xstatus = 0 then xstat2=0
   if xstatus = 1 then xstat1=1
   do workx over extent                         /* - go over all orders    */
      xstatus = workx~getstatus                 /* - and check the status  */
      if xstatus >= xstat1 & xstatus <= xstat2 then do
         if xstatus = 0 then statusx = 'Incomplete'
                        else statusx = 'Complete'
         workstring = workx~number~left(3) ''  workx~date ,
                      workx~cost~right(6) statusx~left(11) ,
                      (workx~getvehicle~make~strip || ,
                        '-'workx~getvehicle~model~strip)~left(20) ,
                      workx~getcustomer~name
         worklist~insert(workstring,.nil)       /* - add to result         */
      end
   end
   return worklist~makearray                    /* - return result as array*/

::method newNumber class                        /* return a new number     */
```

Figure 119 (Part 2 of 6). Base Work Order Class (BASE\CARWORK.CLS)

```
   expose extent
   if extent~items = 0 then return 1
   newnum = 0
   do workx over extent                          /* - find maximum number   */
      newnum = max(newnum, workx~number)
   end
   return newnum + 1                             /* - return next higher    */

::method extent class
   expose extent                                 /* return extent as array  */
   return extent~makearray

/*----- instance methods ---------------------------------------------*/

::method init                                    /* initialize new workorder*/
   expose orderNumber cost date status customer car listindex
   self~init:super
   status = 0                                    /* - incomplete            */
   cost = -1                                     /* - unknown cost          */
   orderNumber = 0
   if arg() = 3 then do                          /* - new work order        */
      use arg date, customer, car
      orderNumber = self~class~newNumber         /* - find new number       */
      listindex = self~class~add(self)           /* - add to extent         */
      customer~addOrder(self)                    /* - add to customer       */
      self~persistentInsert                      /* - add to persistent stor*/
      end
   else if arg() = 6 then do                     /* - load from persistent  */
      use arg orderNumber, date, cost, status, customer, car
      listindex = self~class~add(self)           /* - add to extent         */
      customer~addOrder(self)                    /* - add to customer       */
      end
   else self~setnil

::method setnil private                          /* set workorder data nil  */
   expose orderNumber cost date status customer car listindex
   customer~removeOrder(self)
   self~class~remove(listindex,self)             /* - remove from extent    */
   status = 0
   cost = -1
   orderNumber = 0
   date = '00/00/00'
   customer = .nil
   car = .nil
   listindex = 0
   return .nil

::method delete                                  /* delete a work order     */
   expose orderNumber cost date status customer car listindex
   self~class~remove(listindex,self)             /* - remove from extent    */
   self~persistentDelete                         /* - delete persistent stor*/
   self~setnil

::method number unguarded                        /* return workorder number */
   expose orderNumber
   return orderNumber

::method cost unguarded                          /* return cost of workorder*/
   expose cost
   return cost

::method date unguarded                          /* return date of workorder*/
   expose date
   return date
```

Figure 119 (Part 3 of 6). Base Work Order Class (BASE\CARWORK.CLS)

```
::method setstatus                              /* change the status       */
   expose status
   use arg newstatus
   if newstatus = 0 | newstatus = 1 then do     /* - change peristent stor */
      if status \= newstatus then self~persistentUpdate
      status = newstatus
   end

::method getstatus unguarded                    /* return the status       */
   expose status
   return status

::method getstatust unguarded                   /* return status as text   */
   expose status
   if status = 0 then return 'incomplete'
   else               return 'complete'

::method getindex unguarded private             /* return index in extent  */
  expose listindex
  return listindex

::method getCustomer unguarded                  /* return the customer     */
   expose customer
   return customer

::method getVehicle unguarded                   /* return the vehicle      */
   expose car
   return car

::method getServices                            /* return all services     */
   return self~class~getWorkServRel~allat(self)

::method addServiceItem                         /* add service to workorder*/
   use arg itemx
   workserv = self~class~getWorkServRel         /* - get the relation      */
   if workserv~hasitem(itemx,self) then return  /* - cannot add same item  */
   workserv[self] = itemx                       /* - record in relation    */
   if arg() = 2 then return self~persistentInsertServ(itemx~number)

::method removeServiceItem                      /* remove a service        */
   use arg itemx
   workserv = self~class~getWorkServRel
   workserv~removeitem(itemx,self)              /* - remove in relation    */
   if arg() = 2 then return self~persistentDeleteServ(itemx~number)

::method getTotalCost                           /* compute total cost      */
   expose cost
   totalcost = 0
   do servx over self~getServices               /* - sum up all services   */
      totalcost = totalcost + servx~laborcost + servx~getPartsCost
   end
   if cost \= totalcost then do                 /* - update cost attribute */
      cost = totalcost
      self~persistentUpdate
   end
   return totalcost

::method checkAndDecreaseStock                  /* check if enough parts   */
   expose status
   if status = 1 then return 0                  /* - not for complete ones */
   enough = 1
   do servx over self~getServices               /* - check all services    */
      partsx = servx~getparts
```

Figure 119 (Part 4 of 6). Base Work Order Class (BASE\CARWORK.CLS)

```
      do partx over partsx                        /* - and parts in service  */
         quan = servx~getquantity(partx)
         partno = partx~number                    /* - get part number       */
         if symbol("stock."partno) = 'LIT' then   /* - record stock          */
            stock.partno = partx~stock
         stock.partno = stock.partno - quan
         if stock.partno < 0 then do              /* - check temporary stock */
            enough = 0
            say ''servx
            say ' --> Not enough stock for' partx
         end
      end
   end
   if enough then do                              /* - all stocks are OK     */
      do servx over self~getServices              /* - go over all services  */
         partsx = servx~getparts
         do partx over partsx                     /* - and all parts         */
            quan = servx~getquantity(partx)
            x = partx~decreaseStock(quan)         /* - decrease stock of part*/
         end
      end
      status = 1
      x = self~getTotalCost                       /* - and compute total cost*/
   end
   return enough

::method generateBill                             /* prepare the bill        */
   expose orderNumber date customer car
   separ = '-'~copies(78)
   bill = .list~new                               /* - result lines          */
   bill~insert('Bill for work order' orderNumber left(' ',30) 'Date:' date)
   bill~insert(separ)
   bill~insert('   Customer:' customer~name)
   bill~insert('    Vehicle:' car~makemodel)
   bill~insert(separ)
   bill~insert('Description         Parts               Unit         ' ,
               'Partcost  Laborcost')
   bill~insert(separ)
   do servx over self~getServices                 /* - over all services     */
      bill~insert(servx~description~left(54) servx~getPartsCost~right(8) ,
                  servx~laborcost~right(10))
      partsx = servx~getparts
      do partx over partsx                        /* - and parts in service  */
         quan = servx~getquantity(partx)
         costx = quan * partx~price
         bill~insert(' '~left(18) quan~right(3) partx~description~left(16) ,
                     '$'partx~price~right(4) '=' costx~right(5))
      end
   end
   bill~insert(separ)
   bill~insert('Total cost of work order'~left(65) self~getTotalCost~right(8))
   bill~insert(separ)
   return bill~makearray

::method detail                                   /* return a detail line    */
   expose orderNumber cost date status
   return orderNumber~right(3) '   Date:' date~left(8) '  Cost:' ,
          cost~right(5) '  Status: ' self~getstatust

::method detailcust                               /* return cust/vehicle     */
   expose customer car
   return '   Customer:' customer~name~left(20) ,
          '    Vehicle:' car~makemodel~left(20)
```

Figure 119 (Part 5 of 6). Base Work Order Class (BASE\CARWORK.CLS)

```
::method makestring                              /* return default string   */
   expose orderNumber cost date status customer car
   return 'Workorder:' orderNumber date self~getstatust ,
          '('customer~name~left(10)''car~makemodel~left(10)')'

::method makeline                                /* return a short line     */
   expose orderNumber cost date status customer car
   return orderNumber~left(3) ''  date cost~right(6) ,
          self~getstatust~left(11) car~makemodel customer~name

::method display                                 /* display work order data */
   expose orderNumber cost date status customer car
   separ = '-'~copies(78)
   say workx~detail
   say workx~detailcust
   first = 1
   do servx over self~getServices
      if first then say '   Services:' servx~number~right(3) servx~description
      else          say '            ' servx~number~right(3) servx~description
      first = 0
      lines = lines + 1
   end
```

Figure 119 (Part 6 of 6). Base Work Order Class (BASE\CARWORK.CLS)

Base Service Item Class

```
/*--------------------------------------------------------------------*/
/* Base\carserv.cls      CarDealer - ServiceItem class(base) ITSO-SJC */
/*--------------------------------------------------------------------*/

::class ServiceItemBase public

/*----- class methods ---------------------------------------------*/

::method initialize class                        /* prepare the class       */
   expose extent WorkServRel
   extent = .list~new                            /* - extent as a list      */
   if .local['Cardeal.WorkServRel'] = .nil then  /* - prepare relation      */
      .local['Cardeal.WorkServRel'] = .Relation~new
   WorkServRel = .local['Cardeal.WorkServRel']   /* - to work orders        */
   self~persistentLoad                           /* - load into memory      */

::method getWorkServRel class                    /* return the relation     */
   expose WorkServRel
   return WorkServRel

::method add class                               /* add service to extent   */
   expose extent
   use arg servx
   if servx~class = self then                    /* - add to extent         */
      return extent~insert(servx)

::method remove class                            /* remove service from ext.*/
   expose extent
   use arg indx, servx
   if extent~at(indx) = servx then               /* - remove ffrom extent   */
```

Figure 120 (Part 1 of 3). Base Service Item Class (BASE\CARSERV.CLS)

```
      extent~remove(indx)

::method findNumber class                          /* find service by number  */
   expose extent
   parse arg servnum
   if extent~items > 0 then                        /* - check the extent      */
      do servx over extent
         if servx~number = servnum then return servx
      end
   return .nil

::method extent class                              /* return extent as array  */
   expose extent
   return extent~makearray

::method heading class                             /* return a heading line   */
   return 'Item  LaborCost  Description  Quantity  Part'

/*----- instance methods ---------------------------------------------*/

::method init                                      /* initialize new service  */
   expose itemNumber description laborCost parts quantity. listindex
   self~init:super
   use arg itemNumber, description, laborCost
   parts = .set~new                                /* - set of parts          */
   quantity. = ''                                  /* - with quantity         */
   if arg() \= 3 then self~setnil
   else listindex = self~class~add(self)           /* - add to extent list    */

::method setnil private                            /* set service data nil    */
   expose itemNumber description laborCost parts listindex
   self~class~remove(listindex,self)               /* - remove from extent    */
   itemNumber = 0
   description = '-none-'
   laborCost = 0
   parts = .nil
   quantity. = ''
   listindex = 0
   return .nil

::method delete                                    /* delete a service item   */
   expose listindex
   self~class~remove(listindex,self)               /* - remove from extent    */
   /* self~persistentDelete */
   self~setnil

::method number unguarded                          /* return service number   */
   expose itemNumber
   return itemNumber

::method laborcost unguarded                       /* return labor cost       */
   expose laborCost
   return laborCost

::method description unguarded                     /* return description      */
   expose description
   return description

::method usesPart                                  /* record used part        */
   expose parts quantity.
   if arg() \= 2 then return
   use arg partx, quan
   parts~put(partx)                                /* - add to parts list     */
   quantity.partx = quan                           /* - with quantity         */
```

Figure 120 (Part 2 of 3). Base Service Item Class (BASE\CARSERV.CLS)

```
::method getParts                                /* return all parts        */
   expose parts
   return parts~makearray                        /* - as an array           */

::method getQuantity                             /* return quantity         */
   expose quantity.
   use arg partx
   return quantity.partx                         /* - of a part             */

::method getPartsCost                            /* calculate cost of parts */
   expose parts quantity.
   partcost = 0
   do partx over parts                           /* - over all parts        */
      partcost = partcost + partx~price * quantity.partx
   end
   return partcost

::method getWorkOrders                           /* return workorders       */
   return self~class~getWorkServRel~allindex(self)/* - using this service    */

::method detail                                  /* return detail line      */
   expose itemNumber description laborCost
   return itemNumber~right(3) laborCost~right(11) '' description~left(20)

::method makestring                              /* return default string   */
   expose itemNumber description laborCost
   return 'ServiceItem:' itemNumber '($'laborCost')' description

::method display                                 /* display service data    */
   expose itemNumber description laborCost parts quantity.
   say '-'~copies(78)
   say self~class~heading
   say self~detail
   do partx over parts
      say ' '~left(30) quantity.partx~right(6) ' ' ,
          partx~number~right(3) partx~description
   end
   do workx over self~getWorkOrders
      say '-' workx
   end
```

Figure 120 (Part 3 of 3). Base Service Item Class (BASE\CARSERV.CLS)

Base Part Class

```
/*--------------------------------------------------------------------*/
/* Base\part.ori         CarDealer - Part class (base)       ITSO-SJC */
/*                       (original class, becomes carpart.cls)        */
/*--------------------------------------------------------------------*/

   .local['Cardeal.Part.som'] = 'No'             /* mark as NOT in SOM      */

::class PartBase public

/*----- class methods ------------------------------------------------*/

::method initialize class                        /* prepare the class       */
```

Figure 121 (Part 1 of 3). Base Part Class (BASE\PART.ORI)

```
   expose extent
   extent = .set~new                              /* - extent of parts       */
   self~persistentLoad                            /* - load into memory      */

::method add class                                /* add new part to extent  */
   expose extent
   use arg partx
   if partx~class = self then                     /* - add to extent         */
      extent~put(partx)

::method remove class                             /* remove part from extent */
   expose extent
   use arg partx
   if partx~class = self then                     /* - remove                */
      extent~remove(partx)

::method findNumber class                         /* find part by number     */
   expose extent
   parse arg partnum
   do partx over extent                           /* - check the extent      */
      if partx~number = partnum then return partx
   end
   return .nil

::method extent class                             /* return extent as array  */
   expose extent
   return extent~makearray

::method heading class                            /* return a heading line   */
   return 'Partid   Description           Price    Stock'

/*----- instance methods ---------------------------------------------*/

::method init                                     /* initialize a new part   */
   expose partid description price stock
   self~init:super
   use arg partid, description, price, stock
   if arg() \= 4 & arg() \= 5 then self~setnil
   else self~class~add(self)                      /* - add to extent         */
   if arg() = 5 then self~persistentInsert        /* - add to persistent     */

::method setnil private                           /* set part data nil       */
   expose partid description price stock
   self~class~remove(self)                        /* - remove from extent    */
   partid = 0
   description = '-none-'
   price = 0
   stock = 0
   return .nil

::method delete                                   /* delete a part           */
   self~class~remove(self)                        /* - remove from extent    */
   /* self~persistentDelete */                    /* - not implemented       */
   self~setnil

::method number unguarded                         /* return parts number     */
   expose partid
   return partid

::method price unguarded                          /* return price of part    */
   expose price
   return price

::method description unguarded                    /* return description      */
```

Figure 121 (Part 2 of 3). Base Part Class (BASE\PART.ORI)

```
   expose description
   return description

::method stock unguarded                          /* return stock of part    */
   expose stock
   return stock

::method increaseStock                            /* increase stock of part  */
   expose stock
   parse arg stockchange
   stock = stock + stockchange                    /* - add change            */
   return self~persistentUpdate                   /* - store persistently    */

::method decreaseStock                            /* decrease stock of part  */
   expose stock
   parse arg stockchange
   if stockchange > stock then return -1          /* - check if possible     */
   stock = stock - stockchange                    /* - subtract change       */
   return self~persistentUpdate                   /* - store persistently    */

::method detail                                   /* return a detail line    */
   expose partid description price stock
   return partid~right(5) '  ' description~left(15) '  ' ,
          price~right(8) '  '  stock~right(5)

::method makestring                               /* return default string   */
   expose partid description
   return 'Part:' partid description

::method display                                  /* display part data       */
   expose partid description price stock
   say partid~right(5) '  ' description~left(15) '  ' ,
       price~right(8) '  '  stock~right(5)
```

Figure 121 (Part 3 of 3). Base Part Class (BASE\PART.ORI)

Base Part Class as Subclass of a SOM Class

```
/*--------------------------------------------------------------------*/
/* Base\part.som         CarDealer - Part class (base/SOM)   ITSO-SJC */
/*                       (SOM part class, becomes carpart.cls)        */
/*--------------------------------------------------------------------*/

   .local['Cardeal.Part.som'] = 'Yes'             /* mark as part in SOM     */

::Class SOMPart   EXTERNAL 'SOM Part'

::Class PartBase public subclass SOMPart

/*----- add OREXX class methods to the SOMObject Part ----------------*/

::method initialize class                         /* prepare class           */
   self~persistentLoad                            /* - load into memory      */

/*----- instance methods ---------------------------------------------*/

::method init                                     /* initialize new part     */
   use arg partid, description, price, stock
```

Figure 122 (Part 1 of 2). Base Part Class as Subclass of a SOM Class (BASE\PART.SOM)

```
   self~_set_pid(partid)                          /* - set all attributes    */
   self~_set_pprice(price)
   self~_set_pstock(stock)
   self~_set_pdesc(description)
   if arg() \= 4 & arg() \= 5 then self~setnil
   else self~class~add(self)                      /* - add to extent         */
   if arg() = 5 then self~persistentInsert        /* - real persistent new   */

::method setnil private                           /* set part data nil       */
   self~class~remove(self)                        /* - remove from extent    */
   self~_set_pid(0)
   self~_set_pprice(0)
   self~_set_pstock(0)
   self~_set_pdesc('-none-')
   return .nil

::method free                                     /* free SOM storage        */
   self~class~remove(self)                        /* - remove from extent    */
   self~somFree

::method delete                                   /* delete a part           */
   self~class~remove(self)                        /* - remove from extent    */
   self~setnil
   self~persistentDelete                          /* - persistent delete     */

::method increaseStock                            /* increase stock of part  */
   parse arg stockchange
   self~_set_pstock(self~stock + stockchange)     /* - add the change        */
   return self~persistentUpdate                   /* - store persistently    */

::method decreaseStock                            /* decrease stock of part  */
   parse arg stockchange
   if stockchange > self~stock then return -1     /* - check if enough       */
   self~_set_pstock(self~stock - stockchange)     /* - subtract the change   */
   return self~persistentUpdate                   /* - store presistently    */

::method makestring                               /* return default string   */
   return 'Part:' self~detail~substr(3,22)
```

Figure 122 (Part 2 of 2). Base Part Class as Subclass of a SOM Class (BASE\PART.SOM)

Persistence Class

```
/*--------------------------------------------------------------------*/
/* Base\persist.cls      CarDealer - Persistent class        ITSO-SJC */
/*--------------------------------------------------------------------*/

::class Persistent public mixinclass Object

/*----- class methods ------------------------------------------------*/

::method persistentLoad class                     /* default load into memory*/
   return 0

::method persistentStore class                    /* default store back      */
   return 0
```

Figure 123 (Part 1 of 2). Persistence Class (BASE\PERSIST.CLS)

```
/*----- instance methods ---------------------------------------------*/

::method persistentInsert                       /* default new object      */
   return self~class~persistentStore

::method persistentDelete                       /* default delete object   */
   return self~class~persistentStore

::method persistentUpdate                       /* default update object   */
   return self~class~persistentStore

::method persistentInsertServ                   /* new work-serv relation  */
   return self~class~persistentStore

::method persistentDeleteServ                   /* delete work-serv relat. */
   return self~class~persistentStore
```

Figure 123 (Part 2 of 2). Persistence Class (BASE\PERSIST.CLS)

Base Cardeal Class

```
/*--------------------------------------------------------------------*/
/* Base\cardeal.cls      CarDealer - Cardeal class          ITSO-SJC */
/*--------------------------------------------------------------------*/

   .local['Cardeal.Cardeal.class'] = .Cardeal

::class Cardeal public

/*----- class methods ------------------------------------------------*/

::method initialize class                       /* prepare the class       */
   if RxFuncQuery('SysLoadFuncs') then do       /* - load rexx utilities   */
      call RxFuncAdd 'SysLoadFuncs', 'RexxUtil', 'SysLoadFuncs'
      call SysLoadFuncs
   end
   x = RxFuncDrop('mciRxInit')  /* drop mciRx */  /* - drop multimedia funct.*/
   self~mciRxInit                               /* - init multimedia funct.*/
   .local['Cardeal.Part.class']~initialize      /* - initialize all classes*/
   .local['Cardeal.ServiceItem.class']~initialize
   .local['Cardeal.Customer.class']~initialize
   .local['Cardeal.Vehicle.class']~initialize
   .local['Cardeal.WorkOrder.class']~initialize
   return 0

::method terminate class                        /* application terminate   */
   if .local['Cardeal.Data.type'] = 'DB2' then do /* - check if DB2        */
      call sqlexec "CONNECT RESET"              /* - disconnect            */
      temp = value('TMP',,'OS2ENVIRONMENT')
      if temp = '' then temp = directory()
      call SysFileTree temp"\tem*.*", tempfiles, 'FO'
      do i=1 to tempfiles.0                     /* - erase temp files      */
         parse upper value substr(tempfiles.i,lastpos('\',tempfiles.i)+1) ,
               with fn '.' fx
         if pos('.'fx'.','.BMP.WAV.AVI.')>0 then "@erase" tempfiles.i
      end
   end
```

Figure 124 (Part 1 of 2). Base Cardeal Class (BASE\CARDEAL.CLS)

```
   if .local['Cardeal.Part.som']  = 'Yes' then do /* - check if SOM part     */
      do part1 over .local['Cardeal.Part.class']~extent
         part1~free
      end
      .local['Cardeal.Part.class']~somUninit      /* - uninitialize SOM      */
   end
   do localx over .local~makearray               /* - delete all local      */
      if localx~left(8) = 'Cardeal.' then .local~remove(localx)
   end

::method playaudio class                         /* play an audio file      */
   arg filename MultiMedia
   if filename = '' | MultiMedia = 0 then return
   call mciRxSendString 'open waveaudio alias audio shareable wait', 'RetSt', '0', '0'
   call mciRxSendString 'load audio' filename 'wait', 'RetSt', '0', '0'
   call mciRxSendString 'set audio time format ms', 'RetSt', '0', '0'
   call mciRxSendString 'play audio wait', 'RetSt', '0', '0'
   call mciRxSendString 'close audio wait', 'RetSt', '0', '0'
   call mciRxExit

::method playvideo class                         /* play a video file       */
   arg filename MultiMedia
   if filename = '' | MultiMedia = 0 then return
   call mciRxSendString 'open digitalvideo alias video shareable wait', 'RetSt', '0', '0'
   call mciRxSendString 'load video' filename 'wait', 'RetSt', '0', '0'
   call mciRxSendString 'set video time format ms', 'RetSt', '0', '0'
   call mciRxSendString 'play video wait', 'RetSt', '0', '0'
   call mciRxSendString 'close video wait', 'RetSt', '0', '0'
   call mciRxExit

::method mciRxInit class private                 /* initialize multimedia   */
   expose done MultiMedia
   if symbol('done') = 'VAR' then return MultiMedia
   /* Load the DLL, initialize MCI REXX support */
   if RxFuncQuery('mciRxInit') then do           /* - load rex functions    */
      MultiMedia = (RXFUNCADD('mciRxInit','MCIAPI','mciRxInit')=0)
      if MultiMedia then InitRC = mciRxInit()
      end
   else MultiMedia = 1
   done = 1
   return MultiMedia
```

Figure 124 (Part 2 of 2). Base Cardeal Class (BASE\CARDEAL.CLS)

Persistence in Files

Configuration for File Storage

```
/*-------------------------------------------------------------------*/
/* FAT\carmodel.cfg      CarDealer - Model Config. (FAT)     ITSO-SJC */
/*-------------------------------------------------------------------*/

   Parse source . . me .
   maindir = me~left(me~lastpos('\')-1)     /* main cardeal directory */
```

Figure 125 (Part 1 of 2). Configuration for File Storage (FAT\CARMODEL.CFG)

```
   if stream(maindir'\base\cardeal.cls',c,'query exists') = '' then
      call carerror maindir

   .local['Cardeal.Data.type'] = 'FAT'             /* Data in Files   */
   .local['Cardeal.Data.dir']  = maindir'\FAT\Data'/* Data directory  */
   .local['Cardeal.Media.dir'] = maindir'\Media'   /* Media directory */

::requires 'base\cardeal.cls'

::requires 'fat\carcust.cls'
::requires 'fat\carvehi.cls'
::requires 'fat\carpart.cls'
::requires 'fat\carserv.cls'
::requires 'fat\carwork.cls'
```

Figure 125 (Part 2 of 2). Configuration for File Storage (FAT\CARMODEL.CFG)

File Customer Class

```
/*--------------------------------------------------------------------*/
/* FAT\carcust.cls       CarDealer - Customer class (FAT)    ITSO-SJC */
/*--------------------------------------------------------------------*/

   .local['Cardeal.Customer.class'] = .Customer

::requires 'base\carcust.cls'
::requires 'base\persist.cls'

::class Customer public subclass CustomerBase inherit Persistent

/*----- class methods ------------------------------------------------*/

::method persistentLoad class                   /* load customers from file*/
   expose file
   file = .local['Cardeal.Data.dir']'\customer.dat'
   call stream file, 'c', 'open read'
   do i = 0 by 1 while lines(file)              /* - read the file         */
      parse value linein(file) with customerNumber '9'x name '9'x address
      if left(customerNumber,2) = '/*' then iterate
      self~new(strip(customerNumber), strip(name), strip(address))
   end
   call stream file, 'c', 'close'
   return i

::method persistentStore class                  /* store customers in file */
   expose file
   call stream file, 'c', 'open write replace'
   do custx over self~extent                    /* - run over extent       */
      x = lineout(file,custx~fileFormat)
   end
   call stream file, 'c', 'close'
   return 0

/*----- instance methods ---------------------------------------------*/

::method fileFormat                             /* prepare record for file */
   return strip(self~number)'9'x || left(self~name,20)'9'x || ,
```

Figure 126 (Part 1 of 2). File Customer Class (FAT\CARCUST.CLS)

```
            left(self~address,20)
```

Figure 126 (Part 2 of 2). File Customer Class (FAT\CARCUST.CLS)

File Vehicle Class

```
/*--------------------------------------------------------------------*/
/* FAT\carvehi.cls       CarDealer - Vehicle class (FAT)     ITSO-SJC */
/*--------------------------------------------------------------------*/

   .local['Cardeal.Vehicle.class'] = .Vehicle

::requires 'base\carvehi.cls'
::requires 'base\persist.cls'

::class Vehicle public subclass VehicleBase inherit Persistent

/*----- class methods ------------------------------------------------*/

::method persistentLoad class                    /* load vehicles from file */
   expose file
   file = .local['Cardeal.Data.dir']'\vehicle.dat'
   custclass = .local['Cardeal.Customer.class']
   call stream file, 'c', 'open read'
   do i = 0 by 1 while lines(file)               /* - read the file         */
      parse value linein(file) ,
            with serialNumber '9'X make '9'X model '9'X year '9'X owner
      if left(serialNumber,2) = '/*' then iterate
      self~new(strip(serialNumber), strip(make), strip(model), strip(year), ,
               custclass~findNumber(owner))
   end
   call stream file, 'c', 'close'
   return i

::method persistentStore class                   /* store vehicle in file   */
   expose file
   call stream file, 'c', 'open write replace'    /* - run over customers    */
   do custx over .local['Cardeal.Customer.class']~extent
      do carx over custx~getVehicles             /* - and their vehicles    */
         x = lineout(file,carx~fileFormat)
      end
   end
   call stream file, 'c', 'close'
   return 0

/*----- instance methods ---------------------------------------------*/

::method fileFormat                              /* prepare record for file */
   return strip(self~serial)'9'x || left(self~make,12)'9'x || ,
          left(self~model,10)'9'x || strip(self~year)'9'x || ,
          strip(self~getowner~number)

::method getmedianumber                          /* return number of media  */
   expose medianumber mediacontrol picfile
   if symbol('medianumber') = 'VAR' then return medianumber
   medianumber = 0
   mediacontrol = ''
   picfile = .array~new
```

Figure 127 (Part 1 of 2). File Vehicle Class (FAT\CARVEHI.CLS)

```
   mediafile = .local['Cardeal.Media.dir']'\media.dat'
   do i=1 by 1 while lines(mediafile)>0          /* - read media controlfile*/
     line = linein(mediafile)
     if left(line,2) = '/*' then iterate
     parse var line serial ',' title ',' file
     if self~serial = strip(serial) then do      /* - check for serial      */
        medianumber = medianumber + 1
        picfile[medianumber] = strip(file)       /* - build control info    */
        mediacontrol = mediacontrol''left(strip(title),20)',file    ;'
     end
   end
   x = stream(mediafile,'c','close')
   return medianumber

::method getmediacontrol                         /* return media controlinfo*/
   expose medianumber mediacontrol
   if symbol("medianumber") = 'LIT' then return ''
   return mediacontrol

::method getmediainfo                            /* return a media file     */
   expose medianumber mediacontrol picfile
   if symbol("medianumber") = 'LIT' then return ''
   arg medianum
   if medianumber = 0 | mediacontrol = '' | ,
      medianum > medianumber | medianum <= 0 then return ''
   mediatitle  = substr(mediacontrol,medianum*30-29,20)
   vfacts = .local['Cardeal.Media.dir']'\'picfile[medianum]
   if mediatitle = 'Fact-sheet' then do
     factdata = linein(vfacts)
     x = stream(vfacts,'c','close')
     vfacts = factdata
   end
   return mediatitle'::'vfacts
```

Figure 127 (Part 2 of 2). File Vehicle Class (FAT\CARVEHI.CLS)

File Work Order Class

```
/*--------------------------------------------------------------------*/
/* FAT\carwork.cls       CarDealer - WorkOrder class (FAT)   ITSO-SJC */
/*--------------------------------------------------------------------*/

   .local['Cardeal.WorkOrder.class'] = .WorkOrder

::requires 'base\carwork.cls'
::requires 'base\persist.cls'

::class WorkOrder public subclass WorkOrderBase inherit Persistent

/*----- class methods ------------------------------------------------*/

::method persistentLoad class                    /* load work orders file   */
   expose file
   file = .local['Cardeal.Data.dir']'\workord.dat'
   custclass = .local['Cardeal.Customer.class']
   servclass = .local['Cardeal.ServiceItem.class']
   call stream file, 'c', 'open read'
   do i = 0 by 1 while lines(file)               /* - read the file         */
```

Figure 128 (Part 1 of 2). File Work Order Class (FAT\CARWORK.CLS)

```
      parse value linein(file) with orderno '9'x date '9'x cost ,
                    '9'x status '9'x owner '9'x car '9'x items
      if left(orderno,2) = '/*' then iterate
      custx = custclass~findNumber(owner)         /* - create new work order */
      wo = self~new(strip(orderno), strip(date), strip(cost), ,
                   strip(status), custx, custx~findVehicle(car))
      do while items \= ''                        /* - add services to order */
         parse var items itemx '9'x items
         wo~addServiceItem(servclass~findNumber(itemx))
      end
   end
   call stream file, 'c', 'close'
   return i

::method persistentStore class                   /* store workorders in file*/
   expose file
   call stream file, 'c', 'open write replace'
   do ordrx over self~extent                      /* - run over extent       */
      x = lineout(file,ordrx~fileFormat)
   end
   call stream file, 'c', 'close'
   return 0

/*----- instance methods ---------------------------------------------*/

::method fileFormat                               /* prepare record for file */
   out = strip(self~number)'9'x || strip(self~date)'9'x || ,
         strip(self~cost)'9'x || strip(self~getstatus)'9'x || ,
         strip(self~getcustomer~number)'9'x || strip(self~getvehicle~serial)
   workserv = self~class~getWorkServRel
   do servx over workserv~allat(self)
      out = out'9'x || servx~number
   end
   return out
```

Figure 128 (Part 2 of 2). File Work Order Class (FAT\CARWORK.CLS)

File Service Item Class

```
/*--------------------------------------------------------------------*/
/* FAT\carserv.cls       CarDealer - ServiceItem class (FAT) ITSO-SJC */
/*--------------------------------------------------------------------*/

   .local['Cardeal.ServiceItem.class'] = .ServiceItem

::requires 'base\carserv.cls'
::requires 'base\persist.cls'

::class ServiceItem public subclass ServiceItemBase inherit Persistent

/*----- class methods ------------------------------------------------*/

::method persistentLoad class                     /* load service from file  */
   expose file
   file = .local['Cardeal.Data.dir']'\service.dat'
   partclass = .local['Cardeal.Part.class']
   call stream file, 'c', 'open read'
```

Figure 129 (Part 1 of 2). File Service Item Class (FAT\CARSERV.CLS)

```
   do i = 0 by 1 while lines(file)               /* - read the file        */
      parse value linein(file) with ,
            itemNumber '9'x description '9'x laborCost '9'x parts
      if left(itemNumber,2) = '/*' then iterate
      si = self~new(strip(itemNumber), strip(description), strip(laborCost))
      do while parts \= ''                       /* - add parts to service  */
         parse var parts partnum '9'x quant '9'x parts
         si~usesPart(partclass~findNumber(partnum), strip(quant))
      end
   end
   call stream file, 'c', 'close'
   return i

::method persistentStore class                   /* store services in file  */
   /* no change in data ever */
   return 0

/*----- instance methods ---------------------------------------------*/

::method fileFormat                              /* prepare record for file */
   /* never used since service items are not updated */
   out = strip(self~number)'9'x || left(self~description,20)'9'x || ,
         strip(self~laborcost)
   do partx over parts
      out = out'9'x || right(partx~number,2) || ,
               '9'x || right(self~getquantity(partx),2)
   end
   return out
```

Figure 129 (Part 2 of 2). File Service Item Class (FAT\CARSERV.CLS)

File Part Class

```
/*--------------------------------------------------------------------*/
/* FAT\carpart.cls       CarDealer - Part class (FAT)        ITSO-SJC */
/*--------------------------------------------------------------------*/

   .local['Cardeal.Part.class'] = .Part

::requires 'base\carpart.cls'
::requires 'base\persist.cls'

::class Part public subclass PartBase inherit Persistent

/*----- class methods ------------------------------------------------*/

::method persistentLoad class                    /* load parts from file    */
   expose file
   file = .local['Cardeal.Data.dir']'\part.dat'
   call stream file, 'c', 'open read'
   do i = 0 by 1 while lines(file)               /* - read the file        */
      parse value linein(file) with ,
            partid '9'x description '9'x price '9'x stock
      if left(partid,2) = '/*' then iterate
      self~new(strip(partid), strip(description), strip(price), strip(stock))
   end
   call stream file, 'c', 'close'
```

Figure 130 (Part 1 of 2). File Part Class (FAT\CARPART.CLS)

```
   return i

::method persistentStore class                    /* store parts in file     */
   expose file
   call stream file, 'c', 'open write replace'
   do partx over self~extent                      /* - run over extent       */
      x = lineout(file,partx~fileFormat)
   end
   call stream file, 'c', 'close'
   return 0

/*----- instance methods ---------------------------------------------*/

::method fileFormat                                /* prepare record for file */
   return strip(self~number)'9'x || left(self~description,15)'9'x || ,
          strip(self~price)'9'x  || strip(self~stock)
```

Figure 130 (Part 2 of 2). File Part Class (FAT\CARPART.CLS)

Persistence in DB2

Configuration for DB2 Storage

```
/*--------------------------------------------------------------------*/
/* DB2\carmodel.cfg      CarDealer - Model Config. (DB2)     ITSO-SJC */
/*--------------------------------------------------------------------*/

   Parse source . . me .
   maindir = me~left(me~lastpos('\')-1)     /* main cardeal directory */
   if stream(maindir'\base\cardeal.cls',c,'query exists') = '' then
      call carerror maindir

   call rxfctsql                            /* Rexx DB2 functions     */
   call sqlexec "CONNECT RESET"
   call sqlexec "CONNECT TO DEALERDB"       /* connect to database    */
   if sqlca.sqlcode \= 0 then do; say 'Cannot connect to DEALERDB'
                                  exit 16;  end

   .local['Cardeal.Data.type'] = 'DB2'      /* Data in DB2            */
   .local['Cardeal.Data.dir']  = '-none-'   /* Data in DB2            */
   .local['Cardeal.Media.dir'] = '-none-'   /* Media in DB2           */

::requires 'base\cardeal.cls'

::requires 'db2\carcust.cls'
::requires 'db2\carvehi.cls'
::requires 'db2\carpart.cls'
::requires 'db2\carserv.cls'
::requires 'db2\carwork.cls'
```

Figure 131. Configuration for DB2 Storage (DB2\CARMODEL.CFG)

DB2 Customer Class

```
/*--------------------------------------------------------------------*/
/* DB2\carcust.cls       CarDealer - Customer class (DB2)    ITSO-SJC */
/*--------------------------------------------------------------------*/

   .local['Cardeal.Customer.class'] = .Customer

::requires 'base\carcust.cls'

::class Customer public subclass CustomerBase

/*----- class methods ------------------------------------------------*/

::method persistentLoad class                    /* null, load by demand    */
   return 0

::method findNumber class                        /* load customer by number */
   use arg custnum
   vehiclass = .local['Cardeal.Vehicle.class']
   workclass = .local['Cardeal.WorkOrder.class']
   custx = self~findNumber:super(custnum)        /* - check if in memory    */
   if custx \= .nil then return custx
   stmt = 'select c.custname, c.custaddr' ,
          '  from cardeal.customer c' ,
          ' where c.custnum =' custnum
   call sqlexec 'PREPARE s1 FROM :stmt'
   call sqlexec 'DECLARE c1 CURSOR FOR s1'
   call sqlexec 'OPEN c1'
   call sqlexec 'FETCH c1 INTO :xcustn, :xcusta'
   if sqlca.sqlcode = 0 then do
        custx = self~new(custnum, xcustn, xcusta)
        vehiclass~persistentLoadByCust(custx)    /* - load vehicles of cust.*/
        workclass~persistentLoadByCust(custx)    /* - load workorders       */
        end
   else custx = .nil
   call sqlexec 'CLOSE c1'
   return custx

::method findName class                          /* find customer by name   */
   use arg custsearch
   custnames = .list~new                         /* - prepare result list   */
   stmt = "select c.custnum, c.custname, c.custaddr" ,
          "  from cardeal.customer c" ,
          " where c.custname like ?  order by 2"
   call sqlexec 'PREPARE s1 FROM :stmt'
   call sqlexec 'DECLARE c1 CURSOR FOR s1'
   xsearch = "'"custsearch"%'"
   call sqlexec "OPEN c1 USING :xsearch"
   do icust=0 by 1 until rcc \= 0                /* - search table with LIKE*/
      call sqlexec 'FETCH c1 INTO :xcustno, :xcustn, :xcusta'
      rcc = sqlca.sqlcode
      if rcc = 0 then do
         custstring = xcustno~right(3)'-'xcustn'-'xcusta
         custnames~insert(custstring)
      end
   end
   call sqlexec 'CLOSE c1'
   return custnames~makearray                    /* - return result array   */

::method findAddress class                       /* find customer by address*/
   use arg custsearch
```

Figure 132 (Part 1 of 2). DB2 Customer Class (DB2\CARCUST.CLS)

```
   stmt = "select c.custnum, c.custname, c.custaddr" ,
          "  from cardeal.customer c" ,
          " where c.custaddr = ?"
   call sqlexec 'PREPARE s1 FROM :stmt'
   call sqlexec 'DECLARE c1 CURSOR FOR s1'
   xsearch = "'"custsearch"'"
   call sqlexec "OPEN c1 USING :xsearch"
      call sqlexec 'FETCH c1 INTO :xcustno, :xcustn, :xcusta'
      rcc = sqlca.sqlcode
   call sqlexec 'CLOSE c1'
   if rcc = 0 then return xcustno                 /* return customer number  */
   else return ''

/*----- instance methods ---------------------------------------------*/

::method persistentInsert                         /* store new customer      */
   insertstmt = "insert into cardeal.customer" ,
                "   values("self~number",'"self~name"','"self~address"')"
   call sqlexec 'EXECUTE IMMEDIATE :insertstmt'
   if sqlca.sqlcode \= 0 then do
      say 'cust insert' sqlca.sqlcode sqlmsg
      self~setnil
      end
   else call sqlexec 'COMMIT'
   return sqlca.sqlcode

::method persistentUpdate                         /* update a customer       */
   updatetstmt = "update cardeal.customer" ,
                 "   set custname = '"self~name"', custaddr ='"self~address"'" ,
                 " where custnum =" self~number
   call sqlexec 'EXECUTE IMMEDIATE :updatetstmt'
   if sqlca.sqlcode \= 0 then say 'customer update' sqlca.sqlcode sqlmsg
   else call sqlexec 'COMMIT'
   return sqlca.sqlcode

::method persistentDelete                         /* delete a customer       */
   delstmt = 'delete from cardeal.customer where custnum =' self~number
   call sqlexec 'EXECUTE IMMEDIATE :delstmt'
   if sqlca.sqlcode \= 0 then say 'cust delete' sqlca.sqlcode sqlmsg
   else call sqlexec 'COMMIT'
   return sqlca.sqlcode
```

Figure 132 (Part 2 of 2). DB2 Customer Class (DB2\CARCUST.CLS)

DB2 Vehicle Class

```
/*--------------------------------------------------------------------*/
/* DB2\carvehi.cls       CarDealer - Vehicle class (DB2)     ITSO-SJC */
/*--------------------------------------------------------------------*/

   .local['Cardeal.Vehicle.class'] = .Vehicle

::requires 'base\carvehi.cls'

::class Vehicle public subclass VehicleBase

/*----- class methods ------------------------------------------------*/
```

Figure 133 (Part 1 of 3). DB2 Vehicle Class (DB2\CARVEHI.CLS)

```
::method persistentLoad class                    /* null, load by demand    */
   return 0

::method persistentLoadByCust class              /* load vehicle of customer*/
   use arg custx
   customerNumber = custx~number
   stmt = 'select v.serialnum, v.make, v.model, v.year' ,
          '  from cardeal.vehicle v  where v.custnum =' customerNumber
   call sqlexec 'PREPARE s2 FROM :stmt'
   call sqlexec 'DECLARE c2 CURSOR FOR s2'
   call sqlexec 'OPEN c2'
   do until rcv \=  0                            /* - run over vehicles     */
      call sqlexec 'FETCH c2 INTO :xserial, :xmake, :xmodel, :xyear'
      rcv = sqlca.sqlcode
      if rcv = 0 then
         carx = self~new(xserial, xmake, xmodel, xyear, custx)
   end
   call sqlexec 'CLOSE c2'
   return 0

/*----- instance methods ---------------------------------------------*/

::method persistentInsert                        /* store new vehicle       */
   custnum = self~getowner~number
   insertstmt = "insert into cardeal.vehicle" ,
                " (serialnum, custnum, make, model, year)" ,
                "   values("self~serial","custnum",'"self~make"',"  ,
                "'"self~model"','"self~year")"
   /* say 'created' self 'in DB2' */
   call sqlexec 'EXECUTE IMMEDIATE :insertstmt'
   if sqlca.sqlcode \= 0 then do
      say 'vehicle insert' sqlca.sqlcode sqlca.sqlerrmc
      self~setnil
   end
   call sqlexec 'COMMIT'

::method persistentUpdate                        /* update vehicle data     */
   updatetstmt = "update cardeal.vehicle" ,
                 "   set make ='"self~make"', model ='"self~model"'," ,
                       "year =" selfyear ,
                 " where serialnum =" self~serial
   call sqlexec 'EXECUTE IMMEDIATE :updatetstmt'
   if sqlca.sqlcode \= 0 then say 'customer update' sqlca.sqlcode sqlmsg
   else call sqlexec 'COMMIT'
   return sqlca.sqlcode

::method persistentDelete                        /* delete a vehicle        */
   delstmt = 'delete from cardeal.vehicle where serialnum =' self~serial
   call sqlexec 'EXECUTE IMMEDIATE :delstmt'
   if sqlca.sqlcode \= 0 then say 'vehicle delete' sqlca.sqlcode sqlmsg
   else call sqlexec 'COMMIT'
   return sqlca.sqlcode

::method getmedianumber                          /* number of media files   */
   expose medianumber mediacontrol               /* - in the BLOB           */
   if symbol("medianumber") = 'VAR' then return medianumber
   medianumber = 0
   mediacontrol = ''                             /* - prepare control info  */
   stmt = 'select substr(v.pictures,1,3)' ,
          '  from cardeal.vehicle v  where v.serialnum =' self~serial
   call sqlexec 'PREPARE s2 FROM :stmt'
   if sqlca.sqlcode \= 0 then return 0
   vpicind = -1
   call sqlexec 'DECLARE c2 CURSOR FOR s2'
```

Figure 133 (Part 2 of 3). DB2 Vehicle Class (DB2\CARVEHI.CLS)

```
   call sqlexec 'OPEN c2'
      call sqlexec 'FETCH c2 INTO :vpic :vpicind'
   call sqlexec 'CLOSE c2'
   if vpicind >=0 then medianumber = vpic
   return medianumber

::method getmediacontrol                          /* return media controlinfo*/
   expose medianumber mediacontrol
   if symbol("medianumber") = 'LIT' then return ''
   if medianumber <= 0 then return ''
   stmt = 'select substr(v.pictures,5,30*'medianumber')' ,
          '  from cardeal.vehicle v  where v.serialnum =' self~serial
   call sqlexec 'PREPARE s2 FROM :stmt'
   call sqlexec 'DECLARE c2 CURSOR FOR s2'
   call sqlexec 'OPEN c2'
      call sqlexec 'FETCH c2 INTO :vpic :vpicind'
      rcv = sqlca.sqlcode
   call sqlexec 'CLOSE c2'
   if rcv = 0 & vpicind >= 0 then mediacontrol = vpic
   return mediacontrol

::method getmediainfo                             /* return one media file   */
   expose medianumber mediacontrol
   parse source env .
   if env = 'OS/2' then env = 'OS2ENVIRONMENT'
                   else env = 'ENVIRONMENT'
   if symbol("medianumber") = 'LIT' then return ''
   if mediacontrol = '' then self~getmediacontrol
   arg medianum
   if medianumber = 0 | medianum > medianumber | medianum <= 0 | ,
      mediacontrol = '' then return ''
   mediatitle  = substr(mediacontrol,medianum*30-29,20)
   medialength = substr(mediacontrol,medianum*30- 8, 8)
   mediastart = 7 + 30 * medianumber
   do i=1 to medianum -1
      blg = substr(mediacontrol,i*30-8,8)
      mediastart = mediastart + blg
   end
   call sqlexec 'CLEAR SQL VARIABLE DECLARATIONS'
   call sqlexec 'DECLARE :vpic3 LANGUAGE TYPE BLOB FILE'
   vpic3.file_options = 'OVERWRITE'
   temp = value('TMP',,env)
   if temp = '' then temp = directory()
   select
     when mediatitle = 'Fact-sheet' then vpic3.name = ''
     when mediatitle = 'Audio'      then vpic3.name = temp'\temp.WAV'
     when mediatitle = 'Video'      then vpic3.name = temp'\temp.AVI'
     otherwise                           vpic3.name = temp'\temp'medianum'.BMP'
   end
   vfacts = vpic3.name
   stmt = 'select substr(v.pictures,'mediastart','medialength')' ,
          '  from cardeal.vehicle v  where v.serialnum =' self~serial
   call sqlexec 'PREPARE s2 FROM :stmt'
   call sqlexec 'DECLARE c2 CURSOR FOR s2'
   call sqlexec 'OPEN c2'
      if vfacts = '' then call sqlexec 'FETCH c2 INTO :vfacts'
                     else call sqlexec 'FETCH c2 INTO :vpic3 :vpicind3'
      if sqlca.sqlcode \= 0 then vfacts = ''
   call sqlexec 'CLOSE c2'
   call sqlexec 'CLEAR SQL VARIABLE DECLARATIONS'
   return mediatitle'::'vfacts
```

Figure 133 (Part 3 of 3). DB2 Vehicle Class (DB2\CARVEHI.CLS)

DB2 Work Order Class

```
/*--------------------------------------------------------------------*/
/* DB2\carwork.cls       CarDealer - WorkOrder class (DB2)   ITSO-SJC */
/*--------------------------------------------------------------------*/

   .local['Cardeal.WorkOrder.class'] = .WorkOrder

::requires 'base\carwork.cls'

::class WorkOrder public subclass WorkOrderBase

/*----- class methods ------------------------------------------------*/

::method persistentLoad class                    /* null, load by demand    */
   return 0

::method findNumber class                        /* find workorder by number*/
   use arg worknum
   custclass = .local['Cardeal.Customer.class']
   workx = self~findNumber:super(worknum)        /* - check in memory first */
   if workx \= .nil then return workx            /* - return if found       */
   stmt = 'select w.custnum' ,
          '  from cardeal.workorder w  where w.ordernum =' worknum
   call sqlexec 'PREPARE s3 FROM :stmt'
   call sqlexec 'DECLARE c3 CURSOR FOR s3'
   call sqlexec 'OPEN c3'
   call sqlexec 'FETCH c3 INTO :xcustnum'
   rcw = sqlca.sqlcode
   call sqlexec 'CLOSE c3'
   if rcw = 0 then do
      custx = custclass~findNumber(xcustnum)
      if custx \= .nil then
         do workx over self~extent
            if workx~number = worknum then return workx
         end
   end
   return .nil

::method findStatus class                        /* find workorder by status*/
   use arg xstatus
   worklist = .list~new                          /* - prepare result list   */
   stmt = 'select w.ordernum, w.orderdate, w.cost, w.status,' ,
          '       c.custname, v.make, v.model' ,
          '  from cardeal.workorder w, cardeal.customer c, cardeal.vehicle v' ,
          ' where w.custnum = c.custnum and w.serialnum = v.serialnum' ,
          '   and w.status in (?, ?)' ,
          ' order by 1'
   hostvar = ':xordno, :xdate, :xcost, :xstatus, :xcustn, :xmake, :xmodel'
   call sqlexec 'PREPARE s3 FROM :stmt'
   call sqlexec 'DECLARE c3 CURSOR FOR s3'
   xstat1 = 0
   xstat2 = 1
   if xstatus = 0 then xstat2=0
   if xstatus = 1 then xstat1=1
   call sqlexec 'OPEN c3 USING :xstat1, :xstat2'
   do iwork = 0 by -1 until rcw \= 0
      call sqlexec 'FETCH c3 INTO' hostvar
      rcw = sqlca.sqlcode
      if rcw = 0 then do
         if xstatus = 0 then statusx = 'Incomplete'
                        else statusx = 'Complete'
```

Figure 134 (Part 1 of 3). DB2 Work Order Class (DB2\CARWORK.CLS)

```
         workstring = xordno~left(3) '' xdate xcost~right(6) statusx~left(11)  ,
                      (xmake~strip'-'xmodel~strip)~left(20) xcustn
         worklist~insert(workstring,.nil)
      end
   end
   call sqlexec 'CLOSE c3'
   return worklist~makearray

::method newNumber class                          /* create new order number */
   stmt = 'select max(ordernum) from cardeal.workorder'
   call sqlexec 'PREPARE s3 FROM :stmt'
   call sqlexec 'DECLARE c3 CURSOR FOR s3'
   call sqlexec 'OPEN c3'
   call sqlexec 'FETCH c3 INTO :xmax'
   call sqlexec 'CLOSE c3'
   return xmax + 1

::method persistentLoadByCust class               /* load workorders of cust.*/
   use arg custx
   servclass = .local['Cardeal.ServiceItem.class']
   customerNumber = custx~number
   stmt = 'select w.ordernum, w.cost, w.orderdate, w.status, w.serialnum' ,
          '  from cardeal.workorder w  where w.custnum =' customerNumber
   call sqlexec 'PREPARE s4 FROM :stmt'
   call sqlexec 'DECLARE c4 CURSOR FOR s4'
   call sqlexec 'OPEN c4'
   do until rcw \=  0                             /* - run over orders       */
      call sqlexec 'FETCH c4 INTO :xorder, :xcost, :xdate, :xstatus, :xserial'
      rcw = sqlca.sqlcode
      if rcw = 0 then do
         cars = custx~getVehicles
         do carx over cars                        /* - find matching car     */
            if carx~serial = xserial then do      /*   for work order        */
               orderx = self~new(xorder, xdate, xcost, xstatus, custx, carx)
               servitems = servclass~extent
               stmt2 = 'select r.itemnum' ,
                       '  from cardeal.workserv r  where r.ordernum =' xorder
               call sqlexec 'PREPARE s5 FROM :stmt2'
               call sqlexec 'DECLARE c5 CURSOR FOR s5'
               call sqlexec 'OPEN c5'
               do until rcs \=  0                 /* - and add rels to serv, */
                  call sqlexec 'FETCH c5 INTO :xitem'
                  rcs = sqlca.sqlcode
                  if rcs = 0 then
                     do servx over servitems
                        if servx~number = xitem then
                            orderx~addServiceItem(servx)
                     end
               end
               call sqlexec 'CLOSE c5'
            end
         end /*cars*/
      end  /*rcw=0*/
   end
   call sqlexec 'CLOSE c4'
   return 0

/*----- instance methods ---------------------------------------------*/

::method persistentInsert                         /* store new work order    */
   custnum = self~getcustomer~number
   carserial = self~getvehicle~serial
   insertstmt = "insert into cardeal.workorder" ,
                "   values("self~number","custnum","carserial"," ,
```

Figure 134 (Part 2 of 3). DB2 Work Order Class (DB2\CARWORK.CLS)

```
                self~cost",'"self~date"',"self~getstatus")"
   call sqlexec 'EXECUTE IMMEDIATE :insertstmt'
   if sqlca.sqlcode \= 0 then do
      say 'workorder insert' sqlca.sqlcode sqlmsg
      self~setnil
      end
   else call sqlexec 'COMMIT'
   return sqlca.sqlcode

::method persistentDelete                          /* delete work order       */
   delstmt = 'delete from cardeal.workorder where ordernum =' self~number
   call sqlexec 'EXECUTE IMMEDIATE :delstmt'
   if sqlca.sqlcode \= 0 then say 'order delete' sqlca.sqlcode sqlca.sqlerrmc
   delstmt = 'delete from cardeal.workserv where ordernum =' self~number
   call sqlexec 'EXECUTE IMMEDIATE :delstmt'
   if sqlca.sqlcode \= 0 & sclca.sqlcode \= 100 then
      say 'order-serv delete' sqlca.sqlcode sqlmsg
   else call sqlexec 'COMMIT'
   return sqlca.sqlcode

::method persistentInsertServ                      /* add service item        */
   use arg itemnum
   insertstmt = 'insert into cardeal.workserv values('self~number',' itemnum')'
   call sqlexec 'EXECUTE IMMEDIATE :insertstmt'
   rci = sqlca.sqlcode
   if rci \= 0 then say 'workserv insert' sqlca.sqlcode sqlmsg
   else call sqlexec 'COMMIT'
   return sqlca.sqlcode

::method persistentDeleteServ                      /* delete service item     */
   use arg itemnum
   deletestmt = 'delete from cardeal.workserv' ,
                ' where ordernum =' self~number 'and itemnum =' itemnum
   call sqlexec 'EXECUTE IMMEDIATE :deletestmt'
   if sqlca.sqlcode \= 0 then say 'workserv delete' sqlca.sqlcode sqlca.sqlerrmc
   else call sqlexec 'COMMIT'
   return sqlca.sqlcode

::method persistentUpdate                          /* update work order data  */
   updatestmt = 'update cardeal.workorder' ,
                '   set cost =' self~cost', status =' self~getstatus ,
                ' where ordernum =' self~number
   call sqlexec 'EXECUTE IMMEDIATE :updatestmt'
   if sqlca.sqlcode \= 0 then say 'workorder update' sqlca.sqlcode sqlmsg
   else call sqlexec 'COMMIT'
   return sqlca.sqlcode
```

Figure 134 (Part 3 of 3). DB2 Work Order Class (DB2\CARWORK.CLS)

DB2 Service Item Class

```
/*--------------------------------------------------------------------*/
/* DB2\carserv.cls       CarDealer - ServiceItem class (DB2) ITSO-SJC */
/*--------------------------------------------------------------------*/

   .local['Cardeal.ServiceItem.class'] = .ServiceItem
```

Figure 135 (Part 1 of 3). DB2 Service Item Class (DB2\CARSERV.CLS)

```
::requires 'base\carserv.cls'

::class ServiceItem public subclass ServiceItemBase

/*----- class methods ---------------------------------------------*/

::method persistentLoad class                    /* load all service items  */
   partclass = .local['Cardeal.Part.class']
   stmt = 'select s.itemnum, s.labor, s.description' ,
          '  from cardeal.service s' ,
          ' order by 1'
   hostvar = ':xitem, :xlabor, :xdesc1'
   call sqlexec 'PREPARE s1 FROM :stmt'
   if sqlca.sqlcode \= 0 then
      say 'sqlerror service items prepare:' sqlca.sqlcode sqlmsg
   call sqlexec 'DECLARE c1 CURSOR FOR s1'
   call sqlexec 'OPEN c1'
   if sqlca.sqlcode \= 0 then
      say 'sqlerror service items open:' sqlca.sqlcode sqlmsg
   do iserv = 0 by 1 until sqlca.sqlcode \= 0     /* - run over service table*/
      call sqlexec 'FETCH c1 INTO' hostvar
      if sqlca.sqlcode \= 0 & sqlca.sqlcode \= 100 then
         say 'sqlerror service items fetch:' sqlca.sqlcode sqlmsg
      else if sqlca.sqlcode = 0 then do
           /* say 'creating service item' xitem */
           servx = self~findNumber(xitem)
           if servx = .nil then
              servx = self~new(xitem, xdesc1, xlabor)
      end
   end
   call sqlexec 'CLOSE c1'
   if sqlca.sqlcode \= 0 then
      say 'sqlerror service items close:' sqlca.sqlcode sqlmsg
   /* say 'Loaded' self~getextent~items 'service items' */
                                                   /* - add service-part rels */
   stmt = 'select r.itemnum, r.quantity, r.partnum' ,
          '  from cardeal.servpart r'
   hostvar = ':xitem, :xquan, :xpartid'
   call sqlexec 'PREPARE s1 FROM :stmt'
   if sqlca.sqlcode \= 0 then
      say 'sqlerror service-parts prepare:' sqlca.sqlcode sqlmsg
   call sqlexec 'DECLARE c1 CURSOR FOR s1'
   call sqlexec 'OPEN c1'
   if sqlca.sqlcode \= 0 then
      say 'sqlerror service-parts open:' sqlca.sqlcode sqlmsg
   do iservprt = 0 by 1 until sqlca.sqlcode \= 0  /* - run over servpart tab.*/
      call sqlexec 'FETCH c1 INTO' hostvar
      if sqlca.sqlcode \= 0 & sqlca.sqlcode \= 100 then
         say 'sqlerror service-parts fetch:' sqlca.sqlcode sqlmsg
      else if sqlca.sqlcode = 0 then do
           /* say 'creating service-part' xitem xpartid */
           partx = partclass~findNumber(xpartid)
           if partx = .nil then
              say 'Service item' xitem 'uses non-existing part' xpartid
           servx = self~findNumber(xitem)
           if servx = .nil then
              say 'Service item' xitem 'not in service table'
           else
              servx~usesPart(partx, xquan)
      end
   end
   call sqlexec 'CLOSE c1'
   if sqlca.sqlcode \= 0 then
      say 'sqlerror service-parts close:' sqlca.sqlcode sqlmsg
```

Figure 135 (Part 2 of 3). DB2 Service Item Class (DB2\CARSERV.CLS)

```
   /* say 'Loaded' partclass~getextent~items 'parts' */
   /* say 'Loaded' iservprt 'service/part relationships' */
   /* say 'All sample data read'                         */
   return iserv
```

Figure 135 (Part 3 of 3). DB2 Service Item Class (DB2\CARSERV.CLS)

DB2 Part Class

```
/*--------------------------------------------------------------------*/
/* DB2\carpart.cls       CarDealer - Part class (DB2)        ITSO-SJC */
/*--------------------------------------------------------------------*/

   .local['Cardeal.Part.class'] = .Part

::requires 'base\carpart.cls'

::class Part public subclass PartBase

/*----- class methods ------------------------------------------------*/

::method persistentLoad class                    /* load all parts from DB2 */
   stmt = 'select p.partnum, p.price, p.stock, p.description' ,
          '  from cardeal.part p' ,
          ' order by 1'
   hostvar = ':xpartid, :xprice, :xstock, :xdesc2'
   call sqlexec 'PREPARE s1 FROM :stmt'
   if sqlca.sqlcode \= 0 then
      say 'sqlerror parts prepare:' sqlca.sqlcode sqlmsg
   call sqlexec 'DECLARE c1 CURSOR FOR s1'
   call sqlexec 'OPEN c1'
   if sqlca.sqlcode \= 0 then
      say 'sqlerror parts open:' sqlca.sqlcode sqlmsg
   do ipart = 0 by 1 until sqlca.sqlcode \= 0     /* - run over all parts    */
      call sqlexec 'FETCH c1 INTO' hostvar
      if sqlca.sqlcode \= 0 & sqlca.sqlcode \= 100 then
         say 'sqlerror parts fetch:' sqlca.sqlcode sqlmsg
      else if sqlca.sqlcode = 0 then do
           partx = self~findNumber(xpartid)
           if partx = .nil then
              partx = self~new(xpartid, xdesc2, xprice, xstock)
      end
   end
   call sqlexec 'CLOSE c1'
   if sqlca.sqlcode \= 0 then
      say 'sqlerror parts close:' sqlca.sqlcode sqlmsg
   return ipart

/*----- instance methods ---------------------------------------------*/

::method persistentUpdate                        /* update a part           */
   use arg quant
   updatestmt = 'update cardeal.part set stock =' self~stock ,
                ' where partnum =' self~number
   call sqlexec 'EXECUTE IMMEDIATE :updatestmt'
   if sqlca.sqlcode \= 0 then say 'part-update' sqlca.sqlcode sqlmsg
   else call sqlexec 'COMMIT'
```

Figure 136 (Part 1 of 2). DB2 Part Class (DB2\CARPART.CLS)

```
   return sqlca.sqlcode

::method persistentInsert                          /* store new part          */
   insertstmt = "insert into cardeal.part" ,
                "   values("self~number","self~price","self~stock"," ,
                       "'"self~description"')"
   call sqlexec 'EXECUTE IMMEDIATE :insertstmt'
   if sqlca.sqlcode \= 0 then say 'part-insert' sqlca.sqlcode sqlmsg
   else call sqlexec 'COMMIT'
   return sqlca.sqlcode
```

Figure 136 (Part 2 of 2). DB2 Part Class (DB2\CARPART.CLS)

Objects in Memory

Configuration for Objects in Memory

```
/*--------------------------------------------------------------------*/
/* RAM\carmodel.cfg      CarDealer - Model Config. (Memory)  ITSO-SJC */
/*--------------------------------------------------------------------*/

   Parse source . . me .
   maindir = me~left(me~lastpos('\')-1)     /* main cardeal directory */
   if stream(maindir'\base\cardeal.cls',c,'query exists') = '' then
      call carerror maindir

   .local['Cardeal.Data.type'] = 'RAM'             /* Data in Memory  */
   .local['Cardeal.Data.dir']  = '-none-'          /* Data in Memory  */
   .local['Cardeal.Media.dir'] = '-none-'          /* Media not avail.*/

::requires 'base\cardeal.cls'

::requires 'ram\carcust.cls'
::requires 'ram\carvehi.cls'
::requires 'ram\carpart.cls'
::requires 'ram\carserv.cls'
::requires 'ram\carwork.cls'
```

Figure 137. Configuration for Objects in Memory (RAM\CARMODEL.CFG)

RAM Customer Class

```
/*--------------------------------------------------------------------*/
/* RAM\carcust.cls       CarDealer - Customer class (RAM)    ITSO-SJC */
/*                       (generate sample data)                       */
/*--------------------------------------------------------------------*/

   .local['Cardeal.Customer.class'] = .Customer
```

Figure 138 (Part 1 of 2). RAM Customer Class (RAM\CARCUST.CLS)

```
::requires 'base\carcust.cls'
::requires 'base\persist.cls'

::class Customer public subclass CustomerBase inherit Persistent

::method persistentLoad class                    /* create some customers   */
   c1  = .Customer~new(101,"Senator, Dale"     ,"Washington")
   c2  = .Customer~new(102,"Akropolis, Ida"    ,"Athen"     )
   c3  = .Customer~new(103,"Dolcevita, Felicia","Rome"      )
   c4  = .Customer~new(104,"DuPont, Jean"      ,"Paris"     )
   c5  = .Customer~new(105,"Deutsch, Hans"     ,"Stuttgart" )
   c6  = .Customer~new(106,"Helvetia, Toni"    ,"Zurich"    )
   c7  = .Customer~new(107,"Rising Star"       ,"Hollywood" )
   c8  = .Customer~new(108,"Zabrowski, Russkie","Moscow"    )
   c9  = .Customer~new(109,"Valencia, Maria de","Barcelona" )
```

Figure 138 (Part 2 of 2). RAM Customer Class (RAM\CARCUST.CLS)

RAM Vehicle Class

```
/*--------------------------------------------------------------------*/
/* RAM\carvehi.cls       CarDealer - Vehicle class (RAM)     ITSO-SJC */
/*                       (generate sample data)                       */
/*--------------------------------------------------------------------*/

   .local['Cardeal.Vehicle.class'] = .Vehicle

::requires 'base\carvehi.cls'
::requires 'base\persist.cls'

::class Vehicle public subclass VehicleBase inherit Persistent

::method persistentLoad class                    /* create some vehicles    */
   custcl = .local['Cardeal.Customer.class']
   v1  = .Vehicle~new(123456, "Ford"       ,"T"       ,1931,custcl~findNumber(101))
   v2  = .Vehicle~new(111111, "Porsche"    ,"Targa"   ,1989,custcl~findNumber(102))
   v3  = .Vehicle~new(222222, "Lamborghini","Countach",1992,custcl~findNumber(103))
   v4  = .Vehicle~new(334455, "Chevrolet"  ,"Impala"  ,1985,custcl~findNumber(104))
   v5  = .Vehicle~new(456456, "Toyota"     ,"Camry"   ,1988,custcl~findNumber(105))
   v6  = .Vehicle~new(543543, "Pontiac"    ,"Firebird",1979,custcl~findNumber(106))
   v7  = .Vehicle~new(199999, "Acura"      ,"Legend"  ,1990,custcl~findNumber(107))
   v8  = .Vehicle~new(777777, "Mercedes"   ,"380S"    ,1990,custcl~findNumber(108))
   v9  = .Vehicle~new(666888, "Lincoln"    ,"Towncar" ,1986,custcl~findNumber(109))
   v10 = .Vehicle~new(911911, "Chrysler"   ,"Le Baron",1982,custcl~findNumber(106))
   v11 = .Vehicle~new(176549, "Oldsmobile" ,"Aurora"  ,1980,custcl~findNumber(107))
   v12 = .Vehicle~new(298653, "Mercury"    ,"Sable"   ,1987,custcl~findNumber(106))
   v13 = .Vehicle~new(398674, "Cadillac"   ,"Alliante",1991,custcl~findNumber(103))
   v14 = .Vehicle~new(297465, "Volkswagen" ,"Camper"  ,1971,custcl~findNumber(102))

::method getmedianumber                          /* force no multimedia     */
   return 0                                      /* - no multimedia         */
```

Figure 139. RAM Vehicle Class (RAM\CARVEHI.CLS)

RAM Work Order Class

```
/*-------------------------------------------------------------------*/
/* RAM\carwork.cls       CarDealer - WorkOrder class (RAM)   ITSO-SJC */
/*                       (generate sample data)                      */
/*-------------------------------------------------------------------*/

   .local['Cardeal.WorkOrder.class'] = .WorkOrder

::requires 'base\carwork.cls'
::requires 'base\persist.cls'

::class WorkOrder public subclass WorkOrderBase inherit Persistent

::method persistentLoad class                    /* create some work orders */
   custcl = .local['Cardeal.Customer.class']
   servcl = .local['Cardeal.ServiceItem.class']
   c101 = custcl~findNumber(101)                 /* - for some customer     */
   c103 = custcl~findNumber(103)
   c106 = custcl~findNumber(106)
   c108 = custcl~findNumber(108)
   w1  = .WorkOrder~new("10/16/93",c101,c101~findVehicle(123456))
   w2  = .WorkOrder~new("11/11/93",c103,c103~findVehicle(398674))
   w3  = .WorkOrder~new("12/24/93",c106,c106~findVehicle(911911))
   w4  = .WorkOrder~new("09/17/93",c108,c108~findVehicle(777777))
   w1~addServiceItem(servcl~findnumber(1))       /* - add some services     */
   w2~addServiceItem(servcl~findnumber(4))
   w2~addServiceItem(servcl~findnumber(9))
   w2~addServiceItem(servcl~findnumber(10))
   w3~addServiceItem(servcl~findnumber(6))
   w3~addServiceItem(servcl~findnumber(7))
   w4~addServiceItem(servcl~findnumber(11))
```

Figure 140. RAM Work Order Class (RAM\CARWORK.CLS)

RAM Service Item Class

```
/*-------------------------------------------------------------------*/
/* RAM\carserv.cls       CarDealer - ServiceItem class (RAM) ITSO-SJC */
/*                       (generate sample data)                      */
/*-------------------------------------------------------------------*/

   .local['Cardeal.ServiceItem.class'] = .ServiceItem

::requires 'base\carserv.cls'
::requires 'base\persist.cls'

::class ServiceItem public subclass ServiceItemBase inherit Persistent

::method persistentLoad class                    /* create some services    */
   partclass = .local['Cardeal.Part.class']
   s1  = .ServiceItem~new( 1, "Brake job"          , 110)
   s2  = .ServiceItem~new( 2, "Check fluids"       ,  25)
   s3  = .ServiceItem~new( 3, "Tire Rotate/Balance",  20)
   s4  = .ServiceItem~new( 4, "Tires new Sedan"    ,   0)
```

Figure 141 (Part 1 of 2). RAM Service Item Class (RAM\CARSERV.CLS)

```
    s5  = .ServiceItem~new( 5, "Tires new Sport"    ,  10)
    s6  = .ServiceItem~new( 6, "Starter"            ,  75)
    s7  = .ServiceItem~new( 7, "Alternator"         ,  90)
    s8  = .ServiceItem~new( 8, "Heating system"     , 145)
    s9  = .ServiceItem~new( 9, "Electrical"         ,  85)
    s10 = .ServiceItem~new(10, "Exhaust system"     ,  85)
    s11 = .ServiceItem~new(11, "Fenders"            ,  45)
    s1~usesPart(partclass~findNumber(21), 1)       /* - using some parts      */
    s1~usesPart(partclass~findNumber(22), 2)
    s1~usesPart(partclass~findNumber(23), 2)
    s1~usesPart(partclass~findNumber(24), 2)
    s2~usesPart(partclass~findNumber(10), 5)
    s2~usesPart(partclass~findNumber(11), 1)
    s2~usesPart(partclass~findNumber(31), 1)
    s4~usesPart(partclass~findNumber(51), 4)
    s5~usesPart(partclass~findNumber(52), 4)
    s6~usesPart(partclass~findNumber(71), 1)
    s7~usesPart(partclass~findNumber(72), 1)
    s8~usesPart(partclass~findNumber(61), 1)
    s8~usesPart(partclass~findNumber(62), 1)
    s8~usesPart(partclass~findNumber(81), 1)
    s8~usesPart(partclass~findNumber(82), 1)
    s9~usesPart(partclass~findNumber(45), 3)
    s9~usesPart(partclass~findNumber(91), 1)
   s10~usesPart(partclass~findNumber( 1), 1)
   s11~usesPart(partclass~findNumber(41), 2)
```

Figure 141 (Part 2 of 2). RAM Service Item Class (RAM\CARSERV.CLS)

RAM Part Class

```
/*--------------------------------------------------------------------*/
/* RAM\carpart.cls       CarDealer - Part class (RAM)        ITSO-SJC */
/*                       (generate sample data)                       */
/*--------------------------------------------------------------------*/

   .local['Cardeal.Part.class'] = .Part

::requires 'base\carpart.cls'
::requires 'base\persist.cls'

::class Part public subclass PartBase inherit Persistent

::method persistentLoad class                    /* create some parts       */
   p1  = .Part~new( 1, "Muffler"        , 120,  3)
   p2  = .Part~new(10, "Oil 10-40 quart",   5, 30)
   p3  = .Part~new(11, "Oil filter"     ,  22, 15)
   p4  = .Part~new(21, "Brake cylinder" , 120,  3)
   p5  = .Part~new(22, "Brake fluid"    ,   7, 13)
   p6  = .Part~new(23, "Brake drum"     ,  28,  6)
   p7  = .Part~new(24, "Brake disk"     ,  35,  9)
   p8  = .Part~new(31, "Steering fluid" ,   8, 40)
   p9  = .Part~new(41, "Fender"         ,  67,  1)
   p10 = .Part~new(45, "Light bulb"     ,   2, 20)
   p11 = .Part~new(51, "Tire 185-70"    ,  57,  8)
   p12 = .Part~new(52, "Tire 205-60"    ,  73, 12)
   p13 = .Part~new(61, "Belt"           ,  12,  2)
```

Figure 142 (Part 1 of 2). RAM Part Class (RAM\CARPART.CLS)

```
   p14 = .Part~new(62, "Radiator"       , 133,  1)
   p15 = .Part~new(71, "Starter"        , 189,  4)
   p16 = .Part~new(72, "Alternator"     , 165,  2)
   p17 = .Part~new(81, "Water pump"     ,  97,  1)
   p18 = .Part~new(82, "Heating control",  43,  1)
   p19 = .Part~new(91, "Cruise control" ,  54,  2)
```

Figure 142 (Part 2 of 2). RAM Part Class (RAM\CARPART.CLS)

ASCII OS/2 Window Interface

ASCII User Interface Class

```
/*--------------------------------------------------------------------*/
/* AUI\caraui.cls        CarDealer - AUI class              ITSO-SJC */
/*                       (ASCII OS/2 window interface)               */
/*--------------------------------------------------------------------*/

   .local['Cardeal.AUI.class'] = .AUI

::class AUI public

/*----- instance methods -------------------------------------------*/

::method init                          /* initialize , query window */
   expose rows cols
   call RxFuncAdd 'SysTextScreenSize', 'RexxUtil', 'SysTextScreenSize'
   parse value SysTextScreenSize() with rows cols
   call RxFuncAdd 'SysCurPos', 'RexxUtil', 'SysCurPos'
   .local['Cardeal.aui.object'] = self

::method getrows                       /* return number of rows     */
   expose rows
   if rows = 0 then return 999
   else return rows

::method ClearScreen                   /* clear the window          */
   call SysCls

::method UserInput                     /* ask user for input        */
   use arg prompt, type                /* if 2nd parm is N          */
   say prompt':'                       /* input must be numeric     */
   parse pull ans
   if type = 'N' & ans~datatype('W') = 0 then do
      self~Error('"'prompt'" - must be numeric')
      return ''
   end
   return ans

::method EnterKey                      /* wait until user presses   */
   say 'press Enter key ...'           /* the enter key             */
   pull ans
   self~ClearScreen
```

Figure 143 (Part 1 of 2). ASCII User Interface Class (AUI\CARAUI.CLS)

```
::method YesNo                          /* ask user for yes or no    */
   use arg prompt
   do until 'YN'~pos(yn) > 0
      yn = self~UserInput(prompt)~left(1)~translate
   end
   return (yn = 'Y')

::method Error                          /* display error message     */
   expose rows
   use arg msg
   if rows > 0 then do
      say
      say 'Error:' msg
      self~EnterKey                     /* ask user for enter key    */
      end
   else
      x = RxMessageBox(msg,'Car-Dealer','OK','ERROR')

::method AckMessage
   do i=1 to arg()                      /* output acknowledge msg    */
      say '======>' arg(i)
   end
   self~EnterKey                        /* ask use for enter key     */

::method LineOut     /* write a line to the screen (clear if full)    */
   expose rows
   parse value SysCurPos() with row col  /* were's the cursor?        */
   if row > rows-2 then                 /* not enough space left...  */
      self~EnterKey                     /* clear the screen          */
   use arg line                         /* get the caller's line     */
   say line
   return 1

::method CheckRows  /* clear screen if insufficient lines remain     */
   expose rows
   use arg lines    /* how many lines does the caller need?          */
   parse value SysCurPos() with row col  /* were's the cursor?        */
   if row + lines > rows-2 then         /* not enough space left...  */
      self~EnterKey                     /* clear the screen          */
   return 1
```

Figure 143 (Part 2 of 2). ASCII User Interface Class (AUI\CARAUI.CLS)

Menu User Interface Class

```
/*--------------------------------------------------------------------*/
/* AUI\carmenu.cls       CarDealer - Menu class              ITSO-SJC */
/*                       (ASCII OS/2 window menu handling)            */
/*--------------------------------------------------------------------*/

   .local['Cardeal.Menu.class'] = .Menu

::class Menu public

/*----- class methods ------------------------------------------------*/

::method initialize class                /* build the menu structure */
```

Figure 144 (Part 1 of 3). Menu User Interface Class (AUI\CARMENU.CLS)

```
   expose extent file
   extent = .list~new                     /* allocate extent of menus */
   parse source . . me .
   file = .stream~new(me~left(me~lastpos('\'))'menu.dat')
   file~open('read')                      /* read the MENU.DAT file   */
   do i = 0 by 1 while file~lines>0
      parse value file~linein() with menuname '9'x caption '9'x action
      if menuname~left(2) = '/*' then iterate
      menux = .Menu~findMenu(menuname)    /* find menu/allocate new   */
      if action~word(1) = 'showMenu' then do
         newMenu = action~word(2)         /* action is another menu   */
         submenu = .Menu~findMenu(newMenu)
         menux~addItem(caption,submenu)   /* add the menu item line   */
         end
      else                                /* menu item is not submenu */
         menux~addItem(caption,action)    /* add the call action line */
   end
   file~close
   say 'Loaded' extent~items 'menus'
   return extent~firstitem                /* return to top menu       */

::method findMenu class private           /* find an existing menu    */
   expose extent
   arg menuname
   do menux over extent                   /* search the extent        */
      if menuname = menux~getname then return menux  /* return object */
   end
   menux = .Menu~new(menuname)            /* allocate new menu        */
   extent~insert(menux)                   /* add it to  list of menus */
   return menux

/*----- instance methods ---------------------------------------------*/

::method init                             /* initialize new menu obj. */
   expose menuname menuData
   use arg menuname                       /* save the name            */
   menuData = .array~new(0,2)             /* allocate array of items  */
   return menuData

::method getname                          /* return the name of a menu*/
   expose menuname
   return menuname

::method addItem                          /* add a menu item to menut */
   expose menuData
   use arg caption, action                /* new item is added at end */
   index = menuData~dimension(1) + 1
   menuData[index, 1] = caption           /* menu caption (text)      */
   menuData[index, 2] = action            /* menu action              */
   return index

::method showMenu                         /* display menu, prompt user*/
   expose menuData
   aui = .local['Cardeal.aui.object']     /* find aui object          */
   size = menuData~dimension(1)
   do forever                             /* display the menu         */
      aui~ClearScreen
      aui~lineout('*'~copies(60))
      aui~lineout('')
      aui~lineout(' '~copies(7) menuData[1, 1])
      aui~lineout('')
      aui~lineout('-'~copies(60))
      aui~lineout('')
      do i = 2 to size
```

Figure 144 (Part 2 of 3). Menu User Interface Class (AUI\CARMENU.CLS)

```
            aui~lineout((i-1)~right(6)':' menuData[i, 1])
         end
         aui~lineout('')
         aui~lineout(0~right(6)':' 'return')
         aui~lineout('')
         aui~lineout('*'~copies(60))
         aui~lineout('')
         selection = aui~UserInput('Select') /****** prompt user *********/
         aui~ClearScreen
         select
            when selection = '0' then return .nil
            when (selection > 0 & selection <= size) then
                    return menuData[selection+1, 2]  /*** return the item*/
            otherwise nop
         end
      end

   ::method makestring                        /* default string           */
      expose menuname menuData
      return 'Menu:' menuname 'with' menuData~dimension(1) 'items'
```

Figure 144 (Part 3 of 3). Menu User Interface Class (AUI\CARMENU.CLS)

Menu Definition File

```
/*--------------------------------------------------------------------*/
/* AUI\menu.dat          CarDealer - Menu definition         ITSO-SJC */
/*--------------------------------------------------------------------*/
Main¬CAR DEALER - GENERAL MENU
Main¬List (customer, part, work order, service)¬showMenu List
Main¬Update customer and part information      ¬showMenu Update
Main¬Setup and complete a work order           ¬showMenu Setup
Main¬New and used cars (multi-media)           ¬showMenu Media
List¬CAR DEALER - LISTING MENU
List¬List customers                  ¬call ListCustomerShort
List¬List customers and vehicles     ¬call ListCustomerLong
List¬List parts                      ¬call ListPart
List¬List service items              ¬call ListService
List¬List work orders                ¬call ListWorkOrder -1
Update¬CAR DEALER - UPDATE MENU
Update¬Create a new customer   ¬call Newcust
Update¬Delete a customer       ¬call Delcust
Update¬Add a car to a customer ¬call Newcar
Update¬Delete a car of a customer¬call Delcar
Update¬Increase stock of a part  ¬call Addstock
Setup¬CAR DEALER - WORK ORDER SETUP MENU
Setup¬Create a work order               ¬call Newwork
Setup¬Delete a work order               ¬call Delwork
Setup¬Add a service item to a work order¬call Newserv
Setup¬Complete a work order             ¬call Compwork
Setup¬Print the bill                    ¬call Workbill
Media¬CAR DEALER - USED CAR LOT
Media¬View media of a used car¬call carmedia
```

Figure 145. Menu Definition File (AUI\MENU.DAT)

Note: The not signs (¬) represent tab characters in the listing above.

List Routines

List Routines for ASCII Output

```
/*--------------------------------------------------------------------*/
/* AUI\carlist.rtn       CarDealer - ASCII list routines     ITSO-SJC */
/*                       (customer, part, service, workorder)         */
/*--------------------------------------------------------------------*/

     /* install the correct list routines for customer and work order */

if .local['Cardeal.Data.type'] = 'DB2' then "@copy db2\carlist.cfg AUI >null"
if .local['Cardeal.Data.type'] = 'FAT' then "@copy fat\carlist.cfg AUI >null"
if .local['Cardeal.Data.type'] = 'RAM' then "@copy ram\carlist.cfg AUI >null"
call 'aui\carlist.cfg'

     /* standard set of list routines assuming objects in memory      */

::routine ListCustomerShort public                /* Short customer list     */
   CustClass = .local['Cardeal.Customer.class']
   aui = .local['Cardeal.aui.object']             /* - get output object     */
   aui~LineOut(copies('=',78))
   aui~LineOut('List of customers:')
   aui~LineOut(CustClass~heading)
   customers = CustClass~findName('')
   do custn over customers                        /* - over all customers    */
      parse var custn custno '-' custn '-' custa
      aui~LineOut(right(custno,5) '     ' left(custn,20) '  ' left(custa,20))
   end
   aui~LineOut(copies('=',78))
   aui~enterkey

::routine ListCustomerLong public                 /* Long customer list      */
   CustClass = .local['Cardeal.Customer.class']   /* - with vehicles         */
   aui = .local['Cardeal.aui.object']
   aui~LineOut(copies('=',78))
   aui~LineOut('List of customers:')
        call ListCustomerLongData                 /* - call real routine     */
      /*************************/
   aui~LineOut(copies('=',78))                    /*   FAT or DB2            */
   aui~EnterKey
   return

::routine ListPart public                         /* Part list               */
   PartClass = .local['Cardeal.Part.class']
   aui = .local['Cardeal.aui.object']
   aui~LineOut(copies('=',78))
   aui~LineOut('List of' PartClass~extent~items 'parts:')
   aui~LineOut(PartClass~heading)
   do partx over PartClass~extent                 /* - over all parts        */
      aui~LineOut(partx~detail)
   end
   aui~LineOut(copies('=',78))
   aui~EnterKey
   return

::routine ListService public                      /* Service item list       */
   ServClass = .local['Cardeal.ServiceItem.class']
```

Figure 146 (Part 1 of 2). List Routines for ASCII Output (AUI\CARLIST.RTN)

```
   aui = .local['Cardeal.aui.object']
   aui~LineOut(copies('=',78))
   aui~LineOut('List of' ServClass~extent~items 'service items:')
   do servx over ServClass~extent                /* - over all services     */
      partsx = servx~getparts
      workcount = servx~getWorkOrders~items
      aui~CheckRows(partsx~items + workcount + 5)
      aui~LineOut(copies('-',78))
      aui~LineOut(ServClass~heading)
      aui~LineOut(servx~detail )
      do partx over partsx                       /* - parts within service  */
         aui~LineOut(left(' ',30) right(servx~getquantity(partx),6) ' ' ,
                     right(partx~number,3) partx~description)
      end
      do workx over servx~getWorkOrders          /* - work orders using serv*/
         aui~LineOut('  WorkOrder:' workx~detail)
      end
   end
   aui~LineOut(copies('=',78))
   aui~EnterKey
   return

::routine ListWorkOrder public                   /* Work order list         */
   use arg status
   WorkClass = .local['Cardeal.WorkOrder.class']
   aui = .local['Cardeal.aui.object']
   if status >= 0 then do                        /* - short list by status  */
      if status = 0 then aui~LineOut('List of incomplete work orders')
      if status = 1 then aui~LineOut('List of complete work orders')
      if status = 2 then aui~LineOut('List of all work orders')
      ordersx = WorkClass~findStatus(status)
      do orderx over ordersx                     /*   over all orders       */
         aui~LineOut(orderx)
      end
      end
   else do                                       /* - long list             */
      aui~LineOut(copies('=',78))
      aui~LineOut('List of work orders:')
           call ListWorkOrderData                /* - call real routine     */
         /************************/
      aui~LineOut(copies('=',78))                /*   FAT or DB2            */
      aui~EnterKey
   end
   return
```

Figure 146 (Part 2 of 2). List Routines for ASCII Output (AUI\CARLIST.RTN)

List Routine Configuration for File

```
/*--------------------------------------------------------------------*/
/* FAT\carlist.cfg       CarDealer - Config for list rout.   ITSO-SJC */
/*                       (copied to AUI\ if data in files)            */
/*--------------------------------------------------------------------*/

::requires 'fat\carlist.rtn'
```

Figure 147. List Routine Configuration for File (FAT\CARLIST.CFG)

List Routine Configuration for DB2

```
/*--------------------------------------------------------------------*/
/* DB2\carlist.cfg       CarDealer - Config for list rout.   ITSO-SJC */
/*                       (copied to AUI\ if data in DB2)              */
/*--------------------------------------------------------------------*/

::requires  'db2\carlist.rtn'
```

Figure 148. List Routine Configuration for DB2 (DB2\CARLIST.CFG)

List Routines for File

```
/*--------------------------------------------------------------------*/
/* FAT\carlist.rtn       CarDealer - ASCII list rout. (FAT)  ITSO-SJC */
/*                       (customer/workorder additions)               */
/*--------------------------------------------------------------------*/

::routine ListCustomerLongData public             /* Long customer list      */
   CustClass = .local['Cardeal.Customer.class']
   aui = .local['Cardeal.aui.object']
   do custx over CustClass~extent                 /* - over all customer     */
      carsx = custx~getVehicles
      ordersx = custx~getOrders
      aui~CheckRows(carsx~items + 4 + ordersx~items)
      aui~LineOut(copies('-',78))
      aui~LineOut(CustClass~heading)
      aui~LineOut(custx~detail)
      if carsx~items > 0 then                     /* - and their vehicles    */
         do carx over carsx
            aui~LineOut('   Vehicle:' carx~detail)
         end
      if ordersx~items > 0 then do                /* - and their work orders */
         do orderx over ordersx
            aui~LineOut(' WorkOrder:' orderx~detail)
         end
      end
   end

::routine ListWorkOrderData public                /* Work order list         */
   WorkClass = .local['Cardeal.WorkOrder.class']
   aui = .local['Cardeal.aui.object']
   do workx over WorkClass~extent                 /* - over all work orders  */
      itemcount = workx~getServices~items
      aui~CheckRows(itemcount + 4)  /* eject page if items would overflow */
      aui~LineOut(copies('-',78))
      aui~LineOut(workx~detail)
      aui~LineOut(workx~detailcust)
      first = 1
      do servx over workx~getServices             /* - and their services    */
         if first then
              aui~LineOut('   Services:' right(servx~number,3) servx~description)
         else aui~LineOut('            ' right(servx~number,3) servx~description)
         first = 0
      end
   end
```

Figure 149. List Routines for File (FAT\CARLIST.RTN)

List Routines for DB2

```
/*--------------------------------------------------------------------*/
/* DB2\carlist.rtn       CarDealer - ASCII list rout. (DB2)  ITSO-SJC */
/*                       (customer/workorder additions)               */
/*--------------------------------------------------------------------*/

::routine ListCustomerLongData public             /* Long customer list      */
   CustClass = .local['Cardeal.Customer.class']   /* - with vehicles:  DB2   */
   aui = .local['Cardeal.aui.object']
   stmtc = 'select c.custnum, c.custname, c.custaddr' ,
          '  from cardeal.customer c order by 1'
   hostvarc = ':xcustno, :xcustn, :xcusta'
   call sqlexec 'PREPARE s1 FROM :stmtc'
   call sqlexec 'DECLARE c1 CURSOR FOR s1'

   stmtv = 'select v.serialnum, v.make, v.model, v.year' ,
           '  from cardeal.vehicle v' ,
           ' where v.custnum = ?'
   hostvarv = ':xserial, :xmake, :xmodel, :xyear'
   call sqlexec 'PREPARE s2 FROM :stmtv'
   call sqlexec 'DECLARE c2 CURSOR FOR s2'

   stmtw = 'select w.ordernum, w.serialnum, w.cost, w.orderdate, w.status' ,
           '  from cardeal.workorder w' ,
           ' where w.custnum = ?'
   hostvarw = ':xordno, :xserial, :xcost, :xdate, :xstatus'
   call sqlexec 'PREPARE s3 FROM :stmtw'
   call sqlexec 'DECLARE c3 CURSOR FOR s3'

   call sqlexec 'OPEN c1'
   do icust = 0 by 1 until rcc \= 0               /* - over all customers    */
      call sqlexec 'FETCH c1 INTO' hostvarc
      rcc = sqlca.sqlcode
      if rcc = 0 then do
         aui~CheckRows(10)
         aui~LineOut(copies('-',78))
         aui~LineOut(CustClass~heading)
         aui~LineOut(right(xcustno,5) '     ' left(xcustn,20) '  ' ,
                     left(xcusta,20))
         call sqlexec 'OPEN c2 USING :xcustno'
         do ivehi = 0 by 1 until rcv \= 0         /* - vehicles of customer  */
            call sqlexec 'FETCH c2 INTO' hostvarv
            rcv = sqlca.sqlcode
            if rcv = 0 then
               aui~LineOut('   Vehicle:' right(xserial,8) '  ' left(xmake,12) ,
                           '  ' left(xmodel,10) '  ' xyear)
         end
         call sqlexec 'CLOSE' c2
         call sqlexec 'OPEN c3 USING :xcustno'
         do iwork = 0 by 1 until rcw \= 0         /* - workorders of customer*/
            call sqlexec 'FETCH c3 INTO' hostvarw
            rcw = sqlca.sqlcode
            if rcw = 0 then do
               if xstatus = 0 then xstatust = 'Incomplete'
                              else xstatust = 'Complete'
               aui~LineOut(' WorkOrder:' right(xordno,3) ' Date:' ,
                           left(xdate,8) ' Cost:' right(xcost,5) ,
                           ' Status: ' left(xstatust,10) '('xserial')')
            end
         end
         call sqlexec 'CLOSE' c3
```

Figure 150 (Part 1 of 2). List Routines for DB2 (DB2\CARLIST.RTN)

```
      end /*rcc*/
   end
   call sqlexec 'CLOSE c1'

::routine listWorkOrderData public               /* Work order list         */
   aui = .local['Cardeal.aui.object']            /*  - from DB2             */
   stmt = 'select w.ordernum, w.orderdate, w.cost, w.status,' ,
          '       c.custname, v.make, v.model' ,
          '  from cardeal.workorder w, cardeal.customer c, cardeal.vehicle v' ,
          ' where w.custnum = c.custnum and w.serialnum = v.serialnum' ,
          ' order by 1 desc'
   hostvar = ':xordno, :xdate, :xcost, :xstatus, :xcustn, :xmake, :xmodel'
   call sqlexec 'PREPARE s4 FROM :stmt'
   call sqlexec 'DECLARE c4 CURSOR FOR s4'
   stmts = 'select r.itemnum, s.description' ,
           '  from cardeal.workserv r, cardeal.service s' ,
           ' where r.ordernum = ? and r.itemnum = s.itemnum'
   hostvars = ':xitem, :xdesc'
   call sqlexec 'PREPARE s5 FROM :stmts'
   call sqlexec 'DECLARE c5 CURSOR FOR s5'

   call sqlexec 'OPEN c4'
   do iwork = 0 by -1 until rcw \= 0             /* - over all work orders  */
      call sqlexec 'FETCH c4 INTO' hostvar
      rcw = sqlca.sqlcode
      if rcw = 0 then do
         aui~CheckRows(8)
         aui~LineOut(copies('-',78))
         if xstatus = 0 then xstatust = 'Incomplete'
                        else xstatust = 'Complete'
         aui~LineOut(right(xordno,3) '   Date:' left(xdate,8) '  Cost:' ,
             right(xcost,5) '  Status: ' xstatust)
         aui~LineOut('   Customer:' xcustn '    Vehicle:' ,
                     strip(xmake)'-'strip(xmodel))
         first = 1
         call sqlexec 'OPEN c5 USING :xordno'
         do iserv = 0 by 1 until rcs \= 0        /* - and its services      */
            call sqlexec 'FETCH c5 INTO' hostvars
            rcs = sqlca.sqlcode
            if rcs = 0 then do
               if first then
                    aui~LineOut('   Services:' right(xitem,3) xdesc)
               else aui~LineOut('            ' right(xitem,3) xdesc)
               first = 0
            end
         end
         call sqlexec 'CLOSE c5'
      end
   end
   call sqlexec 'CLOSE c4'
```

Figure 150 (Part 2 of 2). List Routines for DB2 (DB2\CARLIST.RTN)

Implementing Parts in SOM

SOM IDL for Part Class

```
/*------------------------------------------------------------------*/
/* SOM\part.idl          CarDealer - Part class in SOM       ITSO-SJC */
/*------------------------------------------------------------------*/

#include <somobj.idl>
#include <somcls.idl>
#include "partmeta.idl"

    interface Part : SOMObject
    {
      attribute  short   pid;           // part number
      attribute  short   pprice;        // part price
      attribute  short   pstock;        // part stock
      attribute  string  pdesc;         // part description

      short   number();                 // get number
      short   price();                  // get price
      short   stock();                  // get stock
      string  description();            // get description
      string  detail();                 // make a detail line
      void    display();                // display to standard out

#ifdef __SOMIDL__
      implementation {
         releaseorder: _get_pid, _set_pid, _get_pprice, _set_pprice,
                       _get_pstock, _set_pstock, _get_pdesc, _set_pdesc,
                       number, price, stock, description, detail, display;
         metaclass    = PartMeta;
         majorversion = 0;
         minorversion = 0;
         dllname      = "part.dll";

         //# Method Modifiers
         somInit:   override;
         somUninit: override;
      };
#endif /* __SOMIDL__ */
    };
```

Figure 151. SOM IDL for Part Class (SOM\PART.IDL)

SOM IDL for Part Meta Class

```
/*------------------------------------------------------------------*/
/* SOM\partmeta.idl      CarDealer - Part meta class (SOM)   ITSO-SJC */
/*                       (class methods for Part class)             */
/*------------------------------------------------------------------*/
```

Figure 152 (Part 1 of 2). SOM IDL for Part Meta Class (SOM\PARTMETA.IDL)

```
#include <somobj.idl>
#include <somcls.idl>

    interface Part;

    interface PartMeta : SOMClass
    {
      attribute       sequence<Part>   pextent;

      void            add(in Part partx);
      void            remove(in Part partx);
      sequence<Part>  extent();
      Part            findNumber(in short pnum);
      string          heading();

#ifdef __SOMIDL__
      implementation {
         releaseorder: _get_pextent, _set_pextent,
                       add, remove, extent, findNumber, heading;
         majorversion = 0;
         minorversion = 0;
         dllname      = "part.dll";

         //# Method Modifiers
         somInit: override;
         somUninit: override;
      };
#endif /* __SOMIDL__ */
    };
```

Figure 152 (Part 2 of 2). SOM IDL for Part Meta Class (SOM\PARTMETA.IDL)

SOM Overwrite Code for Part Description

```
/*--------------------------------------------------------------------*/
/* SOM\setpdesc.xih      CarDealer - Code for               ITSO-SJC */
/*--------------------------------------------------------------------*/

    This code must be copied into:         PART.XIH
    to overwrite the generated method:     _set_pdesc
    Look for the routine near end of file

/**************** Code generated by SOM emitter in part.xih ***********/

SOM_Scope void  SOMLINK _set_pdesc(Part *somSelf, Environment *ev,
         string pdesc){
    PartData *somThis = PartGetData(somSelf);
    PartMethodDebug("Part","_set_pdesc");
    SOM_IgnoreWarning(ev);

    somThis->pdesc = pdesc;
}

/**************** Replacement code ************************************/

SOM_Scope void  SOMLINK _set_pdesc(Part *somSelf, Environment *ev,
         string pdesc){
    PartData *somThis = PartGetData(somSelf);
```

Figure 153 (Part 1 of 2). SOM Overwrite Code for Part Description (SOM\SETPDESC.XIH)

```
    PartMethodDebug("Part","_set_pdesc");
    SOM_IgnoreWarning(ev);

 /* somThis->pdesc = pdesc; ***************** eliminated ******/

    /************************************* replacement *****/
    if (somThis->pdesc)
        SOMFree(somThis->pdesc);
    somThis->pdesc = (string) SOMMalloc(strlen(pdesc) + 1);
    strcpy(somThis->pdesc, pdesc);
    /************************************* replacement *****/
}
```

Figure 153 (Part 2 of 2). SOM Overwrite Code for Part Description (SOM\SETPDESC.XIH)

Creating the SOM Part

Command to Run the SOM Compiler

```
/*--------------------------------------------------------------------*/
/* SOM\somcomp.cmd       CarDealer - SOM compiler/emitter    ITSO-SJC */
/*--------------------------------------------------------------------*/

                                          /* config.sys overwrites */
"SET SMADDSTAR=1"                         /* pointer notation      */
"SET SMEMIT=xh;xih;xc;def"                /* c++ and def emitters  */

'SC.EXE -u part.idl'                      /* compile the IDL files */
'SC.EXE -u partmeta.idl'

say
say 'Be sure to update "part.xih" with "setpdesc.xih" instructions'
say 'Check that "parttot.def" includes both "part.def" and "partmeta.def"'
```

Figure 154. Command to Run the SOM Compiler (SOM\SOMCOMP.CMD)

Command to Run C++ Compile and Link

```
/*--------------------------------------------------------------------*/
/* SOM\complink.cmd      CarDealer - Compile and link C++    ITSO-SJC */
/*--------------------------------------------------------------------*/

"ICC -I. -I%SOMBASE%\include  -Q+ -W3 -Gd- -Ge- -c  part.cpp"

"ICC -I. -I%SOMBASE%\include  -Q+ -W3 -Gd- -Ge- -c  partmeta.cpp"

"ILINK /packd /packc /exepack /align:16 /noi /nol /De /PM:VIO /Freeformat" ,
    "part.obj  partmeta.obj" ,
```

Figure 155 (Part 1 of 2). Command to Run C++ Compile and Link (SOM\COMPLINK.CMD)

```
    "/OUT:part.dll  somtk.lib  os2386.lib  parttot.def"

say
say 'Be sure to copy "part.dll" into a LIBPATH directory'
```

Figure 155 (Part 2 of 2). Command to Run C++ Compile and Link (SOM\COMPLINK.CMD)

SOM C++ Code for Part Class

```
/*
 *  This file was generated by the SOM Compiler.
 *  Generated using:
 *     SOM incremental update: 2.42
 */

/*
 *  This file was generated by the SOM Compiler and Emitter Framework.
 *  Generated using:
 *      SOM Emitter emitxtm: 2.42
 */

#ifndef SOM_Module_part_Source
#define SOM_Module_part_Source
#endif
#define Part_Class_Source

#include "part.xih"
#include <stdlib.h>
#include <string.h>
#include <iostream.h>

/*-- out ------ routine to convert number into 5 characters */
void out (int aNum, char* aChar)            // convert "aNum"
{                                           // to 5 characters, output
 char  buffer[35] = "     ";                // return: xxxxx\0
 char* p;
 char* pbuffer = &buffer[0];
 if      (aNum<10)     p = _itoa(aNum,&buffer[4],10);
 else if (aNum<100)    p = _itoa(aNum,&buffer[3],10);
 else if (aNum<1000)   p = _itoa(aNum,&buffer[2],10);
 else if (aNum<10000)  p = _itoa(aNum,&buffer[1],10);
 else if (aNum<100000) p = _itoa(aNum,&buffer[0],10);
 else                  p = _itoa(99999,&buffer[0],10);
 strcpy(aChar,pbuffer);
}

/*
 * get number                                    return the part number
 */

SOM_Scope short  SOMLINK number(Part *somSelf,  Environment *ev)
{
    PartData *somThis = PartGetData(somSelf);
    PartMethodDebug("Part","number");
    return somThis->pid;
}
```

Figure 156 (Part 1 of 3). SOM C++ Code for Part Class (SOM\PART.CPP)

```
/*
 * get price                                    return the part price
 */

SOM_Scope short  SOMLINK price(Part *somSelf,  Environment *ev)
{
    PartData *somThis = PartGetData(somSelf);
    PartMethodDebug("Part","price");
    return somThis->pprice;
}

/*
 * get stock                                    return the part stock
 */

SOM_Scope short  SOMLINK stock(Part *somSelf,  Environment *ev)
{
    PartData *somThis = PartGetData(somSelf);
    PartMethodDebug("Part","stock");
    return somThis->pstock;
}

/*
 * get description                              return the part description
 */

SOM_Scope string  SOMLINK description(Part *somSelf,  Environment *ev)
{
    PartData *somThis = PartGetData(somSelf);
    PartMethodDebug("Part","description");
    return somThis->pdesc;
}

/*
 * make a detail line                           prepare a detail line
 */

SOM_Scope string  SOMLINK detail(Part *somSelf,  Environment *ev)
{
    PartData *somThis = PartGetData(somSelf);
    PartMethodDebug("Part","detail");

    string detail = (string) SOMMalloc(46);
    out(somThis->pid,&detail[0]);
    strcpy(&detail[5],"     ");
    strcpy(&detail[9],somThis->pdesc);
    strcpy(&detail[9+strlen(somThis->pdesc)],"                       ");
    out(somThis->pprice,&detail[31]);
    strcpy(&detail[36],"     ");
    out(somThis->pstock,&detail[40]);
    return detail;
}

/*
 * display to standard out                      display the part data
 */

SOM_Scope void  SOMLINK display(Part *somSelf,  Environment *ev)
{
    PartData *somThis = PartGetData(somSelf);
    PartMethodDebug("Part","display");

    cout << " | ";
```

Figure 156 (Part 2 of 3). SOM C++ Code for Part Class (SOM\PART.CPP)

```
    cout.width(4);
    cout.setf(ios::right, ios::adjustfield);
    cout << somThis->pid;
    cout.width(0);
    cout << " | ";
    cout.width(15);
    cout.setf(ios::right, ios::adjustfield);
    cout << somThis->pdesc;
    cout.width(0);
    cout << " | ";
    cout.width(5);
    cout.setf(ios::right, ios::adjustfield);
    cout << somThis->pstock;
    cout.width(0);
    cout << " | ";
    cout.width(8);
    cout.setf(ios::right, ios::adjustfield);
    cout << somThis->pprice << " $" << endl;
}

/*                                              SOM initialize */
SOM_Scope void  SOMLINK somInit(Part *somSelf)
{
    PartData *somThis = PartGetData(somSelf);
    PartMethodDebug("Part","somInit");

    Part_parent_SOMObject_somInit(somSelf);

    somThis->pid = 0;
    somThis->pprice = 0;
    somThis->pstock = 0;
    somThis->pdesc = "-none-";
}

/*                                              SOM free       */
SOM_Scope void  SOMLINK somUninit(Part *somSelf)
{
    PartData *somThis = PartGetData(somSelf);
    PartMethodDebug("Part","somUninit");

    if (somThis->pdesc)
        SOMFree(somThis->pdesc);

    Part_parent_SOMObject_somUninit(somSelf);
}
```

Figure 156 (Part 3 of 3). SOM C++ Code for Part Class (SOM\PART.CPP)

SOM C++ Code for Part Meta Class

```
/*
 *  This file was generated by the SOM Compiler.
 *  Generated using:
 *     SOM incremental update: 2.42
 */

/*
```

Figure 157 (Part 1 of 3). SOM C++ Code for Part Meta Class (SOM\PARTMETA.CPP)

```
 *  This file was generated by the SOM Compiler and Emitter Framework.
 *  Generated using:
 *      SOM Emitter emitxtm: 2.42
 */

#ifndef SOM_Module_partmeta_Source
#define SOM_Module_partmeta_Source
#endif
#define PartMeta_Class_Source

#include "PARTMETA.xih"
#include "PART.xih"
#include <iostream.h>


/*                                              add part to sequence       */
SOM_Scope void  SOMLINK add(PartMeta *somSelf,  Environment *ev,
                            Part* partx)
{
    PartMetaData *somThis = PartMetaGetData(somSelf);
    PartMetaMethodDebug("PartMeta","add");

    for ( int i=0; i < somThis->pextent._length ; i++ )
       {
         if (somThis->pextent._buffer[i]->number(ev) == partx->number(ev))
           { return; }
       }
    i = somThis->pextent._length;
    if (i < somThis->pextent._maximum)
      {
        somThis->pextent._length = i + 1;
        somThis->pextent._buffer[i] = partx;
      }
    else
      {
         cout << "Sequence array of parts is full, not added" << endl;
      }
}

/*                                              remove part from sequence  */
SOM_Scope void  SOMLINK remove(PartMeta *somSelf,  Environment *ev,
                               Part* partx)
{
    PartMetaData *somThis = PartMetaGetData(somSelf);
    PartMetaMethodDebug("PartMeta","remove");

    for ( int i=0; i < somThis->pextent._length ; i++ )
       {
         if (somThis->pextent._buffer[i] == partx)
           {
             for (int j=i; j < somThis->pextent._length-1; j++ )
                {
                  somThis->pextent._buffer[j] =
                               somThis->pextent._buffer[j+1];
                }
             somThis->pextent._length = somThis->pextent._length - 1;
             return ;
           }
       }
}

/*                                              return extent (sequence)   */
SOM_Scope _IDL_SEQUENCE_Part  SOMLINK extent(PartMeta *somSelf,
                                             Environment *ev)
```

Figure 157 (Part 2 of 3). SOM C++ Code for Part Meta Class (SOM\PARTMETA.CPP)

```
{
    PartMetaData *somThis = PartMetaGetData(somSelf);
    PartMetaMethodDebug("PartMeta","extent");

    /* return (somThis->pextent);       works only once */

    _IDL_SEQUENCE_Part* res =
       (_IDL_SEQUENCE_Part*) SOMMalloc( sizeof(somThis->pextent) );
    res->_maximum = somThis->pextent._length;
    res->_length  = somThis->pextent._length;
    res->_buffer  = (Part**) SOMMalloc(120);
    for ( int i=0; i < res->_length ; i++ )
       { res->_buffer[i] = somThis->pextent._buffer[i]; }
    return *res;
}

/*                                              find part by number        */
SOM_Scope Part*  SOMLINK findNumber(PartMeta *somSelf,  Environment *ev,
                                    short pnum)
{
    PartMetaData *somThis = PartMetaGetData(somSelf);
    PartMetaMethodDebug("PartMeta","findNumber");

    for ( int i=0; i < somThis->pextent._length ; i++ )
       {
         if (somThis->pextent._buffer[i]->number(ev) == pnum)
           { return somThis->pextent._buffer[i]; }
       }
    return NULL;
}

/*                                              prepare a heading line     */
SOM_Scope string  SOMLINK heading(PartMeta *somSelf,  Environment *ev)
{
    PartMetaData *somThis = PartMetaGetData(somSelf);
    PartMetaMethodDebug("PartMeta","heading");
    return "Partid   Description           Price    Stock";
}

/*                                              SOM initialize             */
SOM_Scope void  SOMLINK somInit(PartMeta *somSelf)
{
    PartMetaData *somThis = PartMetaGetData(somSelf);
    PartMetaMethodDebug("PartMeta","somInit");

    PartMeta_parent_SOMClass_somInit(somSelf);

    somThis->pextent._maximum = 30;
    somThis->pextent._length = 0;
    somThis->pextent._buffer = (Part**) SOMMalloc(120);
}

/*                                              SOM free                   */
SOM_Scope void  SOMLINK somUninit(PartMeta *somSelf)
{
    PartMetaData *somThis = PartMetaGetData(somSelf);
    PartMetaMethodDebug("PartMeta","somUninit");

    SOMFree(somThis->pextent._buffer);

    PartMeta_parent_SOMClass_somUninit(somSelf);
}
```

Figure 157 (Part 3 of 3). SOM C++ Code for Part Meta Class (SOM\PARTMETA.CPP)

SOM DEF File for Link

```
;*-------------------------------------------------------------------------*/
;* SOM\parttot.def       CarDealer - DEF file for link       ITSO-SJC */
;*-------------------------------------------------------------------------*/
;
;  This file was merged from PART.DEF and PARTMETA.DEF
;  which are generated by the SOM compiler DEF emitter
;
LIBRARY PART INITINSTANCE
DESCRIPTION 'Part Class Library'
PROTMODE
DATA MULTIPLE NONSHARED LOADONCALL
EXPORTS
   PartCClassData
   PartClassData
   PartNewClass
   PartMetaCClassData
   PartMetaClassData
   PartMetaNewClass
```

Figure 158. SOM DEF File for Link (SOM\PARTTOT.DEF)

Workplace Shell (WPS) Demonstration

WPS Sample Car Dealer Demonstration

```
/*-------------------------------------------------------------------------*/
/* WPS\carshow.cmd       CarDealer - Workplace shell sample  ITSO-SJC */
/*                       (show car dealer info as folders)            */
/*-------------------------------------------------------------------------*/

 curdir = directory()
 parse source . . me .
 mydir = me~left(me~lastpos('\')-1)
 mydir = directory(mydir)

 .Cardeal~initialize             /* initialize car dealer application*/

 if pos('Workplace Shell',.wps) = 0 then do
    say 'Workplace Shell is not registered'
    say 'You need to run the WPSINST.CMD in the OREXX directory'
    return 8
 end
 wpAbstract = .wps~import('WPAbstract')

 call wpconst                    /* define WorkPlace Shell constants */

 parse source . . me .
 iconPath = me~left(me~lastpos('\'))'icons\'
 dealicon = iconPath'cardeal.ico'
 dataicon = iconPath'database.ico'
 custicon = iconPath'customer.ico'
```

Figure 159 (Part 1 of 5). WPS Sample Car Dealer Demonstration (WPS\CARSHOW.CMD)

```
 caricon =  iconPath'vehicle.ico'
 workicon = iconPath'workordr.ico'
 servicon = iconPath'service.ico'
 particon = iconPath'parts.ico'

 dealertext = 'Car Dealer Show'

 dealer = foldfind(dealertext, .wpdesktop)  /* find folder            */
 if dealer \= .nil then do                  /* if already exists      */
    dealer~wpopen(0,0,0)                    /* open it                */
    return
 end

 dealer = .wpfolder~new(dealertext, '', .wpdesktop, 1)
 dealer~wpsetup('NODELETE=NO;ICONFILE='dealicon)
 dealer~wpopen(0,0,0)
                                           /* build some templates   */
 call buildtemplate
                                           /* build all the views    */
 call buildcustview
 call buildworkview
 call buildservview
 call buildpartview
 call buildvehiview

 .Cardeal~terminate                        /* terminate application  */

 curdir = directory(curdir)
 return

/****** build a WPS tree structure for all customers ******************/

BUILDCUSTVIEW:
 say
 say 'Building customer view...'
 custView = addFolder('Customer View', dataicon, dealer)
 do custn over .Customer~findName('')              /* get all customers  */
                                                   /* this makes sure it */
    customer = .Customer~findNumber(custn~left(3)) /* works from DB2 too */
    say customer
    custFolder = addFolder(customer~makestring~substr(11), custicon, custView)
    workOrders = customer~getOrders
    carOrders = .table~new
    do workorder over workOrders  /* scan this customer's workorders */
       carOrders[workorder~getvehicle] = workorder  /* point car to w/o */
    end
    do car over customer~getVehicles
       carFolder = addFolder(car~makemodel, caricon, custFolder)
       if carOrders[car] <> .nil then do  /* is there a workorder for this car? */
          workorder = carOrders[car]
          woText = 'W/O:' workorder~number'-'workorder~date',' workorder~getstatust
          woFolder = addFolder(woText, workicon, carFolder)
          do service over workorder~getServices  /* services of w/o */
             servFolder = addFolder(service, servicon, woFolder)
             do part over service~getparts  /* parts of service */
                partFolder = addFolder(service~getquantity(part) 'of' part, ,
                                       particon, servFolder)
             end /* do parts */
          end /* do services */
       end /* do workorders */
    end /* do cars */
    carOrders = .nil
 end /* do customers */
 custView~wpopen(0,0,0)
```

Figure 159 (Part 2 of 5). WPS Sample Car Dealer Demonstration (WPS\CARSHOW.CMD)

```
 return

/****** build a WPS tree structure for all work orders ****************/

BUILDWORKVIEW:
 say
 say 'Building work order view...'
 workView = addFolder('Work Order View', dataicon, dealer)
 do workorder over .WorkOrder~extent  /* all work orders */
    woText = workorder~number'-'workorder~date',' workorder~getstatust
    say workorder
    woFolder = addFolder(woText, workicon, workView)
       custFolder = addFolder(workorder~getcustomer~makestring~substr(11), ,
                              custicon, woFolder)
       carFolder  = addFolder(workorder~getvehicle~makemodel, caricon, woFolder)
       do service over workorder~getServices  /* services of w/o */
          servFolder = addFolder(service, servicon, woFolder)
          do part over service~getparts  /* parts of service */
             partFolder = addFolder(service~getquantity(part) 'of' part, ,
                                    particon, servFolder)
          end /* do parts */
       end /* do services */
 end /* do workorders */
 /* workView~wpopen(0,0,0) */
 return

/****** build a WPS tree structure for all service items **************/

BUILDSERVVIEW:
 say
 say 'Building service item view...'
 servView = addFolder('Service Item View', dataicon, dealer)
 do service over .ServiceItem~extent /* all service items */
    say service
    servFolder = addFolder(service~makestring~substr(14), servicon, servView)
    do workorder over service~getWorkOrders /* workorders of service */
       woText = 'W/O:' workorder~number'-'workorder~date',' workorder~getstatust
       woFolder = addFolder(woText, workicon, servFolder)
          custFolder = addFolder(workorder~getcustomer~makestring~substr(11), ,
                                 custicon, woFolder)
          carFolder  = addFolder(workorder~getvehicle~makemodel, caricon, woFolder)
    end /* do workorders */
    do part over service~getparts  /* parts of service */
       partFolder = addFolder(service~getquantity(part) 'of' part, ,
                              particon, servFolder)
    end /* do parts */
 end /* do services */
 /* servView~wpopen(0,0,0) */
 return

/****** build a WPS tree structure for all parts **********************/

BUILDPARTVIEW:
 say
 say 'Building part view...'
 partView = addFolder('Part View', dataicon, dealer)
 do part over .Part~extent /* all parts */
    say part
    partFolder = addFolder(part~makestring~substr(7), particon, partView)
    do service over .ServiceItem~extent /* check services */
       do partx over service~getparts  /* parts of service */
          if partx = part then do  /* matching part, service is good */
             servFolder = addFolder(service, servicon, partFolder)
             do workorder over service~getWorkOrders /* workorders of service */
```

Figure 159 (Part 3 of 5). WPS Sample Car Dealer Demonstration (WPS\CARSHOW.CMD)

```
               woText = 'W/O:' workorder~number'-'workorder~date',' workorder~getstatust
               woFolder = addFolder(woText, workicon, servFolder)
                  custFolder = addFolder(workorder~getcustomer~makestring~substr(11), ,
                                         custicon, woFolder)
                  carFolder  = addFolder(workorder~getvehicle~makemodel, caricon, woFolder)
            end /* do workorders */
            leave
         end  /* do service uses part */
      end /* check parts in service */
   end /* do services */
end /* do parts */
/* partView~wpopen(0,0,0) */
return

/****** build a WPS tree structure for all vehicles ******************/

BUILDVEHIVIEW:
say
say 'Building vehicle view...'
vehiView = addFolder('Vehicle View', dataicon, dealer)
do customer over .Customer~extent  /* get all customers */
   do car over customer~getVehicles /* get cars of customer */
      say car
      carFolder = addFolder(car~makemodel, caricon, vehiView)
      custFolder = addFolder(customer~makestring~substr(11), custicon, carFolder)
      workOrders = customer~getOrders
      do workorder over workOrders  /* scan this customer's workorders */
         if car = workorder~getvehicle then do /* matching car */
            woText = 'W/O:' workorder~number'-'workorder~date',' workorder~getstatust
            woFolder = addFolder(woText, workicon, carFolder)
            do service over workorder~getServices  /* an array of services */
               servFolder = addFolder(service, servicon, woFolder)
               do part over service~getparts  /* an array of parts */
                  partFolder = addFolder(service~getquantity(part) 'of' part, ,
                                         particon, servFolder)
               end /* do parts */
            end /* do services */
         end  /* workorder for this car */
      end /* do workorders */
   end /* do cars */
end /* do customers */
/* vehiView~wpopen(0,0,0) */
return

/****** build templates for the classes ******************************/

BUILDTEMPLATE:
say
say 'Adding templates...'
custpad = addTemplate('New customers', custicon, dealer)
carpad  = addTemplate('New vehicles', caricon, dealer)
workpad = addTemplate('New workorders', workicon, dealer)
servpad = addTemplate('New services', servicon, dealer)
return

/****** Workplace Shell - subprocedure *******************************/

addFolder: procedure
   use arg name, iconFile, parent
   folder = .wpfolder~new(name~makestring, '', parent, 1)
   folder~wpsetup('NODELETE=NO;ICONFILE='iconFile)
   folder~wpSetDefaultView(.wpconst[OPEN_TREE])
   return folder
```

Figure 159 (Part 4 of 5). WPS Sample Car Dealer Demonstration (WPS\CARSHOW.CMD)

```
addTemplate: procedure
   use arg title, icon, parent
   template = .wpfolder~new(title, '', parent, 1)
   template~wpsetup('NODELETE=NO;ICONFILE='icon';TEMPLATE=YES')
   return template

/****** configuration file ******************************************/

::requires 'carmodel.cfg'
```

Figure 159 (Part 5 of 5). WPS Sample Car Dealer Demonstration (WPS\CARSHOW.CMD)

WPS Find a Folder

```
/*--------------------------------------------------------------------*/
/* WPS\foldfind.cmd      CarDealer - Find Folder in WP Shell ITSO-SJC */
/*                       (find folder or program entry)               */
/*--------------------------------------------------------------------*/

   use arg path, folder                 /* find a folder in a folder */
   if path = '' then return 16
   if arg() = 1 then folder = .wpdesktop /* by default, on desktop    */

   path = path~strip
   folder~wpPopulate(0, folder~wpQueryTitle, .false)
   first = folder~wpQueryContent(folder,0)              /* first item */
   last  = folder~wpQueryContent(folder,2)              /* last  item */
   this = first
   do while this \= .nil
     namet = this~wpQueryTitle
     if namet = path then return this                   /* found      */
     else do
        previous = this
        if this = last then this = .nil
        else this = folder~wpQueryContent(this, 1)      /* next item  */
        previous~wpUnLockObject
     end
   end
   return .nil
```

Figure 160. WPS Find a Folder (WPS\FOLDFIND.CMD)

WPS ObjectRexx Redbook Folder

```
/*--------------------------------------------------------------------*/
/* WPS\genfold.cmd       CarDealer - Workplace shell sample  ITSO-SJC */
/*                       (create installation folder)                 */
/*--------------------------------------------------------------------*/

orexxredfolder = "ObjectRexx Redbook"

if RxFuncQuery('SysLoadFuncs') then do
```

Figure 161 (Part 1 of 5). WPS ObjectRexx Redbook Folder (WPS\GENFOLD.CMD)

```
   call RxFuncAdd 'SysLoadFuncs', 'RexxUtil', 'SysLoadFuncs'
   call SysLoadFuncs
end

 if pos('Workplace Shell',.wps) = 0 then do
    say 'Workplace Shell is not registered'
    say 'You need to run the WPSINST.CMD in the OREXX directory'
    return 8
 end
wpAbstract = .wps~import('WPAbstract')
wpShadow = .wps~import('WPShadow')
call wpconst                        /* define WorkPlace Shell constants */

cardir  = SysIni('USER','OREXXRED','CARDEAL')
phildir = SysIni('USER','OREXXRED','PHILFORK')

parse source . . me .
iconPath = me~left(me~lastpos('\'))'icons'

redicon  = iconPath'\myorexx.ico'
dealicon = iconPath'\cardeal.ico'
dataicon = iconPath'\database.ico'
custicon = iconPath'\customer.ico'
caricon =  iconPath'\vehicle.ico'
workicon = iconPath'\workordr.ico'
servicon = iconPath'\service.ico'
particon = iconPath'\parts.ico'
philicon = iconPath'\philfork.ico'
drdicon  = iconPath'\drdialog.ico'
vpricon  = iconPath'\vprfldr.ico'
vxricon  = iconPath'\watcom2.ico'
funicon  = iconPath'\funny.ico'
rexxicon = iconPath'\rexx.ico'
db2icon  = iconPath'\db2fldr.ico'
db2ricon = iconPath'\db2run.ico'
insticon = iconPath'\install.ico'
mmicon   = iconPath'\media.ico'
wpicon   = iconPath'\wp.ico'

                                    /****** create the folder ***********/

orexxred = addFolder(orexxredfolder, redicon, .wpdesktop)

orexxinst = addProgram('ObjectRexx Redbook-Installation', ,
                  cardir'\Red-inst.exe', ,
                  '', cardir, insticon, '', orexxred)

orexxrun = addProgram('ObjectRexx Redbook-Application Run Menu', ,
                  cardir'\Red-run.exe', ,
                  '', cardir, redicon, '', orexxred)

carsetup = addProgram('Car Dealer-Setup Storage and SOM', ,
                  cardir'\car-run.cmd', ,
                  '[File | DB2 | RAM]   [Orexx-part | SOM-part]', ,
                  cardir, dealicon, 'NOAUTOCLOSE=YES', orexxred)

carrun = addProgram('Car Dealer Command-Run ASCII or GUI', ,
                  cardir'\car-run.cmd', ,
                  '[A-Ascii, G-DrDialog, P-VisPro, X-VxRexx]', ,
                  cardir, dealicon, '', orexxred)

caraui = addProgram('Car Dealer-Run ASCII', ,
                  cardir'\AUI\car-aui.cmd', ,
                  '', cardir, dealicon, '', orexxred)
```

Figure 161 (Part 2 of 5). WPS ObjectRexx Redbook Folder (WPS\GENFOLD.CMD)

```
cardrdia = addProgram('Car Dealer-Run DrDialog', ,
                  cardir'\drdialcd\car-gui.exe', ,
                  '', cardir, drdicon, '', orexxred)

carvispr = addProgram('Car Dealer-Run VisPro/Rexx', ,
                  cardir'\visprocd\car-gui.exe', ,
                  '', cardir, vpricon, '', orexxred)

carvxrex = addProgram('Car Dealer-Run Vx-Rexx', ,
                  cardir'\vxrexxcd\car-gui.exe', ,
                  '', '', vxricon, '', orexxred)

carwps = addProgram('Car Dealer-Run Workplace Shell', ,
                  cardir'\wps\carshow.cmd', ,
                  '', cardir'\wps', wpicon, '', orexxred)

cardb2 = addFolder('Car Dealer DB2 Setup-Folder', db2icon, orexxred)

db2setup = addProgram('Car Dealer-Table Setup & Load', ,
                  cardir'\install\db2setup.cmd', ,
                  '', cardir'\install', db2ricon, ,
                  'NOAUTOCLOSE=YES', cardb2)

db2load = addProgram('Car Dealer-Table Load', ,
                  cardir'\install\load-db2.cmd', ,
                  '', cardir'\install', db2ricon, ,
                  'NOAUTOCLOSE=YES', cardb2)

db2mm = addProgram('Car Dealer-Multi-Media Load', ,
                  cardir'\install\load-mm.cmd', ,
                  '', cardir'\install', mmicon, ,
                  'NOAUTOCLOSE=YES', cardb2)

philfork = addFolder("Philospher's Forks-Folder", philicon, orexxred)

pfdrdialog = addProgram("Philosopher's Forks-DrDialog", ,
                  phildir'\drdialpf\philfork.exe', ,
                  '', '', drdicon, '', philfork)

pfvispro = addProgram("Philosopher's Forks-VisProRexx", ,
                  phildir'\vispropf\philfork.exe', ,
                  '', '', vpricon, '', philfork)

pfvxrexx = addProgram("Philosopher's Forks-VxRexx", ,
                  phildir'\vxrexxpf\philfork.exe', ,
                  '', '', vxricon, '', philfork)

pffunny  = addProgram("Philosopher's Forks-Funny-Faces", ,
                  phildir'\zdialfun\philfork.exe', ,
                  '', '', funicon, '', philfork)

cardrdial  = addShadow('DrDialCD', cardir'\DrDialCD', orexxred)

carvispro  = addShadow('VisProCD', cardir'\VisProCD', orexxred)

carvxrexx  = addShadow('VxRexxCD', cardir'\VxRexxCD', orexxred)

phildrdial = addShadow('DrDialPF', phildir'\DrDialPF', philfork)

philvispro = addShadow('VisProPF', phildir'\VisProPF', philfork)

philvxrexx = addShadow('VxRexxPF', phildir'\VxRexxPF', philfork)
```

Figure 161 (Part 3 of 5). WPS ObjectRexx Redbook Folder (WPS\GENFOLD.CMD)

```
philfunny  = addShadow('ZdialFun',phildir'\ZdialFun',philfork)

orexxred~wpopen(0,0,0)

return 0

/****** subprocedures ************************************************/

addFolder: procedure
   use arg name, iconFile, parent
   namet = translate(name,'0a'x,'¬')
   child = foldfind(namet, parent)
   if child = .nil then do
      child = .wpfolder~new(namet, '', parent, 1)
      if iconfile = .nil then
         say 'Folder create failed:' name
      else do
         child~wpsetup('NODELETE=NO;ICONFILE='iconFile)
         say 'Folder created:' name
      end
      end
   else say 'Folder already exists:' name
   return child

addProgram: procedure
   use arg name, program, parms, curdir, iconfile, addit, parent
   namet = translate(name,'0a'x,'¬')
   call SysFileTree program, 'files', 'FO'
   if files.0 \= 1 then do
      say 'Program does not exist:' program '--> not added'
      return .nil
   end
   prog = foldfind(namet,parent)
   ptext = 'replaced:'
   if prog \= .nil then prog~wpdelete(0)
   else ptext = 'created:'
   def = 'EXENAME='program
   if parms \= '' then def = def';PARAMETERS='parms
   if curdir \= '' then def = def';STARTUPDIR='curdir
   if iconfile \= '' then def = def';ICONFILE='iconfile
   if addit \= '' then def = def';'addit
   prog = .wpprogram~new(namet, def, parent, 1)
   if prog = .nil then
      say 'Program create failed:' name
   else
      say 'Program' ptext name
   return prog

addShadow: procedure expose wpShadow
   use arg name, shadowdir, parent
   namet = translate(name,'0a'x,'¬')
   call SysFileTree shadowdir, 'files', 'DO'
   if files.0 \= 1 then do
      say 'Directory does not exist:' shadowdir '--> shadow not added'
      return .nil
   end
   shadow = foldfind(namet,parent)
   if shadow = .nil then do
      def = 'SHADOWID='shadowdir';'
      shadow = wpShadow~new(namet, def, parent, 1)
      if shadow = .nil then
         say 'Shadow create failed:' name
      else
         say 'Shadow created:' name
```

Figure 161 (Part 4 of 5). WPS ObjectRexx Redbook Folder (WPS\GENFOLD.CMD)

```
      end
   else say 'Shadow already exists:' name
   return shadow

addTemplate: procedure expose dealer
   use arg name, icon, parent
   namet = translate(name,'0a'x,'¬')
   template = foldfind(namet,parent)
   if template = .nil then do
      template = .wpfolder~new(namet, '', parent, 1)
      if template = .nil then
         say 'Template create failed:' name
      else do
         template~wpsetup('NODELETE=NO;ICONFILE='icon';TEMPLATE=YES')
         say 'Template created:' name
      end
      end
   else say 'Template already exists:' name
   return template
```

Figure 161 (Part 5 of 5). WPS ObjectRexx Redbook Folder (WPS\GENFOLD.CMD)

Car Dealer GUI Using Dr. Dialog

Configuration File for Dr. Dialog

```
/*--------------------------------------------------------------------*/
/* DrDialog\car-gui.rex  CarDealer - DrDialog GUI            ITSO-SJC */
/*                       (configuration, added to car-gui.res)        */
/*--------------------------------------------------------------------*/

::requires 'carmodel.cfg'
```

Figure 162. Configuration File for Dr. Dialog (DRDIALCD\CAR-GUI.REX)

Car Dealer GUI Using VisPro/REXX

Configuration File for VisPro/REXX

```
/*--------------------------------------------------------------------*/
/* VisPro\SubProcs\      CarDealer - VisPro Rexx GUI         ITSO-SJC */
/*        zCargui.cvp    (configuration, added to VisPro code)        */
/*--------------------------------------------------------------------*/
/*        zCargui.cvp    filename must be alphabetically last         */
/*                       of all code in SubProcs library              */

::requires carmodel.cfg

::class dummy
::method dummy     /* VisPro generates a return, which fits here ...  */
```

Figure 163. Configuration File for VisPro/REXX (VISPROCD\ZCARGUI.CVP)

Car Dealer GUI Using Watcom VX·REXX

Configuration File for Watcom VX·REXX

```
/*--------------------------------------------------------------------*/
/* VxRexx\car-gui.cvx    CarDealer - VxRexx GUI              ITSO-SJC */
/*                       (configuration, added to VxRexx code)        */
/*--------------------------------------------------------------------*/

::requires CarModel.cfg

::class dummy
::method dummy
   return              /* must have a return at the end! */
```

Figure 164. Configuration File for Watcom VX·REXX (VXREXXCD\CAR-GUI.CVX)

Car Dealer on the World Wide Web

Web Pages

Car Dealer Home Page

```
<!-------------------------------------------------------------------->
<! WWW\cardeal.html      CarDealer - Web - Cardeal Mainpage  ITSO-SJC ->
<!-------------------------------------------------------------------->

<html> <head> <title> Object REXX Car Dealer Application </title> </head>
<body>
<h1> Object REXX Car Dealer Application </h1>
<hr>
<ul>
    <li> <a href="/cardeal/cardesc.htm">
            <img align=middle src="cardeal.gif">
            <strong> Short application description </strong> </a>
<p> <li> <strong> Customer search </strong>

<form method="GET" action="/cgi-bin/cardeal/CustList">
    <p> First get a list of customers ...
    <p> If you have been here before, enter the customer name or
        an abbreviated name (such as one letter),
        otherwise just submit the form for a list of all customers.
    <p> <pre>Name search   <input name="name" type="text" size="20">    <input type="submit">
        </pre>
</form>

    <li> <b> Interact with the database: </b>
         <a href="/cardeal/caryours.htm">
            <img align=middle src="vehicle.gif">
            <strong> Add yourself and your car </strong> </a>

<p> <li> <b> List the Work Orders: </b>
         <a href="/cgi-bin/cardeal/WorkOrders?0">
            <img align=middle src="workordr.gif"> <strong> Incomplete </strong> </a>
         <a href="/cgi-bin/cardeal/WorkOrders?1">
            <img align=middle src="workordr.gif"> <strong> Complete </strong> </a>
         <a href="/cgi-bin/cardeal/WorkOrders?2">
            <img align=middle src="workordr.gif"> <strong> All </strong> </a>

<p> <li> <b> List the Service Items: </b>
         <a href="/cgi-bin/cardeal/Services?all">
            <img align=middle src="service.gif"> <strong> All </strong> </a>

<p> <li> <b> List the Parts: </b>
         <a href="/cgi-bin/cardeal/PartList?all">
            <img align=middle src="parts.gif"> <strong> All </strong> </a>
</ul>

<hr>
  <a href="/cardeal/Hacurs.htm"> <img align=middle src="/cardeal/hacursm.gif">
     <b> Hacurs Home Page </b> </a>
```

Figure 165 (Part 1 of 2). Car Dealer Home Page (WWW\CARDEAL.HTM)

```
  <br> <b>  Hacurs - Car Dealer Application </b>
  <br> Ulrich (Ueli) Wahli - IBM ITSO San Jose
  <address> wahli@vnet.im.com </address>
</body> </html>
```

Figure 165 (Part 2 of 2). Car Dealer Home Page (WWW\CARDEAL.HTM)

Car Dealer Application Not Running Page

```
<!-------------------------------------------------------------------->
<! WWW\cardealN.html     CarDealer - Web - Cardeal Homepage  ITSO-SJC ->
<!-------------------------------------------------------------------->

<html> <head> <title>Object REXX Car Dealer Application </title> </head>
<body>
<h1> Object REXX Car Dealer Application </h1>
<hr>
<ul>
   <li> <strong> Sorry, the Car Dealer Application is not available at this time
        </strong>
   <li> Please try again another day ...
</ul>
<hr>
  <a href="/cardeal/Hacurs.htm"> <img align=middle src="/cardeal/hacursm.gif">
     <b> Hacurs Home Page </b> </a>
  <br> <b>  Hacurs - Car Dealer Application </b>
  <br> Ulrich (Ueli) Wahli - IBM ITSO San Jose
  <address>wahli@vnet.im.com</address>
</body></html>
```

Figure 166. Car Dealer Application Not Running Page (WWW\CARDEALN.HTM)

Add Your Own Car Page

```
<!-------------------------------------------------------------------->
<! WWW\caryours.html     CarDealer - Web - Add your car      ITSO-SJC ->
<!-------------------------------------------------------------------->

<html> <head> <title> Object REXX Car Dealer Application </title> </head>

<body>
<h2> Add your own car to the database </h2>

Fill in this form to add yourself and your car to the database.
<br> You can only be in the database once per TCP/IP address.

<form method="GET" action="/cgi-bin/cardeal/CustYou">
   <p> <input name="lastname"  type="text" size="12"> Lastname
   <br><input name="firstname" type="text" size="12"> Firstname
   <p> <b> Your car: </b>
   <p> <input name="carmake"   type="text" size="12"> Make
   <br><input name="carmodel"  type="text" size="12"> Model
   <br><input name="caryear"   type="text" size="4">  Year
   <p> <input name="cartcp"    type="text" size="15"> <b> Your TCP/IP address </b>
```

Figure 167 (Part 1 of 2). Add Your Own Car Page (WWW\CARYOURS.HTM)

```
   <p> <input type="submit">
</form>

<a href="/cardeal/cardeal.htm"> <img align=middle src="/cardeal/cardeal.gif">
   <b> Car Dealer Home Page </b> </a>
<hr>
  <a href="/cardeal/Hacurs.htm"> <img align=middle src="/cardeal/hacursm.gif">
     <b> Hacurs Home Page </b> </a>
  <br> <b>  Hacurs - Car Dealer Application </b>
  <br> Ulrich (Ueli) Wahli - IBM ITSO San Jose
  <address>wahli@vnet.im.com</address>
</body> </html>
```

Figure 167 (Part 2 of 2). Add Your Own Car Page (WWW\CARYOURS.HTM)

Car Dealer Short Description Page

```
<!-------------------------------------------------------------------->
<! WWW\cardesc.html      CarDealer - Web - Cardeal Descript  ITSO-SJC ->
<!-------------------------------------------------------------------->

<html> <head> <title> Object REXX Car Dealer Application </title> </head>
<body>
<h3> Object REXX Car Dealer Application - Use Case </h3>

<ol>
    <li> <b> Trusty Trucks </b> <em> draws up </em> a list of the
         <b> parts </b> it has in stock.
<p> <li> <b> Trusty Trucks </b> also <em> defines </em> the
         <b> services </b> it offers and <em> lists </em> the
         <b> parts </b> each service needs.
<p> <li> <b>Customers </b> <em> bring in </em> their <b> vehicles </b>
         for servicing.
<p> <li> <b> Trusty Trucks </b> <em> records </em> the <b> customer </b>
         and <b> vehicle </b> details on a <b> work order </b> and
         <em> itemizes </em> the <b> services </b> required.
<p> <li> <b> Service staff </b> <em> carries out </em> the specified
         <b> services </b> on the <b> vehicles </b>.
<p> <li> <b> Clerical staff </b> <em> prepares </em> <b> bills </b>
         based on the <b> work orders </b>.
<p> <li> The <b> customers </b> <em> pay </em> their <b> bills </b> and
         <em> claim </em> their <b> vehicles </b>.
</ol>
<hr>

<h3> Web Sample Application </h3>
<ul>
   <li> <b> Search the DB2 database for customers </b>
        <dir> <li> List customer details (cars, work orders) </dir>
   <li> <b> Add yourself as a customer with a car </b>
        <dir> <li> Add a work order to your car, see the bill </dir>
   <li> <b> List work orders from the database </b> (incomplete, complete)
        <dir> <li> Look at details of a work order (services, parts) </dir>
   <li> <b> List service items the virtual shop performs </b> (and needed parts)
        <p>
   <li> <b> List parts from the database </b> (price, stock)
</ul>

<hr>
```

Figure 168 (Part 1 of 2). Car Dealer Short Description Page (WWW\CARDESC.HTM)

```
   <a href="/cardeal/cardeal.htm"> <img align=middle src="/cardeal/cardeal.gif">
      <b> Car Dealer Home Page </b> </a>
<hr>
  <a href="/cardeal/Hacurs.htm"> <img align=middle src="/cardeal/hacursm.gif">
     <b> Hacurs Home Page </b> </a>
  <br> <b>  Hacurs - Car Dealer Application </b>
  <br> Ulrich (Ueli) Wahli - IBM ITSO San Jose
   <address>wahli@vnet.im.com</address>
</body> </html>
```

Figure 168 (Part 2 of 2). Car Dealer Short Description Page (WWW\CARDESC.HTM)

Web HTML Class

HTML Class for CGI Programs

```
/*--------------------------------------------------------------------*/
/* WWW\html.frm          CarDealer - Web - HTML Framework    ITSO-SJC */
/*--------------------------------------------------------------------*/

::class HTML public subclass array

::method init                          /* initialize an html object         */
  expose array_index type              /* index into the array, docu type   */
  array_index = 1                      /* start at the first item           */
  type = 'text/html'                   /* default document type             */
  forward class (super)                /* do superclass initialization      */
                                       /* Start the html array off          */

::method put                           /* over ride of the put method       */
  expose array_index                   /* get the current index             */
  parse arg text
  self~put:super(text, array_index)
  array_index = array_index + 1

::method type                          /* change the document type          */
  expose type
  parse arg type

::method title                         /* title tag                         */
  parse arg text
  self~put('<html><head><title>'text'</title></head><body>')

::method h1                            /* header 1 tag                      */
  parse arg text
  self~put('<H1>'text'</H1>')

::method h2                            /* header 2 tag                      */
  parse arg text
  self~put('<H2>'text'</H2>')

::method h3                            /* header 3 tag                      */
  parse arg text
  self~put('<H3>'text'</H3>')

::method h4                            /* header 4 tag                      */
```

Figure 169 (Part 1 of 4). HTML Class for CGI Programs (WWW\HTML.FRM)

```
  parse arg text
  self~put('<H4>'text'</H4>')

::method h5                           /* header 5 tag                      */
  parse arg text
  self~put('<H5>'text'</H5>')

::method h6                           /* header 6 tag                      */
  parse arg text
  self~put('<H6>'text'</H6>')

::method href                         /* href tag with text and picture    */
  parse arg ref, text, pic
  if arg()=2 then self~put('<a href="'ref'"> <b>'text '</b></a>')
  else do
     self~put('<a href="'ref'"> <img align=middle src="'pic'">')
     if text \= '' then self~put('                <b>'text '</b></a>')
     else self~put('</a>')
  end

::method tag                          /* generate any tag                  */
  parse arg name, text
  self~put('<'name'>'text)

::method etag                         /* generate any "end" tag            */
  parse arg name, text
  self~put('</'name'>'text)

::method tage                         /* generate any tag with matching end*/
  parse arg name, text
  self~put('<'name'>'text'</'name'>')

::method text                         /* add raw text to the stream        */
  parse arg text
  self~put(text)

::method p                            /* paragraph tag                     */
  parse arg text
  self~put('<p>'text)

::method br                           /* break tag                         */
  parse arg text
  self~put('<br>'text)

::method hr                           /* hr tag                            */
  self~put('<hr>')

::method ul                           /* ul tag                            */
  self~put('<ul>')

::method eul                          /* eul tag                           */
  self~put('</ul>')

::method ol                           /* ol tag                            */
  self~put('<ol>')

::method eol                          /* eol tag                           */
  self~put('</ol>')

::method dir                          /* dir tag                           */
  self~put('<dir>')

::method edir                         /* edir tag                          */
  self~put('</dir>')
```

Figure 169 (Part 2 of 4). HTML Class for CGI Programs (WWW\HTML.FRM)

```
::method li                             /* li tag                          */
  parse arg text
  self~put('<li>'text)

::method strong                         /* strong tag                      */
  parse arg text
  self~put('<strong>'text'</strong>')

::method em                             /* em (emphasis) tag               */
  parse arg text
  self~put('<em>'text'</em>')

::method b                              /* b (bold) tag                    */
  parse arg text
  self~put('<b>'text'</b>')

::method i                              /* i (italic) tag                  */
  parse arg text
  self~put('<i>'text'</i>')

::method u                              /* u (underscore) tag              */
  parse arg text
  self~put('<u>'text'</u>')

::method tt                             /* tt (teletype) tag               */
  parse arg text
  self~put('<tt>'text'</tt>')

::method table                          /* table tag                       */
  parse arg options
  self~put('<table' options'>')

::method etable                         /* table end tag                   */
  self~put('</table>')

::method td                             /* td tag                          */
  parse arg text, options
  if text = '' then self~put('<td' options'>')
  else              self~put('<td' options'>'text'</td>')

::method etd                            /* td end tag                      */
  self~put('</td>')

::method th                             /* th tag                          */
  parse arg text, options
  self~put('<th' options'>'text'</th>')

::method tr                             /* tr tag                          */
  self~put('<tr>')

::method form                           /* form tag                        */
  parse arg action
  self~put('<form method="GET" action="'action'">')

::method eform                          /* eform tag                       */
  self~put('</form>')

::method input                          /* input tag                       */
  parse arg type, name, value, opts, text
  if type = 'submit' then self~put('<input type="submit">')
  else
    self~put('<input type="'type'" name="'name'" value="'value'"' opts'>' text)
```

Figure 169 (Part 3 of 4). HTML Class for CGI Programs (WWW\HTML.FRM)

```
::method address                        /* address tag                      */
  parse arg text
  self~put('<address>'text'</eaddress>')

::method sign                           /* signature/end                    */
  self~~hr~href('/cardeal/Hacurs.htm','Hacurs Home Page','/cardeal/hacursm.gif')
  self~~br~b('Hacurs - Car Dealer Application')
  self~br('Ulrich (Ueli) Wahli - IBM ITSO San Jose')
  self~address('wahli@vnet.im.com')
  self~~hr~~etag('body')~~etag('html')

::method carhome                        /* cardeal home page                */
  self~href('/cardeal/cardeal.htm', 'Car Dealer Home Page', ,
            '/cardeal/cardeal.gif')

::method errormsg                       /* generate an error message        */
  expose array_index
  parse arg text
  if array_index = 1 then self~title('Error Message')
  else self~h4('Error Message')
  self~~p~~b(text)
  self~~hr~carhome
  self~~sign~send

::method write                          /* write html to file (NOT USED)    */
  parse arg output                      /* output file                      */
  stream = .stream~new(output)          /* get a stream object              */
  do line over self                     /* time to write out the data       */
    stream~lineout(line)                /* write out the next line          */
  end
  stream~close                          /* close the file                   */

::method send                           /* send the HTML from the array     */
  expose type
  crlf = '0d0a'x
  say 'Content-Type:' type
  say ''
  say '<!doctype html public "html2.0">'
  do line over self                     /* loop over the array              */
    say line                            /* send out the next line           */
  end
```

Figure 169 (Part 4 of 4). HTML Class for CGI Programs (WWW\HTML.FRM)

Web CGI Programs

Common Gateway Interface for REXX

```
/*--------------------------------------------------------------------*/
/* WWW\cgirexx.cmd       CarDealer - Web - CGI Rexx Int.face ITSO-SJC */
/*--------------------------------------------------------------------*/

/*  say 'Content-Type: text/plain'; say ''; trace 'r'
  */
```

Figure 170 (Part 1 of 3). Common Gateway Interface for REXX (WWW\CGIREXX.CMD)

```
parse source env . me .
if env = 'OS/2' then envir = 'OS2ENVIRONMENT'
                else envir = 'ENVIRONMENT'
sourcedir = me~left(me~lastpos('\')-1)

script = value('SCRIPT_NAME',,envir)       /* Web server variables  */
who    = value('REMOTE_ADDR',,envir)
list   = value('QUERY_STRING',,envir)
parse var script '/cgi-bin/' type          /* extract request type  */
list=translate(list, ' ', '+'||'090a0d'x)  /* Whitespace, etc.      */
ddir   = sourcedir                         /* CARDEAL\WWW directory */
x = directory(ddir)
sqlca.sqlcode = 0                          /* init DB2 return code  */

select
  when left(type,8)='cardeal/' then do  /* Car Dealer Application */
     /* rc=lineout(ddir'\cardeal.act',date() time() ':' left(who,16) ':' left(type,20) ':' list) */
     /* rc=lineout(ddir'\cardeal.act')                                                           */
     if .environment['Cardeal.Data.type'] = .nil then do
        if type='cardeal/start' & pos(left(list,1),'cdf')>0 then do
             call carstart list 'html'
             return
        end
     end
     .local['Cardeal.Data.type']         = .environment['Cardeal.Data.type']
     .local['Cardeal.Data.dir']          = .environment['Cardeal.Data.dir']
     .local['Cardeal.Media.dir']         = .environment['Cardeal.Media.dir']
     .local['Cardeal.Customer.class']    = .environment['Cardeal.Customer.class']
     .local['Cardeal.Vehicle.class']     = .environment['Cardeal.Vehicle.class']
     .local['Cardeal.WorkOrder.class']   = .environment['Cardeal.WorkOrder.class']
     .local['Cardeal.ServiceItem.class'] = .environment['Cardeal.ServiceItem.class']
     .local['Cardeal.Part.class']        = .environment['Cardeal.Part.class']
     .local['Cardeal.WorkServRel']       = .environment['Cardeal.WorkServRel']
     if .local['Cardeal.Data.type'] = 'DB2' then do
        call sqlexec "CONNECT RESET"             /* just to be sure        */
        call sqlexec "CONNECT TO DEALERDB"       /* connect to database    */
     end
     select
        when type='cardeal/start' then
             call error
        when type='cardeal/stop' then
             call carstart 'stop html'
        when type='cardeal/status' then
             call carstart 'query html'
        when .environment['Cardeal.Data.type'] = .nil then
             call returnfile ddir'\cardealN.htm' /* CAR DEALER NOT RUNNING */
        when sqlca.sqlcode \= 0 then
             call returnfile ddir'\cardealN.htm' /* DB2 DATABASE CONNECT   */
        when type='cardeal/cardeal' then
             call returnfile ddir'\cardeal.htm'  /* cardeal home page      */
        when type='cardeal/CustList' then
             call custlist file, type, list, who
        when type='cardeal/CustDetail' then
             call custdeta file, type, list, who
        when type='cardeal/CustYou' then
             call custyou file, type, list, who
        when type='cardeal/VehiPic' then
             call vehipic file, type, list, who
        when type='cardeal/VehiMedi' then
             call vehimedi file, type, list, who
        when type='cardeal/WorkBill' then
             call workbill file, type, list, who
        when type='cardeal/NewWork' then
```

Figure 170 (Part 2 of 3). Common Gateway Interface for REXX (WWW\CGIREXX.CMD)

```
              call worknew file, type, list, who
         when type='cardeal/WorkServ' then
              call workserv file, type, list, who
         when type='cardeal/CDDelete' then
              call cddelete file, type, list, who
         when type='cardeal/WorkOrders' then
              call workord file, type, list, who
         when type='cardeal/WorkDetail' then
              call workdeta file, type, list, who
         when type='cardeal/Services' then
              call servlist file, type, list, who
         when type='cardeal/PartList' then
              call partlist file, type, list, who
         otherwise
              call error
      end
      end /*car dealer*/

   otherwise do
      call error
   end
end /*select*/
return

/*----------------- return a precoded HTML file ----------------------*/
RETURNFILE:
     parse arg resultfile
     say 'Location:' '/cardeal'translate(substr(resultfile,length(ddir)+1),'/','\')
     say ''
     return

/*----------------- return an error HTML file ------------------------*/
ERROR:
     say 'Content-Type: text/html'
     say ''
     say '<p><b>Invalid request of type:' type 'with parms:' list '</b>'
     say '<br>Who   :' who
     say '<br>Script:' script
     say '<br>Dir   :' ddir
     say '<br>Type  :' type
     say '<br>List  :' list
     return
```

Figure 170 (Part 3 of 3). Common Gateway Interface for REXX (WWW\CGIREXX.CMD)

Web Car Dealer Application Start

```
/*--------------------------------------------------------------------*/
/* WWW\carstart.cmd      CarDealer - Web - Start Application ITSO-SJC */
/*--------------------------------------------------------------------*/

  trace 'o'
  parse upper source env . me .
  maindir = me~left(me~lastpos('\WWW\')-1)
  arg action how
  action = left(strip(action),1) /* CURRENT, DB2, FILE, STOP, QUERY  */
  how    = left(strip(how),1)    /* HTML     output in browser "say" */
```

Figure 171 (Part 1 of 3). Web Car Dealer Application Start (WWW\CARSTART.CMD)

```
                                /* QUIET    no output               */
                                /* WAIT     output in window "say"  */
                                /*          and wait (START only)   */
                                /* other    output in window "say"  */

  curdir = directory()
  x = directory(maindir)
  select
    when action = 'C' then .Carstart~start('CURRENT', how)
    when action = 'F' then .Carstart~start('FILE', how)
    when action = 'D' then .Carstart~start('DB2', how)
    when action = 'S' then .Carstart~stop(how)
    when action = 'Q' then .Carstart~display(how)
    otherwise              say 'Carstart wrong parm:' action
  end
  x = directory(curdir)
  return

::class Carstart

::method start class
  parse arg action, how
  if how  = 'H' then do; say 'Content-Type: text/plain'; say ''; end
  if how \= 'Q' then say 'Car Dealer Application start' date() time() 'parm='action
  if action \= 'C' then call 'car-run' action '(' how
  if action = 'D' then if self~startdb2(how) > 0 then return
  call carmodel.cfg
  .Cardeal~initialize
  .environment['Cardeal.Data.type']         = .local['Cardeal.Data.type']
  .environment['Cardeal.Data.dir']          = .local['Cardeal.Data.dir']
  .environment['Cardeal.Media.dir']         = .local['Cardeal.Media.dir']
  .environment['Cardeal.Customer.class']    = .local['Cardeal.Customer.class']
  .environment['Cardeal.Vehicle.class']     = .local['Cardeal.Vehicle.class']
  .environment['Cardeal.WorkOrder.class']   = .local['Cardeal.WorkOrder.class']
  .environment['Cardeal.ServiceItem.class'] = .local['Cardeal.ServiceItem.class']
  .environment['Cardeal.Part.class']        = .local['Cardeal.Part.class']
  .environment['Cardeal.WorkServRel']       = .local['Cardeal.WorkServRel']
  if how \= 'Q' then say 'Car Dealer Application started'
  if how \= 'Q' then self~display('N')
  if how = 'W' then do  /* wait for user to press enter */
     say
     say 'Waiting for you to....'
     say 'Press enter to stop Car Dealer Application'
     pull ans
     self~stop(how)
  end

::method stop class
  parse arg how
  if how  = 'H' then do; say 'Content-Type: text/plain'; say ''; end
  if how \= 'Q' then say 'Car Dealer Application stop' date() time()
  call carmodel.cfg
  .Cardeal~terminate
  .environment['Cardeal.Data.type']         = .nil
  .environment['Cardeal.Data.dir']          = .nil
  .environment['Cardeal.Media.dir']         = .nil
  .environment['Cardeal.Customer.class']    = .nil
  .environment['Cardeal.Vehicle.class']     = .nil
  .environment['Cardeal.WorkOrder.class']   = .nil
  .environment['Cardeal.ServiceItem.class'] = .nil
  .environment['Cardeal.Part.class']        = .nil
  .environment['Cardeal.WorkServRel']       = .nil
  if how \= 'Q' then self~display('N')
```

Figure 171 (Part 2 of 3). Web Car Dealer Application Start (WWW\CARSTART.CMD)

```
::method display class
  parse arg how
  if how = 'Q' then return
  if how = 'H' then do; say 'Content-Type: text/plain'; say ''; end
  say 'Car Dealer Application display' date() time()
  say 'Data-type:      ' .environment['Cardeal.Data.type']
  say 'Data-directory: ' .environment['Cardeal.Data.dir']
  say 'Media-directory:' .environment['Cardeal.Media.dir']
  say 'Classes:        ' .environment['Cardeal.Customer.class']
  say '                ' .environment['Cardeal.Vehicle.class']
  say '                ' .environment['Cardeal.WorkOrder.class']
  say '                ' .environment['Cardeal.ServiceItem.class']
  say '                ' .environment['Cardeal.Part.class']
  say '                ' .environment['Cardeal.WorkServRel']
  say 'Main directory: ' directory()
  say
  if .environment['Cardeal.Data.type'] \= .nil then
       say 'STATUS:         ' 'CAR DEALER APPLICATION RUNNING:' ,
           .environment['Cardeal.Data.type']
  else say 'STATUS:         ' 'CAR DEALER APPLICATION  NOT  RUNNING'

::method startdb2 class
  parse arg how
  parse source env . me
  if how \= 'Q' then say 'Starting DB2'
  if env = 'OS/2' then do; "LOGON USERID /P:PASSWORD /L"; "STARTDBM"; end
                  else "DB2START"
  call rxfctsql                              /* Rexx-DB2 interface */
  call sqlexec "CONNECT RESET"
  call sqlexec "CONNECT TO DEALERDB"
  if sqlca.sqlcode = 0 then do
     if how \= 'Q' then say 'Connected to DEALERDB'
     return 0
     end
  else do
     if how = 'Q' then do; say 'Content-Type: text/plain'; say ''; end
     say 'DEALER database not available'
     say 'CAR DEALER APPLICATION CANNOT BE STARTED'
     call sqlexec "CONNECT RESET"
     return 8
  end
```

Figure 171 (Part 3 of 3). Web Car Dealer Application Start (WWW\CARSTART.CMD)

Web Customer List Program

```
/*--------------------------------------------------------------------*/
/* WWW\custlist.cmd      CarDealer - Web - Customer List     ITSO-SJC */
/*--------------------------------------------------------------------*/

/*  say 'Content-Type: text/plain'; say ''; trace 'r'
  */

  parse arg file, type, list, who
  parse var list 'name=' custsearch '?'

  html = .HTML~new
  custclass = .local['Cardeal.Customer.class']
```

Figure 172 (Part 1 of 2). Web Customer List Program (WWW\CUSTLIST.CMD)

```
  custnames = custclass~findName(custsearch)
  select
    when custnames~items = 0 then do
      html~errormsg("Sorry, no customers with this name ...")
      end
    when custnames~items = 1 then do
      parse value custnames[1] with custnum '-' custname '-' custaddr
      call custdeta file, type, 'cust='custnum'&refresh=no?', who
      end
  otherwise do
   html~title('Object REXX Car Dealer Application')
   html~carhome
   html~h2('Customer List')
   html~strong('Select a customer in the list by clicking on the name ...')
   html~p
   html~table('border=2 cellpadding=0')
   html~tr
   html~~th('Number')~~th('Name')~~th('Address')
   html~tr
   do icust = 1 to custnames~items
     parse value custnames[icust] with custnum '-' custname '-' custaddr
     html~td(custnum,'align=center')
     html~td('','align=left')
     html~href('CustDetail?cust='custnum'&refresh=no',custname)
     html~etd
     html~td(custaddr)
     check = ''
     html~tr
   end
   html~etable
   html~~p~carhome
   html~sign
   html~send
   end
  end /*select*/
  return

::requires html.frm
```

Figure 172 (Part 2 of 2). Web Customer List Program (WWW\CUSTLIST.CMD)

Web Customer Detail Program

```
/*--------------------------------------------------------------------*/
/* WWW\custdeta.cmd      CarDealer - Web - Customer Details  ITSO-SJC */
/*--------------------------------------------------------------------*/

/*  say 'Content-Type: text/plain'; say ''; trace 'r'
  */

  parse arg file, type, list, who
  parse var list 'cust=' custnum '&refresh=' refresh '?'
  if custnum = '' then do
     html~errormsg("No customer was selected")
     return
  end
  custclass = .local['Cardeal.Customer.class']
```

Figure 173 (Part 1 of 3). Web Customer Detail Program (WWW\CUSTDETA.CMD)

```
customer = custclass~findNumber(custnum)
html = .HTML~new
html~title('Object REXX Car Dealer Application')
html~carhome
html~h2('Customer Details')
if refresh = 'already' then do
   html~~hr~ul
   html~~li~b('There is already a customer at address' customer~address)
   html~~p~li('If this is not your TCP/IP address, turn off the socks or proxy server')
   html~~eul~hr
end
html~~dir~~b('('customer~number')' customer~name) ~tt(' - ')
html~~text('Address:')~em(customer~address)
if customer~address = who then
   html~~tt('......')~href('CDDelete?cust='customer~number, ,
                        'Delete the customer', '/cardeal/customer.gif')
html~edir
html~form("VehiPic")
html~h2('Vehicles')

workOrders = customer~getOrders
do car over customer~getVehicles
   html~~p~input("radio","car",car~serial,'', ,
                '<strong>' car~make '-' car~model '-' car~year '</strong>')
   html~ul
   carwo = 0
   do workorder over workOrders
     if car = workorder~getvehicle then do
        carwo = carwo + 1
        html~~li~b('Workorder:' workorder~number)
        html~text('dated:' workorder~date 'status:' workorder~getstatust)
        html~ol
        do service over workorder~getServices  /* services of w/o */
           html~li(service)
           do part over service~getparts  /* parts of service */
              html~br('<em>' service~getquantity(part) 'of' part '</em>')
           end /* do parts */
           html~p
        end /* do services */
        html~eol
        html~href('WorkBill?order='workorder~number, ,
                  'Look at the bill', '/cardeal/bill.gif')
        if customer~address = who then
           html~href('CDDelete?order='workorder~number, ,
                     'Delete the work order', '/cardeal/workordr.gif')
     end /* car matches */
   end /* workorder */
   html~eul
   if customer~address = who  &  carwo < 2 then do
        html~ul
        html~~li~href('NewWork?cust='custnum'&car='car~serial, ,
                      'Create a new workorder', '/cardeal/workordr.gif')
        html~eul
   end /* new workorder for current customer */
   if car~getmedianumber>0 then do
      html~ul
      html~~li~~b('Multimedia information')~ol
      mediacontrol = car~getmediacontrol
      pictures=0
      do ip = 1 to car~getmedianumber
         mediatitle  = substr(mediacontrol,ip*30-29,20)
         select
           when mediatitle = 'Fact-sheet' then do
              mediainfo = car~getmediainfo(ip)
```

Figure 173 (Part 2 of 3). Web Customer Detail Program (WWW\CUSTDETA.CMD)

```
                parse var mediainfo '::' minfo
                html~~li~b(mediatitle)
                html~br(minfo)
                end
             when mediatitle = 'Audio' then
                html~~li('Audio:')~href('VehiMedi?cust='custnum'&car='car~serial'&media='ip, ,
                                        'Listen to the sound (WAV file)', ,
                                        '/cardeal/audio.gif')
             when mediatitle = 'Video' then
                html~~li('Video:')~href('VehiMedi?cust='custnum'&car='car~serial'&media='ip, ,
                                        'View the movie (AVI file)', ,
                                        '/cardeal/video.gif')
             otherwise do
                if pictures=0 then html~li('Pictures:')
                else if pictures // 3 = 0 then html~br('Pictures:')
                pictures = pictures + 1
                html~href('VehiPic?cust='custnum'&car='car~serial'&media='ip, ,
                          mediatitle, '/cardeal/vehicle.gif')
             end
           end
         end
         html~~eol~eul
      end
   end /* do cars */
     carOrders = .nil

   html~eform
   html~~p~carhome
   html~sign
   html~send
   return

::requires html.frm
```

Figure 173 (Part 3 of 3). Web Customer Detail Program (WWW\CUSTDETA.CMD)

Web New Customer Program

```
/*--------------------------------------------------------------------*/
/* WWW\custyou.cmd       CarDealer - Web - Add Customer      ITSO-SJC */
/*--------------------------------------------------------------------*/

/*  say 'Content-Type: text/plain'; say ''; trace 'r'
  */

  parse arg file, type, list, who
  parse var list 'lastname=' lastname '&firstname=' firstname ,
                 '&carmake=' carmake '&carmodel=' carmodel ,
                 '&caryear=' caryear '&cartcp=' cartcp '?'
  html = .HTML~new
  if lastname = '' | firstname = '' | ,
     carmake = '' | carmodel = '' | caryear = '' | cartcp = '' then do
     html~errormsg("Not all information was provided - fill in all fields")
     return
  end
  if cartcp \= who then do
     html~errormsg("Your TCP/IP address does not match what the system tells me." ,
            "<p>Disable the socks or proxy server to use the Car Dealer application")
```

Figure 174 (Part 1 of 2). Web New Customer Program (WWW\CUSTYOU.CMD)

```
      return
   end

   custclass = .local['Cardeal.Customer.class']
   vehiclass = .local['Cardeal.Vehicle.class']
   custnum = custclass~findAddress(who)
   if custnum \= '' then do
      call custdeta file, type, 'cust='custnum'&refresh=already', who
      return
   end

   parse var who who1 '.' who2 '.' who3 '.' who4
   custnum = who1 + who2 + who3 + who4
   custx = custclass~findNumber(custnum)
   if custx \= .nil then do
      do i = 1 to 10
         custnum = random(200,998)
         if custclass~findNumber(custnum) = .nil then leave
      end
      if i>10 then do
        html~p("I cannot find a customer number for you!")
        html~br("Sorry - you may try again later")
        html~~p~carhome
        html~send
        return ''
      end
   end
   custname = strip(lastname)',' strip(firstname)
   custx = custclass~new(custnum,custname,who,'p')
   car = vehiclass~new(custnum'001', carmake, carmodel, caryear, custx, 'p')

   call custdeta file, type, 'cust='custnum'&refresh=yes', who
   return

::requires html.frm
```

Figure 174 (Part 2 of 2). Web New Customer Program (WWW\CUSTYOU.CMD)

Web Part List Program

```
/*--------------------------------------------------------------------*/
/* WWW\partlist.cmd      CarDealer - Web - Part list         ITSO-SJC */
/*--------------------------------------------------------------------*/

/*  say 'Content-Type: text/plain'; say ''; trace 'r'
  */

  parse arg file, type, list, who
  parse var list all

  partclass = .local['Cardeal.Part.class']
   html = .HTML~new
   html~title('Object REXX Car Dealer Application')
   html~carhome
   html~h2('Part List')
   html~table('border=2 cellpadding=0')
   html~tr
   html~~th('Number')~~th('Description')~~th('Price')~~th('Stock')
```

Figure 175 (Part 1 of 2). Web Part List Program (WWW\PARTLIST.CMD)

```
    html~tr
    do part over partclass~extent
      html~~td(part~number)~~td(part~description)
      html~~td(part~price,'align=right')~~td(part~stock,'align=right')
      html~tr
    end
    html~etable
    html~~p~carhome
    html~sign
    html~send
    return

::requires html.frm
```

Figure 175 (Part 2 of 2). Web Part List Program (WWW\PARTLIST.CMD)

Web Service List Program

```
/*--------------------------------------------------------------------*/
/* WWW\servlist.cmd      CarDealer - Web - ServiceItem List  ITSO-SJC */
/*--------------------------------------------------------------------*/

/* say 'Content-Type: text/plain'; say ''; trace 'r'
  */

  parse arg file, type, list, who
  parse var list all

  servclass = .local['Cardeal.ServiceItem.class']
   html = .HTML~new
   html~title('Object REXX Car Dealer Application')
   html~carhome
   html~h2('Service Item List')
   html~table('border=2 cellpadding=0')
   html~tr
   html~~th('Number')~~th('Description')~~th('Laborcost')
   html~~th('Parts (number - price - stock)')
   html~tr
   do service over servclass~extent
     html~~td(service~number)~~td(service~description)
     html~~td(service~laborcost,'align=right')
     html~tag('td')
       do part over service~getparts  /* parts of service */
          html~br(service~getquantity(part) '-' part~description ,
                  '<em>('part~number '- $'part~price '-' part~stock') </em>')
       end
       if service~getparts~items = 0 then html~br('none')
     html~etag('td')
     html~tr
   end
   html~etable
   html~~p~carhome
   html~sign
   html~send
   return

::requires html.frm
```

Figure 176. Web Service List Program (WWW\SERVLIST.CMD)

Web Work Order List Program

```
/*--------------------------------------------------------------------*/
/* WWW\workord.cmd       CarDealer - Web - WorkOrder List    ITSO-SJC */
/*--------------------------------------------------------------------*/

/*  say 'Content-Type: text/plain'; say ''; trace 'r'
  */

  parse arg file, type, list, who
  parse var list status

  woclass = .local['Cardeal.WorkOrder.class']
   html = .HTML~new
   html~title('Object REXX Car Dealer Application')
   html~carhome
   html~h2('Work Order List')
   html~strong('Select a work order in the list by clicking on the number ...')
   html~p
   html~table('border=2 cellpadding=0')
   html~tr
   html~~th('Number')~~th('Date')~~th('Cost')~~th('Status')
   html~~th('Car')~~th('Customer')
   do workx over woclass~findStatus(status)
     parse var workx num date cost status carcust
     car = left(carcust,20)
     cust = substr(carcust,21)
     html~tr
     html~~td('','align=center')
     html~~href('WorkDetail?order='num,num)
     html~etd
     html~~td(date)~~td(cost,'align=right')~~td(status)~~td(car)~~td(cust)
     check = ''
   end
   html~tr
   html~etable
   html~~p~carhome
   html~sign
   html~send
   return

::requires html.frm
```

Figure 177. Web Work Order List Program (WWW\WORKORD.CMD)

Web Work Order Detail Program

```
/*--------------------------------------------------------------------*/
/* WWW\workdeta.cmd      CarDealer - Web - WorkOrder Detail  ITSO-SJC */
/*--------------------------------------------------------------------*/

/*  say 'Content-Type: text/plain'; say ''; trace 'r'
  */

  parse arg file, type, list, who
```

Figure 178 (Part 1 of 2). Web Work Order Detail Program (WWW\WORKDETA.CMD)

```
   parse var list 'order=' ordnum '?'
   if ordnum = '' then do
      html~errormsg("No work order was selected")
      return
   end
   woclass = .local['Cardeal.WorkOrder.class']
   workorder = woclass~findNumber(ordnum)
   html = .HTML~new
   html~title('Object REXX Car Dealer Application')
   html~carhome
   html~h2('Work Order Details')
   woText = 'Workorder:' workorder~number 'dated:' workorder~date ,
            'status:' workorder~getstatust
   html~b(woText)
   html~ol
   do service over workorder~getServices  /* services of w/o */
      html~li(service)
      do part over service~getparts  /* parts of service */
         html~br('<em>' service~getquantity(part) 'of' part '</em>')
      end
      html~p
   end
   html~~p~href('WorkBill?order='workorder~number, ,
                'Look at the bill', '/cardeal/bill.gif')
   html~eol
   html~p
   html~b('Customer:')
   html~href('CustDetail?cust='workorder~getCustomer~number, ,
             '('workorder~getCustomer~number')' workorder~getCustomer~name, ,
             '/cardeal/customer.gif')
   html~b('Car: <em>'workorder~getVehicle~makemodel'</em>')
   html~~p~carhome
   html~sign
   html~send
   return

::requires html.frm
```

Figure 178 (Part 2 of 2). Web Work Order Detail Program (WWW\WORKDETA.CMD)

Web Work Order Bill

```
/*--------------------------------------------------------------------*/
/* WWW\workbill.cmd      CarDealer - Web - WorkOrder Bill    ITSO-SJC */
/*--------------------------------------------------------------------*/

/*  say 'Content-Type: text/plain'; say ''; trace 'r'
  */

  parse arg file, type, list, who
  parse var list 'order=' orderno '?'

  WOclass = .local['Cardeal.WorkOrder.class']
  ordx = WOclass~findNumber(orderno)
  if ordx = .nil then return 'string <b>Workorder' orderno 'not found'

  bill = ordx~generateBill
  html = .HTML~new
```

Figure 179 (Part 1 of 2). Web Work Order Bill (WWW\WORKBILL.CMD)

```
    html~title('Object REXX Car Dealer Application')
    html~carhome
    html~h2('Work Order Bill')
    html~table('border=5 cellpadding=0')
    html~tr
    html~td
    html~~tag('pre')~tag('tt')
    do line over bill
       html~br(' 'line)
    end
    html~~etag('tt')~etag('pre')
    html~etd
    html~tr
    html~etable
    html~~p~carhome
    html~sign
    html~send
    return

  ::requires html.frm
```

Figure 179 (Part 2 of 2). Web Work Order Bill (WWW\WORKBILL.CMD)

Web New Work Order Program

```
/*--------------------------------------------------------------------*/
/* WWW\worknew.cmd       CarDealer - Web - New Work Order    ITSO-SJC */
/*--------------------------------------------------------------------*/

/*  say 'Content-Type: text/plain'; say ''; trace 'r'
  */

  parse arg file, type, list, who
  parse var list 'cust=' custnum '&car=' serial '?'

  custclass = .local['Cardeal.Customer.class']
  WOclass   = .local['Cardeal.WorkOrder.class']
  SIclass   = .local['Cardeal.ServiceItem.class']
  custx = custclass~findNumber(custnum)
  if custx \= .nil then car = custx~findVehicle(serial)
  html = .HTML~new
  if custx = .nil | car = .nil then do
     html~errmsg("Bad information passed to New Work Order routine")
     return
  end
  if custx~address \= who then do
     html~errmsg("Sorry, you cannot create a work order for this customer")
     return
  end
  workx = WOclass~new(date('U'), custx, car)

  html~title("Object REXX Car Dealer Application")
  html~carhome
  html~h2('New Work Order')
  html~text('Work order' workx~number 'created on' workx~date)
  html~p('Select service items from list below, then submit')
```

Figure 180 (Part 1 of 2). Web New Work Order Program (WWW\WORKNEW.CMD)

```
   html~form("WorkServ")
   html~~br~input("hidden","order",workx~number)
   html~h4("Service Items")
   do servx over SIclass~extent
      html~~br~input("checkbox","service",servx~number,'', servx~description)
   end
   html~~p~input('submit')
   html~eform
   html~~p~carhome
   html~sign
   html~send
   return

::requires html.frm
```

Figure 180 (Part 2 of 2). Web New Work Order Program (WWW\WORKNEW.CMD)

Web Add Service Items to Work Order Program

```
/*--------------------------------------------------------------------*/
/* WWW\workserv.cmd      CarDealer - Web - Add ServiceItem   ITSO-SJC */
/*--------------------------------------------------------------------*/

/*  say 'Content-Type: text/plain'; say ''; trace 'r'
  */

  parse arg file, type, list, who
  parse var list 'order=' orderno '&' services '?'

  html = .HTML~new
  WOclass   = .local['Cardeal.WorkOrder.class']
  SIclass   = .local['Cardeal.ServiceItem.class']
  ordx = WOclass~findNumber(orderno)
  if ordx = .nil then do
     html~errormsg("Bad information passed to Work Order Services routine")
     return
  end
  custx = ordx~getCustomer
  if custx~address \= who then do
     html~errmsg("Sorry, you cannot add services for this customer")
     return
  end
  custnum = custx~number
  if ordx~getServices~items > 0 then
     call custdeta file, type, 'cust='custnum'&refresh=no?', who
  else do
     do i=1 to SIclass~extent~items while services \= ''
        parse var services 'service=' servnum '&' services
        servx = SIclass~findNumber(servnum)
        if servx \= .nil then ordx~addServiceItem(servx,'p')
     end
     call custdeta file, type, 'cust='custnum'&refresh=yes?', who
  end
  return

::requires html.frm
```

Figure 181. Web Add Service Items to Work Order Program (WWW\WORKSERV.CMD)

Web Vehicle Picture Program

```
/*--------------------------------------------------------------------*/
/* WWW\vehipic.cmd       CarDealer - Web - Vehicle Picture   ITSO-SJC */
/*--------------------------------------------------------------------*/

/*  say 'Content-Type: text/plain'; say ''; trace 'r'
  */

  parse arg file, type, list, who
  parse var list 'cust=' custnum '&car=' serial '&media=' media '?'
  parse source env . me .
  if env = 'OS/2' then envir = 'OS2ENVIRONMENT'
                  else envir = 'ENVIRONMENT'
  tmpdir = value('TMP',,envir)'\'

  html = .HTML~new
  html~title("Object REXX Car Dealer Application")
  html~carhome
  html~h2("Vehicle Picture")
  mediainfo = ''
  custclass = .local['Cardeal.Customer.class']
  custx = custclass~findNumber(custnum)
  if custx \= .nil then car = custx~findVehicle(serial)
  if car \= .nil & datatype(media,'W') then do
     medianum  = car~getmedianumber
     mediainfo = car~getmediainfo(media)
  end
  if mediainfo = '' then do
     html~~p("Bad information passed to Vehicle Picture routine")~~sign~send
     return
  end
  parse var mediainfo title '::' mediafile '.' ext
  mediafilename = mediafile~substr(mediafile~lastpos('\')+1)
  if pos(tmpdir,mediafile) > 0 then picfile = '/tmp/'mediafilename'.'ext
  else picfile = '/cardeal/media/'mediafilename'.'ext

  html~~br('Customer:')~b(custx~name)
  html~~br('Car:')~b(car~make '-' car~model '-' car~year)
  html~~p('Picture:')~b(title)
  html~p('<img src="'picfile'" alt="A picture">')
  html~href(picfile,'Click here for picture')
  html~~p~carhome
  html~sign
  html~send
  return

::requires html.frm
```

Figure 182. Web Vehicle Picture Program (WWW\VEHIPIC.CMD)

Web Vehicle Multimedia Program

```
/*--------------------------------------------------------------------*/
/* WWW\vehimedi.cmd      CarDealer - Web - Vehicle Media     ITSO-SJC */
```

Figure 183 (Part 1 of 2). Web Vehicle Multimedia Program (WWW\VEHIMEDI.CMD)

```
/*--------------------------------------------------------------------*/

/*  say 'Content-Type: text/plain'; say ''; trace 'r'
  */

  parse arg file, type, list, who
  parse var list 'cust=' custnum '&car=' serial '&media=' media '?'
  parse source env . me .
  if env = 'OS/2' then envir = 'OS2ENVIRONMENT'
                  else envir = 'ENVIRONMENT'
  tmpdir = value('TMP',,envir)'\'

  html = .HTML~new
  html~title("Object REXX Car Dealer Application")
  html~carhome
  html~h2("Vehicle Multimedia")
  mediainfo = ''
  custclass = .local['Cardeal.Customer.class']
  custx = custclass~findNumber(custnum)
  if custx \= .nil then car = custx~findVehicle(serial)
  if car \= .nil & datatype(media,'W') then do
     medianum  = car~getmedianumber
     mediainfo = car~getmediainfo(media)
  end
  if mediainfo = '' then do
     html~errormsg("Bad information passed to Vehicle Audio/Video routine")
     return
  end
  parse var mediainfo title '::' mediafile '.' ext
  mediafilename = mediafile~substr(mediafile~lastpos('\')+1)
  if pos(tmpdir,mediafile) > 0 then audiofile = '/tmp/'mediafilename'.'ext
  else audiofile = '/cardeal/media/'mediafilename'.'ext

  /* code below copies picture into CARDEAL\WWW -
     but not necessary if HTTPD.CNF has a mapping for /tmp */
  /* audiofile = custnum'-'serial'-'media'.'ext
     audiocopy = directory()'\'audiofile
     address CMD "@copy" mediafile'.'ext audiocopy ">null"   */

  ext = translate(ext)
  select
     when ext = 'WAV' then do
         say 'Content-Type: audio/x-wav'
         say 'Location:' audiofile
         say ''
         /*html~errormsg("Not supported yet")*/
        end
     when ext = 'AVI' then do
         say 'Content-Type: video/x-msvideo'
         say 'Location:' audiofile
         say ''
         /*html~errormsg("Not supported yet")*/
        end
     otherwise html~errormsg('Unsupported data types (ext='ext')')
  end
  return

::requires html.frm
```

Figure 183 (Part 2 of 2). Web Vehicle Multimedia Program (WWW\VEHIMEDI.CMD)

Display Object REXX Redbook Sysini Information

```
/*--------------------------------------------------------------------*/
/* Install\sysini.cmd    ObjectRexx Redbook - SysIni         ITSO-SJC */
/*                       (display and modify redbook SysIni info)     */
/*--------------------------------------------------------------------*/

   if RxFuncQuery('SysLoadFuncs') then do
      call RxFuncAdd 'SysLoadFuncs', 'RexxUtil', 'SysLoadFuncs'
      call SysLoadFuncs
   end

   say
   say 'Displaying ObjectRexx Redbook SYSINI Information'
   say '-----------------------------------------------------'
   say 'SysIni is used to record the installation directories'
   say

   rc = SysIni('USER','OREXXRED','ALL:','allkeys')
   if rc = 'ERROR:' then do
      say 'No entries found'
      return
   end

   say 'Application:' 'OREXXRED'
   do key over allkeys.
      if key>0 then say 'Key:'~right(12) allkeys.key~left(16) 'Value:' ,
                        SysIni('USER','OREXXRED',allkeys.key)
   end

   say
   say 'Enter "ALL" to delete all entries'
   say 'Enter one of the leys to delete one entry'
   say 'Enter blank to exit'
   pull ans
   if ans~left(1) = ' ' then return

   if ans~left(3) = 'ALL' then
      rc = SysIni('USER','OREXXRED','DELETE:')
   else
      rc = SysIni('USER','OREXXRED',ans,'DELETE:')
   say 'OREXXRED entry' ans 'deleted'
   say 'Entries can be recreated using the RED-INST (install) program'

   return
```

Figure 184. Display Object REXX Redbook Sysini Information (INSTALL\SYSINI.CMD)

DB2 Setup

Create Car Dealer Database DDL

```
/*--------------------------------------------------------------------*/
/* Install\createdb.ddl  CarDealer - Create DEALERDB         ITSO-SJC */
/*--------------------------------------------------------------------*/

-- tailor the disk drive!

    CREATE DATABASE DEALERDB ON C;

--  CHANGE DATABASE DEALERDB  COMMENT
--     WITH "Database for Car Dealer Application";
```

Figure 185. Create Car Dealer Database DDL (INSTALL\CREATEDB.DDL)

Create Tables DDL for DB2/2 Version 1

```
/*--------------------------------------------------------------------*/
/* Install\createt1.ddl  CarDealer - Create tables           ITSO-SJC */
/*                       (for DB2/2 version 1, no multi-media)        */
/*--------------------------------------------------------------------*/

  CONNECT TO DEALERDB;

  CREATE TABLE CARDEAL.CUSTOMER
      (CUSTNUM             SMALLINT  NOT NULL,
       CUSTNAME            CHAR(20)  NOT NULL,
       CUSTADDR            CHAR(20)  NOT NULL)
    ;
  CREATE TABLE CARDEAL.PART
      (PARTNUM             SMALLINT  NOT NULL,
       PRICE               SMALLINT  NOT NULL,
       STOCK               SMALLINT  NOT NULL,
       DESCRIPTION         CHAR(15)  NOT NULL)
    ;
  CREATE TABLE CARDEAL.SERVICE
      (ITEMNUM             SMALLINT  NOT NULL,
       LABOR               SMALLINT  NOT NULL,
       DESCRIPTION         CHAR(20)  NOT NULL)
    ;
  CREATE TABLE CARDEAL.WORKORDER
      (ORDERNUM            SMALLINT  NOT NULL,
       CUSTNUM             SMALLINT  NOT NULL,
       SERIALNUM           INTEGER   NOT NULL,
       COST                INTEGER   NOT NULL,
       ORDERDATE           CHAR(08)  NOT NULL,
       STATUS              SMALLINT  NOT NULL)
    ;
  CREATE TABLE CARDEAL.SERVPART
      (ITEMNUM             SMALLINT  NOT NULL,
       PARTNUM             SMALLINT  NOT NULL,
```

Figure 186 (Part 1 of 2). Create Tables DDL for DB2/2 Version 1 (INSTALL\CREATET1.DDL)

```
      QUANTITY            SMALLINT  NOT NULL)
  ;
CREATE TABLE CARDEAL.WORKSERV
    (ORDERNUM             SMALLINT  NOT NULL,
     ITEMNUM              SMALLINT  NOT NULL)
  ;
CREATE TABLE CARDEAL.VEHICLE
    (SERIALNUM            INTEGER   NOT NULL,
     CUSTNUM              SMALLINT  NOT NULL,
     MAKE                 CHAR(12)  NOT NULL,
     MODEL                CHAR(10)  NOT NULL,
     YEAR                 SMALLINT  NOT NULL)
  ;
CONNECT RESET;
```

Figure 186 (Part 2 of 2). Create Tables DDL for DB2/2 Version 1 (INSTALL\CREATET1.DDL)

Create Tables DDL for DB2/2 Version 2

```
/*--------------------------------------------------------------------*/
/* Install\createtb.ddl  CarDealer - Create tables          ITSO-SJC */
/*                       (for DB2/2 version 2, with multi-media)     */
/*--------------------------------------------------------------------*/

  CONNECT TO DEALERDB;

  CREATE TABLE CARDEAL.CUSTOMER
      (CUSTNUM             SMALLINT  NOT NULL,
       CUSTNAME            CHAR(20)  NOT NULL,
       CUSTADDR            CHAR(20)  NOT NULL)
    ;
  CREATE TABLE CARDEAL.PART
      (PARTNUM             SMALLINT  NOT NULL,
       PRICE               SMALLINT  NOT NULL,
       STOCK               SMALLINT  NOT NULL,
       DESCRIPTION         CHAR(15)  NOT NULL)
    ;
  CREATE TABLE CARDEAL.SERVICE
      (ITEMNUM             SMALLINT  NOT NULL,
       LABOR               SMALLINT  NOT NULL,
       DESCRIPTION         CHAR(20)  NOT NULL)
    ;
  CREATE TABLE CARDEAL.WORKORDER
      (ORDERNUM            SMALLINT  NOT NULL,
       CUSTNUM             SMALLINT  NOT NULL,
       SERIALNUM           INTEGER   NOT NULL,
       COST                INTEGER   NOT NULL,
       ORDERDATE           CHAR(08)  NOT NULL,
       STATUS              SMALLINT  NOT NULL)
    ;
  CREATE TABLE CARDEAL.SERVPART
      (ITEMNUM             SMALLINT  NOT NULL,
       PARTNUM             SMALLINT  NOT NULL,
       QUANTITY            SMALLINT  NOT NULL)
    ;
  CREATE TABLE CARDEAL.WORKSERV
      (ORDERNUM            SMALLINT  NOT NULL,
       ITEMNUM             SMALLINT  NOT NULL)
    ;
```

Figure 187 (Part 1 of 2). Create Tables DDL for DB2/2 Version 2 (INSTALL\CREATETB.DDL)

```
CREATE REGULAR TABLESPACE VEHICLESPACE
     MANAGED BY DATABASE
     USING ( FILE 'vehiclea' 300)
  ;
CREATE LONG TABLESPACE VEHICLESLOB
     MANAGED BY DATABASE
     USING ( FILE 'vehicleb' 2000)
  ;
CREATE TABLE CARDEAL.VEHICLE
    (SERIALNUM           INTEGER   NOT NULL,
     CUSTNUM             SMALLINT  NOT NULL,
     MAKE                CHAR(12)  NOT NULL,
     MODEL               CHAR(10)  NOT NULL,
     YEAR                SMALLINT  NOT NULL,
     PICTURES            BLOB(4M)  NOT LOGGED )
  IN VEHICLESPACE  LONG IN VEHICLESLOB
  ;
CONNECT RESET;
```

Figure 187 (Part 2 of 2). Create Tables DDL for DB2/2 Version 2 (INSTALL\CREATETB.DDL)

Create Indexes DDL

```
/*-----------------------------------------------------------------------*/
/* Install\createix.ddl  CarDealer - Create indexes          ITSO-SJC */
/*-----------------------------------------------------------------------*/

  CONNECT TO DEALERDB;

  CREATE UNIQUE INDEX CUSTOMER_IX
    ON CARDEAL.CUSTOMER (CUSTNUM)
    ;
  CREATE UNIQUE INDEX VEHICLE_IX
    ON CARDEAL.VEHICLE (SERIALNUM)
    ;
  CREATE UNIQUE INDEX PART_IX
    ON CARDEAL.PART (PARTNUM)
    ;
  CREATE UNIQUE INDEX SERVICE_IX
    ON CARDEAL.SERVICE (ITEMNUM)
    ;
  CREATE UNIQUE INDEX WORKORDER_IX
    ON CARDEAL.WORKORDER (ORDERNUM)
    ;
  CREATE UNIQUE INDEX SERVPART_IX
    ON CARDEAL.SERVPART (ITEMNUM, PARTNUM)
    ;
  CREATE UNIQUE INDEX WORKSERV_IX
    ON CARDEAL.WORKSERV (ORDERNUM, ITEMNUM)
    ;
  CONNECT RESET;
```

Figure 188. Create Indexes DDL (INSTALL\CREATEIX.DDL)

Recreate Tables DDL for DB2/2 Version 2

```
/*-------------------------------------------------------------------*/
/* Install\createtv.ddl  CarDealer - Re-create vehicle table ITSO-SJC */
/*                       (for DB2/2 version 2, with multi-media)     */
/*-------------------------------------------------------------------*/

  CONNECT TO DEALERDB;

  DROP   TABLE CARDEAL.VEHICLE;
  DROP   TABLESPACE VEHICLESPACE;
  DROP   TABLESPACE VEHICLESLOB;

  CREATE REGULAR TABLESPACE VEHICLESPACE
       MANAGED BY DATABASE
       USING ( FILE 'vehiclea' 300)
    ;

  CREATE LONG TABLESPACE VEHICLESLOB
       MANAGED BY DATABASE
       USING ( FILE 'vehicleb' 2000)
    ;

  CREATE TABLE CARDEAL.VEHICLE
      (SERIALNUM           INTEGER   NOT NULL,
       CUSTNUM             SMALLINT  NOT NULL,
       MAKE                CHAR(12)  NOT NULL,
       MODEL               CHAR(10)  NOT NULL,
       YEAR                SMALLINT  NOT NULL,
       PICTURES            BLOB(4M)  NOT LOGGED )
    IN VEHICLESPACE  LONG IN VEHICLESLOB
    ;

  CREATE UNIQUE INDEX VEHICLE_IX
    ON CARDEAL.VEHICLE (SERIALNUM);

  CONNECT RESET;
```

Figure 189. Recreate Tables DDL for DB2/2 Version 2 (INSTALL\CREATETV.DDL)

Drop Database DDL

```
/*-------------------------------------------------------------------*/
/* Install\dropdb.ddl    CarDealer - Drop DEALERDB           ITSO-SJC */
/*-------------------------------------------------------------------*/

  DROP DATABASE DEALERDB;
```

Figure 190. Drop Database DDL (INSTALL\DROPDB.DDL)

Drop Tables DDL for DB2/2 Version 1

```
/*-------------------------------------------------------------------*/
/* Install\dropt1.ddl    CarDealer - Dropt tables           ITSO-SJC */
/*                       (for DB2/2 version 1, no multi-media)       */
/*-------------------------------------------------------------------*/

  CONNECT TO DEALERDB;

  DROP   TABLE CARDEAL.CUSTOMER;
  DROP   TABLE CARDEAL.PART;
  DROP   TABLE CARDEAL.SERVICE;
  DROP   TABLE CARDEAL.WORKORDER;
  DROP   TABLE CARDEAL.WORKSERV;
  DROP   TABLE CARDEAL.SERVPART;
  DROP   TABLE CARDEAL.VEHICLE;

  CONNECT RESET;
```

Figure 191. Drop Tables DDL for DB2/2 Version 1 (INSTALL\DROPT1.DDL)

Drop Tables DDL for DB2/2 Version 2

```
/*-------------------------------------------------------------------*/
/* Install\droptb.ddl    CarDealer - Drop tables            ITSO-SJC */
/*                       (for DB2/2 version 2, with multi-media)     */
/*-------------------------------------------------------------------*/

  CONNECT TO DEALERDB;

  DROP   TABLE CARDEAL.CUSTOMER;
  DROP   TABLE CARDEAL.PART;
  DROP   TABLE CARDEAL.SERVICE;
  DROP   TABLE CARDEAL.WORKORDER;
  DROP   TABLE CARDEAL.WORKSERV;
  DROP   TABLE CARDEAL.SERVPART;
  DROP   TABLE CARDEAL.VEHICLE;

  DROP   TABLESPACE VEHICLESPACE;
  DROP   TABLESPACE VEHICLESLOB;

  CONNECT RESET;
```

Figure 192. Drop Tables DDL for DB2/2 Version 2 (INSTALL\DROPTB.DDL)

Command File to Set Up DB2 Tables

```
/*-------------------------------------------------------------------*/
/* Install\db2setup.cmd  CarDealer - Setup/load DB2 data     ITSO-SJC */
/*-------------------------------------------------------------------*/
```

Figure 193 (Part 1 of 2). Command File to Set Up DB2 Tables (INSTALL\DB2SETUP.CMD)

```
arg newrep version                                  /* parameters       */

if newrep \= '' & version = ''  then version = 'V2'

newrep = left(strip(newrep),3)                      /*  new/replace/load*/
if newrep \= 'NEW' & newrep \= 'REP' & newrep \= 'LOA' then
   do until newrep = 'NEW' | newrep = 'REP' | newrep = 'LOA'
      say 'Enter NEW for new installation, REP for table redefine'
      say 'enter LOAD for table reload, EXIT to stop'
      pull newrep
      newrep = left(strip(newrep),3)
      if newrep = 'EXI' then exit
   end

version = left(strip(version),2)                    /* version 1 or 2   */
if version \= 'V2' & version \= 'V1' then
   do until version = 'V2' | version = 'V1'
      say 'Enter DB2/2 version as V2 or V1, or EXIT to stop'
      pull version
      version = left(strip(version),2)
      if version = 'EX' then exit
   end

curdir = directory()                                /* save current dir */
parse source . . me .
mydir = me~left(me~lastpos('\')-1)
mydir = directory(mydir)

runsql  = mydir'\runsql.cmd'                        /* called programs  */
loaddb2 = mydir'\load-db2.cmd'
loadmm  = mydir'\load-mm.cmd'

/*------ define tables and indexes -----------------------------------*/

if newrep = 'NEW' then
   call (runsql) mydir'\createdb.ddl (' version

if newrep = 'REP' then
   if version = 'V1' then call (runsql) mydir'\dropt1.ddl ( V1'
                     else call (runsql) mydir'\droptb.ddl'

if newrep \= 'LOA' then do
   if version = 'V1' then call (runsql) mydir'\createt1.ddl ( V1'
                     else call (runsql) mydir'\createtb.ddl'
   call (runsql) mydir'\createix.ddl (' version
end

/*------ load data into tables ---------------------------------------*/

call (loaddb2)

if version = 'V2' then call (loadmm)

/*------ reset directory ------*/

curdir = directory(curdir)
```

Figure 193 (Part 2 of 2). Command File to Set Up DB2 Tables (INSTALL\DB2SETUP.CMD)

Command File to Load DB2 Tables

```
/*--------------------------------------------------------------------*/
/* Install\load-db2.cmd  CarDealer - Load DB2 tables         ITSO-SJC */
/*                       (data used from \SampData)                   */
/*--------------------------------------------------------------------*/

  curdir = directory()
  parse source . . me .
  mydir = me~left(me~lastpos('\')-1)
  mydir = directory(mydir)                          /* my directory     */
  datadir = '..\SampData'                           /* locate samp-data */

  call '..\rxfctsql'                                /* Rexx DB2 funct.  */
  call sqlexec "CONNECT RESET"
  call sqlexec "CONNECT TO DEALERDB"                /* connect to DB    */

  call sql "DELETE FROM CARDEAL.CUSTOMER"           /* delete existing  */
  call sql "DELETE FROM CARDEAL.VEHICLE"
  call sql "DELETE FROM CARDEAL.PART"
  call sql "DELETE FROM CARDEAL.SERVICE"
  call sql "DELETE FROM CARDEAL.WORKORDER"
  call sql "DELETE FROM CARDEAL.SERVPART"
  call sql "DELETE FROM CARDEAL.WORKSERV"

  call sql "COMMIT"                                 /* commit deletes   */

  say 'Loading customer...'                         /* load customers   */
  file = datadir'\customer.dat'
  call stream file, 'c', 'open read'
  do i = 0 by 1 while lines(file)
     parse value linein(file) with customerNumber '9'x name '9'x address
     if left(customerNumber,2) = '/*' then iterate
     call sql "INSERT INTO CARDEAL.CUSTOMER" ,
              "values ("strip(customerNumber)", '"strip(name)"'," ,
                       "'"strip(address)"')"
  end
  call stream file, 'c', 'close'

  say 'Loading vehicles...'                         /* load vehicles    */
  file = datadir'\vehicle.dat'
  call stream file, 'c', 'open read'
  do i = 0 by 1 while lines(file)
     parse value linein(file) ,
           with serialNumber '9'X make '9'X model '9'X year '9'X owner
     if left(serialNumber,2) = '/*' then iterate
     call sql "INSERT INTO CARDEAL.VEHICLE (SERIALNUM, CUSTNUM, MAKE, MODEL, YEAR)" ,
              "values ("serialNumber"," strip(owner)", '"strip(make)"'","  ,
                       "'"strip(model)"'," strip(year)")"
  end
  call stream file, 'c', 'close'

  say 'Loading parts...'                            /* load parts       */
  file = datadir'\part.dat'
  call stream file, 'c', 'open read'
  do i = 0 by 1 while lines(file)
     parse value linein(file) with ,
           partid '9'x description '9'x price '9'x stock
     if left(partid,2) = '/*' then iterate
     call sql "INSERT INTO CARDEAL.PART" ,
              "values ("strip(partid)"," strip(price)"," ,
                       strip(stock)", '"strip(description)"')"
```

Figure 194 (Part 1 of 2). Command File to Load DB2 Tables (INSTALL\LOAD-DB2.CMD)

```
  end
  call stream file, 'c', 'close'

  say 'Loading services...'                      /* load service item*/
  file = datadir'\service.dat'
  call stream file, 'c', 'open read'
  do i = 0 by 1 while lines(file)
     parse value linein(file) with ,
           itemNumber '9'x description '9'x laborCost '9'x parts
     if left(itemNumber,2) = '/*' then iterate
     call sql "INSERT INTO CARDEAL.SERVICE" ,
              "values("strip(itemNumber)"," strip(laborCost)"," ,
                       "'"strip(description)"')"

     do while parts \= ''  /* add parts to the service items */
        parse var parts partnum '9'x quant '9'x parts
        call sql "INSERT INTO CARDEAL.SERVPART" ,
                 "values("strip(itemNumber)"," strip(partnum)"," ,
                          strip(quant)")"
     end
  end
  call stream file, 'c', 'close'

  say 'Loading workorders...'                    /* load work orders */
  file = datadir'\workord.dat'
  call stream file, 'c', 'open read'
  do i = 0 by 1 while lines(file)
     parse value linein(file) with orderno '9'x date '9'x cost ,
                  '9'x status '9'x owner '9'x car '9'x items
     if left(orderno,2) = '/*' then iterate
     call sql "INSERT INTO CARDEAL.WORKORDER" ,
              "values ("strip(orderno)"," strip(owner)"," ,
                       strip(car)"," strip(cost)"," ,
                       "'"strip(date)"'," strip(status)")"

     do while items \= ''    /* add service items to the works order */
        parse var items itemx '9'x items
        call sql "INSERT INTO CARDEAL.WORKSERV" ,
                 "values("strip(orderno)"," strip(itemx)")"
     end
  end
  call stream file, 'c', 'close'

  call sql "COMMIT"                              /* COMMIT everything*/
  call sqlexec "CONNECT RESET"                   /* disconnect DB    */
  curdir = directory(curdir)

  say 'For DB2 Version 2 - run Multimedia load next (load-mm.cmd)'
  say

return

/*------ execute an SQL statement ------*/
SQL:
   parse arg stmt
   call sqlexec 'EXECUTE IMMEDIATE :stmt'
   say 'Execute:' sqlca.sqlcode ':' stmt
   if sqlca.sqlcode \=0 & sqlca.sqlcode \= 100 then exit
   return
```

Figure 194 (Part 2 of 2). Command File to Load DB2 Tables (INSTALL\LOAD-DB2.CMD)

Command File to Load Multimedia Data

```
/*--------------------------------------------------------------------*/
/* Install\load-mm.cmd   CarDealer - Load multi-media data   ITSO-SJC */
/*                       (update vehicle table BLOB)                  */
/*--------------------------------------------------------------------*/

  arg test              /* halt after every BLOB update if non-blank */

  curdir = directory()
  parse source . . me .
  mydir = me~left(me~lastpos('\')-1)
  mydir = directory(mydir)                        /* my directory     */
  mediadir = '..\media'                           /* locate media file*/

  call '..\rxfctsql'                              /* Rexx DB2 funct.  */
  call sqlexec "CONNECT RESET"
  call sqlexec "CONNECT TO DEALERDB"              /* connect to DB    */

  call sqlexec 'CLEAR SQL VARIABLE DECLARATIONS'

/*------ read MEDIA.DAT file ---------------------------------------*/

  inpfile = mediadir'\media.dat'
  if stream(inpfile,'c','query size') = 0 then do
     say 'Error in multi-media load...'
     say 'File not found:' inpfile
     say 'Check that \MEDIA subdirectory exists'
     return 16
  end

  oldserial = ''                                  /* init serial numb */
  numpic = 0
  do j=1 by 1 while lines(inpfile)>0              /* read media file  */
     line = linein(inpfile)
     if left(line,2) = '/*' then iterate
     parse var line serial ',' title ',' file     /* parse a line     */
     serial = strip(serial)
     title  = strip(title)
     file   = strip(file)
     if serial \= oldserial then do               /* serial changes   */
        if numpic > 0 then call updvehi           /* --> update vehi  */
        numpic = 0
        oldserial = serial
        pictitle. = ''
        picfile. = ''
     end
     numpic = numpic + 1                          /* count pictures   */
     pictitle.numpic = title                      /* save titles      */
     picfile.numpic = mediadir'\'file             /* and file name    */
  end

  call sqlexec 'COMMIT'                           /* done - COMMIT    */
  call sqlexec 'CLEAR SQL VARIABLE DECLARATIONS'
  x = stream(inpfile,'c','close')

  call sqlexec "CONNECT RESET"                    /* disconnect       */
  curdir = directory(curdir)
  return

/*------ update vehicle row with multi-media data --------------------*/
```

Figure 195 (Part 1 of 2). Command File to Load Multimedia Data (INSTALL\LOAD-MM.CMD)

```
UPDVEHI:

  ctlinfo = right(numpic,3)':'                    /* init controlinfo */
  bloblength = 4 + 30 * numpic + 2
  say
  say 'Updating serial' oldserial
  updatestmt = 'update cardeal.vehicle' ,
               '   set pictures = CAST(? AS BLOB(1K))'
  hvar = ':ctlinfo'                               /* prepare hostvar  */

  do i=1 to numpic                                /* run over pictures*/
     call sqlexec 'DECLARE :vpic'i 'LANGUAGE TYPE BLOB FILE'
     piclength  = stream(picfile.i,'c','query size')
     bloblength = bloblength + piclength
     say ' -' left(pictitle.i,20) 'length' right(piclength,6) 'in' picfile.i
     ctlinfo = ctlinfo''left(pictitle.i,20)','right(piclength,8)';'
     updatestmt = updatestmt '||  CAST(? AS BLOB(4M))'
     call value 'vpic'i'.name', picfile.i
     call value 'vpic'i'.file_options', 'READ'
     hvar = hvar', :vpic'i
  end
                                                  /* finish ctl-info  */
  ctlinfo = "BIN'"ctlinfo"@@'"
  say 'Ctlinfo='ctlinfo
  say 'BLOB length='bloblength

  updatestmt = updatestmt 'where serialnum =' oldserial
  say 'SQL='updatestmt
  say 'VAR='hvar
  call sqlexec 'prepare s1 from :updatestmt'      /* run the SQL upd. */
  say 'prepare='sqlca.sqlcode sqlmsg
  call sqlexec 'execute s1 using' hvar
  say 'execute='sqlca.sqlcode sqlmsg
  call sqlexec 'CLEAR SQL VARIABLE DECLARATIONS'

  if test \= '' then do                           /* wait of test     */
     say '...press enter to continue...'
     pull ans
  end

  return
```

Figure 195 (Part 2 of 2). Command File to Load Multimedia Data (INSTALL\LOAD-MM.CMD)

Command File to Run SQL DDL Statements

```
/*--------------------------------------------------------------------*/
/* Install\runsql.cmd    CarDealer - Run SQL stmts from file ITSO-SJC */
/*                       (read file, submit to DB2)                   */
/*--------------------------------------------------------------------*/

   arg file '(' version                    /* input file             */
                                           /* DB2/2 version          */
   stat = STREAM(file,'C','open read')     /* open file              */
   if left(stat,5) <> 'READY' then
      call error 'Cannot open SQL file: ' file
   stmt = ''                               /* init SQL statement     */
   complete = 0
```

Figure 196 (Part 1 of 2). Command File to Run SQL DDL Statements (INSTALL\RUNSQL.CMD)

```
    do while lines(file)>0
         line = linein(file)
         line = strip(line,'T')
         if left(line,2)='--' then iterate   /* ignore comments        */
         if left(line,2)='/*' then iterate   /* ignore comments        */
         lg = length(line)
         if lg>0 then                        /* check for ;            */
            if substr(line,lg,1) = ';' then do
               complete = 1
               line = left(line,lg-1)
            end
         if stmt='' then stmt = left(line,72)' '
                    else stmt = stmt''left(line,72)' '
         if complete then do                 /* submit complete stmt   */
            say
            say 'Executing:'                 /* display statement      */
            do i=1 by 73 to length(stmt)
               say '    ' substr(stmt,i,73)
            end
            stmt = space(stmt)               /* remove extra blanks    */
            if version = 'V1' then
               "@CALL DBM" stmt              /* call DBM processor V1  */
            else
               "@DB2 +O" stmt                /* call DB2 processor V2  */
            say 'DBM return code' rc
            stmt = ''
            complete = 0
         end
    end /* do */
    stat = STREAM(file,'C','close')          /* close input file       */
    return

error:                                       /* error messages         */
    parse arg msg
    say 'RUNSQL ERROR:' msg
    exit 8
```

Figure 196 (Part 2 of 2). Command File to Run SQL DDL Statements (INSTALL\RUNSQL.CMD)

Command File to Submit DDL Statement from GUI Installation

```
/*-------------------------------------------------------------------*/
/* db2xmit.cmd          CarDealer - Submit a DDL statement  ITSO-SJC */
/*                      (Used by installation program only)          */
/*-------------------------------------------------------------------*/

parse arg statement ';' version          /* called from Dr Dialog GUI */
version = strip(version)

if left(statement,8) = 'CONNECT ' then return 0

call db2submit "CONNECT TO DEALERDB"     /* connect to db first       */
call db2submit statement                 /* submit real statement     */
retcode = result                         /* save return code          */
call db2submit "CONNECT RESET"           /* disconnect database       */
return retcode
```

Figure 197 (Part 1 of 2). Command File to Submit DDL Statement from GUI Installation (INSTALL\DB2XMIT.CMD)

```
db2submit:                              /* submit to DB2 or DBM      */
   use arg stmt
   if version = 'V1' then "CALL DBM -o -r" stmt
                     else "DB2 +o -w -ldbm.rpt" stmt
   if RC > 32000 then RC = RC - 65536    /* DBM V1 returns funny      */
   return RC
```

Figure 197 (Part 2 of 2). Command File to Submit DDL Statement from GUI Installation (INSTALL\DB2XMIT.CMD)

Running the Car Dealer Programs

Command to Run the Car Dealer

```
/*--------------------------------------------------------------------*/
/* car-run.cmd           CarDealer - Run Car Dealer          ITSO-SJC */
/*                       (AUI or GUI, File or DB2, optional SOM)      */
/*--------------------------------------------------------------------*/

parse source . . me .
sourcedir = me~left(me~lastpos('\')-1)
curdir = directory()         /* save current directory         */
new = directory(sourcedir)   /* make CARDEAL current directory */

arg p1 p2 p3 '(' quiet
if left(strip(quiet),1) = 'Q' then talk = 0
else talk = 1

if p1 = '' | p1 = '?' then do
   say 'Syntax: CAR-RUN  [F | D | R]  ' ,
       '[O | S]  ' ,
       '[A | G | P | X]'
   say '   first  parm:  F = File, D = DB2/2, R = RAM (memory) only'
   say '   second parm:  O = OREXX Part class(default), S = SOM Part class'
   say '   third  parm:  A = Ascii window, G = DrRexx, P = VisProRexx, X = Vx-Rexx'
   say '   parameters :  in any sequence, blank separated'
   say '                 setup F|D|M is saved, O|S is saved'
   return
end

opt = left(strip(p1),1)''left(strip(p2),1)''left(strip(p3),1)

/* setup data storage */

select
   when pos('F',opt)>0 then do; "@copy FAT\carmodel.cfg    >null"
                                if talk then say 'Setup for FAT data'; end
   when pos('D',opt)>0 then do; "@copy DB2\carmodel.cfg    >null"
                                if talk then say 'Setup for DB2 data'; end
   when pos('R',opt)>0 then do; "@copy RAM\carmodel.cfg    >null"
                                if talk then say 'Setup for Memory data'; end
   otherwise nop
end
```

Figure 198 (Part 1 of 2). Command to Run the Car Dealer (\CAR-RUN.CMD)

```
/* setup if SOM is used or not */

select
   when pos('O',opt)>0 then do; "@copy Base\part.ori Base\carpart.cls >null"
                                if talk then say 'Setup for ORexx part class'; end
   when pos('S',opt)>0 then do; "@copy Base\part.som Base\carpart.cls >null"
                                if talk then say 'Setup for SOM part class'; end
   otherwise nop
end

/* Run program in AUI or GUI mode */

select
   when pos('A',opt)>0 then     call "AUI\car-aui"
   when pos('G',opt)>0 then     "DrDialCD\car-gui.exe"
   when pos('P',opt)>0 then     "VisProCD\car-gui.exe"
   when pos('X',opt)>0 then     "VxRexxCD\car-gui.exe"
   otherwise
      if talk then say 'You can now run any Car Dealer application (ASCII or GUI)'
end

curdir = directory(curdir)   /* restore current directory      */
return
```

Figure 198 (Part 2 of 2). Command to Run the Car Dealer (\CAR-RUN.CMD)

Command to Run the Car Dealer in ASCII

```
/*--------------------------------------------------------------------*/
/* AUI\car-aui.cmd       CarDealer - Run CarDealer Appl.     ITSO-SJC */
/*                       (ASCII OS/2 window, file or DB2)             */
/*--------------------------------------------------------------------*/

  say 'Data type is   :' .local['Cardeal.Data.type']
  say 'Data directory :' .local['Cardeal.Data.dir']
  say 'Media directory:' .local['Cardeal.Media.dir']
  say 'SOM Part class :' .local['Cardeal.Part.som']

  say 'Initializing the application, load objects in memory...'

  .Cardeal~initialize                           /* initialize application  */

  say 'Loaded' .Customer~extent~items    'customers'
  say 'Loaded' .Part~extent~items        'parts'
  say 'Loaded' .ServiceItem~extent~items 'service items'
  say 'Loaded' .WorkOrder~extent~items   'work orders'

  aui = .AUI~new                                /* make an AUI object      */

  menus=.array~new                              /* allocate menu structure */
  menus[1] = .Menu~initialize                   /* - and read menu data    */

  say 'Application is ready, press enter to start...'
  pull ans

  level = 1                                     /* run over the menus      */
  do until level < 1                            /* - until exit from main  */
     action = menus[level]~showMenu
```

Figure 199 (Part 1 of 6). Command to Run the Car Dealer in ASCII (AUI\CAR-AUI.CMD)

```
      select                                    /* - check the selection   */
         when action = .nil then level = level - 1 /* - action is a menu      */
         when action~class = .Menu then do      /* - next menu down        */
                 level = level +1
                 menus[level] = action
              end
         otherwise interpret action             /* - action is a function  */
      end
   end

   .Cardeal~terminate                           /* terminate nicely        */

   say
   say 'Good-bye....'                           /* - and end               */
   exit


/*------------------------------------------------------------------- */
/*------------------------------------------------------------------- */
FINDCUST:                                       /* ask user for customer   */
   arg custname
   if custname = '' then
      custname = aui~UserInput('Enter customer name or number')
   if datatype(custname) = 'NUM' then           /* - is it a number        */
      custx = .Customer~findNumber(custname)
   else do                                      /* - or a name             */
      custarray = .Customer~findName(custname)  /*   find bu name          */
      icust = 0
      if custarray~items > 1 then do
         do custn over custarray                /* - display matching cust.*/
            icust = icust + 1
            aui~LineOut(icust~right(2)':' custn)
         end
         icusti = aui~UserInput('Enter index number 1 to' icust)
         if icusti > 0 & icusti <= icust then
            custn = custarray[icusti]
         else do
            aui~Error('Index number wrong')
            return .nil
         end
         end
      else
         if custarray~items = 1 then custn = custarray[1]
         else custn = .nil
      if custn \= .nil then do
         parse var custn custnum '-' custn '-' custa
         custx = .Customer~findNumber(custnum)
         end
      else custx = .nil
   end
   if custx = .nil then do
      aui~Error('Customer' custname 'not found')
      return .nil
      end
   else return custx

/*------------------------------------------------------------------- */
NEWCUST:                                        /* new customer            */
   custnum  = aui~UserInput('Enter customer number','N')
   if custnum \= '' then do
      custname = aui~UserInput('Enter name')
      custaddr = aui~UserInput('Enter address')
      custx = .Customer~new(custnum, custname, custaddr, 'P')
      aui~LineOut('' custx)
```

Figure 199 (Part 2 of 6). Command to Run the Car Dealer in ASCII (AUI\CAR-AUI.CMD)

```
      if custx~number=0 then
           aui~AckMessage('Customer number invalid (100-999):' custnum)
      else aui~AckMessage('Customer created')
   end
   return

/*-------------------------------------------------------------------- */
DELCUST:                                          /* delete a customer       */
   custx = findcust()
   if custx \= .nil then do
      custname = custx~name
      custx~delete
      aui~AckMessage('Customer' custname 'deleted')
   end
   return

/*-------------------------------------------------------------------- */
NEWCAR:                                           /* add car to cstomer      */
   custx = findcust()
   if custx \= .nil then do
      aui~LineOut(''custx':')
      serial = aui~UserInput('Enter car serial number','N')
      if serial = '' then return
      make   = aui~UserInput('Enter make')
      model  = aui~UserInput('Enter model')
      year   = aui~UserInput('Enter year')
      if year = '' then return
      carx = .Vehicle~new(serial, make, model, year, custx, 'P')
      aui~AckMessage(''carx 'has been added')
   end
   return

/*-------------------------------------------------------------------- */
DELCAR:                                           /* delete car from customer*/
   custx = findcust()
   carx = .nil
   if custx \= .nil then do
      cars = custx~getVehicles
      if cars~items = 0 then aui~Error(''custx 'has no cars')
      else do
           aui~LineOut(''custx':')
           if cars~items = 1 then
              carx = cars[1]
           else do
              icar = 0
              do cary over cars
                 icar = icar + 1
                 aui~LineOut(icar':' cary)
              end
              icarx = aui~UserInput('Enter index number 1 to' icar)
              if icarx > 0 & icarx <= icar then carx = cars[icarx]
              else aui~Error('Index number wrong')
           end
      end
      if carx \= .nil then do
              carname = carx~makestring
              custx~removeVehicle(carx)
              carx~delete
              aui~AckMessage('Car has been removed:' carname)
      end
   end
   return

/*-------------------------------------------------------------------- */
```

Figure 199 (Part 3 of 6). Command to Run the Car Dealer in ASCII (AUI\CAR-AUI.CMD)

```
ADDSTOCK:                                       /* increase stock of part  */
   partnum = aui~UserInput('Enter part number','N')
   partx = .Part~findNumber(partnum)
   if partx = .nil then
      aui~Error('Part' partnum 'not found')
   else do
      aui~LineOut('Part:' partx~description ' stock:' partx~stock)
      quant = aui~UserInput('Increase stock by how much','N')
      if quant \= '' then do
         partx~increaseStock(quant)
         aui~AckMessage('Stock increased')
      end
   end
   return

/*------------------------------------------------------------------- */
FINDWORK:                                       /* ask user for work order */
   arg statust
   if statust = 'COMPLETE' then status = 1
   else if statust = 'INCOMPLETE' then status = 0
   else status = 2
   call ListWorkOrder status
   worknum = aui~UserInput('Enter a work order number','N')
   if worknum = '' then workx = .nil
   else do
      workx = .WorkOrder~findNumber(worknum)
      if workx = .nil then aui~Error('WorkOrder' worknum 'not found')
      else if status \= 2 then
         if workx~getstatus \= status then do
            aui~Error('Select a' statust 'WorkOrder')
            workx = .nil
         end
   end
   return workx

/*------------------------------------------------------------------- */
NEWWORK:                                        /* create new work order   */
   custx = findcust()
   carx = .nil
   if custx \= .nil then do
      aui~LineOut(''custx':')
      cars = custx~getVehicles
      if cars~items = 0 then do
         aui~Error('Cannot create work order for customer without car')
         return
      end
      if cars~items = 1 then
         carx = cars[1]
      else do
              icar = 0
              do cary over cars
                 icar = icar + 1
                 aui~LineOut(icar "" cary)
              end
              icarx = aui~UserInput('Enter index number 1 to' icar)
              if icarx > 0 & icarx <= icar then carx = cars[icarx]
              else aui~Error('Car number wrong')
           end
      if carx \= .nil then do
         aui~LineOut(''carx':')
         workx = .WorkOrder~new(date('U'), custx, carx)
         aui~AckMessage('Created:' workx)
      end
   end
```

Figure 199 (Part 4 of 6). Command to Run the Car Dealer in ASCII (AUI\CAR-AUI.CMD)

```
   return

/*-------------------------------------------------------------------- */
DELWORK:                                          /* delete a work order     */
   workx = findwork('all')
   if workx \= .nil then do
      aui~LineOut('Deleting' workx)
      workx~delete
      aui~AckMessage('Work order deleted')
   end
   return

/*-------------------------------------------------------------------- */
NEWSERV:                                          /* add service to workorder*/
   workx = findwork('incomplete')
   if workx \= .nil then do
      do until servnum = ''
         aui~LineOut('' workx)
         servnum = aui~UserInput('Enter a service item number','N')
         if servnum = 0  then return
         if servnum = ''  then servx = .nil
         else do
            servx = .ServiceItem~findNumber(servnum)
            if servx = .nil then
               aui~Error('ServiceItem' servnum 'not found')
            else do
               workx~addServiceItem(servx, 'P')
               aui~AckMessage('Added' servx)
            end
            aui~LineOut('Enter 0 to return, or...')
         end
      end
   end
   return

/*-------------------------------------------------------------------- */
COMPWORK:                                         /* complete a wrok order   */
   workx = findwork('incomplete')
   if workx \= .nil then do
      aui~LineOut('Checking part stock...')
      if workx~checkAndDecreaseStock then do
         aui~LineOut('Total cost of work order:' workx~cost)
         aui~AckMessage('Work order completed')
         end
      else aui~Error('Not enough part-stock to complete work order')
   end
   return

/*-------------------------------------------------------------------- */
WORKBILL:                                         /* generate the bill       */
   workx = findwork('all')
   if workx \= .nil then do
      aui~LineOut('Generating the bill...')
      aui~ClearScreen
      do printline over workx~generateBill
         aui~LineOut(printline)
      end
      aui~AckMessage('Bill completed')
   end
   return

/*-------------------------------------------------------------------- */
CARMEDIA:                                         /* display multimedia info */
   custx = findcust(999)
```

Figure 199 (Part 5 of 6). Command to Run the Car Dealer in ASCII (AUI\CAR-AUI.CMD)

```
   carx = .nil
   if custx \= .nil then do
      cars = custx~getVehicles
      if cars~items = 0 then aui~Error('There are no used cars')
      else do
              icar = 0
              do cary over cars
                 icar = icar + 1
                 aui~LineOut(icar':' cary)
              end
              icarx = aui~UserInput('Enter index number 1 to' icar)
              if icarx > 0 & icarx <= icar then carx = cars[icarx]
              else aui~Error('Index number wrong')
      end
      if carx \= .nil then do
         carname = carx~makestring
         aui~ClearScreen
         aui~LineOut('Media for car' carname)
         aui~LineOut('-'~copies(78))
         medianum = carx~getmedianumber
         if medianum = 0 then aui~AckMessage('There is no media info')
         else do
            aui~LineOut('There are' medianum 'media info')
            do i=1 to medianum
               media = carx~getmediainfo(i)
               parse var media title '::' mediafile
               aui~LineOut(i':' title)
               select
                  when title=''           then aui~LineOut('Empty...')
                  when title='Fact-sheet' then aui~LineOut(mediafile)
                  when title='Audio'      then
                            .Cardeal~playaudio(mediafile)
                  when title='Video'      then
                            "start mppm.exe" mediafile "/SC"
                  otherwise
                            call bitmapdisplay mediafile
               end
              aui~Enterkey
            end
            aui~AckMessage('Car media info has been shown')
         end
      end
   end
   return

/*-------------------------------------------------------------------- */
BITMAPDISPLAY:                                  /* display a bitmap */
   arg bitmapfile
   aui~LineOut('Displaying picture in folder, make it bigger if desired')
   /* "ICONEDIT" bitmapfile */                  /* not very nice    */
   call SysCreateObject "WPFolder", "Car Dealer Picture Display", ,
          "<WP_DESKTOP>", "OBJECTID=<CARDEAL_BITMAP>;" ||,
                          "BACKGROUND="bitmapfile",NORMAL;", "U"
   call SysOpenObject "<CARDEAL_BITMAP>", "DEFAULT", "TRUE"
   return

/*-------------------------------------------------------------------- */
/*-------------------------------------------------------------------- */
                                                /* configuration          */
::requires 'carmodel.cfg'

::requires 'aui\caraui.cls'
::requires 'aui\carmenu.cls'
::requires 'aui\carlist.rtn'
```

Figure 199 (Part 6 of 6). Command to Run the Car Dealer in ASCII (AUI\CAR-AUI.CMD)

Appendix B. Definition for Syntax-Diagram Structure

Throughout this book, syntax is described using the structure defined below:

- Syntax diagrams are read from left to right, top to bottom, following the path of the line.

  The ▸▸— symbol indicates the beginning of a statement.

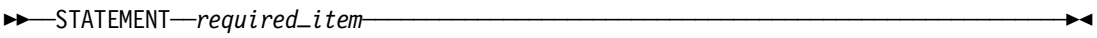
  The —▸ symbol indicates that the statement syntax is continued on the next line.

  The ▸— symbol indicates that a statement is continued from the previous line.

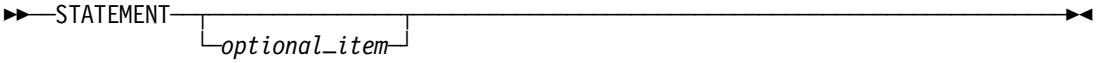
  The —▸◂ symbol indicates the end of a statement.

  Diagrams of syntactical units other than complete statements start with the ▸— symbol and end with the —▸ symbol.

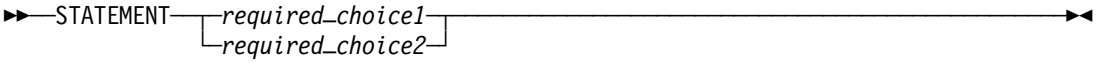
- Required items appear on the horizontal line (the main path).



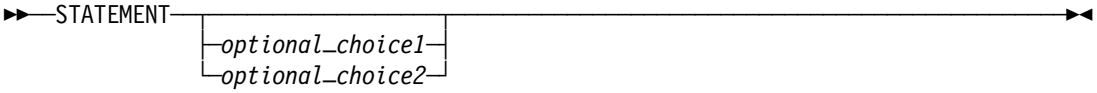
- Optional items appear below the main path.



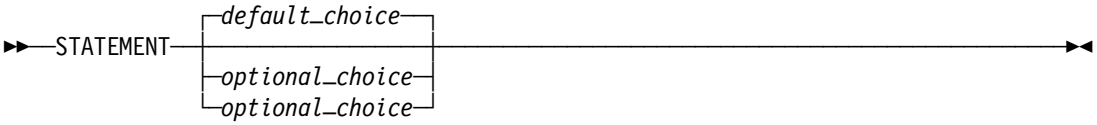
- Choices appear vertically, in a stack. If one item *must* be chosen, it will appear on the main path.



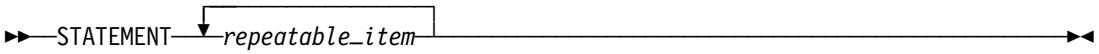
  If choosing one of the items is optional, the entire stack appears below the main path.



- If one of the items is the default, it appears above the main path, and the remaining choices are shown below it.



- An arrow returning to the left above the main line indicates an item that can be repeated.



A repeat arrow above a stack indicates that the items in the stack can be repeated.

- Keywords appear in uppercase (for example, `PARM1`). They must be spelled exactly as shown but can be entered in lowercase. Variables appear in all lowercase letters (for example, *parmx*). They represent user-supplied names or values.
- If punctuation marks, parentheses, arithmetic operators, or such symbols are shown, they must be entered as part of the syntax.

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Special Characters

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