                   Export of BGP Community Information in
                     IP Flow Information Export (IPFIX)

Abstract

   By introducing new Information Elements (IEs), this document extends
   the existing BGP-related IEs to enable IP Flow Information Export
   (IPFIX) to export BGP community information, including the BGP
   Standard Communities defined in RFC 1997, BGP Extended Communities
   defined in RFC 4360, and BGP Large Communities defined in RFC 8092.
   According to the network operator's BGP community planning, network
   traffic information can then be accumulated and analyzed at the BGP
   community granularity, which represents the traffic of different
   kinds of customers, services, or geographical regions. Network
   traffic information at the BGP community granularity is useful for
   network traffic analysis and engineering.

Status of This Memo

   This is an Internet Standards Track document.

   This document is a product of the Internet Engineering Task Force
   (IETF). It represents the consensus of the IETF community. It has
   received public review and has been approved for publication by the
   Internet Engineering Steering Group (IESG). Further information on
   Internet Standards is available in Section 2 of RFC 7841.

   Information about the current status of this document, any errata,
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1. Introduction

   IP Flow Information Export (IPFIX) [RFC7011] provides network
   administrators with traffic flow information using the Information
   Elements (IEs) defined in the "IPFIX Information Elements" registry
   [IANA-IPFIX]. Based on the traffic flow information, network
   administrators know the amount and direction of the traffic in their
   network and can then optimize the network when needed. For example,
   the collected information could be used for traffic monitoring and,
   optionally, for traffic optimization according to the operator's
   policy.

   The "IPFIX Information Elements" registry [IANA-IPFIX] defines the
   following IEs for traffic flow information export in different
   granularities: sourceIPv4Address, sourceIPv4Prefix,
   destinationIPv4Address, destinationIPv4Prefix, bgpSourceAsNumber,
   bgpDestinationAsNumber, bgpNextHopIPv4Address, etc. In some
   circumstances, however, traffic flow information based on these IEs
   may not be completely suitable or sufficient, especially when traffic
   engineering and optimization are executed in Tier 1 or Tier 2
   operators' backbone networks. For example, flow information based on
   IP address or IP prefix may provide much too fine granularity for a
   large network. On the contrary, flow information based on Autonomous
   System Number (ASN) may be too coarse.

   BGP community is a BGP path attribute that includes Standard
   Communities [RFC1997], Extended Communities [RFC4360], and Large
   Communities [RFC8092]. The BGP community attribute has a variety of
   use cases, one of which is to use BGP community with planned specific
   values to represent groups of customers, services, and geographical
   or topological regions, as used by operators in their networks.
   Detailed examples can be found in [RFC4384], [RFC8195], and Section 3
   of this document. To understand the traffic generated 1) by
   different kinds of customers, 2) from different geographical or
   topological regions, or 3) by different kinds of customers from
   different regions, we need the community information corresponding to
   the traffic flow information exported by IPFIX. Network traffic
   statistics at the BGP community granularity are useful not only for
   traffic analysis, but also for use by other applications, such as
   traffic optimization applications located in an IPFIX Collector,
   Software-Defined Networking (SDN) controller, or PCE. [COMMUNITY-TE]
   also states that analyzing network traffic information at the BGP
   community granularity is preferred for inbound traffic engineering.
   However, the "IPFIX Information Elements" registry [IANA-IPFIX]
   lacked IEs defined for the BGP community attribute.

Flow information based on the BGP community attribute may be
collected by an IPFIX Mediator (defined in [RFC6183]). The IPFIX
Mediator is responsible for the correlation between flow information
and the BGP community attribute. However, no IEs are defined in
[RFC6183] for exporting BGP community information in IPFIX.
Furthermore, to correlate the BGP community attribute with the flow
information, the IPFIX Mediator needs to learn BGP routes and perform
lookups in the BGP routing table to get the matching entry for a
specific flow. BGP route learning and routing table lookup are not
trivial for an IPFIX Mediator. The IPFIX Mediator is mainly
introduced to reduce the performance requirement for the Exporter
[RFC5982]. In fact, to obtain information for the already-defined
BGP-related IEs, such as bgpSourceAsNumber, bgpDestinationAsNumber,
and bgpNextHopIPv4Address, etc., the Exporter has to hold the up-to-
date BGP routing table and perform lookups in the table. The
Exporter can obtain the BGP community information in the same
procedure; thus, the additional load added by exporting BGP community
information is minimal if the Exporter is already exporting the
existing BGP-related IEs. It is RECOMMENDED that the BGP community
information be exported by the Exporter directly using IPFIX.

By running BGP [RFC4271] or the BGP Monitoring Protocol (BMP)
[RFC7854] and performing lookups in the BGP routing table to
correlate the matching entry for a specific flow, IPFIX Collectors
and other applications, such as an SDN controller or PCE, can
determine the network traffic at the BGP community granularity.
However, running BGP or BMP and performing routing table lookup are
not trivial for the IPFIX Collectors and other applications.
Moreover, correlation between IPFIX flow information and the BGP RIB
on the Exporter (such as a router) is more accurate compared to the
correlation on a Collector, since the BGP routing table may be
updated when the IPFIX Collectors and other applications receive the
IPFIX flow information. As stated above, the Exporter can obtain the
BGP community information during the same procedure when it obtains
other BGP-related information. Therefore, exporting the BGP
community information directly by the Exporter to the Collector is
both efficient and accurate. If the IPFIX Collectors and other
applications only want to determine the network traffic at the BGP
community granularity, they do not need to run the full BGP or BMP
protocols when the BGP community information can be obtained by
IPFIX. However, BMP has its own application scenario, and the
mechanism introduced in this document is not meant to replace it.

By introducing new IEs, this document extends the existing BGP-
related IEs to enable IPFIX [RFC7011] to export BGP community
information, including the BGP Standard Communities [RFC1997], BGP
Extended Communities [RFC4360], and BGP Large Communities [RFC8092].
Flow information (including packetDeltaCount [RFC7011] [RFC7012],

octetDeltaCount [RFC7011] [RFC7012], etc.) can then be accumulated
and analyzed by the Collector or other applications, such as an SDN
controller or PCE [RFC4655], at the BGP community granularity. This
is useful for measuring the traffic generated 1) by different kinds
of customers or 2) from different geographical or topological regions
according to the operator's BGP community plan. Flow information can
then be used by the traffic engineering or traffic optimization
applications, especially in the backbone network.

The IEs introduced in this document are applicable to both IPv4 and
IPv6 traffic. Both the Exporter and the IPFIX Mediator can use these
IEs to export BGP community information in IPFIX. When needed, the
IPFIX Mediator or Collector can use these IEs to report BGP
community-related traffic flow information it gets either from
Exporters or through local correlation to other IPFIX devices.

As stated above, the method introduced in this document is not the
sole, definitive one for obtaining BGP community information related
to a specific traffic flow, but it is possible, efficient, and
accurate.

No new BGP community attributes are defined in this document.

Note that this document does not update the IPFIX specification
[RFC7011] or information model [RFC7012]. Rather, the "IPFIX
Information Elements" registry [IANA-IPFIX] contains the current
complete reference for IPFIX Information Elements, per Section 1 of
[RFC7012].

Please refer to the "IPFIX Information Elements" registry
[IANA-IPFIX] for the complete list of BGP-related IEs.

Please refer to Appendix A of this document for the encoding example
and Section 3 for a detailed use case.

2. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
"SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and
"OPTIONAL" in this document are to be interpreted as described in
BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all
capitals, as shown here.

The IPFIX-specific terminology used in this document is defined in
Section 2 of [RFC7011] and Section 2 of [RFC6183].

This document uses the term "BGP Standard Community" to refer to the
BGP community attribute defined in [RFC1997] in order to distinguish
it from BGP Extended Community [RFC4360] and Large Community
[RFC8092].

3. Traffic Collection Based on BGP Community

[RFC4384] introduces the mechanism of using BGP Standard Community
and Extended Community to collect geographical and topological
information in the BGP routing system. [RFC8195] gives some examples
of the application of BGP Large Communities to represent the
geographical regions. Since the network traffic at the BGP community
granularity represents the traffic generated 1) by different kinds of
customers or 2) from different geographical regions according to the
network operator's BGP community plan, it is useful for network
operators to analyze and optimize the network traffic among different
customers and regions. This section gives a use case in which the
network operator uses traffic information based on BGP community to
adjust the network paths for different traffic flows.

Consider the following scenario. Autonomous System (AS) C provides a
transit connection between ASes A and B. By tagging different BGP
communities, the routes of AS A and B are categorized into several
groups in the operator's plan. For example, communities A:X and A:Y
are used for routes that originated from different geographical
regions in AS A, and communities B:M and B:N are used for routes
representing the different kinds of customers in AS B (e.g., B:M is
for mobile customers and B:N is for fixed line customers). By
default, all traffic originating from AS A and destined for AS B
(i.e., traffic A-B) goes through path C1-C2-C3 (i.e., Path-1) in AS
C. When the link between C1 and C2 is congested, we cannot simply
steer all the traffic A-B from Path-1 to Path C1-C4-C3 (i.e., Path-2)
because it will cause congestion in Path-2.

```
                        +----------+
                        │ PCE/SDN  │
              +---------│Controller│-------+
              │         +----------+       │
              │                            │
              │           AS C             │
       │      │        +----------+        │      │
       │      │    +---│Router C2 │---+     │      │
       │      │    │   +----------+   │     │      │
  AS A │      │    │100              50│    │      │ AS B
 +--------+   │  +---------+       +---------+   │  +--------+
 │Router A│-- │--│Router C1│       │Router C3│-- │--│Router B│
 +--------+   │  +---------+       +---------+   │  +--------+
 Community:   │    │100              100│        │  Community:
    A:X       │    │   +----------+   │          │     B:M
    A:Y       │    +---│Router C4 │---+          │     B:N
              │        +----------+              │
              │                                  │
```
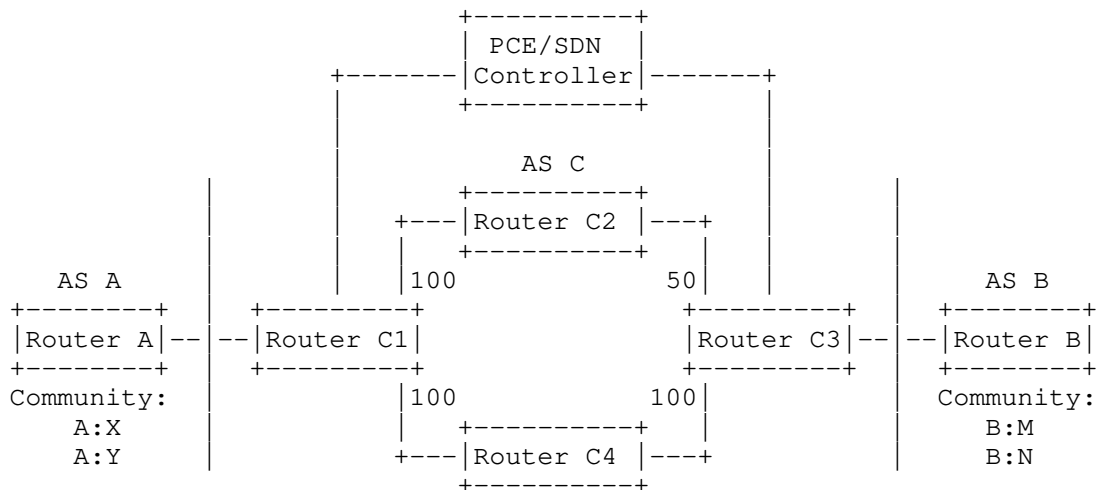
              Figure 1: Traffic Collection Based on BGP Community

   If the PCE/SDN controller in AS C can obtain network traffic
   information at the BGP community granularity, it can steer some
   traffic related to some BGP communities (when we consider only the
   source or destination of the traffic) or some BGP community pairs
   (when we consider both the source and the destination of the traffic)
   from Path-1 to Path-2 according to the utilization of different
   paths. For instance, it can steer the traffic generated by community
   A:X from Path-1 to Path-2 by deploying a route policy at Router C1 or
   steer the traffic from community A:Y to community B:M from Path-1 to
   Path-2. Using the IEs defined in this document, IPFIX can export the
   BGP community information related to a specific traffic flow together
   with other flow information. The traffic information can then be
   accumulated at the BGP community granularity and used by the PCE/SDN
   controller to steer the appropriate traffic from Path-1 to Path-2.

4. IEs for BGP Standard Community

   [RFC1997] defines the BGP community attribute (referred to as "BGP
   Standard Community" in this document), which describes a group of
   routes sharing some common properties. BGP Standard Community is
   treated as a 32-bit value, as stated in [RFC1997].

   In order to export BGP Standard Community information along with
   other flow information defined by IPFIX, this document introduces
   three new IEs:

   o bgpCommunity - used to identify that the value in this IE is a BGP
      Standard Community.

   o bgpSourceCommunityList - a basicList [RFC6313] of bgpCommunity
      used to export BGP Standard Community information corresponding to
      a specific flow's source IP address.

   o bgpDestinationCommunityList - a basicList [RFC6313] of
      bgpCommunity used to export BGP Standard Community information
      corresponding to a specific flow's destination IP address.

   See Section 9 ("IANA Considerations") for detailed information about
   these three new IEs.

5. IEs for BGP Extended Community

   [RFC4360] defines the BGP Extended Communities attribute, which
   provides a mechanism for labeling the information carried in BGP.
   Each Extended Community is encoded as an 8-octet quantity with the
   format defined in [RFC4360].

   In order to export BGP Extended Community information together with
   other flow information by IPFIX, this document introduces three new
   IEs:

   o bgpExtendedCommunity - used to identify that the value in this IE
      is a BGP Extended Community.

   o bgpSourceExtendedCommunityList - a basicList [RFC6313] of
      bgpExtendedCommunity used to export the BGP Extended Community
      information corresponding to a specific flow's source IP address.

   o bgpDestinationExtendedCommunityList - a basicList [RFC6313] of
      bgpExtendedCommunity used to export the BGP Extended Community
      information corresponding to a specific flow's destination IP
      address.

   See Section 9 ("IANA Considerations") for detailed information about
   these three new IEs.

6. IEs for BGP Large Community

   [RFC8092] defines the BGP Large Communities attribute, which is
   suitable for use with all Autonomous System Numbers (ASNs), including
   4-octet ASNs. Each BGP Large Community is encoded as a 12-octet
   quantity with the format defined in [RFC8092].

In order to export BGP Large Community information together with
other flow information by IPFIX, this document introduces three new
IEs:

o bgpLargeCommunity - used to identify that the value in this IE is
   a BGP Large Community.

o bgpSourceLargeCommunityList - a basicList [RFC6313] of
   bgpLargeCommunity used to export the BGP Large Community
   information corresponding to a specific flow's source IP address.

o bgpDestinationLargeCommunityList - a basicList [RFC6313] of
   bgpLargeCommunity used to export the BGP Large Community
   information corresponding to a specific flow's destination IP
   address.

See Section 9 ("IANA Considerations") for detailed information about
these three new IEs.

7. Operational Considerations

The maximum length of an IPFIX message is 65535 bytes as per
[RFC7011], and the maximum length of a normal BGP message is 4096
bytes as per [RFC4271]. Since BGP communities, including Standard,
Extended, and Large Communities, are BGP path attributes carried in
BGP Update messages, the total length of these attributes cannot
exceed the length of a BGP message, i.e., 4096 bytes. Therefore, one
IPFIX message with a maximum length of 65535 bytes has enough space
to fit all the communities relating to a specific flow's source and
destination IP address.

[EXT-MSG] extends the maximum size of a BGP Update message to 65535
bytes. In that case, the BGP community information related to a
specific flow could theoretically exceed the length of one IPFIX
message. However, according to information regarding actual networks
in the field, the number of BGP communities in one BGP route is
usually no more than ten. Nevertheless, BGP speakers that support
the extended message SHOULD only convey as many communities as
possible without exceeding the 65535-byte limit of an IPFIX message.
The Collector, which receives an IPFIX message with the maximum
length and BGP communities contained in its data set, SHOULD generate
a warning or log message to indicate that the BGP communities may be
truncated due to limited message space. In this case, it is
recommended that the export policy of BGP communities be configured
to limit the BGP communities by including or excluding specific
communities.

If needed, the IPFIX message length can be extended from 16 bits to
32 bits to solve this problem completely. The details about
increasing the IPFIX message length is out of scope of this document.

To align with the sizes of the BGP Extended Community and Large
Community attributes, the sizes of bgpExtendedCommunity and
bgpLargeCommunity are 8 octets and 12 octets, respectively. In the
event that the bgpExtendedCommunity or bgpLargeCommunity IE is not
the expected size, the IPFIX Collector SHOULD ignore it. This is
intended to protect implementations using BGP logic from calling
their parsing routines with invalid lengths.

To properly process the Exporter when it receives the template
requesting to report the BGP community information (refer to
Appendix A for an example), the Exporter SHOULD obtain the
corresponding BGP community information through a BGP lookup using
the corresponding source or destination IP address of the specific
traffic flow. When exporting the IPFIX information to the Collector,
the Exporter SHOULD include the corresponding BGP communities in the
IPFIX message.

8. Security Considerations

   This document defines new IEs for IPFIX. The same security
   considerations as for the IPFIX protocol specification [RFC7011] and
   information model [RFC7012] apply.

   Systems processing BGP community information collected by IPFIX
   Collectors need to be aware of the use of communities as an attack
   vector [WEAPONIZING-BGP] and only include BGP community information
   in decisions where they are confident of its validity. Thus, we
   cannot assume that all BGP community information collected by IPFIX
   Collectors is credible and accurate. It is RECOMMENDED to use only
   the IPFIX-collected BGP community information that the processing
   system can trust, for example, the BGP communities generated by the
   consecutive neighboring ASes within the same trust domain as the
   processing system (i.e., the consecutive neighboring ASes and the
   processing system are operated by one carrier).

   [RFC7011] notes that the storage of the information collected by
   IPFIX must be protected and its visibility confined to authorized
   users via technical as well as policy means to ensure the privacy of
   the information collected. [RFC7011] also provides mechanisms to
   ensure the confidentiality and integrity of IPFIX data transferred
   from an Exporting Process to a Collecting Process. The mechanism to
   authenticate IPFIX Collecting and Exporting Processes is also
   provided in [RFC7011]. If sensitive information is contained in the

community information, the above recommendations and mechanisms are
recommended. No additional privacy risks are introduced by this
document.

9. IANA Considerations

This document specifies IPFIX IEs to enable export of BGP community
information along with other flow information. IANA has assigned the
following ElementIDs for these IEs in the "IPFIX Information
Elements" registry [IANA-IPFIX]:

   |ElementID| Name | Abstract | Data Type |
		Data Type	Semantics
483	bgpCommunity	unsigned32	identifier
484	bgpSourceCommunityList	basicList	list
485	bgpDestinationCommunityList	basicList	list
486	bgpExtendedCommunity	octetArray	default
487	bgpSourceExtended		
	CommunityList	basicList	list
488	bgpDestinationExtended		
	CommunityList	basicList	list
489	bgpLargeCommunity	octetArray	default
490	bgpSourceLargeCommunityList	basicList	list
491	bgpDestinationLarge		
	CommunityList	basicList	list

```
 ------------------------------------------------------------
|ElementID|                  Description                     |
|---------------------------------------------------------- |
|   483   |     BGP community as defined in [RFC1997]        |
|---------|------------------------------------------------- |
|         |      basicList of zero or more bgpCommunity IEs,  |
|   484   |     containing the BGP communities corresponding |
|         |     with source IP address of a specific flow    |
|---------|------------------------------------------------- |
|         |      basicList of zero or more bgpCommunity IEs,  |
|   485   |  containing the BGP communities corresponding    |
|         |  with destination IP address of a specific flow  |
|---------|------------------------------------------------- |
|   486   | BGP Extended Community as defined in RFC 4360;   |
|         | the size of this IE MUST be 8 octets             |
|---------|------------------------------------------------- |
|         | basicList of zero or more bgpExtendedCommunity   |
|   487   | IEs, containing the BGP Extended Communities     |
|         | corresponding with source IP address of          |
|         |              a specific flow                     |
|---------|------------------------------------------------- |
|         | basicList of zero or more bgpExtendedCommunity   |
|   488   | IEs, containing the BGP Extended Communities     |
|         |  corresponding with destination IP address       |
|         |              of a specific flow                  |
|---------|------------------------------------------------- |
|   489   |  BGP Large Community as defined in [RFC8092];    |
|         |  the size of this IE MUST be 12 octets           |
|---------|------------------------------------------------- |
|         |      basicList of zero or more bgpLargeCommunity  |
|         |      IEs, containing the BGP Large Communities    |
|   490   |      corresponding with source IP address        |
|         |              of a specific flow                  |
|---------|------------------------------------------------- |
|         |      basicList of zero or more bgpLargeCommunity  |
|         |      IEs, containing the BGP Large Communities    |
|   491   |   corresponding with destination IP address      |
|         |              of a specific flow                  |
|---------------------------------------------------------- |
```

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      ---------------------------------------------------------
     |ElementID|      References       | Requester | Revision |
     |---------------------------------------------------------|
     |   483   |     RFC 1997         | RFC 8549  |    0     |
     |---------------------------------------------------------|
     |   484   |  RFC 6313, RFC 1997  | RFC 8549  |    0     |
     |---------------------------------------------------------|
     |   485   |  RFC 6313, RFC 1997  | RFC 8549  |    0     |
     |---------------------------------------------------------|
     |   486   |     RFC 4360         | RFC 8549  |    0     |
     |---------------------------------------------------------|
     |   487   |  RFC 6313, RFC 4360  | RFC 8549  |    0     |
     |---------------------------------------------------------|
     |   488   |  RFC 6313, RFC 4360  | RFC 8549  |    0     |
     |---------------------------------------------------------|
     |   489   |     RFC 8092         | RFC 8549  |    0     |
     |---------------------------------------------------------|
     |   490   |  RFC 6313, RFC 8092  | RFC 8549  |    0     |
     |---------------------------------------------------------|
     |   491   |  RFC 6313, RFC 8092  | RFC 8549  |    0     |
     |---------------------------------------------------------|
```

          Figure 2: Updates to "IPFIX Information Elements" Registry

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Appendix A. Encoding Example

   In this section, we provide an example to show the encoding format
   for the newly introduced IEs.

   Flow information, including BGP communities, is shown in the
   following table. In this example, all the fields are reported by
   IPFIX.

Source	Destination	BGP community	BGP community
IP	IP	corresponding with	corresponding with
		Source IP	Destination IP

   | 1.1.1.1 | 2.2.2.2 | 1:1001, 1:1002, 8:1001 | 2:1002, 8:1001 |

   | 3.3.3.3 | 4.4.4.4 | 3:1001, 3:1002, 8:1001 | 4:1001, 8:1001 |

            Figure 3: Flow Information Including BGP Communities

A.1. Template Record

    0   1   2   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+
   | SET ID = 2 | Length = 24 |
   +-+
   | Template ID = 256 | Field Count = 4 |
   +-+
   |0| SourceIPv4Address = 8 | Field Length = 4 |
   +-+
   |0| DestinationIPv4Address = 12 | Field Length = 4 |
   +-+
   |0| bgpSourceCommunityList=484 | Field Length = 0xFFFF |
   +-+
   |0| bgpDestinationCommunityList | Field Length = 0xFFFF |
   | | = 485 | |
   +-+

               Figure 4: Template Record Encoding Format

   In this example, the Template ID is 256, which will be used in the
   Data Record. The field length for bgpSourceCommunityList and
   bgpDestinationCommunityList is 0xFFFF, which means the length of this
   IE is variable, and the actual length of this IE is indicated by the
   List Length field in the basicList format as per [RFC6313].

A.2. Data Set

   The data set is represented as follows:

```
0                   1                   2                   3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           SET ID = 256        |           Length = 92         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   SourceIPv4Address = 1.1.1.1                 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                DestinationIPv4Address = 2.2.2.2               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     255       |       List Length = 17        |semantic=allof |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    bgpCommunity = 483         |       Field Length = 4        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       BGP Source Community Value 1 = 1:1001                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       BGP Source Community Value 2 = 1:1002                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       BGP Source Community Value 3 = 8:1001                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     255       |       List Length = 13        |semantic=allof |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    bgpCommunity = 483         |       Field Length = 4        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      BGP Destination Community Value 1 = 2:1002               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      BGP Destination Community Value 2 = 8:1001               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   SourceIPv4Address = 3.3.3.3                 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                DestinationIPv4Address = 4.4.4.4               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     255       |       List Length = 17        | semantic=allof|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    bgpCommunity = 483         |       Field Length = 4        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       BGP Source Community Value 1 = 3:1001                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       BGP Source Community Value 2 = 3:1002                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       BGP Source Community Value 3 = 8:1001                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     255       |       List Length = 13        | semantic=allof|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      bgpCommunity = 483        |        Field Length = 4       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

```
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            BGP Destination Community Value 1 = 4:1001          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            BGP Destination Community Value 2 = 8:1001          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 5: Data Set Encoding Format

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