Cisco Systems NetFlow Services Export Version 9

Status of this Memo

This document is an Internet-Draft and is in full conformance with all provisions of Section 10 of RFC2026.

Abstract

This document specifies the data export format for version 9 of Cisco Systems' NetFlow services, for use by implementations on the network elements and/or matching collector programs. The version 9 export format uses templates to provide access to observations of IP packet flows in a flexible and extensible manner. A template defines a collection of fields, with corresponding descriptions of structure and semantics

Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

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1. Introduction

Cisco Systems' NetFlow services provide network administrators with
access to IP flow information from their data networks. Network
elements (routers and switches) gather flow data and export it to
collectors. The collected data provides fine-grained metering for
highly flexible and detailed resource usage accounting.

A flow is defined as a unidirectional sequence of packets with some
common properties that pass through a network device. These
collected flows are exported to an external device, the NetFlow
collector. Network flows are highly granular; for example, flow
records include details such as IP addresses, packet and byte
counts, timestamps, Type of Service (ToS), application ports, input
and output interfaces, etc.

Exported NetFlow data is used for a variety of purposes, including
enterprise accounting and departmental chargebacks, ISP billing,
data warehousing, network monitoring, capacity planning, application
monitoring and profiling, user monitoring and profiling, security
analysis, and data mining for marketing purposes.

This document specifies NetFlow version 9. It describes the
implementation specifications both from network element and NetFlow
collector points of view. These specifications should help the
deployment of NetFlow version 9 across different platforms and
different vendors by limiting the interoperability risks. The
NetFlow export format version 9 uses templates to provide access to
observations of IP packet flows in a flexible and extensible manner.

A template defines a collection of fields, with corresponding descriptions of structure and semantics.

The template-based approach provides the following advantages:

   - New fields can be added to NetFlow flow records without changing the structure of the export record format. With previous NetFlow versions, adding a new field in the flow record implied a new version of the export protocol format and a new version of the NetFlow collector that supported the parsing of the new export protocol format.

   - Templates that are sent to the NetFlow collector contain the structural information about the exported flow record fields; therefore, if the NetFlow collector does not understand the semantics of new fields, it can still interpret the flow record.

   - Because the template mechanism is flexible, it allows the export of only the required fields from the flows to the NetFlow collector. This helps to reduce the exported flow data volume and provides possible memory savings for the exporter and NetFlow collector. Sending only the required information can also reduce network load.

The IETF IPFIX Working Group (IP Flow Information eXport) is developing a new protocol, based on the version 9 of Cisco Systems' NetFlow services. Some enhancements in different domains (congestion aware transport protocol, built-in security, etc...) have been incorporated in this new IPFIX protocol. Refer to the IPFIX Working Group documents for more details.

2.   Terminology

Various terms used in this document are described in this section. Note that the terminology summary table in Section 2.1 gives a quick overview of the relationships between some of the different terms defined.

Observation Point
An Observation Point is a location in the network where IP packets can be observed; for example, one or a set of interfaces on a network device like a router. Every Observation Point is associated with an Observation Domain.

Observation Domain
The set of Observation Points that is the largest aggregatable set of flow information at the network device with NetFlow services enabled is termed an Observation Domain. For example, a router line card composed of several interfaces with each interface being an

Observation Point.

IP Flow or Flow

An IP Flow, also called a Flow, is defined as a set of IP packets
passing an Observation Point in the network during a certain time
interval. All packets that belong to a particular Flow have a set
of common properties derived from the data contained in the packet
and from the packet treatment at the Observation Point.

Flow Record
A Flow Record provides information about an IP Flow observed at an
Observation Point. In this document, the Flow Data Records are also
referred to as NetFlow services data and NetFlow data.

Exporter
A device (for example, a router) with the NetFlow services enabled,
the Exporter monitors packets entering an Observation Point and
creates Flows from these packets. The information from these Flows
is exported in the form of Flow Records to the NetFlow Collector.

NetFlow Collector
The NetFlow Collector receives Flow Records from one or more
Exporters. It processes the received Export Packet(s); that is, it
parses and stores the Flow Record information. Flow Records can be
optionally aggregated before being stored on the hard disk.
The NetFlow Collector is also referred to as the Collector in this
document.

Export Packet
An Export Packet is a packet originating at the Exporter that
carries the Flow Records of this Exporter and whose destination is
the NetFlow Collector.

Packet Header
The Packet Header is the first part of an Export Packet. The Packet
Header provides basic information about the packet such as the
NetFlow version, number of records contained within the packet, and
sequence numbering.

Template Record
A Template Record defines the structure and interpretation of
fields in a Flow Data Record.

Flow Data Record
A Flow Data Record is a data record that contains values of the
Flow parameters corresponding to a Template Record.

Options Template Record
An Options Template Record defines the structure and interpretation
of fields in an Options Data Record, including defining the scope
within which the Options Data Record is relevant.

Options Data Record

The data record that contains values and scope information of the
Flow measurement parameters, corresponding to an Options Template
Record.

FlowSet
FlowSet is a generic term for a collection of Flow Records that
have a similar structure. In an Export Packet, one or more FlowSets
follow the Packet Header. There are three different types of
FlowSets: Template FlowSet, Options Template FlowSet, and Data
FlowSet.

Template FlowSet
A Template FlowSet is one or more Template Records that have been
grouped together in an Export Packet.

Options Template FlowSet
An Options Template FlowSet is one or more Options Template Records
that have been grouped together in an Export Packet.

Data FlowSet
A Data FlowSet is one or more records, of the same type, that are
grouped together in an Export Packet. Each record is either a Flow
Data Record or an Options Data Record previously defined by a
Template Record or an Options Template Record.

2.1   Terminology Summary Table

```
+------------------+--------------------+------------------------+
|                  |                     Contents                |
|                  +--------------------+------------------------+
|     FlowSet      | Template  Record   |    Data Record         |
+------------------+--------------------+------------------------+
|                  |                    | Flow Data Record(s)    |
| Data FlowSet     |         /          |         or             |
|                  |                    | Options Data Record(s) |
+------------------+--------------------+------------------------+
| Template FlowSet | Template Record(s) |         /              |
+------------------+--------------------+------------------------+
| Options Template | Options Template   |         /              |
| FlowSet          | Record(s)          |                        |
+------------------+--------------------+------------------------+
```

A Data FlowSet is composed of an Options Data Record(s) or Flow
Data Record(s). No Template Record is included.
A Template Record defines the Flow Data Record, and an Options
Template Record defines the Options Data Record.

A Template FlowSet is composed of Template Record(s). No Flow or
Options Data Record is included.

An Options Template FlowSet is composed of Options Template
Record(s). No Flow or Options Data Record is included.

3.   **NetFlow High-Level Picture on the Exporter**

3.1   **The NetFlow Process on the Exporter**

   The NetFlow process on the Exporter is responsible for the creation
   of Flows from the observed IP packets. The details of this process
   are beyond the scope of this document.

3.2   **Flow Expiration**

   A Flow is considered to be inactive if no packets belonging to the
   Flow have been observed at the Observation Point for a given
   timeout. If any packet is seen within the timeout, the flow is
   considered an active flow.
   A Flow can be exported under the following conditions:

      1. If the Exporter can detect the end of a Flow. For example, if
      the FIN or RST bit is detected in a TCP [RFC793] connection, the
      Flow Record is exported.

      2. If the Flow has been inactive for a certain period of time.
      This inactivity timeout SHOULD be configurable at the Exporter,
      with a minimum value of 0 for an immediate expiration.

      3. For long-lasting Flows, the Exporter SHOULD export the Flow
      Records on a regular basis. This timeout SHOULD be configurable
      at the Exporter.

      4. If the Exporter experiences internal constraints, a Flow MAY
      be forced to expire prematurely; for example, counters wrapping
      or low memory.

3.3   **Transport Protocol**

   To achieve efficiency in terms of processing at the Exporter while
   handling high volumes of Export Packets, the NetFlow Export Packets
   are encapsulated into UDP [RFC768] datagrams for export to the
   NetFlow Collector. However, NetFlow version 9 has been designed to
   be transport protocol independent. Hence, it can also operate over
   congestion-aware protocols such as SCTP [RFC2960].

   Note that the Exporter can export to multiple Collectors, using
   independent transport protocols.

   UDP [RFC768] is a non congestion-aware protocol, so when deploying
   NetFlow version 9 in a congestion-sensitive environment, make the
   connection between Exporter and NetFlow Collector through a
   dedicated link. This ensures that any burstiness in the NetFlow

traffic affects only this dedicated link. When the NetFlow
Collector can not be placed within a one-hop distance from the
Exporter or when the export path from the Exporter to the NetFlow

Collector can not be exclusively used for the NetFlow Export
Packets, the export path should be designed so that it can always
sustain the maximum burstiness of NetFlow traffic from the
Exporter. Note that the congestion can occur on the Exporter in
case the export path speed is too low.

4.   **Packet Layout**

An Export Packet consists of a Packet Header followed by one or
more FlowSets. The FlowSets can be any of the possible three types:
Template, Data, or Options Template.

```
   +--------+--------------------------------------------+
   |        | +----------+ +---------+ +----------+       |
   | Packet | | Template | | Data    | | Options  |       |
   | Header | | FlowSet  | | FlowSet | | Template | ... |
   |        | |          | |         | | FlowSet  |       |
   |        | +----------+ +---------+ +----------+       |
   +--------+--------------------------------------------+
                       Export Packet
```
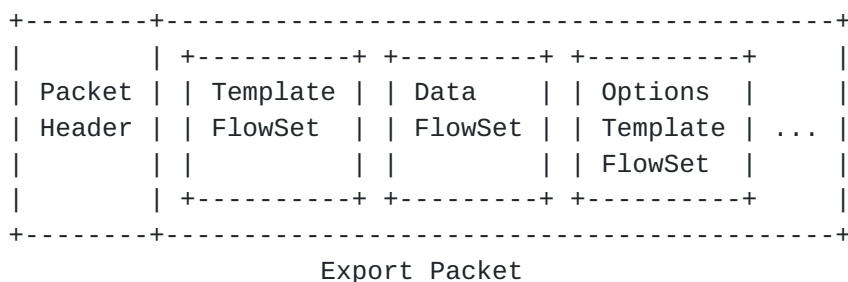
A FlowSet ID is used to distinguish the different types of
FlowSets. FlowSet IDs lower than 256 are reserved for special
FlowSets, such as the Template FlowSet (ID 0) and the Options
Template FlowSet (ID 1). The Data FlowSets have a FlowSet ID
greater than 255.

The format of the Template, Data, and Options Template FlowSets
will be discussed later in this document. The Exporter MUST code all
binary integers of the Packet Header and the different FlowSets in
network byte order (also known as the big-endian byte ordering).

Following are some examples of export packets:

1. An Export Packet consisting of interleaved Template, Data, and
Options Template FlowSets-A newly created Template is exported as
soon as possible. So if there is already an Export Packet with a
Data FlowSet that is being prepared for export, the Template and
Option FlowSets are also interleaved with this information, subject
to availability of space.

Export Packet:
```
+--------+------------------------------------------------------------+
|        | +----------+ +---------+     +-----------+ +---------+ |
| Packet | | Template | | Data    |     | Options   | | Data    | |
| Header | | FlowSet  | | FlowSet | ... | Template  | | FlowSet | |
|        | |          | |         |     | FlowSet   | |         | |
|        | +----------+ +---------+     +-----------+ +---------+ |
+--------+------------------------------------------------------------+
```
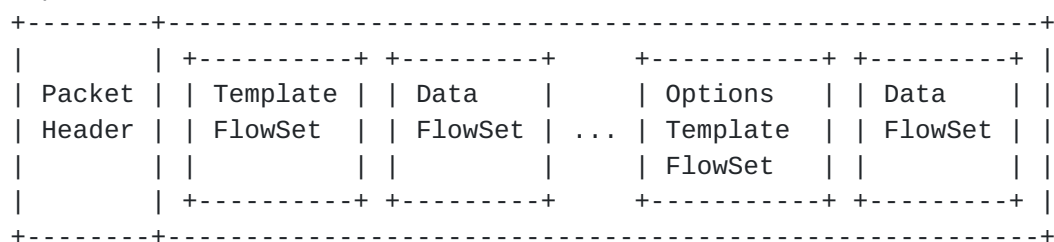
2. An Export Packet consisting entirely of Data FlowSets-After the
      appropriate Template Records have been defined and transmitted to

the NetFlow Collector device, the majority of Export Packets
consists solely of Data FlowSets.

Export Packet:
```
+--------+------------------------------------------------+
|        | +---------+     +---------+     +---------+ |
| Packet | | Data    | ... | Data    | ... | Data    | |
| Header | | FlowSet | ... | FlowSet | ... | FlowSet | |
|        | +---------+     +---------+     +---------+ |
+--------+------------------------------------------------+
```

3. An Export Packet consisting entirely of Template and Options
Template FlowSets-The Exporter MAY transmit a packet containing
Template and Options Template FlowSets periodically to help ensure
that the NetFlow Collector has the correct Template Records and
Options Template Records when the corresponding Flow Data records
are received.

Export Packet:
```
+--------+----------------------------------------------------+
|        | +----------+     +----------+     +----------+ |
| Packet | | Template |     | Template |     | Options  | |
| Header | | FlowSet  | ... | FlowSet  | ... | Template | |
|        | |          |     |          |     | FlowSet  | |
|        | +----------+     +----------+     +----------+ |
+--------+----------------------------------------------------+
```

5. Export Packet Format

5.1 Header Format

The Packet Header format in this version is the same as that
defined in the previous versions.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       Version Number          |            Count              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           sysUpTime                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           UNIX Secs                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Sequence Number                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           Source ID                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Packet Header Field Descriptions

Version

Version of Flow Record format exported in this packet. The
value of this field is 9 for the current version.

Count

The total number of records in the Export Packet, which is
the sum of Options FlowSet records, Template FlowSet
records, and Data FlowSet records.

sysUpTime

Time in milliseconds since this device was first booted.

UNIX Secs

Time in seconds since 0000 UTC 1970, at which the Export
Packet leaves the Exporter

Sequence Number

Incremental sequence counter of all Export Packets sent from
the current Observation Domain by the Exporter. This value
MUST be cumulative, and SHOULD be used by the Collector to
identify whether any Export Packets have been missed.

Source ID

A 32-bit value that identifies the Exporter Observation
Domain. NetFlow Collectors SHOULD use the combination of the
source IP address and the Source ID field to separate
different export streams originating from the same Exporter.

5.2   Template FlowSet Format

One of the essential elements in the NetFlow format is the Template
FlowSet. Templates greatly enhance the flexibility of the Flow
Record format because they allow the NetFlow Collector to process
Flow Records without necessarily knowing the interpretation of all
the data in the Flow Record. The format of the Template FlowSet is
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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        FlowSet ID = 0         |            Length             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Template ID 1          |          Field Count          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Field Type 1          |         Field Length 1        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Field Type 2          |         Field Length 2        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             ...               |             ...               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Field Type N          |         Field Length N        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Template ID 2          |          Field Count          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Field Type 1          |         Field Length 1        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Field Type 2          |         Field Length 2        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             ...               |             ...               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Field Type M          |         Field Length M        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             ...               |             ...               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Template ID K          |          Field Count          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             ...               |             ...               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Template FlowSet Field Descriptions

FlowSet ID
      FlowSet ID value of 0 is reserved for the Template FlowSet.

Length
      Total length of this FlowSet. Because an individual Template
      FlowSet MAY contain multiple Template Records, the Length
      value MUST be used to determine the position of the next
      FlowSet record, which could be any type of FlowSet. Length
      is the sum of the lengths of the FlowSet ID, the Length
      itself, and all Template Records within this FlowSet.

Template ID
      Each of the newly generated Template Records is given a
      unique Template ID. This uniqueness is local to the

Observation Domain that generated the Template ID.
Template IDs 0-255 are reserved for Template FlowSets,
Options FlowSets, and other reserved FlowSets yet to be

created. Template IDs of Data FlowSets are numbered from 256
to 65535.

Field Count
      Number of fields in this Template Record. Because a Template
      FlowSet usually contains multiple Template Records, this
      field allows the Collector to determine the end of the
      current Template Record and the start of the next.

Field Type
      A numeric value that represents the type of the field. Refer
      to the "Field Type Definitions" section.

Field Length
      The length of the corresponding Field Type, in bytes. Refer
      to the "Field Type Definitions" section.

5.3   Data FlowSet Format

The format of the Data FlowSet is 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   FlowSet ID = Template ID    |           Length              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Record 1 - Field Value 1    |   Record 1 - Field Value 2    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Record 1 - Field Value 3    |            ...                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Record 2 - Field Value 1    |   Record 2 - Field Value 2    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Record 2 - Field Value 3    |            ...                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Record 3 - Field Value 1    |            ...                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            ...                |           Padding             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Data FlowSet Field Descriptions

FlowSet ID = Template ID
      Each Data FlowSet is associated with a FlowSet ID. The
      FlowSet ID maps to a (previously generated) Template ID. The
      Collector MUST use the FlowSet ID to find the corresponding
      Template Record and decode the Flow Records from the
      FlowSet.

Length

The length of this FlowSet. Length is the sum of the lengths
of the FlowSet ID, Length itself, all Flow Records within
this FlowSet, and the padding bytes, if any.

   Record N - Field Value M
          The remainder of the Data FlowSet is a collection of Flow
          Data Record(s), each containing a set of field values. The
          Type and Length of the fields have been previously defined
          in the Template Record referenced by the FlowSet ID or
          Template ID.

   Padding
          The Exporter SHOULD insert some padding bytes so that the
          subsequent FlowSet starts at a 4-byte aligned boundary. It
          is important to note that the Length field includes the
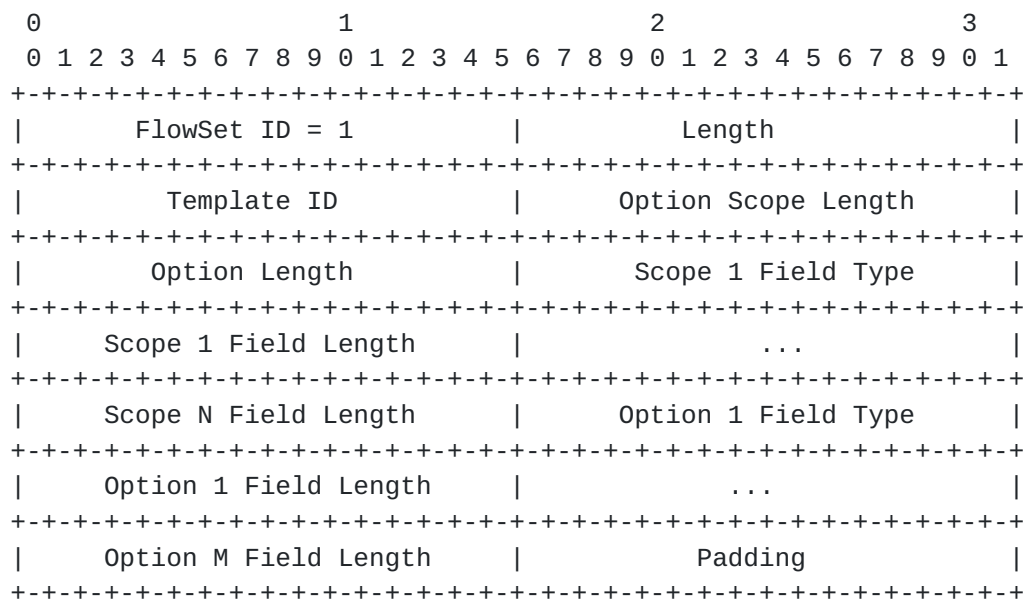   padding bytes. Padding SHOULD be using zeros.

   Interpretation of the Data FlowSet format can be done only if the
   Template FlowSet corresponding to the Template ID is available at
   the Collector.

6. Options

6.1   Options Template FlowSet Format

   The Options Template Record (and its corresponding Options Data
   Record) is used to supply information about the NetFlow process
   configuration or NetFlow process specific data, rather than
   supplying information about IP Flows.
   For example, the Options Template FlowSet can report the sample
   rate of a specific interface, if sampling is supported, along with
   the sampling method used.

   The format of the Options Template FlowSet 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       FlowSet ID = 1          |          Length               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Template ID            |      Option Scope Length       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       Option Length           |      Scope 1 Field Type        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Scope 1 Field Length      |              ...               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Scope N Field Length      |      Option 1 Field Type       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Option 1 Field Length     |              ...               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Option M Field Length     |            Padding             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Options Template FlowSet Field Definitions

 FlowSet ID = 1
        A FlowSet ID value of 1 is reserved for the Options
        Template.

 Length
        Total length of this FlowSet. Each Options Template FlowSet
        MAY contain multiple Options Template Records. Thus, the
        Length value MUST be used to determine the position of the
        next FlowSet record, which could be either a Template
        FlowSet or Data FlowSet.
        Length is the sum of the lengths of the FlowSet ID, the
        Length itself, and all Options Template Records within this
        FlowSet Template ID.

 Template ID
        Template ID of this Options Template. This value is greater
        than 255.

 Option Scope Length
        The length in bytes of any Scope field definition contained
        in the Options Template Record (The use of "Scope" is
        described below).

 Option Length
        The length (in bytes) of any options field definitions
        contained in this Options Template Record.

 Scope 1 Field Type
        The relevant portion of the Exporter/NetFlow process to
        which the Options Template Record refers.
        Currently defined values are:
             1 System
             2 Interface
             3 Line Card
             4 Cache
             5 Template
        For example, the NetFlow process can be implemented on a
        per-interface basis, so if the Options Template Record were
        reporting on how the NetFlow process is configured, the
        Scope for the report would be 2 (interface). The associated
        interface ID would then be carried in the associated Options
        Data FlowSet. The Scope can be limited further by listing
        multiple scopes that all must match at the same time. Note
        that the Scope fields always precede the Option fields.

 Scope 1 Field Length
        The length (in bytes) of the Scope field, as it would appear
        in an Options Data Record.

Option 1 Field Type

A numeric value that represents the type of field that would
appear in the Options Template Record. Refer to the Field
Type Definitions section.

Option 1 Field Length
       The length (in bytes) of the Option field.

Padding
       The Exporter SHOULD insert some padding bytes so that the
       subsequent FlowSet starts at a 4-byte aligned boundary. It
       is important to note that the Length field includes the
       padding bytes. Padding SHOULD be using zeros.

6.2   Options Data Record Format

The Options Data Records are sent in Data FlowSets, on a regular
basis, but not with every Flow Data Record. How frequently these
Options Data Records are exported is configurable. See the
"Templates Management" section for more details.

The format of the Data FlowSet containing Options Data Records
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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    FlowSet ID = Template ID   |            Length             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Record 1 - Scope 1 Value   |Record 1 - Option Field 1 Value|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Record 1 - Option Field 2 Value|            ...                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Record 2 - Scope 1 Value   |Record 2 - Option Field 1 Value|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Record 2 - Option Field 2 Value|            ...                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Record 3 - Scope 1 Value   |Record 3 - Option Field 1 Value|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Record 3 - Option Field 2 Value|            ...                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             ...               |            Padding            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Options Data Records of the Data FlowSet Field Descriptions

FlowSet ID = Template ID
       A FlowSet ID precedes each group of Options Data Records
       within a Data FlowSet. The FlowSet ID maps to a previously
       generated Template ID corresponding to this Options Template

Record. The Collector MUST use the FlowSet ID to map the
appropriate type and length to any field values that follow.

Length
        The length of this FlowSet.
        Length is the sum of the lengths of the FlowSet ID, Length
        itself, all the Options Data Records within this FlowSet,
        and the padding bytes, if any.

Record N - Option Field M Value
        The remainder of the Data FlowSet is a collection of Flow
        Records, each containing a set of scope and field values.
        The type and length of the fields were previously defined in
        the Options Template Record referenced by the FlowSet ID or
        Template ID.

Padding
        The Exporter SHOULD insert some padding bytes so that the
        subsequent FlowSet starts at a 4-byte aligned boundary. It
        is important to note that the Length field includes the
        padding bytes. Padding SHOULD be using zeros.

The Data FlowSet format can be interpreted only if the Options
Template FlowSet corresponding to the Template ID is available at
the Collector.

7.   Template Management

Flow Data records that correspond to a Template Record MAY appear
in the same and/or subsequent Export Packets. The Template Record
is not necessarily carried in every Export Packet. As such, the
NetFlow Collector MUST store the Template Record to interpret the
corresponding Flow Data Records that are received in subsequent
data packets.

A NetFlow Collector that receives Export Packets from several
Observation Domains from the same Exporter MUST be aware that the
uniqueness of the Template ID is not guaranteed across Observation
Domains.

The Template IDs must remain constant for the life of the NetFlow
process on the Exporter. If the Exporter or the NetFlow process
restarts for any reason, all information about Templates will be
lost and new Template IDs will be created. Template IDs are thus
not guaranteed to be consistent across an Exporter or NetFlow
process restart.

A newly created Template record is assigned an unused Template ID
from the Exporter. If the template configuration is changed, the
current Template ID is abandoned and SHOULD NOT be reused until the
NetFlow process or Exporter restarts. If a Collector should receive
a new definition for an already existing Template ID, it MUST

discard the previous template definition and use the new one.

If a configured Template Record on the Exporter is deleted, and re-
configured with exactly the same parameters, the same Template ID
COULD be reused.

The Exporter sends the Template FlowSet and Options Template
FlowSet under the following conditions:

1. After a NetFlow process restarts, the Exporter MUST NOT send any
   Data FlowSet without sending the corresponding Template FlowSet
   and the required Options Template FlowSet in a previous packet
   or including it in the same Export Packet. It MAY transmit the
   Template FlowSet and Options Template FlowSet, without any Data
   FlowSets, in advance to help ensure that the Collector will have
   the correct Template Record before receiving the first Flow or
   Options Data Record.

2. In the event of configuration changes, the Exporter SHOULD send
   the new template definitions at an accelerated rate. In such a
   case, it MAY transmit the changed Template Record(s) and Options
   Template Record(s), without any data, in advance to help ensure
   that the Collector will have the correct template information
   before receiving the first data.

3. On a regular basis, the Exporter MUST send all the Template
   Records and Options Template Records to refresh the Collector.
   Template IDs have a limited lifetime at the Collector and MUST
   be periodically refreshed.
   Two approaches are taken to make sure that Templates get
   refreshed at the Collector:
      * Every N number of Export Packets.
      * On a time basis, so every N number of minutes.
   Both options MUST be configurable by the user on the Exporter.
   When one of these expiry conditions is met, the Exporter MUST
   send the Template FlowSet and Options Template.

4. In the event of a clock configuration change on the Exporter,
   the Exporter SHOULD send the template definitions at an
   accelerated rate.

8.   Field Type Definitions

The following table describes all the field type definitions that
an Exporter MAY support. The fields are a selection of Packet
Header fields, lookup results (for example, the autonomous system
numbers or the subnet masks), and properties of the packet such as
length.

```
Field Type                Value Length  Description
                             (bytes)
```

Incoming counter with

IN_BYTES	1	N	length N x 8 bits for the number of bytes associated with an IP Flow. By default N is 4
IN_PKTS	2	N	Incoming counter with length N x 8 bits for the number of packets associated with an IP Flow. By default N is 4
FLOWS	3	N	Number of Flows that were aggregated; by default N is 4
PROTOCOL	4	1	IP protocol byte
TOS	5	1	Type of service byte setting when entering the incoming interface
TCP_FLAGS	6	1	TCP flags; cumulative of all the TCP flags seen in this Flow
L4_SRC_PORT	7	2	TCP/UDP source port number (for example, FTP, Telnet, or equivalent)
IPV4_SRC_ADDR	8	4	IPv4 source address
SRC_MASK	9	1	The number of contiguous bits in the source subnet mask (i.e. the mask in slash notation)
INPUT_SNMP	10	N	Input interface index. By default N is 2, but higher values can be used
L4_DST_PORT	11	2	TCP/UDP destination port number (for example, FTP, Telnet, or equivalent)
IPV4_DST_ADDR	12	4	IPv4 destination address
DST_MASK	13	1	The number of contiguous bits in the destination subnet mask (i.e. the mask

in slash notation)

                              Output interface index.

OUTPUT_SNMP	14	N	By default N is 2, but higher values can be used
IPV4_NEXT_HOP	15	4	IPv4 address of the next-hop router
SRC_AS	16	N	Source BGP autonomous system number where N could be 2 or 4. By default N is 2
DST_AS	17	N	Destination BGP autonomous system number where N could be 2 or 4. By default N is 2
BGP_IPV4_NEXT_HOP	18	4	Next-hop router's IP address in the BGP domain
MUL_DST_PKTS	19	N	IP multicast outgoing packet counter with length N x 8 bits for packets associated with the IP Flow. By default N is 4
MUL_DST_BYTES	20	N	IP multicast outgoing Octet (byte) counter with length N x 8 bits for the number of bytes associated with the IP Flow. By default N is 4
LAST_SWITCHED	21	4	sysUptime in msec at which the last packet of this Flow was switched
FIRST_SWITCHED	22	4	sysUptime in msec at which the first packet of this Flow was switched
OUT_BYTES	23	N	Outgoing counter with length N x 8 bits for the number of bytes associated with an IP Flow. By default N is 4
OUT_PKTS	24	N	Outgoing counter with length N x 8 bits for the number of packets

associated with an IP Flow.
                                        By default N is 4

IPV6_SRC_ADDR	27	16	IPv6 source address
IPV6_DST_ADDR	28	16	IPv6 destination address
IPV6_SRC_MASK	29	1	Length of the IPv6 source mask in contiguous bits
IPV6_DST_MASK	30	1	Length of the IPv6 destination mask in contiguous bits
IPV6_FLOW_LABEL	31	3	IPv6 flow label as per RFC 2460 definition
ICMP_TYPE	32	2	Internet Control Message Protocol (ICMP) packet type; reported as ICMP Type * 256 + ICMP code
MUL_IGMP_TYPE	33	1	Internet Group Management Protocol (IGMP) packet type
SAMPLING_INTERVAL	34	4	When using sampled NetFlow, the rate at which packets are sampled; for example, a value of 100 indicates that one of every hundred packets is sampled
SAMPLING_ALGORITHM	35	1	For sampled NetFlow platform-wide: 0x01 deterministic sampling 0x02 random sampling Use in connection with SAMPLING_INTERVAL
FLOW_ACTIVE_TIMEOUT	36	2	Timeout value (in seconds) for active flow entries in the NetFlow cache
FLOW_INACTIVE_TIMEOUT	37	2	Timeout value (in seconds) for inactive Flow entries in the NetFlow cache
ENGINE_TYPE	38	1	Type of Flow switching engine (route processor, linecard, etc...)

ENGINE_ID   39   1   ID number of the Flow
                                               switching engine

TOTAL_BYTES_EXP	40	N	Counter with length N x 8 bits for the number of bytes exported by the Observation Domain. By default N is 4
TOTAL_PKTS_EXP	41	N	Counter with length N x 8 bits for the number of packets exported by the Observation Domain. By default N is 4
TOTAL_FLOWS_EXP	42	N	Counter with length N x 8 bits for the number of Flows exported by the Observation Domain. By default N is 4
MPLS_TOP_LABEL_TYPE	46	1	MPLS Top Label Type: 0x00 UNKNOWN 0x01 TE-MIDPT 0x02 ATOM 0x03 VPN 0x04 BGP 0x05 LDP
MPLS_TOP_LABEL_IP_ADDR	47	4	Forwarding Equivalent Class corresponding to the MPLS Top Label
FLOW_SAMPLER_ID	48	1	Identifier shown in "show flow-sampler"
FLOW_SAMPLER_MODE	49	1	The type of algorithm used for sampling data: 0x02 random sampling Use in connection with FLOW_SAMPLER_MODE
FLOW_SAMPLER_RANDOM_INTERVAL	50	4	Packet interval at which to sample. Use in connection with FLOW_SAMPLER_MODE
DST_TOS	55	1	Type of Service byte setting when exiting outgoing interface
SRC_MAC	56	6	Source MAC Address

```
   DST_MAC                          57   6    Destination MAC Address

                                             Virtual LAN identifier
```

SRC_VLAN	58	2	associated with ingress interface
DST_VLAN	59	2	Virtual LAN identifier associated with egress interface
IP_PROTOCOL_VERSION	60	1	Internet Protocol Version Set to 4 for IPv4, set to 6 for IPv6. If not present in the template, then version 4 is assumed
DIRECTION	61	1	Flow direction: 0 - ingress flow 1 egress flow
IPV6_NEXT_HOP	62	16	IPv6 address of the next-hop router
BPG_IPV6_NEXT_HOP	63	16	Next-hop router in the BGP domain
IPV6_OPTION_HEADERS	64	4	Bit-encoded field identifying IPv6 option headers found in the flow
MPLS_LABEL_1	70	3	MPLS label at position 1 in the stack
MPLS_LABEL_2	71	3	MPLS label at position 2 in the stack
MPLS_LABEL_3	72	3	MPLS label at position 3 in the stack
MPLS_LABEL_4	73	3	MPLS label at position 4 in the stack
MPLS_LABEL_5	74	3	MPLS label at position 5 in the stack
MPLS_LABEL_6	75	3	MPLS label at position 6 in the stack
MPLS_LABEL_7	76	3	MPLS label at position 7 in the stack
MPLS_LABEL_8	77	3	MPLS label at position 8 in

the stack

      MPLS_LABEL_9   78   3   MPLS label at position 9 in

			the stack
MPLS_LABEL_10	79	3	MPLS label at position 10 in the stack

The value field is a numeric identifier for the field type.
The following value fields are reserved for proprietary field
types: 25, 26, 43 to 45, 51 to 54, and 65 to 69.

When extensibility is required, the new field types will be added
to the list. The new field types have to be updated on the Exporter
and Collector but the NetFlow export format would remain unchanged.
Refer to the latest documentation at http://www.cisco.com for the
newly updated list.

In some cases the size of a field type is fixed by definition, for
example PROTOCOL, or IPV4_SRC_ADDR. However in other cases they are
defined as a variant type. This improves the memory efficiency in
the collector and reduces the network bandwidth requirement between
the Exporter and the Collector. As an example, in the case
IN_BYTES, on an access router it might be sufficient to use a 32
bit counter (N = 4), whilst on a core router a 64 bit counter (N =
8) would be required.

All counters and counter-like objects are unsigned integers of
size N * 8 bits.

9. The Collector Side

The Collector receives Template Records from the Exporter, normally
before receiving Flow Data Records (or Options Data Records). The
Flow Data Records (or Options Data Records) can then be decoded and
stored locally on the devices. If the Template Records have not
been received at the time Flow Data Records (or Options Data
Records) are received, the Collector SHOULD store the Flow Data
Records (or Options Data Records) and decode them after the
Template Records are received. A Collector device MUST NOT assume
that the Data FlowSet and the associated Template FlowSet (or
Options Template FlowSet) are exported in the same Export Packet.

The Collector MUST NOT assume that one and only one Template
FlowSet is present in an Export Packet.

The life of a template at the Collector is limited to a fixed
refresh timeout. Templates not refreshed from the Exporter within
the timeout are expired at the Collector. The Collector MUST NOT
attempt to decode the Flow or Options Data Records with an expired
Template. At any given time the Collector SHOULD maintain the
following for all the current Template Records and Options Template

Records: Exporter, Observation Domain, Template ID, Template
Definition, Last Received.

   Note that the Observation Domain is identified by the Source ID
   field from the Export Packet.
   In the event of a clock configuration change on the Exporter, the
   Collector SHOULD discard all Template Records and Options Template
   Records associated with that Exporter, in order for Collector to
   learn the new set of fields: Exporter, Observation Domain, Template
   ID, Template Definition, Last Received.

   Template IDs are unique per Exporter and per Observation Domain.

   If the Collector receives a new Template Record (for example, in
   the case of an Exporter restart) it MUST immediately override the
   existing Template Record.

   Finally, note that the Collector MUST accept padding in the Data
   FlowSet and Options Template FlowSet, which means for the Flow Data
   Records, the Options Data Records and the Template Records.
   Refer to the terminology summary table in Section 2.1.

10.   Security Considerations

   The NetFlow version 9 protocol was designed with the expectation
   that the Exporter and Collector would remain within a single
   private network. However the NetFlow version 9 protocol might be
   used to transport Flow Records over the public Internet which
   exposes the Flow Records to a number of security risks. For example
   an attacker might capture, modify or insert Export Packets. There
   is therefore a risk that IP Flow information might be captured or
   forged, or that attacks might be directed at the NetFlow Collector.

   The designers of NetFlow Version 9 did not impose any
   confidentiality, integrity or authentication requirements on the
   protocol because this reduced the efficiency of the implementation
   and it was believed at the time that the majority of deployments
   would confine the Flow Records to private networks, with the
   Collector(s) and Exporter(s) in close proximity.

   The IPFIX protocol (IP Flow Information eXport), which has chosen
   the NetFlow version 9 protocol as the base protocol, addresses the
   security considerations discussed in this section. See the security
   section of IPFIX requirement draft [IPFIX-REQ] for more
   information.

10.1   Disclosure of Flow Information Data

   Because the NetFlow Version 9 Export Packets are not encrypted, the
   observation of Flow Records can give an attacker information about
   the active flows in the network, communication endpoints and
   traffic patterns. This information can be used both to spy on user

behavior and to plan and conceal future attacks.

The information that an attacker could derive from the interception of Flow Records depends on the Flow definition. For example, a Flow Record containing the source and destination IP addresses might reveal privacy sensitive information regarding the end user's activities, whilst a Flow Record only containing the source and destination IP network would be less revealing.

10.2   Forgery of Flow Records or Template Records

If Flow Records are used in accounting and/or security applications, there may be a strong incentive to forge exported Flow Records (for example to defraud the service provider, or to prevent the detection of an attack). This can be done either by altering the Flow Records on the path between the Observer and the Collector, or by injecting forged Flow Records that pretend to be originated by the Exporter.

An attacker could forge Templates and/or Options Templates and thereby try to confuse the NetFlow Collector, rendering it unable to decode the Export Packets.

10.3   Attacks on the NetFlow Collector

Denial of service attacks on the NetFlow Collector can consume so many resources from the machine that, the Collector is unable to capture or decode some NetFlow Export Packets. Such hazards are not explicitly addressed by the NetFlow Version 9 protocol, although the normal methods used to protect a server from a DoS attack will mitigate the problem.

11.   Examples

Let us consider the example of an Export Packet composed of a Template FlowSet, a Data FlowSet (which contains three Flow Data Records), an Options Template FlowSet, and a Data FlowSet (which contains two Options Data Records).

Export Packet:

```
+--------+----------------------------------------------. . .
|        | +--------------+ +----------------------+
| Packet | | Template     | | Data                 |
| Header | | FlowSet      | | FlowSet              |   . . .
|        | | (1 Template) | | (3 Flow Data Records)|
|        | +--------------+ +----------------------+
+--------+----------------------------------------------. . .

   . . .+--------------------------------------------------+
        +-----------------+ +-------------------------+ |
        | Options         | | Data                    | |
   . . .| Template FlowSet| | FlowSet                 | |
        | (1 Template)    | | (2 Options Data Records)| |
        +-----------------+ +-------------------------+ |
   . . .--------------------------------------------------+
```

11.1   Packet Header Example

The Packet Header is composed of:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      Version = 9              |          Count = 7            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            sysUpTime                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            UNIX Secs                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Sequence Number                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            Source ID                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

11.2   Template FlowSet Example

We want to report the following Field Types:
- The source IP address (IPv4), so the length is 4
- The destination IP address (IPv4), so the length is 4
- The next-hop IP address (IPv4), so the length is 4
- The number of bytes of the Flow
- The number of packets of the Flow

Therefore, the Template FlowSet is composed of the following:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        FlowSet ID = 0         |       Length = 28 bytes       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Template ID 256        |       Field Count = 5         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       IP_SRC_ADDR = 8         |       Field Length = 4        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       IP_DST_ADDR = 12        |       Field Length = 4        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       IP_NEXT_HOP = 15        |       Field Length = 4        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         IN_PKTS = 2           |       Field Length = 4        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        IN_BYTES = 1           |       Field Length = 4        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

11.3   Data FlowSet Example

In this example, we report the following three Flow Records:

Src IP addr.	Dst IP addr.	Next Hop addr.	Packet Number	Bytes Number
198.168.1.12	10.5.12.254	192.168.1.1	5009	5344385
192.168.1.27	10.5.12.23	192.168.1.1	748	388934
192.168.1.56	10.5.12.65	192.168.1.1	5	6534

```
    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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |        FlowSet ID = 256       |          Length = 64          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                          198.168.1.12                         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                          10.5.12.254                          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                          192.168.1.1                          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                             5009                              |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                            5344385                            |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                          192.168.1.27                         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                          10.5.12.23                           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                          192.168.1.1                          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                             748                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                            388934                             |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                          192.168.1.56                         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                          10.5.12.65                           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                          192.168.1.1                          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                              5                                |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                             6534                              |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Note that padding was not necessary in this example.

11.4   Options Template FlowSet Example

Per line card (the Exporter is composed of two line cards), we want
to report the following Field Types:
- Total number of Export Packets
- Total number of exported Flows

The format of the Options Template FlowSet is 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        FlowSet ID = 1          |           Length = 24         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Template ID 257        |   Option Scope Length = 4     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Option Length = 8       |   Scope 1 Field Type = 3      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Scope 1 Field Length = 2     |   TOTAL_EXP_PKTS_SENT = 41    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Field Length = 2        |    TOTAL_FLOWS_EXP = 42       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Field Length = 2        |            Padding            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

11.5   Data FlowSet with Options Data Records Example

In this example, we report the following two records:

```
Line Card ID | Export Packet| Export Flow
--------------------------------------------
Line Card 1  | 345          | 10201
Line Card 2  | 690          | 20402
```

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    FlowSet ID = 257            |           Length = 16         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              1                 |             345               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            10201               |              2                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             690                |            20402              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

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13. Authors

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