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Cisco Systems NetFlow Services Export Version 9

Status of this Memo

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IESG Note

This RFC documents the NetFlow services export protocol Version 9 as it was when submitted to the IETF as a basis for further work in the IPFIX WG.

This RFC itself is not a candidate for any level of Internet Standard. The IETF disclaims any knowledge of the fitness of this RFC for any purpose, and in particular notes that it has not had complete IETF review for such things as security, congestion control, or inappropriate interaction with deployed protocols. The RFC Editor has chosen to publish this document at its discretion.

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.

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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.

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 BCP 14, RFC 2119 [RFC2119].

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
Data FlowSet	/	Flow Data Record(s) or Options Data Record(s)
Template FlowSet	Template Record(s)	/
Options Template FlowSet	Options Template 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. Example: 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. Example: 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. Example: 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 is specified as:

```
    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 256          |         Field Count           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |        Field Type 1           |         Field Length 1        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |        Field Type 2           |         Field Length 2        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |             ...               |              ...              |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |        Field Type N           |         Field Length N        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |      Template ID 257          |         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 (bytes)	Description
IN_BYTES	1	N	Incoming counter with 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_SNMP	14	N	Output interface index. 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
SRC_VLAN	58	2	Virtual LAN identifier 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
BGP_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 [RFC3917] 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	Bytes
			Number	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              |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

12. References

12.1. Normative References

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12.2. Informative References

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13. Authors

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