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               Packet Sampling (PSAMP) Protocol Specifications

Status of This Memo

   This document specifies an Internet standards track protocol for the
   Internet community, and requests discussion and suggestions for
   improvements. Please refer to the current edition of the "Internet
   Official Protocol Standards" (STD 1) for the standardization state
   and status of this protocol. Distribution of this memo is unlimited.

Abstract

   This document specifies the export of packet information from a
   Packet SAMPling (PSAMP) Exporting Process to a PSAMP Collecting
   Process. For export of packet information, the IP Flow Information
   eXport (IPFIX) protocol is used, as both the IPFIX and PSAMP
   architecture match very well, and the means provided by the IPFIX
   protocol are sufficient. The document specifies in detail how the
   IPFIX protocol is used for PSAMP export of packet information.

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1. Introduction

   The name PSAMP is a contraction of the phrase "Packet Sampling". The
   word "Sampling" captures the idea that only a subset of all packets
   passing a network element will be selected for reporting. PSAMP
   selection operations include random selection, deterministic
   selection, and deterministic approximations to random selection
   (Hash-based Selection).

   The IP Flow Information eXport (IPFIX) protocol specified in
   [RFC5101] exports IP traffic information [RFC5102] observed at
   network devices. This matches the general protocol requirements
   outlined in the PSAMP framework [RFC5474]. However, there are some
   architectural differences between IPFIX and PSAMP in the requirements
   for an export protocol. While the IPFIX architecture [RFC5470] is
   focused on gathering and exporting IP traffic flow information, the
   focus of the PSAMP framework [RFC5474] is on exporting information on
   individual packets. This basic difference and a set of derived
   differences in protocol requirements are outlined in Section 4.
   Despite these differences, the IPFIX protocol is well suited for the
   PSAMP protocol. Section 5 specifies how the IPFIX protocol is used
   for the export of packet samples. Required extensions of the IPFIX
   information model are specified in the PSAMP information model
   [RFC5477].

1.1. 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].

2. PSAMP Documents Overview

   This document is one out of a series of documents from the PSAMP
   group.

   [RFC5474]: "A Framework for Packet Selection and Reporting" describes
   the PSAMP framework for network elements to select subsets of packets
   by statistical and other methods, and to export a stream of reports
   on the selected packets to a Collector.

   [RFC5475]: "Sampling and Filtering Techniques for IP Packet
   Selection" describes the set of packet selection techniques supported
   by PSAMP.

   RFC 5476 (this document): "Packet Sampling (PSAMP) Protocol
   Specifications" specifies the export of packet information from a
   PSAMP Exporting Process to a PSAMP Collecting Process.

   [RFC5477]: "Information Model for Packet Sampling Exports" defines an
   information and data model for PSAMP.

3. Terminology

   As the IPFIX export protocol is used to export the PSAMP information,
   the relevant IPFIX terminology from [RFC5101] is copied over in this
   document. All terms defined in this section have their first letter
   capitalized when used in this document. The terminology summary
   table in Section 3.1 gives a quick overview of the relationships
   between the different IPFIX terms. The PSAMP terminology defined
   here is fully consistent with all terms listed in [RFC5475] and
   [RFC5474], but only definitions that are relevant to the PSAMP
   protocol appear here. Section 3.3 applies the PSAMP terminology to
   the IPFIX protocol terminology.

3.1.   IPFIX Terminology

   IPFIX-specific terminology used in this document is defined in
   Section 2 of [RFC5101]. The only exceptions are the Metering
   Process, Exporting Process, and the Collector terms, which are
   defined more precisely in the PSAMP terminology section. In this
   document, as in [RFC5101], the first letter of each IPFIX-specific
   term is capitalized.

```
+-----------------+-------------------------------------------------+
|                 |                     contents                    |
|                 +-------------------+-----------------------------+
|       Set       |      Template     |           record            |
+-----------------+-------------------+-----------------------------+
|    Data Set     |         /         |       Data Record(s)        |
+-----------------+-------------------+-----------------------------+
|   Template Set  | Template Record(s)|             /               |
+-----------------+-------------------+-----------------------------+
| Options Template| Options Template  |             /               |
|       Set       | Record(s)         |                             |
+-----------------+-------------------+-----------------------------+
```

Figure A: Terminology Summary Table

3.2. PSAMP Terminology

The PSAMP terminology section has been copied from [RFC5475].

3.2.1. Packet Streams and Packet Content

* Observed Packet Stream

   The Observed Packet Stream is the set of all packets observed at
   the Observation Point.

* Packet Stream

   A Packet Stream denotes a set of packets from the Observed Packet
   Stream that flows past some specified point within the Metering
   Process. An example of a Packet Stream is the output of the
   Selection Process. Note that packets selected from a stream,
   e.g., by Sampling, do not necessarily possess a property by which
   they can be distinguished from packets that have not been
   selected. For this reason, the term "stream" is favored over
   "flow", which is defined as a set of packets with common
   properties [RFC3917].

* Packet Content

   The Packet Content denotes the union of the packet header (which
   includes link layer, network layer, and other encapsulation
   headers) and the packet payload. Note that, depending on the
   Observation Point, the link layer information might not be
   available.

3.2.2. Selection Process

   * Selection Process

      A Selection Process takes the Observed Packet Stream as its input
      and selects a subset of that stream as its output.

   * Selection State

      A Selection Process may maintain state information for use by the
      Selection Process. At a given time, the Selection State may
      depend on packets observed at and before that time, and other
      variables. Examples include:

         (i) sequence numbers of packets at the input of Selectors;

        (ii) a timestamp of observation of the packet at the Observation
             Point;

       (iii) iterators for pseudorandom number generators;

        (iv) hash values calculated during selection;

         (v) indicators of whether the packet was selected by a given
             Selector.

      Selection Processes may change portions of the Selection State as
      a result of processing a packet. Selection state for a packet is
      to reflect the state after processing the packet.

   * Selector

      A Selector defines the action of a Selection Process on a single
      packet of its input. If selected, the packet becomes an element
      of the output Packet Stream.

      The Selector can make use of the following information in
      determining whether a packet is selected:

         (i) the Packet Content;

        (ii) information derived from the packet's treatment at the
             Observation Point;

       (iii) any selection state that may be maintained by the Selection
             Process.

   * Composite Selector

      A Composite Selector is an ordered composition of Selectors, in
      which the output Packet Stream issuing from one Selector forms the
      input Packet Stream to the succeeding Selector.

   * Primitive Selector

      A Selector is primitive if it is not a Composite Selector.

   * Selector ID

      The Selector ID is the unique ID identifying a Primitive Selector.
      The ID is unique within the Observation Domain.

   * Selection Sequence

      From all the packets observed at an Observation Point, only a few
      packets are selected by one or more Selectors. The Selection
      Sequence is a unique value per Observation Domain describing the
      Observation Point and the Selector IDs through which the packets
      are selected.

3.2.3. Reporting

   * Packet Reports

      Packet Reports comprise a configurable subset of a packet's input
      to the Selection Process, including the Packet Content,
      information relating to its treatment (for example, the output
      interface), and its associated selection state (for example, a
      hash of the Packet Content).

   * Report Interpretation

      Report Interpretation comprises subsidiary information, relating
      to one or more packets, that is used for interpretation of their
      Packet Reports. Examples include configuration parameters of the
      Selection Process.

   * Report Stream

      The Report Stream is the output of a Metering Process, comprising
      two distinguished types of information: Packet Reports and Report
      Interpretation.

3.2.4. Metering Process

   * Metering Process

      A Metering Process selects packets from the Observed Packet Stream
      using a Selection Process, and produces as output a Report Stream
      concerning the selected packets.

      The PSAMP Metering Process can be viewed as analogous to the IPFIX
      Metering Process [RFC5101], which produces Flow Records as its
      output, with the difference that the PSAMP Metering Process always
      contains a Selection Process. The relationship between PSAMP and
      IPFIX is further described in [RFC5477] and [RFC5474].

3.2.5. Exporting Process

   * Exporting Process

      An Exporting Process sends, in the form of Export Packets, the
      output of one or more Metering Processes to one or more
      Collectors.

   * Export Packet

      An Export Packet is a combination of Report Interpretation(s)
      and/or one or more Packet Reports that are bundled by the
      Exporting Process into an Export Packet for exporting to a
      Collector.

3.2.6. PSAMP Device

   * PSAMP Device

      A PSAMP Device is a device hosting at least an Observation Point,
      a Selection Process, and an Exporting Process. Typically,
      corresponding Observation Point(s), Selection Process(es), and
      Exporting Process(es) are co-located at this device, for example,
      at a router.

3.2.7. Collector

   * Collector

      A Collector receives a Report Stream exported by one or more
      Exporting Processes. In some cases, the host of the Metering
      and/or Exporting Processes may also serve as the Collector.

3.2.8. Selection Methods

   * Filtering

      A filter is a Selector that selects a packet deterministically
      based on the Packet Content, or its treatment, or functions of
      these occurring in the Selection State. Two examples are:

         (i) Property Match Filtering: A packet is selected if a
             specific field in the packet equals a predefined value.

         (ii) Hash-based Selection: A Hash Function is applied to the
              Packet Content, and the packet is selected if the result
              falls in a specified range.

   * Sampling

             A Selector that is not a filter is called a Sampling
             operation. This reflects the intuitive notion that if the
             selection of a packet cannot be determined from its content
             alone, there must be some type of Sampling taking place.

   * Content-Independent Sampling

             A Sampling operation that does not use Packet Content (or
             quantities derived from it) as the basis for selection is
             called a Content-independent Sampling operation. Examples
             include systematic Sampling, and uniform pseudorandom
             Sampling driven by a pseudorandom number whose generation
             is independent of Packet Content. Note that in Content-
             independent Sampling, it is not necessary to access the
             Packet Content in order to make the selection decision.

   * Content-Dependent Sampling

             A Sampling operation where selection is dependent on Packet
             Content is called a Content-dependent Sampling operation.
             An example is pseudorandom selection according to a
             probability that depends on the contents of a packet field.
             Note that this is not a filter, because the selection is
             not deterministic.

   * Hash Domain

             A Hash Domain is a subset of the Packet Content and the
             packet treatment, viewed as an N-bit string for some
             positive integer N.

   * Hash Range

          A Hash Range is a set of M-bit strings for some positive
          integer M that define the range of values the result of the
          hash operation can take.

   * Hash Function

          A Hash Function defines a deterministic map from the Hash
          Domain into the Hash Range.

   * Hash Selection Range

          A Hash Selection Range is a subset of the Hash Range. The
          packet is selected if the action of the Hash Function on
          the Hash Domain for the packet yields a result in the Hash
          Selection Range.

   * Hash-based Selection

          A Hash-based Selection is Filtering specified by a Hash
          Domain, a Hash Function, a Hash Range, and a Hash Selection
          Range.

   * Approximative Selection

          Selectors in any of the above categories may be
          approximated by operations in the same or another category
          for the purposes of implementation. For example, uniform
          pseudorandom Sampling may be approximated by Hash-based
          Selection, using a suitable Hash Function and Hash Domain.
          In this case, the closeness of the approximation depends on
          the choice of Hash Function and Hash Domain.

   * Population

          A Population is a Packet Stream, or a subset of a Packet
          Stream. A Population can be considered as a base set from
          which packets are selected. An example is all packets in
          the Observed Packet Stream that are observed within some
          specified time interval.

   * Population Size

          The Population Size is the number of all packets in the
          Population.

   * Sample Size

           The Sample Size is the number of packets selected from the
           Population by a Selector.

   * Configured Selection Fraction

           The Configured Selection Fraction is the expected ratio of
           the Sample Size to the Population Size, as based on the
           configured selection parameters.

   * Attained Selection Fraction

           The Attained Selection Fraction is the ratio of the actual
           Sample Size to the Population Size. For some Sampling
           methods, the Attained Selection Fraction can differ from
           the Configured Selection Fraction due to, for example, the
           inherent statistical variability in Sampling decisions of
           probabilistic Sampling and Hash-based Selection.
           Nevertheless, for large Population Sizes and properly
           configured Selectors, the Attained Selection Fraction
           usually approaches the Configured Selection Fraction.

3.3. IPFIX and PSAMP Terminology Comparison

   The PSAMP terminology has been specified with an IPFIX background, as
   PSAMP and IPFIX have similar terms. However, this section clarifies
   the terms between the IPFIX and PSAMP terminology.

3.3.1. IPFIX and PSAMP Processes

   Figure B indicates the sequence of the IPFIX processes (Metering and
   Exporting) within the PSAMP Device.

```
              +------------------+
              | Metering Process |
              | +----------+     |       +-----------+
     Observed |  | Selection |    |       | Exporting |
     Packet--->|  | Process   |---------->| Process   |--->Collector
     Stream   |  +----------+     |       +-----------+
              +------------------+
```
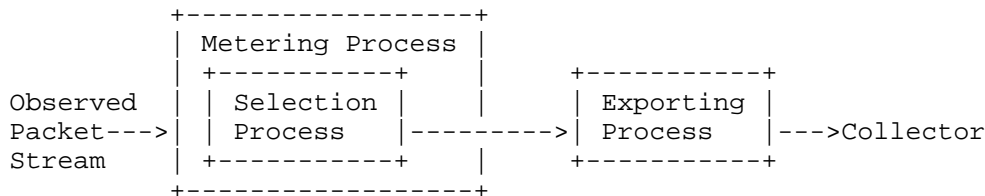
                    Figure B: PSAMP Processes

   The Selection Process, which takes an Observed Packet Stream as its
   input, is an integral part of the Metering Process. The Selection
   Process chooses which packets from its input Packet Stream will be

reported on by the rest of the Metering Process. Note that a
"Process" is not necessarily implemented as a separate CPU thread.

3.3.2. Packet Report, Packet Interpretation, and Data Record

The PSAMP terminology speaks of Packet Report and Packet
Interpretation, while the IPFIX terminology speaks of Data Record and
(Options) Template Record. The PSAMP Packet Report, which comprises
information about the observed packet, can be viewed as analogous to
the IPFIX Data Record defined by a Template Record. The PSAMP Report
Interpretation, which comprises subsidiary information used for the
interpretation of the Packet Reports, can be viewed as analogous to
the IPFIX Data Record defined by an Options Template Record. This
Options Template Record contains subsidiary information, applicable
to the observed packet sent into the PSAMP Packet Report.

4. Differences between PSAMP and IPFIX

The output of the IPFIX working group relevant for this document is
structured into three documents:

    - IP Flow information architecture [RFC5470]

    - IPFIX protocol specifications [RFC5101]

    - IP Flow information export information model [RFC5102]

In the following sections, we investigate the differences between
IPFIX and PSAMP for each of those aspects.

4.1. Architecture Point of View

Traffic Flow measurement as described in the IPFIX requirements
[RFC3917] and the IPFIX architecture [RFC5470] can be separated into
two stages: packet processing and Flow processing. Figure C
illustrates these stages.

In stage 1, all processing steps act on packets. Packets are
captured, timestamped, selected by one or more selection steps, and
finally forwarded to packet classification that maps packets to
Flows. The packets' selection steps may include Filtering and
Sampling functions.

In stage 2, all processing steps act on Flows. After packets are
classified (mapped to Flows), Flows are generated (or updated if they
exist already). Flow generation and update steps may be performed
repeatedly for aggregating Flows. Finally, Flows are exported.

   Packet Sampling as described in the PSAMP framework [RFC5474] covers
   only stage 1 of the IPFIX architecture with the packet classification
   replaced by Packet Report export, while IPFIX covers stage 2 also, as
   it generates Flow Records out of the selected packets.

```
       IPFIX architecture                       PSAMP framework

      packet header                            packet header
       capturing      \                          capturing
          |           |                             |
       timestamping   |                          timestamping
          |           |                             |
          v           |                             v
    +------>+         |  stage 1:           +------>+
    |       |         | > packet            |       |
    |   packet        |   processing        |   packet
    |   selection     |                     |   selection
    |       |         |                     |       |
    +-------+         |                     +-------+
          |           |                             |
          v           |                             v
       packet         /                      Packet Report
      classification  \                         export
          |           |
          v           |
    +------>+         |
    |       |         |
    | Flow generation |
    |   and update    |  stage 2:
    |       |         | > Flow
    |       v         |   processing
    |     Flow        |
    |   selection     |
    |       |         |
    +-------+         |
          |           |
          v           |
       Flow Record    /
         export
```
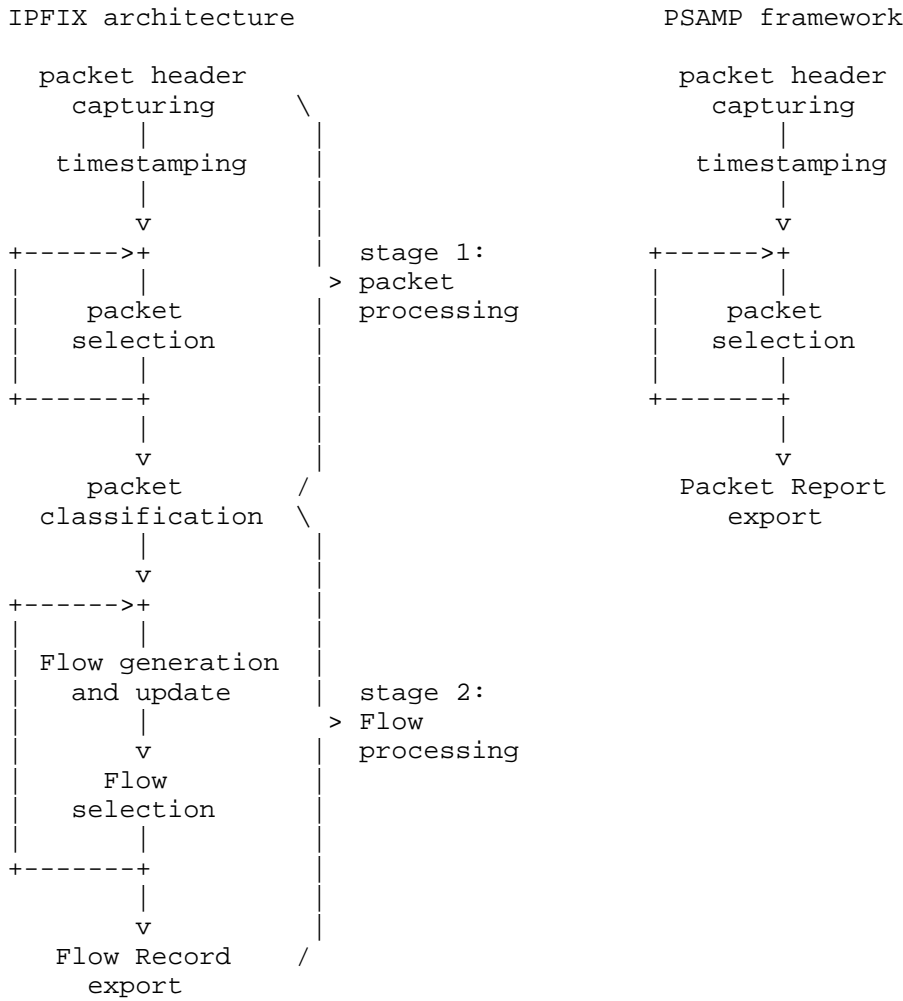
          Figure C: Comparison of IPFIX Architecture and PSAMP Framework

4.2. Protocol Point of View

   Concerning the protocol, the major difference between IPFIX and PSAMP
   is that the IPFIX protocol exports Flow Records while the PSAMP
   protocol exports Packet Reports. From a pure export point of view,
   IPFIX will not distinguish a Flow Record composed of several packets
   aggregated together from a Flow Record composed of a single packet.

   So the PSAMP export can be seen as a special IPFIX Flow Record
   containing information about a single packet.

   All extensions of the IPFIX protocol that are required to satisfy the
   PSAMP requirements have already been incorporated in the IPFIX
   protocol [RFC5101], which was developed in parallel with the PSAMP
   protocol. An example is the need for a data type for protocol fields
   that have flexible length, such as an octet array. This was added to
   the IPFIX protocol specification in order to meet the requirement of
   the PSAMP protocol to report content of captured packets, for
   example, the first octets of a packet.

4.3. Information Model Point of View

   From the information model point of view, the overlap between both
   the IPFIX and PSAMP protocols is quite large. Most of the
   Information Elements in the IPFIX protocol are also relevant for
   exporting packet information, for example, all fields reporting
   packet header properties. Only a few Information Elements, such as
   observedFlowTotalCount (whose value will always be 1 for PSAMP),
   etc., cannot be used in a meaningful way by the PSAMP protocol.
   Also, IPFIX protocol requirements concerning stage 2 of Figure C do
   not apply to the PSAMP Metering Process.

   Further required extensions apply to the information model. Even if
   the IPFIX charter speaks of Sampling, no Sampling-related Information
   Elements are specified in [RFC5102]. The task of specifying them was
   intentionally left for the PSAMP information model [RFC5477]. A set
   of several additional fields is required for satisfying the
   requirements for the PSAMP information model [RFC5475].

   Exploiting the extensibility of the IPFIX information model, the
   required extension is covered by the PSAMP information model
   specified in [RFC5477].

5. PSAMP Requirements versus the IPFIX Solution

   The [RFC5474] contains PSAMP protocol requirements throughout the
   document, with a special focus in Section 4, "Generic Requirements
   for PSAMP", and its subsections.

Section 4 of [RFC5474] describes one requirement that, if not
directly related to the export protocol, will put some constraints on
it. Parallel Measurements: multiple independent Selection Processes
at the same entity.

[RFC5474] also describes a series of requirements specifying the
different Information Elements that MUST and SHOULD be reported to
the Collector. Nevertheless, IPFIX, being a generic export protocol,
can export any Information Elements as long as they are described in
the information model. So these requirements are mainly targeted for
[RFC5477].

The PSAMP protocol specification meets almost all the protocol
requirements stated in the PSAMP framework document [RFC5474]:

   * Extensibility

   * Parallel selection processes

   * Encrypted packets

   * Indication of information loss

   * Accuracy

   * Privacy

   * Timeliness

   * Congestion avoidance

   * Secure export

   * Export rate limit

   * Microsecond timestamp resolution

The only requirement that is not met is Export Packet compression.
With the choice of IPFIX as the PSAMP export protocol, the Export
Packet compression option mentioned in the Section 8.5 of the
framework document [RFC5474] is not addressed.

5.1. High-Level View of the Integration

The Template Record in the Template Set is used to describe the
different PSAMP Information Elements that will be exported to the
Collector. The Collector decodes the Template Record in the Template
Set and knows which Information Elements to expect when it receives

the Data Records in the PSAMP Packet Report Data Set. Typically, in
the base level of the PSAMP functionality, the Template Set will
contain the input sequence number, the packet fragment (some number
of contiguous bytes from the start of the packet or from the start of
the payload), and the Selection Sequence.

The Options Template Record in the Options Template Set is used to
describe the different PSAMP Information Elements that concern the
Metering Process itself: Sampling and/or Filtering functions, and the
associated parameters. The Collector decodes the Options Template
Records in the Options Template Set and knows which Information
Elements to expect when it receives the Data Records in the PSAMP
Report Interpretation Data Set. Typically, the Options Template
would contain the Selection Sequence, the Sampling or Filtering
functions, and the Sampling or Filtering associated parameters.

PSAMP requires all the different possibilities of the IPFIX protocol
specifications [RFC5101], that is, the three types of Sets (Data Set,
Template Set, and Options Templates Set) with the two types of
Template Records (Template Record and Options Template Record), as
described in Figure A. As a consequence, PSAMP can't rely on a
subset of the IPFIX protocol specifications described in [RFC5101].
The entire IPFIX protocol specifications [RFC5101] MUST be
implemented for the PSAMP protocol.

6. Using the IPFIX Protocol for PSAMP

In this section, we describe the usage of the IPFIX protocol for
PSAMP. We describe the record formats and the additional
requirements that must be met. PSAMP uses two different types of
messages:

   - Packet Reports

   - Report Interpretation

The format of Packet Reports is defined in IPFIX Template Records.
The PSAMP data is transferred as Information Elements in IPFIX Data
Records as described by the Template Record. There are two different
types of Packet Reports. Basic Packet Reports contain only the basic
Information Elements required for PSAMP reporting. Extended Packet
Reports MAY contain other Information Elements, and do not
necessarily include Packet Content (See section 6.4.2).

The format of Report Interpretations is defined in the IPFIX Options
Template Record. The Information Elements are transferred in IPFIX
Data Records as described by the Options Template Record. There are
four different types of Report Interpretation messages:

        - Selection Sequence Report Interpretation

        - Selector Report Interpretation

        - Selection Sequence Statistics Report Interpretation

        - Accuracy Report Interpretation

   A description and examples about the usage of those reports are given
   below.

6.1. Selector ID

   The Selector ID is the unique ID identifying a Primitive Selector.
   Each Primitive Selector MUST have a unique ID within the Observation
   Domain. The Selector ID is represented by the selectorId Information
   Element [RFC5477].

6.2. The Selection Sequence ID

   From all the packets observed at an Observation Point, a subset of
   packets is selected by one or more Selectors. The Selection Sequence
   is the combination of an Observation Point and one or more
   Selector(s) through which the packets are selected. The Selection
   Sequence ID is a unique value representing that combination. The
   Selection Sequence ID is represented by the selectionSequenceId
   Information Element [RFC5477].

6.3. The Exporting Process

   An Exporting Process MUST be able to limit the export rate according
   to a configurable value. The Exporting Process MAY limit the export
   rate on a per Collecting Process basis.

6.4. Packet Report

   For each Selection Sequence, for each selected packet, a Packet
   Report MUST be created. The format of the Packet Report is specified
   in a Template Record contained in a Template Set.

   There are two types of Packet Report, as described in [RFC5474]: the
   basic Packet Report and the extended Packet Report.

6.4.1. Basic Packet Report

   For each selected packet, the Packet Report MUST contain the
   following information:

   - The selectionSequenceId Information Element
     If there is a digest function in the Selection Sequence, the Packet
     Report MUST contain the hash value (digestHashValue Information
     Element) generated by the digest Hash Function for each selected
     packet. If there is more than one digest function, then each hash
     value MUST be included in the same order as they appear in the
     Selection Sequence. If there are no digest functions in the
     Selection Sequence, no element for the digest needs to be sent.

   - Some number of contiguous bytes from the start of the packet,
     including the packet header (which includes link layer, network
     layer, and other encapsulation headers) and some subsequent bytes
     of the packet payload. Alternatively, the number of contiguous
     bytes may start at the beginning of the payload. The
     dataLinkFrameSection, mplsLabelStackSection,
     mplsPayloadPacketSection, ipPacketSection, and
     ipPayloadPacketSection PSAMP Information Elements are available for
     this use.

   For each selected packet, the Packet Report SHOULD contain a time-
   related Information Element that matches the Metering Process time
   accuracy. Typically, the observationTimeMicroseconds Information
   Element. Other possible Information Elements are the
   observationTimeSeconds, the observationTimeMilliseconds, or the
   observationTimeNanoseconds.

   In the Packet Report, the PSAMP Device MUST be capable of exporting
   the number of observed packets and the number of packets selected by
   each instance of its Primitive Selectors (as described by the
   non-scope Information Elements of the Selection Sequence Statistics
   Report Interpretation), although it MAY be a configurable option not
   to include them. If exported, the Attained Selection Fraction may be
   calculated precisely for the Observed Packet Stream. The Packet
   Report MAY include only the final selector packetSelected, to act as
   an index for that Selection Sequence in the Selection Sequence
   Statistics Report Interpretation, which also allows the calculation
   of the Attained Selection Fraction.

   The contiguous Information Elements (dataLinkFrameSection,
   mplsLabelStackSection, mplsPayloadPacketSection, ipPacketSection, and
   ipPayloadPacketSection) MAY be encoded with a fixed-length field or
   with a variable-sized field. If one of these Information Elements is
   encoded with a fixed-length field whose length is too long for the
   number of contiguous bytes in the selected packet, padding MUST NOT
   be used. In this case, the Exporting Process MUST export the
   information either in a new Template Record with the correct fixed-
   length field or in a new Template Record with a variable-length
   field.

Here is an example of a basic Packet Report, with a
SelectionSequenceId value of 9 and dataLinkFrameSection Information
Element of 12 bytes, 0x4500 005B A174 0000 FF11 832E, encoded with a
fixed-length field.

IPFIX Template Record:

```
      0                   1                   2                   3
      0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |          Set ID = 2           |          Length = 24          |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |        Template ID = 260      |        Field Count = 4        |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |   selectionSequenceId = 301   |        Field Length = 4       |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |      digestHashValue = 326    |        Field Length = 4       |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |    dataLinkFrameSection = 315 |        Field Length = 12      |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |observationTimeMicroseconds=324|        Field Length = 4       |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The associated IPFIX Data Record:

```
      0                   1                   2                   3
      0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |         Set ID = 260          |          Length = 32          |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                               9                               |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                          0x9123 0613                          |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                          0x4500 005B                          |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                          0xA174 0000                          |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                          0xFF11 832E                          |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                       observation time ...                    |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |       ... encoded as dateTimeMicroSeconds [RFC5101]           |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure D: Example of a Basic Packet Report

Here is an example of a basic Packet Report, with a
SelectionSequenceId value of 9 and ipHeaderPacketSection Information
Element of 12 bytes, 0x4500 005B A174 0000 FF11 832E, encoded with a
variable-sized field.

IPFIX Template Record:

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |            Set ID = 2         |          Length = 16          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |        Template ID = 261      |         Field Count = 2       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |    selectionSequenceId = 301  |        Field Length = 4       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |  ipHeaderPacketSection = 313  |      Field Length = 65535     |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The associated IPFIX Data Record:

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |           Set ID = 261        |           Length = 21         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                               9                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | Length = 12  |                  0x4500 ...                    |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   ... 005B   |                  0xA174 ...                    |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   ... 0000   |                  0xFF11 ...                    |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   ... 832E   |
   +-+-+-+-+-+-+-+-+
```

                 Figure E: Example of a Basic Packet Report
                       with a Variable-Sized Field

6.4.2. Extended Packet Report

   Alternatively to the basic Packet Report, the extended Packet Report
   MAY contain other Information Elements related to the protocols used
   in the packet (such as source and destination IP addresses), related
   to the packet treatment (such as output interface, destination BGP
   autonomous system [RFC4271]), or related to the Selection State
   associated with the packet (such as timestamp, hash value).

   It is envisaged that selection of fields for extended Packet Reports
   may be used to reduce reporting bandwidth, in which case the option
   to report some number of contiguous bytes from the start of the
   packet, mandatory in the basic Packet Report, may not be exercised.
   In this case, the Packet Content MAY be omitted. Note this
   configuration is quite similar to an IPFIX Device for which a
   Template Record containing information about a single packet is
   reported.

   Example of a detailed Extended Packet Report:

   IPFIX Template Record:

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |            Set ID =  2         |          Length = 32          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |        Template ID = 261       |        Field Count = 6        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |0|   selectionSequenceId = 301  |        Field Length = 4       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |0|    sourceIPv4Address = 8     |        Field Length = 4       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |0| destinationIPv4Address = 12 |        Field Length = 4       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |0|    totalLengthIPv4 = 190     |        Field Length = 2       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |0|     tcpSourcePort = 182      |        Field Length = 2       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |0|   tcpDestinationPort = 183   |        Field Length = 2       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The associated IPFIX Data Record:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          Set ID = 261         |            Length = 20        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                               9                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           192.0.2.1                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          192.0.2.106                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              72               |             1372              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              80               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
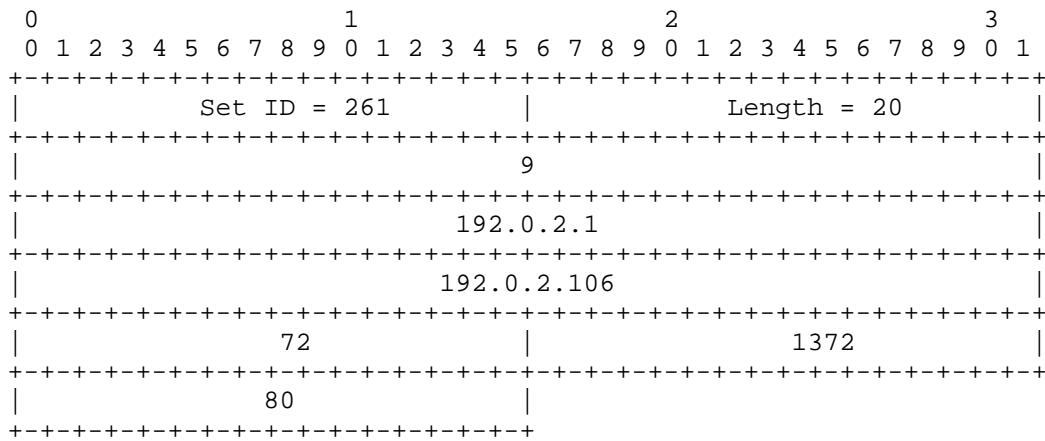
Figure F: Example of an Extended Packet Report

6.5. Report Interpretation

   To make full sense of the Packet Reports, there are a number of
   additional pieces of information that must be communicated to the
   Collector:

   - The details about which Selectors and Observation Points are being
     used within a Selection Sequence MUST be provided using the
     Selection Sequence Report Interpretation.

   - The configuration details of each Selector MUST be provided using
     the Selector Report Interpretation.

   - The Selector ID statistics MUST be provided using the Selection
     Sequence Statistics Report Interpretation.

   - The accuracies of the reported fields MUST be provided using the
     Accuracy Report Interpretation.

6.5.1. Selection Sequence Report Interpretation

   Each Packet Report contains a selectionSequenceId Information Element
   that identifies the particular combination of Observation Point and
   Selector(s) used for its selection. For every selectionSequenceId
   Information Element in use, the PSAMP Device MUST export a Selection
   Sequence Report Interpretation using an Options Template with the
   following Information Elements:

   Scope: selectionSequenceId
   Non-Scope: one Information Element mapping the Observation Point
              selectorId (one or more)

   An Information Element representing the Observation Point would
   typically be taken from the ingressInterface, egressInterface,
   lineCardId, exporterIPv4Address, or exporterIPv6Address Information
   Elements (specified in [RFC5102]), but is not limited to those: any
   Information Element specified in [RFC5102] or [RFC5477] can
   potentially be used. In case of more complex Observation Points
   (such as a list of interfaces, a bus, etc.), a new Information
   Element describing the new type of Observation Point must be
   specified, along with an Options Template Record describing it in
   more detail (if necessary).

   If the packets are selected by a Composite Selector, the Selection
   Sequence is composed of several Primitive Selectors. In such a case,
   the Selection Sequence Report Interpretation MUST contain the list of
   all the Primitive Selector IDs in the Selection Sequence. If
   multiple Selectors are contained in the Selection Sequence Report
   Interpretation, the selectorId's MUST be identified in the order they
   are used.

   Example of two Selection Sequences:

   Selection Sequence 7 (Filter->Sampling):
     ingressInterface   5
     selectorId   5 (Filter, match IPV4SourceAddress 192.0.2.1)
     selectorId   10 (Sampler, Random 1 out-of ten)

   Selection Sequence 9 (Sampling->Filtering):
     ingressInterface   5
     selectorId   10 (Sampler, Random 1 out-of ten)
     selectorId   5 (Filter, match IPV4SourceAddress 192.0.2.1)

IPFIX Options Template Record:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             Set ID = 3        |           Length = 26         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Template ID = 262     |        Field Count = 4        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      Scope Field Count =  1   |0| selectionSequenceId = 301   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       Scope 1 Length = 4      |0|    ingressInterface = 10    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       Field Length = 4        |0|      selectorId = 302       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       Field Length = 4        |0|      selectorId = 302       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       Field Length = 4        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The associated IPFIX Data Record:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             Set ID = 262      |           Length = 36         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                               7                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                               5                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                               5                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                              10                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                               9                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                               5                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                              10                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                               5                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure G: Example of a Selection Sequence Report Interpretation

Notes:

   * There are two Records here in the same Data Set. Each record
     defines a different Selection Sequence.

   * If, for example, a different Selection Sequence is composed of
     three Selectors, then a different Options Template with three
     selectorId Information Elements (instead of two) must be used.

6.5.2. Selector Report Interpretation

   An IPFIX Data Record, defined by an Options Template Record, MUST be
   used to send the configuration details of every Selector in use. The
   Options Template Record MUST contain the selectorId Information
   Element as the Scope field and the SelectorAlgorithm Information
   Element followed by some specific configuration parameters:

   Scope: selectorId
   Non-scope: selectorAlgorithm
               algorithm-specific Information Elements

   The algorithm-specific Information Elements are specified in the
   following subsections, depending on the selection method represented
   by the value of the selectorAlgorithm [RFC5477].

6.5.2.1. Systematic Count-Based Sampling

   In systematic count-based Sampling, the start and stop triggers for
   the Sampling interval are defined in accordance with the spatial
   packet position (packet count) [RFC5475].

   The REQUIRED algorithm-specific Information Elements in the case of
   systematic count-based Sampling are:

      samplingPacketInterval: number of packets selected in a row
      samplingPacketSpace: number of packets between selections

   Example of a simple 1 out-of 10 systematic count-based Selector
   definition, where the samplingPacketInterval is 1 and the
   samplingPacketSpace is 9.

IPFIX Options Template Record:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            Set ID = 3         |           Length = 26         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Template ID =  263     |        Field Count = 4        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Scope Field Count =  1    |0|       selectorId = 302      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       Scope 1 Length = 4      |0| selectorAlgorithm = 304     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       Field Length = 1        |0|samplingPacketInterval = 305 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       Field Length = 1        |0| samplingPacketSpace = 306   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       Field Length = 1        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Associated IPFIX Data Record:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            Set ID = 263       |          Length = 11          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                              15                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      1        |      1        |         9         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

        Figure H: Example of the Selector Report Interpretation
                  for Systematic Count-Based Sampling

   Notes:

   * A selectorAlgorithm value of 1 represents systematic count-based
     Sampling.

   * samplingPacketInterval and samplingPacketSpace are of type
     unsigned32 but are compressed down to one octet here, as allowed by
     the IPFIX protocol specifications [RFC5101].

6.5.2.2. Systematic Time-Based Sampling

   In systematic time-based Sampling, the start and stop triggers are
   used to define the Sampling intervals [RFC5475]. The REQUIRED
   algorithm-specific Information Elements in the case of systematic
   time-based Sampling are:

      samplingTimeInterval: time (in microseconds) when packets are
                            selected
      samplingTimeSpace: time (in microseconds) between selections

   Example of a 100 microsecond out-of 1000 microsecond systematic
   time-based Selector definition, where the samplingTimeInterval is 100
   and the samplingTimeSpace is 900.

   IPFIX Options Template Record:

        0   1   2   3
        0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
       +-+
       | Set ID = 3 | Length = 26 |
       +-+
       | Template ID = 264 | Field Count = 4 |
       +-+
       | Scope Field Count = 1 |0| selectorId = 302 |
       +-+
       | Scope 1 Length = 4 |0| selectorAlgorithm = 304 |
       +-+
       | Field Length = 1 |0| samplingTimeInterval = 307 |
       +-+
       | Field Length = 1 |0| samplingTimeSpace = 308 |
       +-+
       | Field Length = 2 |
       +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

   Associated IPFIX Data Record:

        0   1   2   3
        0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
       +-+
       | Set ID = 264 | Length = 12 |
       +-+
       | 16 |
       +-+
       | 2 | 100 | 900 |
       +-+

           Figure I: Example of the Selector Report Interpretation

                    for Systematic Time-Based Sampling

     Notes:

     * A selectorAlgorithm value of 2 represents systematic time-based
        Sampling.

     * samplingTimeInterval and samplingTimeSpace are of type unsigned32
        but are compressed down here.

6.5.2.3. Random n-out-of-N Sampling

     In random n-out-of-N Sampling, n elements are selected out of the
     parent Population that consists of N elements [RFC5475]. The
     REQUIRED algorithm-specific Information Elements in case of random
     n-out-of-N Sampling are:

         samplingSize: number of packets selected
         samplingPopulation: number of packets in selection Population

     Example of a 1 out-of 10 random n-out-of-N Sampling Selector:

     IPFIX Options Template Record:

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |          Set ID = 3           |           Length = 26         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |       Template ID = 265       |         Field Count = 4       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |     Scope Field Count = 1     |0|        selectorId = 302     |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |      Scope 1 Length = 4       |0|   selectorAlgorithm = 304   |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |       Field Length = 1        |0|      samplingSize = 309     |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |       Field Length = 1        |0|  samplingPopulation = 310   |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |       Field Length = 1        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   Associated IPFIX Data Record:

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |          Set ID = 265         |          Length = 11          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                              17                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |       3       |       1       |      10       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

           Figure J: Example of the Selector Report Interpretation
                      for Random n-out-of-N Sampling

   Notes:

   * A selectorAlgorithm value of 3 represents Random n-out-of-N
     Sampling.

   * samplingSize and samplingPopulation are of type unsigned32 but are
     compressed down to one octet here.

6.5.2.4. Uniform Probabilistic Sampling

   In uniform probabilistic Sampling, each element has the same
   probability p of being selected from the parent Population [RFC5475].
   The algorithm-specific Information Element in case of uniform
   probabilistic Sampling is:

      samplingProbability: a floating point number for the Sampling
                           probability.

Example of a 15% uniform probability Sampling Selector:

IPFIX Options Template Record:

```
     0                   1                   2                   3
     0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |           Set ID = 3          |           Length = 22         |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |        Template ID = 271      |         Field Count = 3       |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |      Scope Field Count = 1    |0|        selectorId = 302     |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |        Field Length = 4       |0|   selectorAlgorithm = 304   |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |        Field Length = 1       |0| samplingProbability = 311   |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |        Field Length = 4       |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Associated IPFIX Data Record:

```
     0                   1                   2                   3
     0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |          Set ID = 271         |          Length = 11          |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                              20                               |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |      4        |                     0.15                      |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |              |
    +-+-+-+-+-+-+-+-+
```

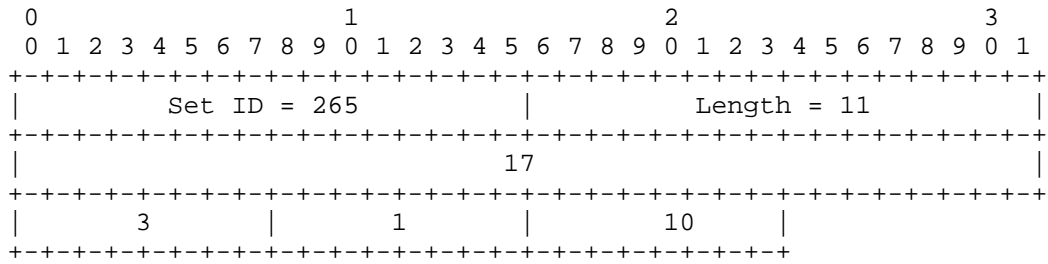   Figure K: Example of the Selector Report Interpretation
                     for Uniform Probabilistic Sampling

Notes:

   * A selectorAlgorithm value of 4 represents Uniform Probabilistic
     Sampling.

   * samplingProbability is of type float64 but is compressed down to a
     float32 here.

6.5.2.5. Property Match Filtering

   This classification includes match(es) on field(s) within a packet
   and/or on properties of the router state. With this method, a packet
   is selected if a specific field in the packet equals a predefined
   value.

   The algorithm-specific Information Elements defining configuration
   parameters for Property Match Filtering are taken from the full range
   of available Information Elements.

   When multiple different Information Elements are defined, the filter
   acts as a logical AND. Note that the logical OR is not covered by
   these PSAMP specifications. The Property Match Filtering Options
   Template Record MUST NOT have multiple identical Information
   Elements. The result of the filter is independent from the order of
   the Information Elements in the Options Template Record, but the
   order may be important for implementation purposes, as the first
   filter will have to work at a higher rate. In any case, an
   implementation is not constrained to respect the filter ordering as
   long as the result is the same, and it may even implement the
   composite Filtering in one single step.

   Since encryption alters the meaning of encrypted fields, when the
   Property Match Filtering classification is based on the encrypted
   field(s) in the packet, it MUST be able to recognize that the
   field(s) are not available and MUST NOT select those packets unless
   specifically directed by the Information Element description. Even
   if they are ignored, the encrypted packets MUST be accounted for in
   the Selector packetsObserved Information Element [RFC5477], part of
   the Selection Sequence Statistics Report Interpretation.

   Example of a match-based filter Selector, whose rules are:
      IPv4 Source Address   = 192.0.2.1
      IPv4 Next-Hop Address = 192.0.2.129

IPFIX Options Template Record:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              Set ID =  3      |            Length = 26        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Template ID = 266   |         Field Count = 4       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       Scope Field Count = 1   |0|      selectorId = 302       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Scope 1 Length = 4     |0| selectorAlgorithm = 304     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Field Length = 1      |0|    sourceIPv4Address = 8    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Field Length = 4      |0|  ipNextHopIPv4Address = 15  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Field Length = 4      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Associated IPFIX Data Record:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            Set ID = 266       |          Length = 11          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                             21                                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      5        |                   192.0.2 ...                 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| ... .1        |                   192.0.2 ...                 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| ... .129      |
+-+-+-+-+-+-+-+-+
```

               Figure L: Example of the Selector Report Interpretation
                    for Match-Based and Router State Filtering

   Notes:

   * A selectorAlgorithm value of 5 represents Property Match Filtering.

   * In this filter, there is a mix of information from the packet and
      information from the router.

6.5.2.6. Hash-Based Filtering

   In Hash-based Selection, a Hash Function is run on IPv4 traffic. The
   following fields MUST be used as input to that Hash Function:

      - IP identification field

      - Flags field

      - Fragment offset

      - Source IP address

      - Destination IP address

      - A number of bytes from the IP payload. The number of bytes and
        starting offset MUST be configurable if the Hash Function
        supports it.

   For the bytes taken from the IP payload, IPSX has a fixed offset of 0
   bytes and a fixed size of 8 bytes. The number and offset of payload
   bytes in the BOB function MUST be configurable.

   The minimum configuration ranges MUST be as follows:

      Number of bytes: from 8 to 32
      Offset: from 0 to 64

   If the selected payload bytes are not available and the Hash Function
   can take a variable-sized input, then the Hash Function MUST be run
   with the information that is available and a shorter size. Passing 0
   as a substitute for missing payload bytes is only acceptable if the
   Hash Function takes a fixed size as is the case with IPSX.

   If the Hash Function can take an initialization value, then this
   value MUST be configurable.

   A Hash-based Selection function MAY be configurable as a digest
   function. Any Selection Process that is configured as a digest
   function MUST have the output value included in the basic Packet
   Report for any selected packet.

   Each Hash Function used as a Hash-based Selection Selector requires
   its own value for the selectorAlgorithm. Currently, we have BOB (6),
   IPSX (7), and CRC (8) defined and any MAY be used for either
   Filtering or creating a Packet Digest. Only BOB is recommended
   though and SHOULD be used.

The REQUIRED algorithm-specific Information Elements in case of
Hash-based Selection are:

hashIPPayloadOffset   - The payload offset used by a Hash-based
                          Selection Selector

hashIPPayloadSize   - The payload size used by a Hash-based
                          Selection Selector

hashOutputRangeMin   - One or more values for the beginning of each
                          potential output range.

hashOutputRangeMax   - One or more values for the end of each
                          potential output range.

hashSelectedRangeMin   - One or more values for the beginning of each
                          selected range.

hashSelectedRangeMax   - One or more values for the end of each
                          selected range.

hashDigestOutput   - A boolean value, TRUE if the output from this
                          Selector has been configured to be included
                          in the Packet Report as a packet digest.

Note: If more than one selection or output range needs to be sent,
then the minimum and maximum elements may be repeated as needed.
These MUST make one or more non-overlapping ranges. The elements
SHOULD be sent as pairs of minimum and maximum in ascending order;
however, if they are sent out of order, then there will only be one
way to interpret the ranges to produce a non-overlapping range and
the Collecting Process MUST be prepared to accept and decode this.

The following algorithm-specific Information Element MAY be sent, but
is optional for security considerations:

hashInitialiserValue - The initialiser value to the Hash Function.

Since encryption alters the meaning of encrypted fields, when the
Hash-based Filtering classification is based on the encrypted
field(s) in the packet, it MUST be able to recognize that the
field(s) are not available and MUST NOT select those packets. Even
if they are ignored, the encrypted packets MUST be accounted for in
the Selector packetsObserved Information Element [RFC5477], which is
part of the Selection Sequence Statistics Report Interpretation.

Example of a Hash-based Filter Selector, whose configuration is:
```
   Hash Function         = BOB
   Hash IP Payload Offset = 0
   Hash IP Payload Size  = 16
   Hash Initialiser Value = 0x9A3F9A3F
   Hash Output Range     = 0 to 0xFFFFFFFF
   Hash Selected Range   = 100 to 200 and 400 to 500
```

IPFIX Options Template Record:

```
0                   1                   2                   3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             Set ID =  3        |           Length = 50         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Template ID = 269       |         Field Count = 8       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      Scope Field Count = 1     |0|       selectorId = 302      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       Scope 1 Length = 4       |0|    selectorAlgorithm = 302  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Field Length = 1        |0|   hashIPpayloadOffset = 327 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Field Length = 4        |0|    hashIPpayloadSize = 328  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Field Length = 4        |0| hashInitialiserValue = 329  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Field Length = 4        |0|    hashOutputRangeMin = 330 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Field Length = 4        |0|    hashOutputRangeMax = 331 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Field Length = 4        |0|  hashSeletionRangeMin = 332 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Field Length = 4        |0|  hashSeletionRangeMax = 333 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Field Length = 4        |0|  hashSeletionRangeMin = 332 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Field Length = 4        |0|  hashSeletionRangeMax = 333 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Field Length = 4        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Associated IPFIX Data Record:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Set ID = 266        |           Length = 45         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                              22                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       6       |                      ...                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| ...   0       |                      ...                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| ...  16       |                  0x9A3F9A ...                 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| ...  3F       |                      ...                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| ...   0       |                 0xFFFFFF ...                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| ...  FF       |                     ... 100                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      ...      |                     ... 200                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      ...      |                     ... 400                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      ...      |                     ... 500                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      ...      |
+-+-+-+-+-+-+-+-+
```

           Figure M: Example of the Selector Report Interpretation
                        for Hash-based Filtering

   Notes:

    * A selectorAlgorithm value of 6 represents Hash-based Filtering
      using the BOB algorithm.

6.5.2.7. Other Selection Methods

   Some potential new selection methods MAY be added. Some of the new
   selection methods, such as non-uniform probabilistic Sampling and
   flow-state-dependent Sampling, are described in [RFC5475], with
   further references.

Each new selection method MUST be assigned a unique value for the
selectorAlgorithm Information Element. Its configuration
parameter(s), along with the way to report it/them with an Options
Template, MUST be clearly specified.

6.5.3. Selection Sequence Statistics Report Interpretation

A Selector MAY be used in multiple Selection Sequences. However,
each use of a Selector must be independent, so each separate logical
instance of a Selector MUST maintain its own individual Selection
State and statistics.

The Selection Sequence Statistics Report Interpretation MUST include
the number of observed packets (Population Size) and the number of
packets selected (Sample Size) by each instance of its Primitive
Selectors.

Within a Selection Sequence composed of several Primitive Selectors,
the number of packets selected for one Selector is equal to the
number of packets seen by the next Selector. The order of the
Selectors in the Selection Sequence Statistics Report Interpretation
MUST match the order of the Selectors in the Selection Sequence.

If the full set of statistics is not sent as part of the Basic Packet
Reports, the PSAMP Device MUST export a Selection Sequence Statistics
Report Interpretation for every Selection Sequence, using an Options
Template containing the following Information Elements:

        Scope: selectionSequenceId
        Non-scope: packetsObserved
                        packetsSelected (first Selector)
                        ...
                        packetsSelected (last Selector)

The packetsObserved Information Element [RFC5477] MUST contain the
number of packets seen at the Observation Point, and as a consequence
passed to the first Selector in the Selection Sequence. The
packetsSelected Information Element [RFC5477] contains the number of
packets selected by a Selector in the Selection Sequence.

The Attained Selection Fraction for the Selection Sequence is
calculated by dividing the number of selected packets
(packetsSelected Information Element) for the last Selector by the
number of observed packets (packetsObserved Information Element).
The Attained Selection Fraction can be calculated for each Selector
by dividing the number of packets selected for that Selector by the
value for the previous Selector.

   The statistics for the whole sequence SHOULD be taken at a single
   logical point in time; the input value for a Selector MUST equal the
   output value of the previous Selector.

   The Selection Sequence Statistics Report Interpretation MUST be
   exported periodically.

   Example of Selection Sequence Statistics Report Interpretation:

   Selection Sequence 7 (Filter->Sampling):

      Observed   100 (observationPointId 1, Interface 5)
      Selected   50 (selectorId 5, match IPV4SourceAddress 192.0.2.1)
      Selected   6 (selectorId 10, Sampler: Random one out-of ten)

   Selection Sequence 9 (Sampling->Filtering):

      Observed   100 (observationPointId 1, Interface 5)
      Selected   10 (selectorId 10, Sampler: Random one out-of ten)
      Selected   3 (selectorId 5, match IPV4SourceAddress 192.0.2.1)

   IPFIX Options Template Record:

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |            Set ID = 3         |            Length = 26        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |        Template ID = 267      |         Field Count = 4       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |      Scope Field Count = 1    |0| selectionSequenceId = 301   |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |      Scope 1 Length = 4       |0|    packetsObserved = 318    |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |       Field Length = 4        |0|    packetsSelected = 319    |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |       Field Length = 4        |0|    packetsSelected = 319    |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |        Field Length = 4       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The associated IPFIX Data Record:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          Set ID =  267        |          Length = 36          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                               7                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                              100                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                              50                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                               6                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                               9                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                              100                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                              10                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                               3                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

                 Figure N: Example of the Selection Sequence Statistics
                              Report Interpretation

   Notes:

   * The Attained Selection Fractions for Selection Sequence 7 are:
           Filter 10: 50/100
           Sampler 5: 6/50
           Number of samples selected: 6

   * The Attained Selection Fractions for Selection Sequence 9 are:
           Sampler 5: 10/100
           Filter 10: 3/10
           Number of samples selected: 3

6.5.4. Accuracy Report Interpretation

   In order for the Collecting Process to determine the inherent
   accuracy of the reported quantities (for example, timestamps), the
   PSAMP Device SHOULD send an Accuracy Report Interpretation.

   The Accuracy Report Interpretation MUST be exported by an Options
   Template Record with a scope that contains the Information Element
   for which the accuracy is required. In case the accuracy is specific

to a template, a second scope containing the templateId value MUST be
added to the Options Template Record. The accuracy SHOULD be
reported either with the absoluteError Information Element [RFC5477]
or with the relativeError Information Element [RFC5477].

Accuracy Report Interpretation using the absoluteError Information
Element:
 Scope: informationElementId
 Non-scope: absoluteError

Accuracy Report Interpretation using the absoluteError Information
Element and a double scope:
 Scope: templateId
            informationElementId
 Non-scope: absoluteError

Accuracy Report Interpretation using the relativeError Information
Element:
 Scope: informationElementId
 Non-scope: relativeError

Accuracy Report Interpretation using the relativeError Information
Element and a double scope:
 Scope: templateId
            informationElementId
 Non-scope: relativeError

For example, the accuracy of an Information Element whose Abstract
Data Type is dateTimeMilliseconds [RFC5102], for which the unit is
specified as milliseconds, can be specified with the absoluteError
Information Element with the milliseconds units. In this case, the
error interval is the Information Element value +/- the value
reported in the absoluteError.

For example, the accuracy of an Information Element to estimate the
accuracy of a sampled flow, for which the unit would be specified in
octets, can be specified with the relativeError Information Element
with the octet units. In this case, the error interval is the
Information Element value +/- the value reported in the relativeError
times the reported Information Element value.

An alternative to reporting either the absoluteError Information
Element or the relativeError Information Element in the Accuracy
Report Interpretation, is to report both. For this case whatever is
least accurate for the reported value should be used.

If the accuracy of a reported quantity changes on the Metering
Process, a new Accuracy Report Interpretation MUST be generated. The

   Collecting Process MUST keep the accuracy of the latest Accuracy
   Report Interpretation.

   Example of an Accuracy Report Interpretation using the absoluteError
   Information Element and a double scope: the timeMicroseconds
   contained in the Template 5 has an accuracy of +/- 2 ms, represented
   by the absoluteError Information Element.

   Scope: templateId = 6
               informationElementId = timeMicroseconds
   Non-scope: absoluteError = 2 ms

   IPFIX Options Template Record:

```
     0                   1                   2                   3
     0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |            Set ID = 3          |          Length = 22          |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |        Template ID = 267       |         Field Count = 3       |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |      Scope Field Count = 2     |0|        templateId = 145     |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |       Scope 1 Length = 2       |0| InformationElementId = 303  |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |       Scope 2 Length = 2       |0|      absoluteError = 320    |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |       Field Length = 4         |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   The associated IPFIX Data Record:

```
     0                   1                   2                   3
     0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |          Set ID =  267         |          Length = 12          |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |               5               |               324             |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                   2  (encoded as a float32)                   |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

                 Figure O: Example of the Selection Sequence
                      Statistics Report Interpretation

   Notes:

   * absoluteError is of type float64 but is compressed down to a
     float32 here.

   The second example displays an Accuracy Report Interpretation using
   the relativeError Information Element and a single scope: the
   timeMicroseconds has an error of 5%, represented by the
   proportionalAccuracy Information Element.

   Scope: informationElementId = timeMicroseconds
   Non-scope: relativeError = 0.05

   IPFIX Options Template Record:

```
     0                   1                   2                   3
     0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |              Set ID = 3        |            Length = 18        |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |         Template ID = 268      |          Field Count = 2      |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |      Scope Field Count = 1     |0| InformationElementId = 303  |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |       Scope 1 Length = 2       |0|      relativeError= 321     |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |         Field Length = 4       |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   The associated IPFIX Data Record:

```
     0                   1                   2                   3
     0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |            Set ID =  267       |            Length = 10        |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |             324               |                     0.05 ...   |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    | ...(encoded as a float32)     |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

                 Figure P: Example of the Selection Sequence
                     Statistics Report Interpretation

   Notes:

   * relativeError is of type float64 but is compressed down to a
     float32 here.

7. Security Considerations

   As IPFIX has been selected as the PSAMP export protocol and as the
   PSAMP security requirements are not stricter than the IPFIX security
   requirements, refer to the IPFIX export protocol [RFC5101] for the
   security considerations.

   In the basic Packet Report, a PSAMP Device exports some number of
   contiguous bytes from the start of the packet, including the packet
   header (which includes link layer, network layer, and other
   encapsulation headers) and some subsequent bytes of the packet
   payload. The PSAMP Device SHOULD NOT export the full payload of
   conversations, as this would mean wiretapping [RFC2804]. The PSAMP
   Device MUST respect local privacy laws.

8. IANA Considerations

   The PSAMP protocol, as set out in this document, has two sets of
   assigned numbers. Considerations for assigning them are discussed in
   this section, using the example policies as set out in [RFC5226],
   "Guidelines for IANA Considerations".

8.1. IPFIX-Related Considerations

   As the PSAMP protocol uses the IPFIX protocol, refer to the IANA
   considerations section in [RFC5101] for the assignments of numbers
   used in the protocol and for the numbers used in the information
   model.

8.2. PSAMP-Related Considerations

   Each new selection method MUST be assigned a unique value for the
   selectorAlgorithm Information Element [RFC5477]. Initial contents of
   this registry are found in Section 8.2.1 in [RFC5477]. Its
   configuration parameter(s), along with the way to report them with an
   Options Template, MUST be clearly specified.

   New assignments for the PSAMP selection method will be administered
   by IANA, on a First Come First Served basis [RFC5226], subject to
   Expert Review [RFC5226]. The group of experts must double check the
   Information Elements definitions with already defined Information
   Elements for completeness, accuracy, and redundancy. These experts
   will initially be drawn from the Working Group Chairs and document
   editors of the IPFIX and PSAMP Working Groups.

9. References

9.1. Normative References

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9.2. Informative References

   [RFC2804] IAB and IESG, "IETF Policy on Wiretapping", RFC 2804, May
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   [RFC5470] Sadasivan, G., Brownlee, N., Claise, B., and J. Quittek,
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10. Acknowledgments

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