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Use of IPFIX for Export of Per-Packet Information

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Use of IPFIX for Export of Per-Packet Information

Abstract

   This document describes the usage of the IP Flow Information
   Export (IPFIX) protocol for the case of exporting and processing
   per-packet information.
   The main idea is to export two types of records per flow: the
   first one contains the usual flow information plus a unique flow
   identifier while the other one consists of the actual per-packet
   information plus a flow identifier that refers to the flow the
   specific packet belongs to -- that means the flow identifier is
   used to associate the packet data to its corresponding flow.

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[1]. Introduction

   In the scope of passive QoS Measurements, there is often the
   need to exchange and export measurement data in a finer
   granularity then per flows. One typical application is passive
   One-Way-Delay measurement; this draft takes it as example when
   demonstrating the need for information export on a per-packet
   basis.

   The IPFIX protocol however, has been designed to export flow
   records. A possible approach to export packet records using
   IPFIX could be exporting flow records containing information
   about single packets. This method has been proposed by the PSAMP
   working group in [Cla204]. Exporting flow related information
   per-packet introduces a high degree of redundancy. This draft
   shows how packet information and flow information can be

efficiently exported and related using IPFIX.

2. **Terminology**

Collecting Process
     The collecting process receives records of flow or packet
     information. The data is stored for later processing (by
     the calculation process)

Exporting Process
     The exporting processes send flow and packet records to the
     collecting processes. The records are generated by the
     measurement process.

Filtering

     Filtering selects a subset of packets by applying
     deterministic functions on parts of the packet content like
     header fields or parts of the payload. A filtering process
     needs to process the packet (look at packet header and/or
     payload) in order to make the selection decision.

  Measurement Device
     A measurement device has access to at least one observation
     point. It is hosting at least one measurement process and
     one export process.

  Metering/Measurement Process
     The measurement process generates records of packet and
     flow information. Packets passing the observation point are
     captured, time stamped, filtered and classified. The
     measurement process calculates the packet Ids.

  Passive One-Way-Delay Measurement
     Abbreviated: POWD Measurement

3. **General Problem Statement**

  In [Cla104] the IPFIX working group has defined a protocol to
  transport measurement data containing flow information.

  The main purpose of the protocol is to exchange information
  about IP traffic flows. In this scope a flow is defined by a set
  of key attributes (source/destination address,
  source/destination port, Layer3 Protocol Type, TOS/DSCP byte,
  interface of the flow exporting network element). As such, a
  flow is a collection of packets that share a set of common
  attributes.

  However, for a number of metrics there is a need to export
  per-packet data.

  Undoubtedly a single packet could be considered a special case
  of a flow and thus, per-packet information could be exported
  using flow records. Doing this though would have consequences on
  the efficiency of the exporting procedure, as it would mean
  additional overhead. Packets belonging to the same flow share
  common attributes, i.e. source address, destination address,
  etc. Exporting these attributes on a per-packet basis, each time
  with a different packet ID, would be redundant information.

  There are cases however, where it is desirable to keep flow
  information along with the per-packet information, that is, when
  analyzing packet characteristics while observing flows. This
  document proposes a solution that reduces the overhead caused by

the flow properties while keeping a link to flow information.

The proposed method does not need any changes to the IPFIX protocol.

[4](#). Export Per-Packet Information

Figure 2 depicts three packets belonging to flow A and one packet that belongs to flow B, respectively. It shows export records containing packet information plus flow information (source and destination address). Undoubtedly, the flow information introduces a huge amount of redundancy, as it is repeated for every packet in every record. Minimizing the redundancy is a common problem in relational data base design and we apply here similar solutions to those proposed in that area.

Use of IPFIX for Export of Per-Packet Information

In Figure 2 we separate flow from packet information. In order
to maintain the relation between Packet Properties and Flow
Properties we introduce indices (idxA and idxB) for the Flow
Properties that are unique for all Flow Property entries. The
purpose of the indices is to serve as "primary key" that
identifies rows of the Flow Properties. The rows are then
referenced by the Packet Properties by using the appropriate
value for the flow identifier.

```
One-packet flows
+------+------+------------+---------+
| srcA | dstA | packet info|   ...   |
+------+------+------------+---------+
| srcA | dstA | packet info|   ...   |
+------+------+------------+---------+
| srcB | dstB | packet info|   ...   |
+------+------+------------+---------+
| srcA | dstA | packet info|   ...   |
+------+------+------------+---------+
```

Figure 1: Flow and packet information represented in one-packet
flows

```
                                  Packet Properties
                                +-----+------------+---------+
Flow Properties                 >idxA | packet info|   ...   |
+------+------+-----+           +-----+------------+---------+
| srcA | dstA |idxA <           >idxA | packet info|   ...   |
+------+------+-----+           +-----+------------+---------+
| srcB | dstB |idxB <-------->idxB | packet info|   ...   |
+------+------+-----+           +-----+------------+---------+
                                >idxB | packet info|   ...   |
                                +-----+------------+---------+

        here, the linkage of one packet and
        flow B (srcB, dstB, idxB) is explicitly drawn
```

Figure 2: Flow information and packet information

The IPFIX protocol is template based like NetFlow version 9. For
a complete description of features of IPFIX refer to [Fehler!
Verweisquelle konnte nicht gefunden werden.].
Templates define the structure of data to be exported, including
describing data fields to be exported together with their type
and meaning.

For Measurement Process Results we define two different template
records, namely Flow Properties and Packet Properties. The Flow

Properties templates SHOULD be sent before the Packet Properties
Templates.

In Figure 3, the Flow Properties template defines the
attributes for a flow; e.g. IP source and destination address
and the flow identifier. The flow identifier is a unique
identifier for flow definitions; this field allows packet
records to reference flow attributes. Subsequent data records of
this template define the actual flows.

The format for the information related to single packets is
defined in the Packet Properties template. This information is
packet specific and normally not shared between many packets.
Otherwise one would rather consider the information as flow
related and therefore it needs not be exported in every record.

Use of IPFIX for Export of Per-Packet Information

```
+------------------+        +------------------+
| Template Set     |        | Template Set     |
|                  |        |                  |  Description of
| Flow Properties  |        | Packet Properties |  exported data
+----------+-------+        +----------+--------+
...........|.........................|.........................
           |                         |
+----------v-------+        +----------v--------+
| Data Set         |        | Data Set          |  exported data
|                  |<------+                    |  with references
| Flow Properties  |        | Packet Properties |  by means of
+------------------+        +------------------+  flow identfier
```
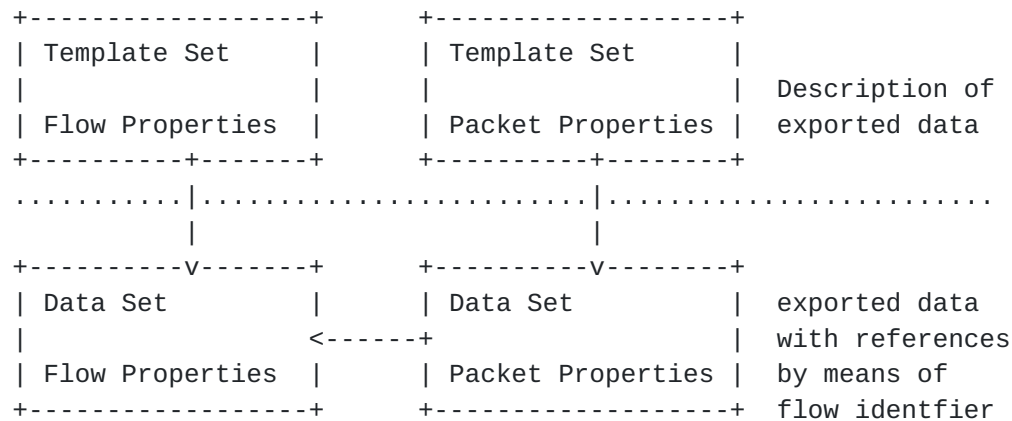
Figure 3: Template FlowSet and Data FlowSet dependencies

5. Flow ID Management

   Like template IDs the flow IDs have to be unique per observation
   domain (source identifier in the IPFIX header). Using 32 bit
   flow IDs allows the export of 2**32 active flows in parallel.

   If it is desired, one can optionally use option templates to
   specify the mapping between two flow and packet properties
   templates. In this case, the flow ID only has to be unique
   within this association.

6. Example of Per-Packet Information Export

   To demonstrate how to use IPFIX efficiently to export per-packet
   information, this section proposes how to use the IPFIX protocol
   for exporting flow information and per-packet information (in
   this case related to a long-lived flow) for OWD computation.

   In order to acquire a One-Way path delay information, two
   measurement points with synchronized clocks must exist, one at
   each end of the path under examination. Both measurement points
   will capture packets, assign them timestamps and generate an
   identifier for a packet passing that point. Each measurement
   point will export its measurement data to a collecting process
   where the data are correlated based on the packet identifiers
   and timestamps and then the delay is calculated as a difference
   of two timestamps of a packet pair.

   The templates that would be needed for exporting measurement
   data of this kind are illustrated in Figure 4.

The upper part of the figure shows the template containing the
information concerning flows. The lower part displays the
template with the packet properties.

For passive One-Way-Delay measurement, the Packet Properties
template consists of at least Timestamp and Packet ID.
Additionally, this template contains a flow identifier field. In
packet records, the value of this field will contain one of the
unique indices of the flow records exported before.

Use of IPFIX for Export of Per-Packet Information

```
+------------------+------------------+---------------------+..
| flowID           | sourceAddressV4  | destinationAddressV4 |
|                  |                  |                     |
| unsigned32/vendor | ipv4Address/ID 8 | ipv4Address/ID 12   |
+------------------+------------------+---------------------+..


..+------------------+------------------+---------------------+..
  | classOfServiceV4 | protocolIdentifier | transportSourcePort |
  |                  |                  |                     |
  | octet/ID 5       | octet/ID 4       | unsigned16/ID 7     |
..+------------------+------------------+---------------------+..


..+------------------------+
  | transportDestinationPort |
  |                        |
  | unsigned16/ID 11       |
..+------------------------+
                                                   FlowPropTemplate
==================================================================
                                                 PacketPropTemplate
+------------------+------------------+------------------+..
| packetTimestamp  | packetID         | packetLength     |
|                  |                  |                  |
| unsigned64/vendor | unsigned32/vendor | unsigned32/vendor |
+------------------+------------------+------------------+..


..+------------------+
  | flowID           |
  |                  |
  | unsigned32/vendor |
..+------------------+
```

Figure 4: Example Templates for Flow and Packet Properties

The delay is derived by a calculation step: At the collection
point packet records of two measurement points are gathered and
correlated by means of the packet ID. The resulting delay data
records are exported in a similar manner as the packet data have
been. Especially, the linkage between delay data and flow
information is represented with the discussed flow identifier
fields. The OWD properties contain the Packet Pair ID (which is
the packet ID matching that of the two contributing packet
records), a timestamp (which is the timestamp of the packet
passing the reference monitor point) in order to reconstruct a
time series, the calculated delay value, and finally a flow
identifier.

7. IPFIX for per-packet information export and PSAMP

   In [Cla204] the PSAMP working group proposes to use IPFIX to
   export packet information from a PSAMP Exporting Process to a
   PSAMP Collecting Process. Even though no new version of the
   draft has been produced the solution seems to be accepted from
   the group.
   While IPFIX is well suited for the purpose due to the good match
   between the IPFIX and PSAMP architectures and to the fact that
   IPFIX satisfies PSAMP requirements, the described approach has a
   high degree of redundancy. It proposes to treat packets as flows
   and export per-packet information using flow records.
   We propose to use the solution described in this draft to
   efficiently export PSAMP packet information.

8. Export and evaluation considerations

The main advantage of this proposed method to export per-packet information is the reduced amount of measurement data that has to be transferred from the exporter to the collector. In addition there is less storage capacity needed at the collector side.

On the other hand there is some extra processing power needed on the exporter side to manage flow information and to assign packets to flows. The collector has to process records of two templates instead of just one but has to read and write less data. Additional effort is needed when post processing the measurement data, because now the correlation of flow and packet information is needed.

In the above example (see Figure 4) using IPFIX to export the measurement data for each received packet 28 bytes have to be transferred (sourceAddressV4=4, destinationAddressV4=4, classOfServiceV4=1, protocolIdentifier=1, transportSourcePort=2, transportDestionationPort=2, packetTimestamp=8, packetID=4, packetLength=2). Disregarding the IPFIX protocol overhead a flow of 1000 packets produces 28000 bytes of measurement data. Using the proposed optimization each packet produces an export of only 16 bytes (packetTimestamp=8, packetID=4, packetLength=2, flowID=2). The export of the flow information produces 16 bytes (sourceAddressV4=4, destinationAddressV4=4, classOfServiceV4=1, protocolIdentifier=1, transportSourcePort=2, transportDestionationPort=2, flowID =2). For a flow of 1000 packet this sums up to 16016 bytes. This is a decrease of more than 40 percent.

9. IANA Consideration

This document does not imply any IANA action.

10. Security Considerations

For the proposed use of the IPFIX protocol for export of per-packet information the security considerations as for the IPFIX protocol apply.

11. References

11.1   Normative References

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