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Information Model for IP Flow Information eXport (IPFIX)
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Abstract

This memo defines an overview of the information model for the IP Flow Information eXport (IPFIX) protocol. It is used by the IPFIX protocol for encoding measured traffic information and information related to the traffic Observation Point, the traffic Metering Process, and the Exporting Process. Although developed for the IPFIX protocol, the model is defined in an open way that easily allows using it in other protocols, interfaces, and applications. This document obsoletes RFC 5102.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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Table of Contents

OPEN ISSUES:

* "revision", "date", "enterprise-specific" added from [IPFIX-IE-DOCTORS]. So we need to change the section 2.1. Harmonize with IE-DOCTORS section 12.

* Do we want to have a new column in IANA for the max length for string, arrary, and potentially others? DISCUSSION on the mailing list

Clarified the dateTimeSeconds and dateTimeMilliseconds. "excluding leap seconds" in the current definition is not clear according to Paul Aitken.

1. Introduction

The IP Flow Information eXport (IPFIX) protocol serves for transmitting information related to measured IP traffic over the Internet. The protocol specification in [RFC5101bis] defines how Information Elements are transmitted. For Information Elements, it specifies the encoding of a set of basic data types. However, the list of Information Elements that can be transmitted by the protocol, such as Flow attributes (source IP address, number of packets, etc.) and information about the Metering and Exporting Process (packet Observation Point, sampling rate, Flow timeout interval, etc.), is not specified in [RFC5101bis].

This document complements the IPFIX protocol specification by providing an overview of the IPFIX information model and specifying data types for it. IPFIX-specific terminology used in this document is defined in Section 2 of [RFC5101bis]. As in [RFC5101bis], these IPFIX-specific terms have the first letter of a word capitalized when used in this document.

The use of the term 'information model' is not fully in line with the definition of this term in [RFC3444]. The IPFIX information model does not specify relationships between Information Elements, but also it does not specify a concrete encoding of Information Elements. Besides the encoding used by the IPFIX protocol, other encodings of IPFIX Information Elements can be applied, for example, XML-based encodings.

The main part of this document is Section 5, which displays some of Information Elements to be transmitted by the IPFIX protocol. Section 2 defines a template for specifying IPFIX Information Elements in Section 5. Section 3 defines the set of abstract data types that are available for IPFIX Information Elements. Section 6 discusses extensibility of the IPFIX information model.

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 [RFC2119].

1.1. Changes since RFC 5102

This document obsoletes the Proposed Standard revision of the IPFIX Protocol Specification [RFC5102]. The following changes have been made to this document with respect to the previous document:

- EDITOR'S NOTE: not sure if we need to this information
  Errata ID: 1307 (technical)
  Errata ID: 1492 (technical)
  Errata ID: 1736 (technical)
  Errata ID: 2879 (editorial)
  Errata ID: 2944, which updates 1737 (technical)
  Errata ID: 2945, which updates 1738 (technical)
  Errata ID: 2946, which updates 1739 (technical)
  Updated the reference to RFC5101bis
  Clarified the time-related IEs

- Since this document is based on the IPFIX Draft Standard [RFC5101bis], all improvements have been taken into account. For example, the timestamps.- Instead of repeating every Information Elements from [RFC5102], a reference to the IPFIX IANA registry [IPFIX-IANA] is introduced. However the category in section 5 have

been kept.- The appendix A and B have been removed- Introduced [IPFIX-IE-DOCTORS]

1.2. IPFIX Documents Overview

The IPFIX protocol provides network administrators with access to IP flow information. The architecture for the export of measured IP flow information out of an IPFIX Exporting Process to a Collecting Process is defined in [RFC5470], per the requirements defined in [RFC3917]. The IPFIX specifications [RFC5101bis] document specifies how IPFIX data records and templates are carried via a number of transport protocols from IPFIX Exporting Processes to IPFIX Collecting Processes.

Four IPFIX optimizations/extensions are currently specified: a bandwidth saving method for the IPFIX protocol in [RFC5473], an efficient method for exporting bidirectional flow in [RFC5103], a method for the definition and export of complex data structures in [RFC6313], and the specification of the Protocol for IPFIX Mediations [IPFIX-MED-PROTO] based on the IPIFX Mediation Framework [RFC6183].

IPFIX has a formal description of IPFIX Information Elements, their name, type and additional semantic information, as specified in this document, with the export of the Information Element types specified in [RFC5610].

[IPFIX-CONF] specifies a data model for configuring and monitoring IPFIX and PSAMP compliant devices using the NETCONF protocol, while the [RFC5815bis] specifies a MIB module for monitoring.

In terms of development, [RFC5153] provides guidelines for the implementation and use of the IPFIX protocol, while [RFC5471] provides guidelines for testing.

Finally, [RFC5472] describes what type of applications can use the IPFIX protocol and how they can use the information provided. It furthermore shows how the IPFIX framework relates to other architectures and frameworks.

2. Properties of IPFIX Protocol Information Elements

2.1. Information Elements Specification Template

Information in messages of the IPFIX protocol is modeled in terms of Information Elements of the IPFIX information model. The IPFIX Information Elements mentioned in Section 5 are specified in [IPFIX-IANA]. For specifying these Information Elements, a template is used

that is described below.

All Information Elements specified for the IPFIX protocol either in this document or by any future extension MUST have the following properties defined:

name - A unique and meaningful name for the Information Element.

elementId - A numeric identifier of the Information Element. If this identifier is used without an enterprise identifier (see [RFC5101bis] and enterpriseId below), then it is globally unique and the list of allowed values is administered by IANA. It is used for compact identification of an Information Element when encoding Templates in the protocol.

description - The semantics of this Information Element. Describes how this Information Element is derived from the Flow or other information available to the observer.

dataType - One of the types listed in Section 3.1 of this document or in a future extension of the information model. The type space for attributes is constrained to facilitate implementation. The existing type space does however encompass most basic types used in modern programming languages, as well as some derived types (such as ipv4Address) that are common to this domain and useful to distinguish.

status - The status of the specification of this Information Element. Allowed values are 'current', 'deprecated', and 'obsolete'.

Enterprise-specific Information Elements MUST have the following property defined:

enterpriseId - Enterprises may wish to define Information Elements without registering them with IANA, for example, for enterprise-internal purposes. For such Information Elements, the Information Element identifier described above is not sufficient when the Information Element is used outside the enterprise. If specifications of enterprise-specific Information Elements are made public and/or if enterprise-specific identifiers are used by the IPFIX protocol outside the enterprise, then the enterprise-specific identifier MUST be made globally unique by combining it with an enterprise identifier. Valid values for the enterpriseId are defined by IANA as Structure of Management Information (SMI) network management private enterprise codes. They are defined at http://www.iana.org/assignments/enterprise-numbers.

All Information Elements specified for the IPFIX protocol either in this document or by any future extension MAY have the following properties defined:

dataTypeSemantics - The integral types may be qualified by additional semantic details. Valid values for the data type semantics are specified in Section 3.2 of this document or in a future extension of the information model.

units - If the Information Element is a measure of some kind, the units identify what the measure is.

range - Some Information Elements may only be able to take on a restricted set of values that can be expressed as a range (e.g., 0 through 511 inclusive). If this is the case, the valid inclusive range should be specified.

reference - Identifies additional specifications that more precisely define this item or provide additional context for its use.

2.2. Scope of Information Elements

By default, most Information Elements have a scope specified in their definitions.

- The Information Elements defined in Sections 5.2 and 5.3 have a default of "a specific Metering Process" or of "a specific Exporting Process", respectively.

- The Information Elements defined in Sections 5.4-5.11 have a scope of "a specific Flow".

Within Data Records defined by Option Templates, the IPFIX protocol allows further limiting of the Information Element scope. The new scope is specified by one or more scope fields and defined as the combination of all specified scope values; see Section 3.4.2.1 on IPFIX scopes in [RFC5101bis].

2.3. Naming Conventions for Information Elements

The following naming conventions were used for naming Information Elements in this document. It is recommended that extensions of the model use the same conventions.

- Names of Information Elements should be descriptive.

- Names of Information Elements that are not enterprise-specific MUST be unique within the IPFIX information model.

Enterprise-specific Information Elements SHOULD be prefixed with a vendor name.

- Names of Information Elements start with non-capitalized letters.

- Composed names use capital letters for the first letter of each component (except for the first one). All other letters are non-capitalized, even for acronyms. Exceptions are made for acronyms containing non-capitalized letter, such as 'IPv4' and 'IPv6'. Examples are sourceMacAddress and destinationIPv4Address.

- Middleboxes [RFC3234] may change Flow properties, such as the Differentiated Service Code Point (DSCP) value or the source IP address. If an IPFIX Observation Point is located in the path of a Flow before one or more middleboxes that potentially modify packets of the Flow, then it may be desirable to also report Flow properties after the modification performed by the middleboxes. An example is an Observation Point before a packet marker changing a packet's IPv4 Type of Service (TOS) field that is encoded in Information Element ipClassOfService. Then the value observed and reported by Information Element ipClassOfService is valid at the Observation Point, but not after the packet passed the packet marker. For reporting the change value of the TOS field, the IPFIX information model uses Information Elements that have a name prefix "post", for example, "postIpClassOfService". Information Elements with prefix "post" report on Flow properties that are not necessarily observed at the Observation Point, but which are obtained within the Flow's Observation Domain by other means considered to be sufficiently reliable, for example, by analyzing the packet marker's marking tables.

3. Type Space

This section describes the abstract data types that can be used for the specification of IPFIX Information Elements in Section 4. Section 3.1 describes the set of abstract data types.

Abstract data types unsigned8, unsigned16, unsigned32, unsigned64, signed8, signed16, signed32, and signed64 are integral data types. As described in Section 3.2, their data type semantics can be further specified, for example, by 'totalCounter', 'deltaCounter', 'identifier', or 'flags'.

3.1. Abstract Data Types

This section describes the set of valid abstract data types of the IPFIX information model. Note that further abstract data types may be specified by future extensions of the IPFIX information model.

3.1.1. unsigned8

The type "unsigned8" represents a non-negative integer value in the range of 0 to 255.

3.1.2. unsigned16

The type "unsigned16" represents a non-negative integer value in the range of 0 to 65535.

3.1.3. unsigned32

The type "unsigned32" represents a non-negative integer value in the range of 0 to 4294967295.

3.1.4. unsigned64

The type "unsigned64" represents a non-negative integer value in the range of 0 to 18446744073709551615.

3.1.5. signed8

The type "signed8" represents an integer value in the range of -128 to 127.

3.1.6. signed16

The type "signed16" represents an integer value in the range of -32768 to 32767.

3.1.7. signed32

The type "signed32" represents an integer value in the range of -2147483648 to 2147483647.

3.1.8. signed64

The type "signed64" represents an integer value in the range of -9223372036854775808 to 9223372036854775807.

3.1.9. float32

The type "float32" corresponds to an IEEE single-precision 32-bit floating point type as defined in [IEEE.754.1985].

3.1.10. float64

The type "float64" corresponds to an IEEE double-precision 64-bit

floating point type as defined in [IEEE.754.1985].

3.1.11. boolean

The type "boolean" represents a binary value. The only allowed values are "true" and "false".

3.1.12. macAddress

The type "macAddress" represents a string of 6 octets.

3.1.13. octetArray

The type "octetArray" represents a finite-length string of octets.

3.1.14. string

The type "string" represents a finite-length string of valid characters from the Unicode character encoding set [ISO.10646-1.1993]. Unicode allows for ASCII [ISO.646.1991] and many other international character sets to be used.

3.1.15. dateTimeSeconds

The type "dateTimeSeconds" represents a time value in units of seconds since the UNIX epoch, 1 January 1970 at 00:00 coordinated universal time (UTC), excluding leap seconds.

3.1.16. dateTimeMilliseconds

The type "dateTimeSeconds" represents a time value in units of milliseconds since the UNIX epoch, 1 January 1970 at 00:00 coordinated universal time (UTC), excluding leap seconds.

3.1.17. dateTimeMicroseconds

The type "dateTimeMicroseconds" represents a time value with microsecond precision according to the NTP Timestamp format as defined in section 6 of [RFC5905]. This field is made up of two unsigned 32-bit integers, Seconds and Fraction. The Seconds field is the number of seconds since the NTP epoch, 1 January 1900 at 00:00 UTC. The Fraction field is the fractional number of seconds in units of 1/(2^32) seconds (approximately 233 picoseconds).

3.1.18. dateTimeNanoseconds

The type "dateTimeMicroseconds" represents a time value with nanosecond precision according to the NTP Timestamp format as defined

in section 6 of [RFC5905]. This field is made up of two unsigned 32-bit integers, Seconds and Fraction. The Seconds field is the number of seconds since the NTP epoch, 1 January 1900 at 00:00 UTC. The Fraction field is the fractional number of seconds in units of 1/(2^32) seconds (approximately 233 picoseconds).

3.1.19. ipv4Address

The type "ipv4Address" represents a value of an IPv4 address.

3.1.20. ipv6Address

The type "ipv6Address" represents a value of an IPv6 address.

3.2. Data Type Semantics

This section describes the set of valid data type semantics of the IPFIX information model. Note that further data type semantics may be specified by future extensions of the IPFIX information model.

3.2.1. quantity

A quantity value represents a discrete measured value pertaining to the record. This is distinguished from counters that represent an ongoing measured value whose "odometer" reading is captured as part of a given record. If no semantic qualifier is given, the Information Elements that have an integral data type should behave as a quantity.

3.2.2. totalCounter

An integral value reporting the value of a counter. Counters are unsigned and wrap back to zero after reaching the limit of the type. For example, an unsigned64 with counter semantics will continue to increment until reaching the value of 2**64 - 1. At this point, the next increment will wrap its value to zero and continue counting from zero. The semantics of a total counter is similar to the semantics of counters used in SNMP, such as Counter32 defined in RFC 2578 [RFC2578]. The only difference between total counters and counters used in SNMP is that the total counters have an initial value of 0. A total counter counts independently of the export of its value.

3.2.3. deltaCounter

An integral value reporting the value of a counter. Counters are unsigned and wrap back to zero after reaching the limit of the type. For example, an unsigned64 with counter semantics will continue to increment until reaching the value of 2**64 - 1. At this point, the

next increment will wrap its value to zero and continue counting from zero. The semantics of a delta counter is similar to the semantics of counters used in SNMP, such as Counter32 defined in RFC 2578 [RFC2578]. The only difference between delta counters and counters used in SNMP is that the delta counters have an initial value of 0. A delta counter is reset to 0 each time its value is exported.

3.2.4. identifier

An integral value that serves as an identifier. Specifically, mathematical operations on two identifiers (aside from the equality operation) are meaningless. For example, Autonomous System ID 1 * Autonomous System ID 2 is meaningless.

3.2.5. flags

An integral value that actually represents a set of bit fields. Logical operations are appropriate on such values, but not other mathematical operations. Flags should always be of an unsigned type.

4. Information Element Identifiers

All Information Elements defined in Section 5 of this document or in future extensions of the IPFIX information model have their identifiers assigned by IANA. Their identifiers can be retrieved at [IPFIX-IANA].

The value of these identifiers is in the range of 1-32767. Within this range, Information Element identifier values in the sub-range of 1-127 are compatible with field types used by NetFlow version 9 [RFC3954].

Range of IANA-assigned Information Element identifiers	Description
0	Reserved.
1-127	Information Element identifiers compatible with NetFlow version 9 field types [RFC3954].
128-32767	Further Information Element identifiers.

Enterprise-specific Information Element identifiers have the same range of 1-32767, but they are coupled with an additional enterprise identifier. For enterprise-specific Information Elements, Information Element identifier 0 is also reserved.

Enterprise-specific Information Element identifiers can be chosen by an enterprise arbitrarily within the range of 1-32767. The same identifier may be assigned by other enterprises for different purposes.

Still, Collecting Processes can distinguish these Information Elements because the Information Element identifier is coupled with an enterprise identifier.

Enterprise identifiers MUST be registered as SMI network management private enterprise code numbers with IANA. The registry can be found at http://www.iana.org/assignments/enterprise-numbers.

The following list gives an overview of the Information Element identifiers that are specified in Section 5 and are compatible with field types used by NetFlow version 9 [RFC3954].

ID	Name	ID	Name
1	octetDeltaCount	43	RESERVED
2	packetDeltaCount	44	sourceIPv4Prefix
3	RESERVED	45	destinationIPv4Prefix
4	protocolIdentifier	46	mplsTopLabelType
5	ipClassOfService	47	mplsTopLabelIPv4Address
6	tcpControlBits	48-51	RESERVED
7	sourceTransportPort	52	minimumTTL
8	sourceIPv4Address	53	maximumTTL
9	sourceIPv4PrefixLength	54	fragmentIdentification
10	ingressInterface	55	postIpClassOfService
11	destinationTransportPort	56	sourceMacAddress
12	destinationIPv4Address	57	postDestinationMacAddress
13	destinationIPv4PrefixLength	58	vlanId
14	egressInterface	59	postVlanId
15	ipNextHopIPv4Address	60	ipVersion
16	bgpSourceAsNumber	61	flowDirection
17	bgpDestinationAsNumber	62	ipNextHopIPv6Address
18	bgpNexthopIPv4Address	63	bgpNexthopIPv6Address
19	postMCastPacketDeltaCount	64	ipv6ExtensionHeaders
20	postMCastOctetDeltaCount	65-69	RESERVED
21	flowEndSysUpTime	70	mplsTopLabelStackSection
22	flowStartSysUpTime	71	mplsLabelStackSection2
23	postOctetDeltaCount	72	mplsLabelStackSection3
24	postPacketDeltaCount	73	mplsLabelStackSection4
25	minimumIpTotalLength	74	mplsLabelStackSection5
26	maximumIpTotalLength	75	mplsLabelStackSection6
27	sourceIPv6Address	76	mplsLabelStackSection7
28	destinationIPv6Address	77	mplsLabelStackSection8
29	sourceIPv6PrefixLength	78	mplsLabelStackSection9
30	destinationIPv6PrefixLength	79	mplsLabelStackSection10
31	flowLabelIPv6	80	destinationMacAddress
32	icmpTypeCodeIPv4	81	postSourceMacAddress
33	igmpType	82-84	RESERVED
34	RESERVED	85	octetTotalCount
35	RESERVED	86	packetTotalCount
36	flowActiveTimeout	87	RESERVED
37	flowIdleTimeout	88	fragmentOffset
38	RESERVED	89	RESERVED
39	RESERVED	90	mplsVpnRouteDistinguisher
40	exportedOctetTotalCount	91-127	RESERVED
41	exportedMessageTotalCount		
42	exportedFlowRecordTotalCount		

The following list gives an overview of the Information Element identifiers that are specified in Section 5 and extends the list of Information Element identifiers specified already in [RFC3954].

ID	Name	ID	Name
128	bgpNextAdjacentAsNumber	169	destinationIPv6Prefix
129	bgpPrevAdjacentAsNumber	170	sourceIPv6Prefix
130	exporterIPv4Address	171	postOctetTotalCount
131	exporterIPv6Address	172	postPacketTotalCount
132	droppedOctetDeltaCount	173	flowKeyIndicator
133	droppedPacketDeltaCount	174	postMCastPacketTotalCount
134	droppedOctetTotalCount	175	postMCastOctetTotalCount
135	droppedPacketTotalCount	176	icmpTypeIPv4
136	flowEndReason	177	icmpCodeIPv4
137	commonPropertiesId	178	icmpTypeIPv6
138	observationPointId	179	icmpCodeIPv6
139	icmpTypeCodeIPv6	180	udpSourcePort
140	mplsTopLabelIPv6Address	181	udpDestinationPort
141	lineCardId	182	tcpSourcePort
142	portId	183	tcpDestinationPort
143	meteringProcessId	184	tcpSequenceNumber
144	exportingProcessId	185	tcpAcknowledgementNumber
145	templateId	186	tcpWindowSize
146	wlanChannelId	187	tcpUrgentPointer
147	wlanSSID	188	tcpHeaderLength
148	flowId	189	ipHeaderLength
149	observationDomainId	190	totalLengthIPv4
150	flowStartSeconds	191	payloadLengthIPv6
151	flowEndSeconds	192	ipTTL
152	flowStartMilliseconds	193	nextHeaderIPv6
153	flowEndMilliseconds	194	mplsPayloadLength
154	flowStartMicroseconds	195	ipDiffServCodePoint
155	flowEndMicroseconds	196	ipPrecedence
156	flowStartNanoseconds	197	fragmentFlags
157	flowEndNanoseconds	198	octetDeltaSumOfSquares
158	flowStartDeltaMicroseconds	199	octetTotalSumOfSquares
159	flowEndDeltaMicroseconds	200	mplsTopLabelTTL
160	systemInitTimeMilliseconds	201	mplsLabelStackLength
161	flowDurationMilliseconds	202	mplsLabelStackDepth
162	flowDurationMicroseconds	203	mplsTopLabelExp
163	observedFlowTotalCount	204	ipPayloadLength
164	ignoredPacketTotalCount	205	udpMessageLength
165	ignoredOctetTotalCount	206	isMulticast
166	notSentFlowTotalCount	207	ipv4IHL
167	notSentPacketTotalCount	208	ipv4Options
168	notSentOctetTotalCount	209	tcpOptions

ID	Name	ID	Name
210	paddingOctets	218	tcpSynTotalCount
211	collectorIPv4Address	219	tcpFinTotalCount
212	collectorIPv6Address	220	tcpRstTotalCount
213	exportInterface	221	tcpPshTotalCount
214	exportProtocolVersion	222	tcpAckTotalCount
215	exportTransportProtocol	223	tcpUrgTotalCount
216	collectorTransportPort	224	ipTotalLength
217	exporterTransportPort	237	postMplsTopLabelExp
		238	tcpWindowScale

5. Information Elements

This section describes the Information Element category for the IPFIX information model at the time that RFC5102 [RFC5102] was published. Since this category field is not part of the IANA process for assigning new Information Element (even though it has been reused, for example, in [RFC5103]), the newest Information Elements in IANA [IPFIX-IANA] don't have this classification. The elements are grouped into 12 groups according to their semantics and their applicability:

1. Identifiers
2. Metering and Exporting Process Configuration
3. Metering and Exporting Process Statistics
4. IP Header Fields
5. Transport Header Fields
6. Sub-IP Header Fields
7. Derived Packet Properties
8. Min/Max Flow Properties
9. Flow Timestamps
10. Per-Flow Counters
11. Miscellaneous Flow Properties
12. Padding

The Information Elements that are derived from fields of packets or from packet treatment, such as the Information Elements in groups 4-7, can typically serve as Flow Keys used for mapping packets to Flows.

If they do not serve as Flow Keys, their value may change from packet to packet within a single Flow. For Information Elements with values that are derived from fields of packets or from packet treatment and for which the value may change from packet to packet within a single Flow, the IPFIX information model defines that their value is

determined by the first packet observed for the corresponding Flow, unless the description of the Information Element explicitly specifies a different semantics. This simple rule allows writing all

Information Elements related to header fields once when the first packet of the Flow is observed. For further observed packets of the same Flow, only Flow properties that depend on more than one packet, such as the Information Elements in groups 8-11, need to be updated.

Information Elements with a name having the "post" prefix, for example, "postIpClassOfService", do not report properties that were actually observed at the Observation Point, but retrieved by other means within the Observation Domain. These Information Elements can be used if there are middlebox functions within the Observation Domain changing Flow properties after packets passed the Observation Point.

5.1. Identifiers

Information Elements grouped in the table below are identifying components of the IPFIX architecture, of an IPFIX Device, or of the IPFIX protocol. All of them have an integral abstract data type and data type semantics "identifier" as described in Section 3.2.4.

Typically, some of them are used for limiting scopes of other Information Elements. However, other Information Elements MAY be used for limiting scopes. Note also that all Information Elements listed below MAY be used for other purposes than limiting scopes.

ID	Name	ID	Name
141	lineCardId	148	flowId
142	portId	145	templateId
10	ingressInterface	149	observationDomainId
14	egressInterface	138	observationPointId
143	meteringProcessId	137	commonPropertiesId
144	exportingProcessId		

See [IPFIX-IANA] for the definitions of these Information Elements.

5.2. Metering and Exporting Process Configuration

Information Elements in this section describe the configuration of the Metering Process or the Exporting Process. The set of these Information Elements is listed in the table below.

ID	Name	ID	Name

130	exporterIPv4Address	213	exportInterface
131	exporterIPv6Address	214	exportProtocolVersion
217	exporterTransportPort	215	exportTransportProtocol
211	collectorIPv4Address	216	collectorTransportPort
212	collectorIPv6Address	173	flowKeyIndicator

See [IPFIX-IANA] for the definitions of these Information Elements.

5.3. Metering and Exporting Process Statistics

Information Elements in this section describe statistics of the Metering Process and/or the Exporting Process. The set of these Information Elements is listed in the table below.

ID	Name	ID	Name
41	exportedMessageTotalCount	165	ignoredOctetTotalCount
40	exportedOctetTotalCount	166	notSentFlowTotalCount
42	exportedFlowRecordTotalCount	167	notSentPacketTotalCount
163	observedFlowTotalCount	168	notSentOctetTotalCount
164	ignoredPacketTotalCount		

See [IPFIX-IANA] for the definitions of these Information Elements.

5.4. IP Header Fields

Information Elements in this section indicate values of IP header fields or are derived from IP header field values in combination with further information.

ID	Name	ID	Name
60	ipVersion	193	nextHeaderIPv6
8	sourceIPv4Address	195	ipDiffServCodePoint
27	sourceIPv6Address	196	ipPrecedence
9	sourceIPv4PrefixLength	5	ipClassOfService
29	sourceIPv6PrefixLength	55	postIpClassOfService
44	sourceIPv4Prefix	31	flowLabelIPv6
170	sourceIPv6Prefix	206	isMulticast

12	destinationIPv4Address	54	fragmentIdentification
28	destinationIPv6Address	88	fragmentOffset
13	destinationIPv4PrefixLength	197	fragmentFlags
30	destinationIPv6PrefixLength	189	ipHeaderLength
45	destinationIPv4Prefix	207	ipv4IHL
169	destinationIPv6Prefix	190	totalLengthIPv4
192	ipTTL	224	ipTotalLength
4	protocolIdentifier	191	payloadLengthIPv6

See [IPFIX-IANA] for the definitions of these Information Elements.

5.5. Transport Header Fields

The set of Information Elements related to transport header fields and length includes the Information Elements listed in the table below.

ID	Name	ID	Name
7	sourceTransportPort	238	tcpWindowScale
11	destinationTransportPort	187	tcpUrgentPointer
180	udpSourcePort	188	tcpHeaderLength
181	udpDestinationPort	32	icmpTypeCodeIPv4
205	udpMessageLength	176	icmpTypeIPv4
182	tcpSourcePort	177	icmpCodeIPv4
183	tcpDestinationPort	139	icmpTypeCodeIPv6
184	tcpSequenceNumber	178	icmpTypeIPv6
185	tcpAcknowledgementNumber	179	icmpCodeIPv6
186	tcpWindowSize	33	igmpType

See [IPFIX-IANA] for the definitions of these Information Elements.

5.6. Sub-IP Header Fields

The set of Information Elements related to Sub-IP header fields includes the Information Elements listed in the table below.

ID	Name	ID	Name
56	sourceMacAddress	201	mplsLabelStackLength
81	postSourceMacAddress	194	mplsPayloadLength
58	vlanId	70	mplsTopLabelStackSection
59	postVlanId	71	mplsLabelStackSection2
80	destinationMacAddress	72	mplsLabelStackSection3
57	postDestinationMacAddress	73	mplsLabelStackSection4
146	wlanChannelId	74	mplsLabelStackSection5
147	wlanSSID	75	mplsLabelStackSection6
200	mplsTopLabelTTL	76	mplsLabelStackSection7
203	mplsTopLabelExp	77	mplsLabelStackSection8
237	postMplsTopLabelExp	78	mplsLabelStackSection9
202	mplsLabelStackDepth	79	mplsLabelStackSection10

See [IPFIX-IANA] for the definitions of these Information Elements.

5.7. Derived Packet Properties

The set of Information Elements derived from packet properties (for example, values of header fields) includes the Information Elements listed in the table below.

ID	Name	ID	Name
204	ipPayloadLength	18	bgpNextHopIPv4Address
15	ipNextHopIPv4Address	63	bgpNextHopIPv6Address
62	ipNextHopIPv6Address	46	mplsTopLabelType
16	bgpSourceAsNumber	47	mplsTopLabelIPv4Address
17	bgpDestinationAsNumber	140	mplsTopLabelIPv6Address
128	bgpNextAdjacentAsNumber	90	mplsVpnRouteDistinguisher
129	bgpPrevAdjacentAsNumber		

See [IPFIX-IANA] for the definitions of these Information Elements.

5.9. Flow Timestamps

Information Elements in this section are timestamps of events.

Timestamps flowStartSeconds, flowEndSeconds, flowStartMilliseconds, flowEndMilliseconds, flowStartMicroseconds, flowEndMicroseconds, flowStartNanoseconds, flowEndNanoseconds, and systemInitTimeMilliseconds are absolute and have a well-defined fixed time base, such as, for example, the number of seconds since 0000 UTC Jan 1st 1970.

Timestamps flowStartDeltaMicroseconds and flowEndDeltaMicroseconds are relative timestamps only valid within the scope of a single IPFIX Message. They contain the negative time offsets relative to the export time specified in the IPFIX Message Header. The maximum time offset that can be encoded by these delta counters is 1 hour, 11 minutes, and 34.967295 seconds.

Timestamps flowStartSysUpTime and flowEndSysUpTime are relative timestamps indicating the time relative to the last (re-)initialization of the IPFIX Device. For reporting the time of the last (re-)initialization, systemInitTimeMilliseconds can be reported, for example, in Data Records defined by Option Templates.

ID	Name	ID	Name
150	flowStartSeconds	156	flowStartNanoseconds
151	flowEndSeconds	157	flowEndNanoseconds
152	flowStartMilliseconds	158	flowStartDeltaMicroseconds
153	flowEndMilliseconds	159	flowEndDeltaMicroseconds
154	flowStartMicroseconds	160	systemInitTimeMilliseconds
155	flowEndMicroseconds	22	flowStartSysUpTime
		21	flowEndSysUpTime

See [IPFIX-IANA] for the definitions of these Information Elements.

5.10. Per-Flow Counters

Information Elements in this section are counters all having integer values. Their values may change for every report they are used in. They cannot serve as part of a Flow Key used for mapping packets to Flows. However, potentially they can be used for selecting exported Flows, for example, by only exporting Flows with more than a threshold number of observed octets.

There are running counters and delta counters. Delta counters are reset to zero each time their values are exported. Running counters

continue counting independently of the Exporting Process.

There are per-Flow counters and counters related to the Metering Process and/or the Exporting Process. Per-Flow counters are Flow properties that potentially change each time a packet belonging to the Flow is observed. The set of per-Flow counters includes the Information Elements listed in the table below. Counters related to the Metering Process and/or the Exporting Process are described in Section 5.3.

ID	Name	ID	Name
1	octetDeltaCount	134	droppedOctetTotalCount
23	postOctetDeltaCount	135	droppedPacketTotalCount
198	octetDeltaSumOfSquares	19	postMCastPacketDeltaCount
85	octetTotalCount	20	postMCastOctetDeltaCount
171	postOctetTotalCount	174	postMCastPacketTotalCount
199	octetTotalSumOfSquares	175	postMCastOctetTotalCount
2	packetDeltaCount	218	tcpSynTotalCount
24	postPacketDeltaCount	219	tcpFinTotalCount
86	packetTotalCount	220	tcpRstTotalCount
172	postPacketTotalCount	221	tcpPshTotalCount
132	droppedOctetDeltaCount	222	tcpAckTotalCount
133	droppedPacketDeltaCount	223	tcpUrgTotalCount

See [IPFIX-IANA] for the definitions of these Information Elements.

5.11. Miscellaneous Flow Properties

Information Elements in this section describe properties of Flows that are related to Flow start, Flow duration, and Flow termination, but they are not timestamps as the Information Elements in Section 5.9 are.

ID	Name	ID	Name
36	flowActiveTimeout	161	flowDurationMilliseconds
37	flowIdleTimeout	162	flowDurationMicroseconds
136	flowEndReason	61	flowDirection

See [IPFIX-IANA] for the definitions of these Information Elements.

5.12. Padding

This section contains a single Information Element that can be used for padding of Flow Records.

IPFIX implementations may wish to align Information Elements within Data Records or to align entire Data Records to 4-octet or 8-octet boundaries. This can be achieved by including one or more paddingOctets Information Elements in a Data Record.

ID	Name	ID	Name
210	paddingOctets		

See [IPFIX-IANA] for the definitions of these Information Elements.

6. Extending the Information Model

A key requirement for IPFIX is to allow for extension of the Information Model maintained by IANA. The process for extending the Information Model is defined in [IPFIX-IE-DOCTORS], which also provides guidelines for authors and reviewers of new Information Element definitions.

For new Information Models, the type space defined in Section 3 can be used. If required, new abstract data types can be added to the subregistry defined in [RFC5610]. New abstract data types MUST be defined in IETF Standards Track documents.

Enterprises may wish to define Information Elements without registering them with IANA. IPFIX explicitly supports enterprise-specific Information Elements. Enterprise-specific Information Elements are described in Sections 2.1 and 4; guidelines for using them appear in [IPFIX-IE-DOCTORS].

7. IANA Considerations

7.1. IPFIX Information Elements

This document refers to the Information Elements, for which the Internet Assigned Numbers Authority (IANA) has created a registry for IPFIX Information Element identifiers [IPFIX-IANA].

New assignments for IPFIX Information Elements will be administered

by IANA through Expert Review [RFC5226], i.e., review by one of a group of experts designated by an IETF Area Director. The group of experts MUST check the requested Information Element for completeness and accuracy of the description and for correct naming according to the naming conventions in Section 2.3. Requests for Information Elements that duplicate the functionality of existing Information Elements SHOULD be declined. The smallest available identifier SHOULD be assigned to a new Information Element.

The specification of new IPFIX Information Elements MUST use the template specified in Section 2.1 and MUST be published using a well-established and persistent publication medium. The experts will initially be drawn from the Working Group Chairs and document editors of the IPFIX and PSAMP Working Groups.

7.2. MPLS Label Type Identifier

Information Element #46, named mplsTopLabelType, carries MPLS label types. Values for 5 different types have initially been defined. For ensuring extensibility of this information, IANA has created a new registry for MPLS label types and filled it with the initial list from the description Information Element #46, mplsTopLabelType.

New assignments for MPLS label types will be administered by IANA through Expert Review [RFC5226], i.e., review by one of a group of experts designated by an IETF Area Director. The group of experts must double check the label type definitions with already defined label types for completeness, accuracy, and redundancy. The specification of new MPLS label types MUST be published using a well-established and persistent publication medium.

7.3. XML Namespace and Schema

[IPFIX-XML-SCHEMA] defines an XML schema for IPFIX Information Element definitions. All Information Elements specified in [IPFIX-IANA] are defined by this schema. This schema may also be used for specifying further Information Elements in future extensions of the IPFIX information model in a machine-readable way.

[IPFIX-XML-SCHEMA] uses URNs to describe an XML namespace and an XML schema for IPFIX Information Elements conforming to a registry mechanism described in [RFC3688]. Two URI assignments have been made.

1. **Registration for the IPFIX information model namespace**
    * URI: urn:ietf:params:xml:ns:ipfix-info
    * Registrant Contact: IETF IPFIX Working Group <ipfix@ietf.org>, as designated by the IESG <iesg@ietf.org>.

* XML: None. Namespace URIs do not represent an XML.

2. Registration for the IPFIX information model schema

* URI: urn:ietf:params:xml:schema:ipfix-info
* Registrant Contact: IETF IPFIX Working Group <ipfix@ietf.org>, as designated by the IESG <iesg@ietf.org>.

Using a machine-readable syntax for the information model enables the creation of IPFIX-aware tools that can automatically adapt to extensions to the information model, by simply reading updated information model specifications.

The wide availability of XML-aware tools and libraries for client devices is a primary consideration for this choice. In particular, libraries for parsing XML documents are readily available. Also, mechanisms such as the Extensible Stylesheet Language (XSL) allow for transforming a source XML document into other documents. This document was authored in XML and transformed according to [RFC2629].

It should be noted that the use of XML in Exporters, Collectors, or other tools is not mandatory for the deployment of IPFIX. In particular, Exporting Processes do not produce or consume XML as part of their operation. It is expected that IPFIX Collectors MAY take advantage of the machine readability of the information model vs. hard coding their behavior or inventing proprietary means for accommodating extensions.

8. Security Considerations

The IPFIX information model itself does not directly introduce security issues. Rather, it defines a set of attributes that may for privacy or business issues be considered sensitive information.

For example, exporting values of header fields may make attacks possible for the receiver of this information, which would otherwise only be possible for direct observers of the reported Flows along the data path.

The underlying protocol used to exchange the information described here must therefore apply appropriate procedures to guarantee the integrity and confidentiality of the exported information. Such protocols are defined in separate documents, specifically the IPFIX protocol document [RFC5101bis].

This document does not specify any Information Element carrying keying material. If future extensions will do so, then appropriate precautions need to be taken for properly protecting such sensitive information.

9. Acknowledgements

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10. References

10.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

[RFC5905] Mills, D., Delaware, U., Martin, J., Burbank, J. and W. Kasch, "Network Time Protocol Version 4: Protocol and Algorithms Specification", RFC 5905, June 2010

[RFC5101bis] Claise, B., and B. Trammell, Editors, "Specification of the IP Flow Information eXport (IPFIX) Protocol for the Exchange of IP Traffic Flow Information", draft-ietf-ipfix-protocol-rfc5101bis-00, Work in Progress, November 2011.

[IPFIX-IE-DOCTORS] Trammell, T., and B. Claise, "Guidelines for Authors and Reviewers of IPFIX Information Elements", draft-ietf-ipfix-ie-doctors-00, Work in Progress, November 2011.

10.2. Informative References

[IEEE.754.1985]
Institute of Electrical and Electronics Engineers, "Standard for Binary Floating-Point Arithmetic", IEEE Standard 754, August 1985.

[ISO.10646-1.1993]
International Organization for Standardization, "Information Technology - Universal Multiple-octet coded Character Set (UCS) - Part 1: Architecture and Basic Multilingual Plane", ISO Standard 10646-1, May 1993.

[ISO.646.1991]
International Organization for Standardization, "Information technology - ISO 7-bit coded character set for information interchange", ISO Standard 646, 1991.

[RFC2578] McCloghrie, K., Perkins, D., and J. Schoenwaelder,

"Structure of Management Information Version 2 (SMIv2)", STD 58, RFC 2578, April 1999.

[RFC2629] Rose, M., "Writing I-Ds and RFCs using XML", RFC 2629, June 1999.

[RFC3234] Carpenter, B. and S. Brim, "Middleboxes: Taxonomy and Issues", RFC 3234, February 2002.

[RFC3444] Pras, A. and J. Schoenwaelder, "On the Difference between Information Models and Data Models", RFC 3444, January 2003.

[RFC3688] Mealling, M., "The IETF XML Registry", BCP 81, RFC 3688, January 2004.

[RFC3917] Quittek, J., Zseby, T., Claise, B., and S. Zander, "Requirements for IP Flow Information Export (IPFIX)", RFC 3917, October 2004.

[RFC3954] Claise, B., Ed., "Cisco Systems NetFlow Services Export Version 9", RFC 3954, October 2004.

[RFC5102] Trammell, B., and E. Boschi, "Bidirectional Flow Export Using IP Flow Information Export (IPFIX)", RFC 5103, January 2008.

[RFC5103] Quittek, J., Bryant, S. Claise, B., Aitken, P., and J. Meyer, "Information Model for IP Flow Information Export", RFC 5102, January 2008.

[RFC5153] Boschi, E., Mark, L., Quittek J., and P. Aitken, "IP Flow Information Export (IPFIX) Implementation Guidelines", RFC5153, April 2008.

[RFC5226] Narten, T. and H. Alvestrand, "Guidelines for Writing an IANA Considerations Section in RFCs", BCP 26, RFC 5226, May 2008.

[RFC5470] Sadasivan, G., Brownlee, N., Claise, B., and J. Quittek, "Architecture for IP Flow Information Export", RFC5470, March 2009.

[RFC5471] Schmoll, C., Aitken, P., and B. Claise, "Guidelines for IP Flow Information Export (IPFIX) Testing", RFC5471, March 2009.

[RFC5472] Zseby, T., Boschi, E., Brownlee, N., and B. Claise, "IP

Flow Information Export (IPFIX) Applicability", RFC5472, March 2009.

[RFC5473] Boschi, E., Mark, L., and B. Claise, "Reducing Redundancy in IP Flow Information Export (IPFIX) and Packet Sampling (PSAMP) Reports", RFC5473, March 2009.

[RFC5610] Boschi, E., Trammell, B., Mark, L., and T. Zseby, "Exporting Type Information for IP Flow Information Export (IPFIX) Information Elements", July 2009.

[RFC6313] Claise, B., Dhandapani, G., Aitken, P, and S. Yates, "Export of Structured Data in IP Flow Information Export (IPFIX)", RFC6313, July 2011.

[RFC6183] Kobayashi, A., Claise, B., Muenz, G, and K. Ishibashi, "IP Flow Information Export (IPFIX) Mediation: Framework", RFC6183, April 2011.

[IPFIX-CONF] Muenz, G., Claise, B., and P. Aitken, "Configuration Data Model for IPFIX and PSAMP", draft-ietf-ipfix-configuration-model-10, Work in Progress, July 2011.

[IPFIX-MED-PROTO] Claise, B., Kobayashi, A., and B. Trammell, "Specification of the Protocol for IPFIX Mediations", draft-ietf-ipfix-mediation-protocol-00, Work in Progress, December 2011.

[RFC5815bis] Dietz, T., Kobayashi, A., Claise, B., and G. Muenz, "Definitions of Managed Objects for IP Flow Information Export", draft-ietf-ipfix-rfc5815bis-01.txt, Work in Progress, January 2012.

[IPFIX-IANA] http://www.iana.org/assignments/ipfix/ipfix.xml

[IPFIX-XML-SCHEMA] http://www.iana.org/assignments/xml-registry/schema/ipfix.xsd

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