Network Working Group
Internet Draft
Obsoletes: 5102
Category: Standards Track
Expires: April 6, 2013

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October 3, 2012

Information Model for IP Flow Information eXport (IPFIX)
draft-ietf-ipfix-information-model-rfc5102bis-06.txt

Abstract

This document provides an overview of the information model for the IP Flow Information eXport (IPFIX) protocol, as defined in the IANA IPFIX Information Element Registry. 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

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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].

The canonical reference for IPFIX Information Elements the IANA IPFIX Information Element registry [IPFIX-IANA]; the initial values for this registry were provided by [RFC5102].

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 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:

- All outstanding technical and editorial errata filed on the [RFC5102] as of publication time have been corrected
- All references into [RFC5101] have been updated to [RFC5101bis], reflecting changes in that document as necessary
- Information element definitions have been removed, as the reference for these is now [IPFIX-IANA]; categorizations of information elements as defines in [RFC5102] have been retained in section 5.
- The process for modifying [IPFIX-IANA] has been improved, and is now described in [IPFIX-IE-DOCTORS]; Section 6 has been updated accordingly, and a new section 7.3 gives IANA considerations for this process.
- Definitions of timestamp data types have been clarified
- Appendices A and B have been removed

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 Element 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 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. Information Elements of dataType string or octetArray which have a length constraints (fixed length, minimum and/or maximum length) MUST note these constraints in their description.

dataType - One of the types listed in Section 3.1 of this document or registered in the IANA IPFIX Information Element Data Types registry. 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' and 'deprecated'. All newly-defined Information Elements have 'current' status. The process for moving Information Elements to the 'deprecated' status is defined in Section 5.2 of [IPFIX-IE-DOCTORS].

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.

The following two Information Element properties are defined to allow the management of an Information Element registry with Information Element definitions that may be updated over time, per the process defined in Section 5.2 of [IPFIX-IE-DOCTORS].

revision - The revision number of an Information Element, starting at 0 for Information Elements at time of definition, and incremented by one for each revision.

date - The date of the entry of this revision of the Information Element into the registry.

For Information Elements of the string or octetArray data types which have size limits (minimum and/or maximum size, or fixed length), the limits MUST be defined within the description of the Information Element.

2.2. Scope of Information Elements

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

o The Information Elements listed in Sections 5.2 and 5.3, and similar Information Elements in [IPFIX-IANA], have a default of "a specific Metering Process" or of "a specific Exporting Process", respectively.

o The Information Elements listed in Sections 5.4-5.11, and similar Information Elements in [IPFIX-IANA], 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 MUST be unique within the IANA registry. Enterprise-specific Information Elements SHOULD be prefixed with a vendor name.

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

- Composed names MUST 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 letters, 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 data type dateTimeSeconds is an unsigned 32-bit integer representing the number of seconds since the UNIX epoch, 1 January 1970 at 00:00 UTC, as defined in [POSIX.1].

3.1.16. dateTimeMilliseconds

The data type dateTimeMilliseconds is an unsigned 64-bit integer containing the number of milliseconds since the UNIX epoch, 1 January 1970 at 00:00 UTC, as defined in [POSIX.1].

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].

3.1.18. dateTimeNanoseconds

The type "dateTimeNanoseconds" represents a time value with nanosecond precision according to the NTP Timestamp format as defined in section 6 of [RFC5905].

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. A registry of data type semantics is established in [RFC5610]; the restrictions on the use of semantics below are compatible with those specified in section 3.10 of that document. These semantics apply only to numeric types, as noted in the description of each semantic below.

Further data type semantics may be specified by future extensions of the IPFIX information model.

3.2.1. quantity

A numeric (integral or floating point) value representing a 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. This is the default semantic type of all numeric data types.

3.2.2. totalCounter

An numeric 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 [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 numeric 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. Identifiers MUST be one of the signed or unsigned data types.

3.2.5. flags

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

4. Information Element Identifiers

All Information Elements defined in the IANA IPFIX Information Element registry [IPFIX-IANA] have their identifiers assigned by 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]; Information Element identifiers in this range MUST NOT be assigned unless the Information Element is compatible with the NetFlow version 9 protocol. Such Information Elements may ONLY be requested by a NetFlow v9 expert, to be designated by the IESG.

In general, IANA will add newly registered Information Elements to the registry, assigning the lowest available Information Element identifier in the range 128-32767.

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; these Information Elements are distinct 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.

4.1. NetFlow version 9 compatible Information Element Identifiers

Information Elements with identifiers from 1-127 are reserved for compatibility with corresponding fields in NetFlow version 9 [RFC3954].

5. Information Element Categories

This section describes the Information Element category for the IPFIX information model at the time that [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 described in [IPFIX-IE-DOCTORS], which also provides guidelines for authors and reviewers of new Information Element definitions.

For new Information Elements, 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 Information Elements, for which the Internet Assigned Numbers Authority (IANA) has created the IPFIX Information Element Registry [IPFIX-IANA]. The columns of this registry must at minimum be able to store the information defined in the template in Section 2.1; it may contain other information as necessary for the management of the registry.

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 the IESG. Further considerations for this review are specified in [IPFIX-IE-DOCTORS].

Future assignments added to the IPFIX Information Element Registry which require subregistries for enumerated values (e.g. section 7.2, below) must have those subregistries added simultaneously with the new assignment; additions to these subregistries must be subject to Expert Review [RFC5226]. Unless specified at assignment time, the experts for the subregistry will be the same as for the Information Element registry as a whole.

Changes may also be made to the entries in this registry from time to time; the process for these changes are specified in [IPFIX-IE-DOCTORS].

[NOTE to IANA: please update the Reference for the IPFIX Information Element Registry to refer to this document.]

[NOTE to IANA: on publication of this document, please set the Revision of all existing Information Elements to 0.]

[NOTE to IANA: on publication of this document, please set the Date of all existing Information Elements to the publication date of this document.]

[NOTE to IANA: on publication of this document, please set the Name of all existing Reserved Information Elements to "Assigned for NetFlow v9 compatibility", and the reference to [RFC3954].]

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 subregistry 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.

[NOTE to IANA: please update the Reference for the IPFIX MPLS Label Type subregistry to refer to this document.]

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.

[NOTE to IANA: please update the Reference for the the IPFIX information model namespace and schema to refer to this document.]

7.4. Addition, Revision, and Deprecation

As stated in Section 6, addition, revision, and deletion of Information Elements in the IPFIX Information Element registry is subject to a process described in [IPFIX-IE-DOCTORS]. The IE-DOCTORS experts mentions in this process are to be appointed by the IESG.

When IANA receives a request to add, revise, or deprecate an Information Element in the IPFIX Information Elements Registr, it forwards the request to the IE-DOCTORS experts for review.

When IANA receives an approval for a request to add an Information Element definition from the IE-DOCTORS experts, it adds that Information Element to the registry. The approved request may include changes from the original request.

When IANA receives an approval for a request to revise an Information Element definition from the IE-DOCTORS experts, it changes that Information Element's definition in the registry, and updates the Revision and Date columns as appropriate. The approved request may include changes from the original request. If the original Information Element was added to the registry with IETF consensus (i.e., was defined by an RFC), the revision will require IETF consensus as well.

When IANA receives an approval for a request to deprecate an Information Element definition from the IE-DOCTORS experts, it changes that Information Element's definition in the registry, and updates the Revision and Date columns as appropriate. The approved request may include changes from the original request. If the original Information Element was added to the registry with IETF consensus (i.e., was defined by an RFC), the deprecation will require IETF consensus as well.

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

The editors would like to thanks the authors of the RFC5102 [RFC5102], as this document is directly based upon this original RFC: Juergen Quittek, Stewart Bryant, Paul Aitken, and Jeff Meyer.

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

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