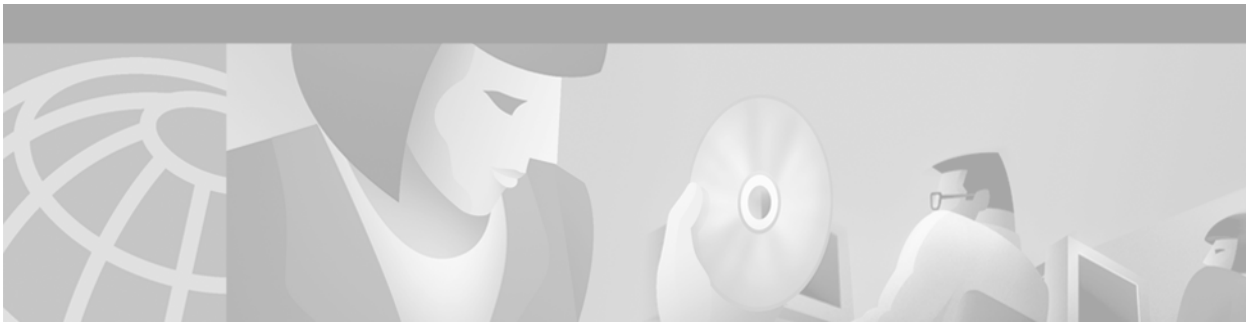

NetFlow Overview

Release 12.2
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NetFlow provides network administrators with access to call detail recording information from their data networks. Exported NetFlow data can be used for a variety of purposes, including network management and planning, enterprise accounting and departmental chargebacks, ISP billing, data warehousing, and data mining for marketing purposes. NetFlow also provides a highly efficient mechanism with which to process security access lists without paying as much of a performance penalty as is incurred with other available switching methods.

Procedures for configuring NetFlow are provided in the "Configuring NetFlow" chapter later in this publication.

This chapter describes NetFlow. It contains the following sections:

Accounting Statistics

NetFlow is a Cisco IOS application that provides statistics on packets flowing through the routing devices in the network. It is emerging as a primary network accounting and security technology.

NetFlow does not involve any connection-setup protocol, either between routers or to any other networking device or end station. NetFlow does not require any change externally—either to the packets themselves or to any networking device. NetFlow is completely transparent to the existing network, including end stations and application software and network devices like LAN switches. Also, NetFlow capture and export are performed independently on each internetworking device; NetFlow need not be operational on each router in the network.

NetFlow is supported on IP and IP encapsulated traffic over most interface types and encapsulations. However, NetFlow does not support ATM LAN emulation (LANE) and does not support an Inter-Switch Link (ISL)/virtual LAN (VLAN), ATM, or Frame Relay interfaces when more than one input access control list (ACL) is used on the interface. Cisco 12000 IP Service Engine ATM line cards do not have this restriction when more than one input ACL is used on the interface.

Capturing Traffic Data

In conventional switching at the network layer, each incoming packet is handled on an individual basis with a series of functions to perform access list checks, capture accounting data, and switch the packet. With NetFlow, after a flow has been identified and access list processing of the first packet in the flow has been performed, all subsequent packets are handled on a connection-oriented basis as part of the flow, where access list checks are bypassed, and packet switching and statistics capture are performed in tandem.

A network flow is identified as a unidirectional stream of packets between a given source and destination—both defined by a network-layer IP address and transport-layer port number. Specifically, a flow is identified as the combination of the following fields:

- Source IP address
- Destination IP address
- Source port number
- Destination port number
- Protocol type
- Type of service
- Input interface

NetFlow Cache

NetFlow operates by creating a flow cache that contains the information needed to switch and perform access list checking for all active flows. The NetFlow cache is built by processing the first packet of a flow through the standard switching path. As a result, each flow is associated with an incoming and outgoing interface port number and with a specific security access permission and encryption policy. The cache also includes entries for traffic statistics that are updated in tandem with the switching of subsequent packets. After the NetFlow cache is created, packets identified as belonging to an existing flow can be switched based on the cached information and security access list checks bypassed. Flow information is maintained within the NetFlow cache for all active flows.

NetFlow Data Format

NetFlow exports flow information in UDP datagrams in one of two formats. The version 1 format was the initially released version, and version 5 is a later enhancement to add Border Gateway Protocol (BGP) autonomous system (AS) information and flow sequence numbers. Versions 2 through 4 were not released.

In version 1 and version 5 formats, the datagram consists of a header and one or more flow records. The first field of the header contain the version number of the export datagram. Typically, a receiving application that accepts either format allocates a buffer large enough for the largest possible datagram from either format and uses the version from the header to determine how to interpret the datagram. The second field in the header is the number of records in the datagram and should be used to index through the records.

All fields in either version 1 or version 5 formats are in network byte order. Table 11 and Table 12 describe the data format for version 1, and Table 13 and Table 14 describe the data format for version 5.

We recommend that receiving applications check datagrams to ensure that the datagrams are from a valid NetFlow source. We recommend that you first check the size of the datagram to make sure it is at least long enough to contain the version and count fields. Next we recommend that you verify that the version is valid (1 or 5) and that the number of received bytes is enough for the header and count flow records (using the appropriate version).

Because NetFlow export uses UDP to send export datagrams, it is possible for datagrams to be lost. To determine whether or flow export information is lost, the version 5 header format contains a flow sequence number. The sequence number is equal to the sequence number of the previous datagram plus the number of flows in the previous datagram. After receiving a new datagram, the receiving application can subtract the expected sequence number from the sequence number in the header to get the number of missed flows.

Table 11 lists the bytes for the version 1 header format.

Table 11 Version 1 Header Format

Bytes	Content	Description
0 to 3	version and count	Netflow export format version number and number of flows exported in this packet (1 to 24).
4 to 7	SysUptime	Current time (in milliseconds) since router booted.
8 to 11	unix_secs	Current seconds since 0000 UTC 1970.
12 to 15	unix_nsecs	Residual nanoseconds since 0000 UTC 1970.

Table 12 lists the byte definitions for version 1 flow record format.

Table 12 Version 1 Flow Record Format

Bytes	Content	Description
0 to 3	srcaddr	Source IP address.
4 to 7	dstaddr	Destination IP address.
8 to 11	nexthop	IP address of the next hop router.
12 to 15	input and output	SNMP index of the input and output interface.
16 to 19	dPkts	Packets in the flow.
20 to 23	dOctets	Total number of Layer 3 bytes in the flow's packets.
24 to 27	First	SysUptime at start of flow.
28 to 31	Last	SysUptime at the time the last packet of flow was received.
32 to 35	srcport and dstport	TCP/UDP source and destination port number or equivalent.
36 to 39	pad1, prot, and tos	Unused (zero) byte, IP protocol (for example, 6 = TCP, 17 = UDP), and IP ToS.
40 to 43	flags, pad2, and pad3	Cumulative OR of TCP flags. Pad 2 and pad 3 are unused (zero) bytes.
44 to 47	reserved	Unused (zero) bytes.

Table 13 lists the byte definitions for the version 5 header format.

Table 13 Version 5 Header Format

Bytes	Content	Description
0 to 3	version and count	Netflow export format version number and number of flows exported in this packet (1 to 30).
4 to 7	SysUptime	Current time (in milliseconds) since the router booted
8 to 11	unix_secs	Current seconds since 0000 UTC 1970.
12 to 15	unix_nsecs	Residual nanoseconds since 0000 UTC 1970.
16 to 19	flow_sequence	Sequence counter of total flows seen.
20 to 23	reserved	Unused (zero) bytes.

Table 14 lists the byte definitions for the version 5 flow record format.

Table 14 Version 5 Flow Record Format

Bytes	Content	Description
0 to 3	srcaddr	Source IP address.
4 to 7	dstaddr	Destination IP address.
8 to 11	nexthop	IP address of the next hop router.
12 to 15	input and output	SNMP index of the input and output interface.
16 to 19	dPkts	Packets in the flow.
20 to 23	dOctets	Total number of Layer 3 bytes in the flow's packets.
24 to 27	First	SysUptime at start of flow.
28 to 31	Last	SysUptime at the time the last packet of flow was received.
32 to 35	srcport and dstport	TCP/UDP source and destination port number or equivalent.
36 to 39	pad1, tcp_flags, prot, and tos	Unused (zero) byte, Cumulative OR of TCP flags, IP protocol (for example, 6 = TCP, 17 = UDP), and IP ToS.
40 to 43	src_as and dst_as	Autonomous system of the source and destination, either origin or peer.
44 to 47	src_mask, dst_mask, and pad2	Source and destination address prefix mask bits. Pad 2 is unused (zero) bytes.

NetFlow Aggregation

By maintaining one or more extra flow caches, called *aggregation caches*, the NetFlow Aggregation feature allows limited aggregation of NetFlow data export streams on a router.

Note To collect NetFlow version 8 data export records, use NetFlow FlowCollector version 3.0. Version 2.0 and earlier versions do not support version 8 data export record formats.

Benefits

The NetFlow Aggregation feature provides the following benefits:

- Reduced bandwidth requirement—NetFlow aggregation caches reduce the bandwidth required between routers and NetFlow management workstations.
- Reduced NetFlow workstation requirements—NetFlow aggregation caches reduce the number of NetFlow management workstations required.
- Improved router scalability—NetFlow aggregation caches improve the scalability of high-flow-per-second routers, such as the Cisco 7500 series.

Aggregation Cache Schemes

The aggregation cache schemes are described in the following sections:

- Autonomous System Aggregation Scheme
- Destination Prefix Aggregation Scheme
- Prefix Aggregation Scheme
- Protocol Port Aggregation Scheme
- Source Prefix Aggregation Scheme
- Aggregation Scheme Fields and Key Fields

You can configure each aggregation cache with its individual cache size, cache ager timeout parameter, export destination IP address, and export destination UDP port. As data flows expire in the main NetFlow cache, the flows are added to each enabled aggregation cache. Each aggregation cache contains different field combinations that determine which data flows are grouped. The default aggregation cache size is 4096.

Table 15 lists definitions for the data export record terms used in each aggregation scheme.

Table 15 Data Export Record Terms and Definitions

Term	Definition
Bytes	Number of bytes in the aggregated flows.
Destination BGP autonomous system	Peer or origin autonomous system of the destination prefix (IP address.)
Destination interface	SNMP index of the output interface.
Destination port	Destination UDP or TCP port number.

Table 15 Data Export Record Terms and Definitions (continued)

Term	Definition
Destination prefix	Destination IP address ANDed with the destination prefix mask.
First	System uptime when the first packet was switched.
Flows	Number of main cache flows that were aggregated.
Last	System uptime when the last packet was switched.
Packets	Number of packets in the aggregated flows.
PAD	Zero field.
Protocol	IP protocol byte.
Source BGP autonomous system	Peer or origin autonomous system of the source prefix.
Source interface	SNMP index of the input interface.
Source port	Source UDP or TCP port number if applicable.
Source prefix	Source IP address ANDed with the source prefix mask, or the prefix that the source IP address of the aggregated flows belong to.

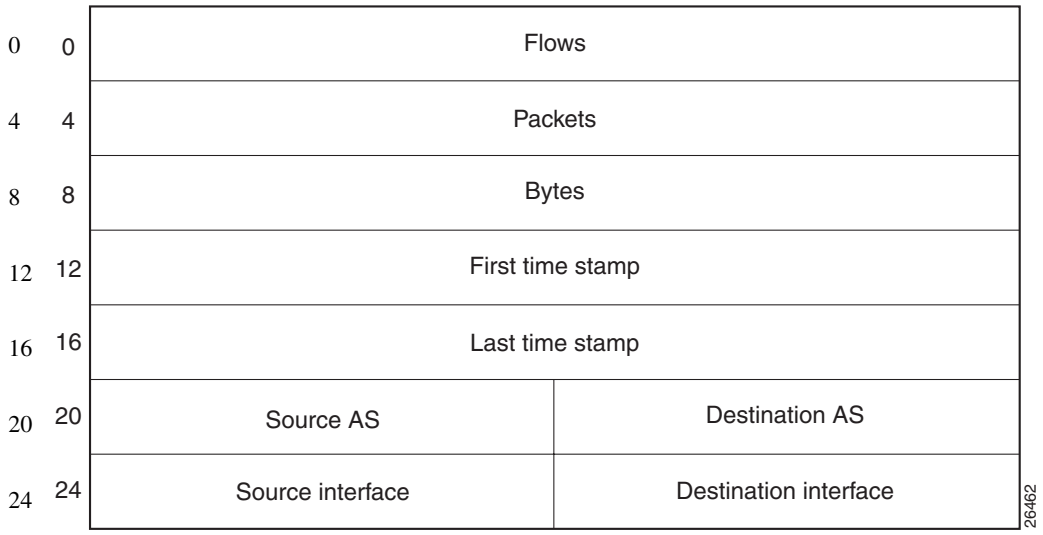
Autonomous System Aggregation Scheme

The Autonomous System aggregation scheme provides substantial NetFlow export data volume reduction and generates autonomous system-to-autonomous system traffic flow data. The scheme groups data flows with the same source BGP autonomous system, destination BGP autonomous system, input interface, and output interface. See Figure 18.

The aggregated NetFlow data export records report the following:

- Source and destination BGP autonomous system
- Number of packets summarized by the aggregated record
- Number of flows summarized by the aggregated record
- Number of bytes summarized by the aggregated record
- Output and input interfaces
- Time stamp when the first packet is switched and time stamp when the last packet is switched

Figure 18 Autonomous System Aggregation Data Export Format



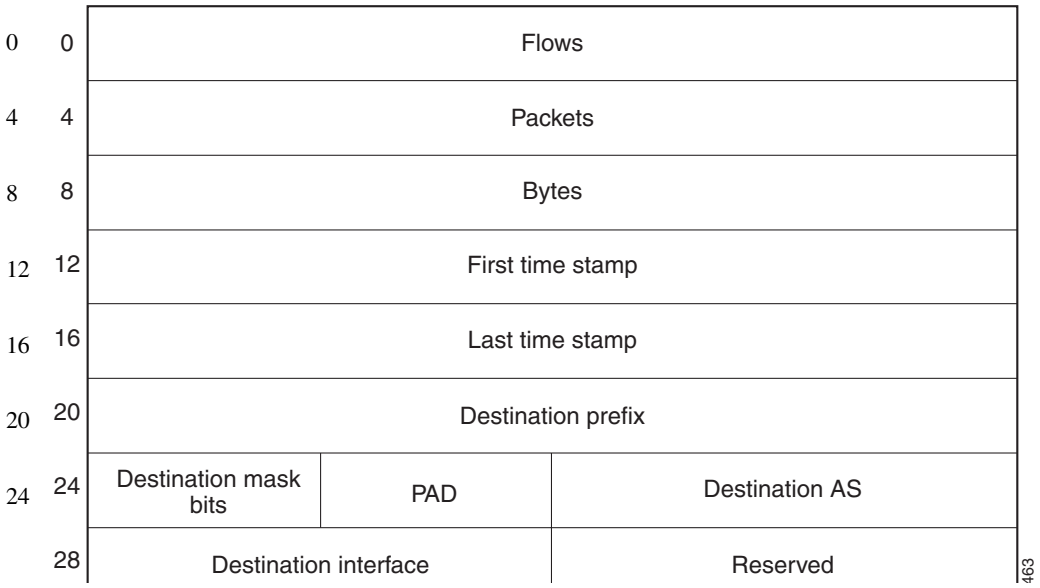
Destination Prefix Aggregation Scheme

The Destination Prefix aggregation scheme generates data so that you can examine the destinations of network traffic passing through a NetFlow-enabled device. The scheme groups data flows with the same destination prefix, destination prefix mask, destination BGP autonomous system, and output interface. See Figure 19.

The aggregated NetFlow data export records report the following:

- Destination prefix
- Destination prefix mask
- Destination BGP autonomous system
- Number of flows summarized by the aggregated record
- Number of bytes summarized by the aggregated record
- Number of packets summarized by the aggregated record
- Output interface
- Time stamp when the first packet is switched and time stamp when the last packet is switched

Figure 19 Destination Prefix Aggregation Data Export Record Format



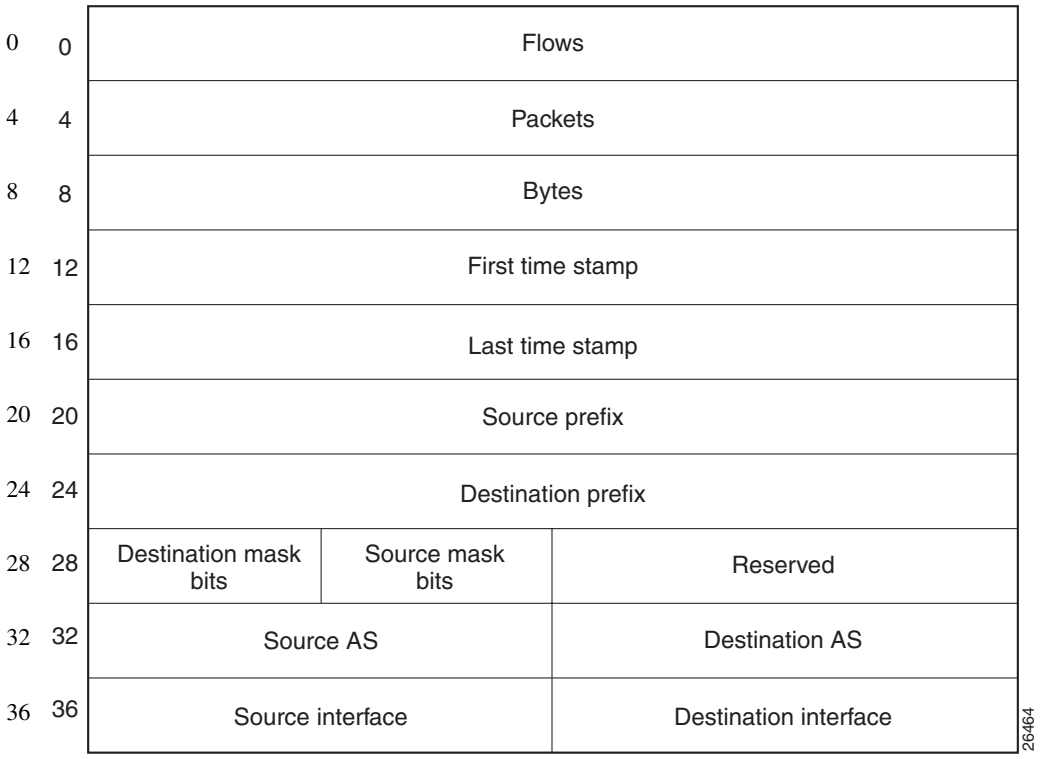
Prefix Aggregation Scheme

The Prefix aggregation scheme generates data so that you can examine the sources and destinations of network traffic passing through a NetFlow-enabled device. The scheme groups data flows with the same source prefix, destination prefix, source prefix mask, destination prefix mask, source BGP autonomous system, destination BGP autonomous system, input interface, and output interface. See Figure 20.

The aggregated NetFlow data export records report the following:

- Source and destination prefix
- Source and destination prefix mask
- Source and destination BGP autonomous system
- Number of flows summarized by the aggregated record
- Number of bytes summarized by the aggregated record
- Number of packets summarized by the aggregated record
- Input and output interface
- Time stamp when the first packet is switched and time stamp when the last packet is switched

Figure 20 Prefix Aggregation Data Export Record Format



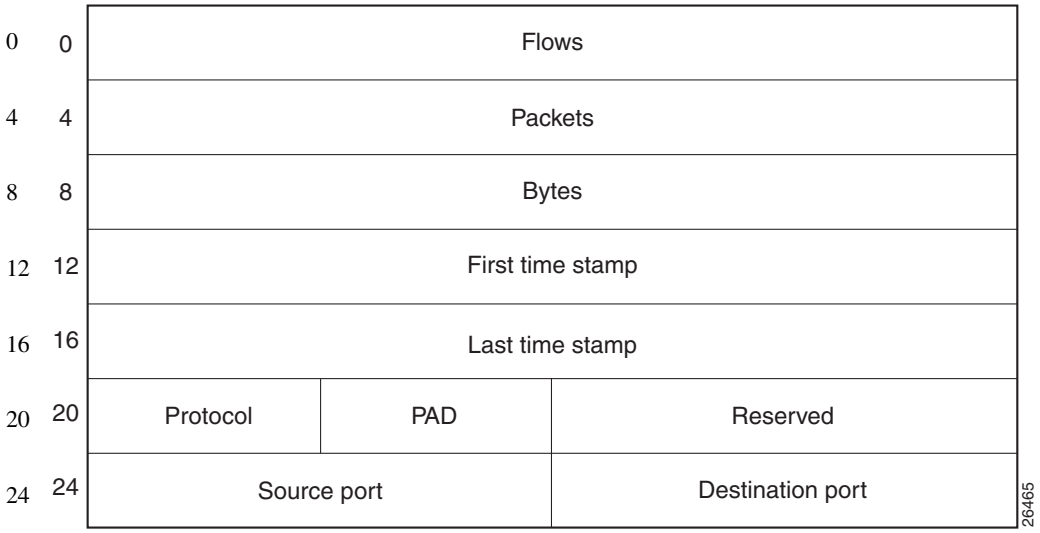
Protocol Port Aggregation Scheme

The Protocol Port aggregation scheme generates data so that you can examine network usage by traffic type. The scheme groups data flows with the same IP protocol, source port number, and destination port number when applicable. See Figure 21.

The aggregated NetFlow data export records report the following:

- Source and destination port numbers
- IP protocol (where 6 = TCP, 17 = UDP, and so on)
- Number of flows summarized by the aggregated record
- Number of bytes summarized by the aggregated record
- Number of packets summarized by the aggregated record
- Time stamp when the first packet is switched and time stamp when the last packet is switched

Figure 21 Protocol Port Aggregation Data Export Record Format



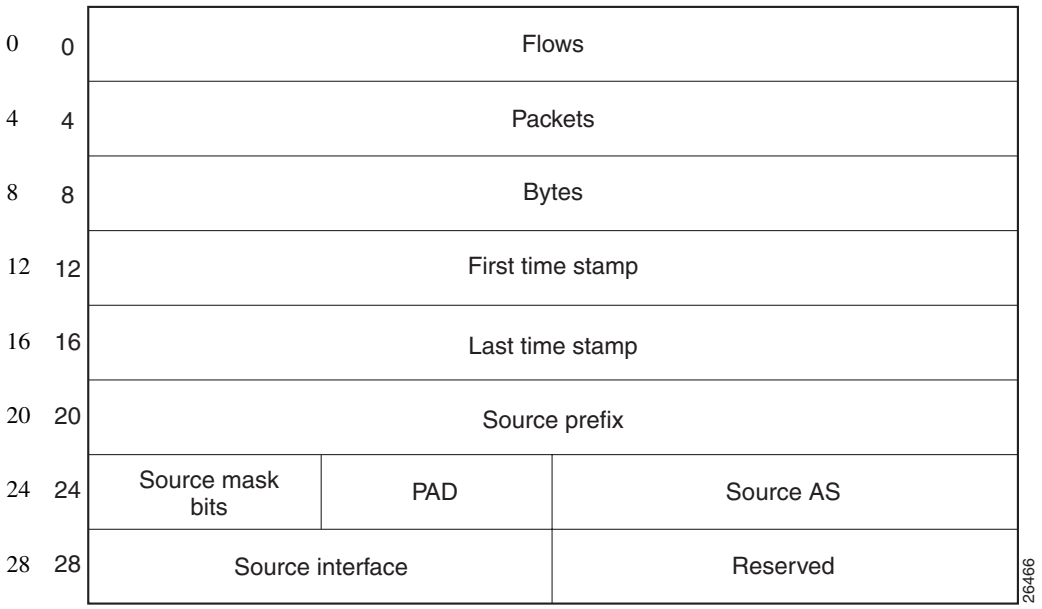
Source Prefix Aggregation Scheme

The Source Prefix aggregation scheme generates data so that you can examine the sources of network traffic passing through a NetFlow-enabled device. The scheme groups data flows with the same source prefix, source prefix mask, source BGP autonomous system, and input interface. See Figure 22.

The aggregated NetFlow data export records report the following:

- Source prefix
- Source prefix mask
- Source BGP autonomous system
- Number of bytes summarized by the aggregated record
- Number of packets summarized by the aggregated record
- Input interface
- Time stamp when the first packet is switched and time stamp when the last packet is switched

Figure 22 Source Prefix Aggregation Data Export Record Format



Aggregation Scheme Fields and Key Fields

To coordinate flow aggregation on your router, determine the fields from which you want to collect data. Table 16 shows which fields are valid for the different aggregation schemes and which fields are part of the keys. Key fields define a unique flow.

Table 16 Aggregation Scheme Data Fields

Data Fields	Aggregation Schemes				
	Autonomous System	**Destination Prefix**	**Prefix**	**Protocol Port**	**Source Prefix**
Source Prefix					
Destination Prefix					
Protocol				*	
Type of Service Byte					
Source Port				*	
Destination Port				*	
Source Interface	*		*		*
Destination Interface	*	*	*		
OR'd TCP Flags					
Source BGP Autonomous System	*		*		*
Destination BGP Autonomous System	*	*	*		
Source Prefix Mask			*		*
Destination Prefix Mask		*	*		
Next Hop IP Adress					
Source Encap Bytes					
Destination Encap Bytes					
Source Prefix			*		*
Destination Prefix		*	*		
First Timestamp	x	x	x	x	x
Last Timestamp	x	x	x	x	x
Flows	x	x	x	x	x
Packets	x	x	x	x	x
Bytes	x	x	x	x	x

* = exported key field

x = exported field

New Version 8 NetFlow Data Export Support

NetFlow exports flow information in UDP datagrams in one of several formats. Version 8, a new data export version, has been added to support data exports from aggregation caches. Version 8 allows for export datagrams to contain a subset of the usual version 5 export data, which is valid for a particular aggregation scheme type.

Figure 23 shows the version 8 header with the version and time stamp information. Table 17 lists definitions for terms used in the version 8 header.

Figure 23 Version 8 Header Format

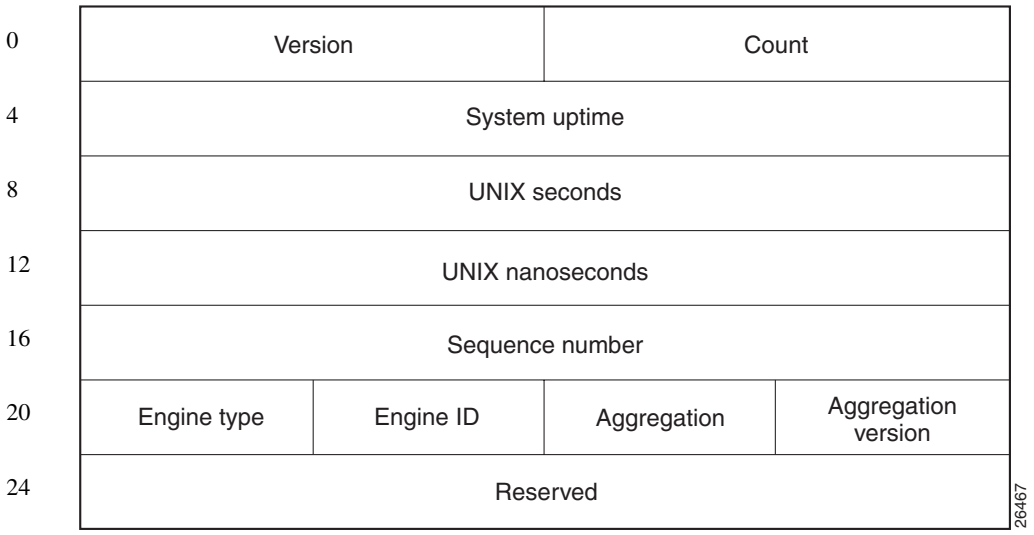


Table 17 Terms and Definitions for Version 8 Headers

Term	Definition
Version	The flow export format version number. In this case, the number is “8.”
Count	The number of export records in the datagram.
System uptime	The number of milliseconds since the router was last booted.
UNIX seconds	The number of seconds since 0000 UTC 1970.
UNIX nanoseconds	The number of residual nanoseconds since 0000UTC 1970.
Sequence number	Sequence counter of total flows sent for this export stream.
Engine type	The type of switching engine. RP = 0 and LC = 1.
Engine ID	The slot number of the NetFlow engine.
Aggregation	The type of aggregation scheme being used.
Aggregation version	The aggregation subformat version number. The current value is “2.”

Setting a NetFlow Minimum Mask

The NetFlow Minimum Prefix Mask for Router Based Aggregation feature allows the user to set a minimum mask size. The IP address that is added to the aggregation cache is ANDed with the maximum of the two masks: user-entered mask and the routing table mask.

To enable this feature for a particular aggregation cache, configure the desired *minimum mask* value using the NetFlow aggregation cache commands. The minimum mask value used by the router selects the granularity of the NetFlow data that will be collected as follows:

- For coarse NetFlow collection granularity, select a low minimum mask value.
- For fine NetFlow collection granularity, select a high minimum mask value.

The mask values range from 1 to 32.

Note Setting a NetFlow minimum mask size is not available in Autonomous System aggregation and Protocol Port aggregation.

NetFlow Policy Routing

NetFlow policy routing (NPR) integrates policy routing, which enables traffic engineering and traffic classification, with NetFlow services, which provide billing, capacity planning, and monitoring information on real-time traffic flows. IP policy routing now works with Cisco Express Forwarding (CEF), Distributed CEF (dCEF), and NetFlow.

As quality of service (QoS) and traffic engineering become more popular, so does interest in the ability of policy routing to selectively set IP precedence and type of service (TOS) bits (based on access lists and packet size), thereby routing packets based on predefined policy. It is important that policy routing work well in large, dynamic routing environments. Hence, distributed support allows you to leverage your investment in distributed architecture.

Cisco IOS introduced three technologies for IP Policy Routing. See Table 18.

Table 18 Three Technologies for IP Policy Routing

Technology	Description
CEF	Looks at a Forwarding Information Base (FIB) table instead of a routing table when switching packets.
dCEF	Addresses the scalability and maintenance problems of a demand caching scheme.
NetFlow	A Cisco IOS software accounting tool for network planning, accounting, billing and security.

NPR leverages these technologies. To configure NetFlow policy routing, see the chapter "Configuring NetFlow" in this publication.

Benefits

NetFlow policy routing provides the following benefits:

- NPR takes advantage of the new switching services. CEF, dCEF, and NetFlow can now use policy routing.
- Now that policy routing is integrated into CEF, policy routing can be deployed on a wide scale and on high-speed interfaces.

Restrictions

NetFlow policy routing has the following restrictions:

- NPR is only available on Cisco IOS CEF-based platforms.
- Distributed FIB-based policy routing is only available on platforms that support dCEF and images that support dCEF.
- dCEF—The **set ip next-hop verify-availability** route-map configuration command is not supported in dCEF because dCEF does not support the Cisco Discovery Protocol (CDP) database.