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Export of GTP-U Information in IP Flow Information Export (IPFIX)
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Abstract

This document introduces IP Flow Information Export (IPFIX) Information Elements to report information contained in the Generic Packet Radio Service Tunneling Protocol (GTP) User Plane header such as Tunnel Endpoint Identifier, and data contained in its session container extension header.

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1. Introduction

A dedicated header, called GPRS Tunneling Protocol (GTP) Header, is defined by 3GPP for the GTP User Plane (GTP-U) [TS.29281] traffic of mobile subscribers.

This document specifies eight IPFIX Information Elements (IEs) [RFC7012] to export GTP-U information.

Specifically, these IEs are used to export the GTP-U Tunnel Endpoint Identifier (TEID), QoS Flow Identifier (QFI), and PDU Type from the PDU Session Container extension header.

Some examples are provided in Appendix A.

2. Terminology

This document makes use of the terms defined in [RFC7011]

- * IPFIX
- * IPFIX Information Element
- * Template
- * Template Record
- * Options Template
- * Options Template Record
- * Data Record
- * Data Set

This document uses the term "User Plane" as used by 3GPP GTP-U in [TS.29281].

The document uses the following abbreviations:

- * IE: Information Element
- * GTP: GPRS Tunneling Protocol
- * GTP-U: GTP User Plane
- * GTP-C: GTP Control Plane
- * PDU: Protocol Data Unit
- * TEID: Tunnel Endpoint Identifier
- * UPF: User Plane Function
- * QFI: QoS Flow Identifier

3. IPFIX GTP-U Information Elements

This section defines IPFIX IEs corresponding to various fields in the GTP-U header. When the corresponding field is not present in the observed packet, or when 3GPP specifications state that the field shall not be interpreted, an Exporting Process SHOULD use a Template that omits the corresponding IE. If operational constraints require use of a fixed Template, the Exporting Process MUST export a value of zero for that IE, and the Collecting Process MUST treat that value in this context as "field not available". Reserved bits in exported gtpuQFI and gtpuPduType values MUST be set to zero by the Exporting Process and MUST be ignored by the Collecting Process.

gtpuFlags

8-bit flags field indicating the version of GTP-U header, protocol type, and presence of extension header, sequence number and N-PDU number defined in Section 5.1 of the 3GPP specification [TS.29281]. The bits are exported as observed.

gtpuMsgType

8-bit field which indicates the type of the GTP-U message as mentioned in section 6.1 of 3GPP specification [TS.29281].

gtpuTEid

32-bit tunnel endpoint identifier field unambiguously identifies a tunnel endpoint in the receiving GTP-U protocol entity for a given UDP/IP endpoint.

gtpuSequenceNum

16-bit sequence number field defined in the GTP-U. This field is interpreted based on the sequence number flag value from gtpuFlags.

gtpuQFI

6-bit QoS flow identifier field defined in PDU Session Container extension header of GTP-U. This may be used to determine the QoS flow and QoS profile which are associated with the received packet. The presence of this extension header is interpreted based on the extension header flag value from gtpuFlags.

gtpuPduType

4-bit PDU type field defined in PDU Session Container extension header of GTP-U. This field indicates the structure of the PDU session user plane frame. The presence of this extension header is interpreted based on the extension header flag value from gtpuFlags.

gtpuTotalHdrLength

8-bit field indicating the total length of the GTP-U header which includes mandatory fields and all the optional headers as defined in Sections 5.1 and 5.2 of the 3GPP specification [TS.29281].

This IE is derived from the observed packet header and does not export the GTP-U Length field defined in Section 5.1 of [TS.29281].

gtpuHeaderSection

This Information Element carries a series of n octets from the GTP-U header mandatory fields and all the following optional headers if any, defined in Section 5 of the 3GPP specification [TS.29281] as a series of octets in IPFIX.

4. Sample Use Cases

The GTP-U related IPFIX IEs are helpful in order to identify the transport performance of PDU Sessions, e.g., with specific QoS class within a network slice (refer to [RFC9889]) or within a group of network slices hosted on the same User Plane Function (UPF).

For example, when a set of UPFs are deployed per 5G slice, the slice is identified first using a list of gNodeB IP addresses composing the slice and a list of IP addresses of UPFs dedicated for the slice. The gNodeB and the UPF form the tunnel endpoints. The traffic for each individual PDU Session per direction is identified using the GTP-U TEID, GTP-U PDU Type together with the above mentioned IP tunnel endpoints. Furthermore, the traffic for a specific QoS class within a PDU Session per traffic direction is identified using the combination of GTP-U TEID, GTP-U PDU Type, and GTP-U QFI attributes. It is possible that for a single PDU session there might be multiple IP flows with different GTP-U QFI but with same GTP-U TEID.

In another scenario when multiple 5G slices share the same UPF, each slice is identified using a separated list of gNodeB IPv4 or IPv6 addresses per slice. If an Uplink Classifier (refer to section 3.1 of [TS.23501]) is deployed there is an addition of a GTP-U tunnel between the Intermediate/Uplink-Classified UPF and the final UPF. This brings a challenge for identifying the end-to-end path for a certain PDU Session - the GTP-U PDU Type and GTP-U QFI attributes from the gNodeB and Intermediate/Uplink-Classified UPF tunnel will be the same on the Intermediate/Uplink-Classified and final UPF tunnels, however the GTP-U TEIDs will be different since on each tunnel.

The use of the IPFIX GTP-U IEs is to identify either a particular PDU Session on a particular slice (using GTP-U TEID in combination with the gNodeB and the UPF IP addresses) or all the IP traffic flows for a 3GPP QoS flow on a slice (using GTP-U QFI in combination with the

gNodeB and the UPF IP addresses) or a 3GPP QoS flow for a particular PDU Session on a slice (using both GTP-U TEID and GTP-U QFI in combination with the gNodeB and UPF IP addresses).

Additionally, exporting GTP-U IEs together with the transportChecksum IE 503 registered in the IANA IPFIX registry [IANA-IPFIX] can help detect misbehaving nodes, particularly when using GTP-U over IPv6.

5. IANA Considerations

IANA has registered the following IEs in the "IPFIX Information Elements" registry available at [IANA-IPFIX].

Table 1 lists the GTP-U IEs:

Element ID	Name
505	gtpuFlags
506	gtpuMsgType
507	gtpuTEid
508	gtpuSequenceNum
509	gtpuQFI
510	gtpuPduType
TBD1	gtpuTotalHdrLength
TBD2	gtpuHeaderSection

Table 1: GTP-U IEs in the "IPFIX Information Elements" Registry

IANA is requested to update the references for the existing GTP-U Information Elements listed in Table 1 to point to this RFC. IANA is also requested to allocate two new Information Element IDs for gtpuTotalHdrLength and gtpuHeaderSection in the "IPFIX Information Elements" registry.

5.1. gtpuFlags

Name: gtpuFlags

ElementID: 505

Description: 8-bit flags field indicating the version of GTP-U header, protocol type, and presence of extension header, sequence number and N-PDU number defined in Section 5.1 of the 3GPP specification [TS.29281]. The bits are exported as observed.

The basic encoding is 8 bits. The layout of the encoding is as follows:

MSB	0	1	2	3	4	5	6	7	LSB
+-----+-----+-----+-----+-----+-----+-----+-----+									
Version(3b) PT 0 E S PN									
+-----+-----+-----+-----+-----+-----+-----+-----+									

Examples:

value : 0x34

binary: 00110100

decode: Version=1, PT=1, spare=0, E=1, S=0, PN=0

value : 0x36

binary: 00110110

decode: Version=1, PT=1, spare=0, E=1, S=1, PN=0

Abstract Data Type: unsigned8

Data Type Semantics: flags

Additional Information: Refer to Section 5.1 of [TS.29281].

Reference: [RFC-to-be]

5.2. gtpuMsgType

Name: gtpuMsgType

ElementID: 506

Description: 8-bit field which indicates the type of the GTP-U message as mentioned in Section 6.1 of the 3GPP specification [TS.29281].

Abstract Data Type: unsigned8

Data Type Semantics: identifier

Additional Information: Refer to Section 6.1 of the 3GPP specification [TS.29281].

Reference: [RFC-to-be]

5.3. gtpuTEid

Name: gtpuTEid

ElementID: 507

Description: 32-bit tunnel endpoint identifier field unambiguously identifies a tunnel endpoint in the receiving GTP-U protocol entity for a given UDP/IP endpoint.

Abstract Data Type: unsigned32

Data Type Semantics: identifier

Additional Information: Refer to Section 5.1 of the 3GPP specification [TS.29281].

Reference: [RFC-to-be]

5.4. gtpuSequenceNum

Name: gtpuSequenceNum

ElementID: 508

Description: 16-bit sequence number field defined in the GTP-U. This field is interpreted based on the sequence number flag value from gtpuFlags. When the S flag is not set, this IE is not meaningful and is exported as specified in Section 3.

Abstract Data Type: unsigned16

Data Type Semantics: identifier

Additional Information: Refer to Section 5.1 of the 3GPP specification [TS.29281].

Reference: [RFC-to-be]

5.5. gtpuQFI

Name: gtpuQFI

ElementID: 509

Description: 6-bit QoS flow identifier field defined in PDU Session Container extension header of GTP-U. This may be used to determine the QoS flow and QoS profile which are associated with the received packet. The presence of this extension header is interpreted based on the extension header flag value from gtpuFlags. When the PDU Session Container extension header is not present, this IE is not meaningful and is exported as specified in Section 3. The two most significant bits are reserved, MUST be exported as zero, and MUST be ignored on receipt.

The basic encoding is 8 bits. The layout of basic encoding is as follows:

MSB	-	0	1	2	3	4	5	6	7	-	LSB
+-----+-----+-----+-----+-----+-----+-----+											
		Reserved		6 bit QFI value							
+-----+-----+-----+-----+-----+-----+-----+											

Examples:

value : 0x08

binary: 00001000

decode: 001000 - QFI value

value : 0x3e

binary: 00111110

decode: 111110 - QFI value

Abstract Data Type: unsigned8

Data Type Semantics: identifier

Additional Information: Refer to Section 5.5.3.3 of the 3GPP specification [TS.38415] and Section 5.7.1.1 of the 3GPP specification [TS.23501]. The reserved bits in the exported octet are set to zero.

Reference: [RFC-to-be]

5.6. gtpuPduType

Name: gtpuPduType

ElementID: 510

Description: 4-bit PDU type field defined in PDU Session Container extension header of GTP-U. This field indicates the structure of the PDU session user plane frame. The presence of this extension header is interpreted based on the extension header flag value from gtpuFlags. When the PDU Session Container extension header is not present, this IE is not meaningful and is exported as specified in Section 3. The four most significant bits are reserved, MUST be exported as zero, and MUST be ignored on receipt.

The basic encoding is 8 bits. The layout of basic encoding is as follows:

MSB	-	0	1	2	3	4	5	6	7	-	LSB
+-----+-----+-----+-----+-----+-----+-----+-----+											
				Reserved				4 bit PDU Type			
+-----+-----+-----+-----+-----+-----+-----+-----+											

Examples:

value : 0x01

binary: 00000001

decode: 0001 - PDU Type value

Abstract Data Type: unsigned8

Data Type Semantics: identifier

Additional Information: Refer to Section 5.5.3 of the 3GPP specification [TS.38415]. The reserved bits in the exported octet are set to zero.

Reference: [RFC-to-be]

5.7. gtpuTotalHdrLength

Name: gtpuTotalHdrLength

ElementID: TBD1

Description: 8-bit field indicating the total length in octets of the observed GTP-U header, including the mandatory 8-octet header and any optional fields and extension headers defined in Sections 5.1 and 5.2 of the 3GPP specification [TS.29281]. This IE is derived from the observed packet header and does not export the GTP-U Length field defined in Section 5.1 of [TS.29281].

Abstract Data Type: unsigned8

Data Type Semantics: quantity

Additional Information: Refer to Sections 5.1 and 5.2 of [TS.29281].

Reference: [RFC-to-be]

5.8. gtpuHeaderSection

Name: gtpuHeaderSection

ElementID: TBD2

Description: This Information Element carries a series of n octets from the observed GTP-U header, including the mandatory header and any optional fields and extension headers defined in Sections 5.1 and 5.2 of the 3GPP specification [TS.29281], as a series of octets in IPFIX.

Abstract Data Type: octetArray

Data Type Semantics: default

Additional Information: Refer to Section 5 of [TS.29281].

Reference: [RFC-to-be]

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8. Implementation Status

Note to the RFC-Editor: Please remove this section before publishing.

8.1. Cisco IOS XR

Cisco implemented the following IEs as part of a test implementation in the IOS XR platform. This implementation currently covers six of the eight IEs defined in this document; it does not yet cover gtpuTotalHdrLength or gtpuHeaderSection:

- * gtpuFlags
- * gtpuMsgType
- * gtpuTEid
- * gtpuSequenceNum
- * gtpuQFI
- * gtpuPduType

9. Security Considerations

The IEs described in this document export GTP user plane information on how packets are being forwarded in a 3GPP network. In particular, TEIDs, QFIs, PDU types, and raw header sections can enable correlation of traffic with individual PDU sessions and, depending on deployment, with subscriber activity. Implementations and operators therefore SHOULD treat this data as sensitive network telemetry.

Applications and operators using the IEs described in this document must evaluate the sensitivity of this information in their implementation context, and apply the data-at-rest storage guidance in Section 11.8 of [RFC7011] as appropriate.

Operators SHOULD restrict access to these exported IEs, apply retention limits appropriate to sensitive operational telemetry, and avoid exporting gtpuHeaderSection unless required by the operational use case.

10. Operational Considerations

The IPFIX IEs defined in this document require extraction of fields from packets. There may exist older devices in the network that do not support extensions defined in this document. For those devices [RFC7133] defines dataLinkFrameSection which is a useful mechanism to export the packet header as a fallback scenario. However, when dataLinkFrameSection is used, Flow aggregation as per [RFC7015] can't be applied. This document will serve as a guideline to extract the necessary fields from the GTP-U header for the above scenarios.

11. References

11.1. Normative References

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- [TS.38415] 3GPP, "NG-RAN; PDU Session User Plane Protocol)", Version 17.1.0, 3GPP TS 38.415, February 2024.

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<<https://www.iana.org/assignments/ipfix/ipfix.xhtml>>.
- [RFC7015] Trammell, B., Wagner, A., and B. Claise, "Flow Aggregation for the IP Flow Information Export (IPFIX) Protocol", RFC 7015, DOI 10.17487/RFC7015, September 2013, <<https://www.rfc-editor.org/info/rfc7015>>.
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- [RFC9889] Szarkowicz, K. G., Ed., Roberts, R., Ed., Lucek, J., Boucadair, M., Ed., and L. M. Contreras, "A Realization of Network Slices for 5G Networks Using Current IP/MPLS Technologies", RFC 9889, November 2025, <<https://www.rfc-editor.org/info/rfc9889>>.

Appendix A. IPFIX Encoding Examples

In this section, an example is provided to show IPFIX encoding format for the GTP-U introduced IEs. Template definition and data set corresponding to an observed GTP-U header is illustrated below.

Observed GTP-U Header:

Flags = 0x34, Message Type = 0xff, GTP-U Length = 0x0064,
TEID = 0x00000001, Sequence Number = 0x0000,
N-PDU Number = 0x00,
Next Extension Header Type = 0x85 (PDU Session Container),
PDU Session Container bytes = 0x01 0x10 0x08 0x00,
PDU Type = 1, QFI = 8, gtpuTotalHdrLength = 16

A.1. Template Record

A.1.1. Template Record and Data Set

Sample template consisting of the GTP-U IEs:

0										1										2										3									
0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1								
SET ID = 2										Length = 40																													
Template ID = 256										Field Count = 8																													
0	gtpuFlags = 505									Field Length = 1																													
0	gtpuMsgType = 506									Field Length = 1																													
0	gtpuSequenceNum = 508									Field Length = 2																													
0	gtpuTEid = 507									Field Length = 4																													
0	gtpuQFI = 509									Field Length = 1																													
0	gtpuPduType = 510									Field Length = 1																													
0	gtpuTotalHdrLength = TBD1									Field Length = 1																													
0	gtpuHeaderSection = TBD2									Field Length = 0xFFFF																													

Figure 1: Sample Template Record

In this example, the Template ID is 256, which will be used in the Data Record.

The data set is represented as follows:

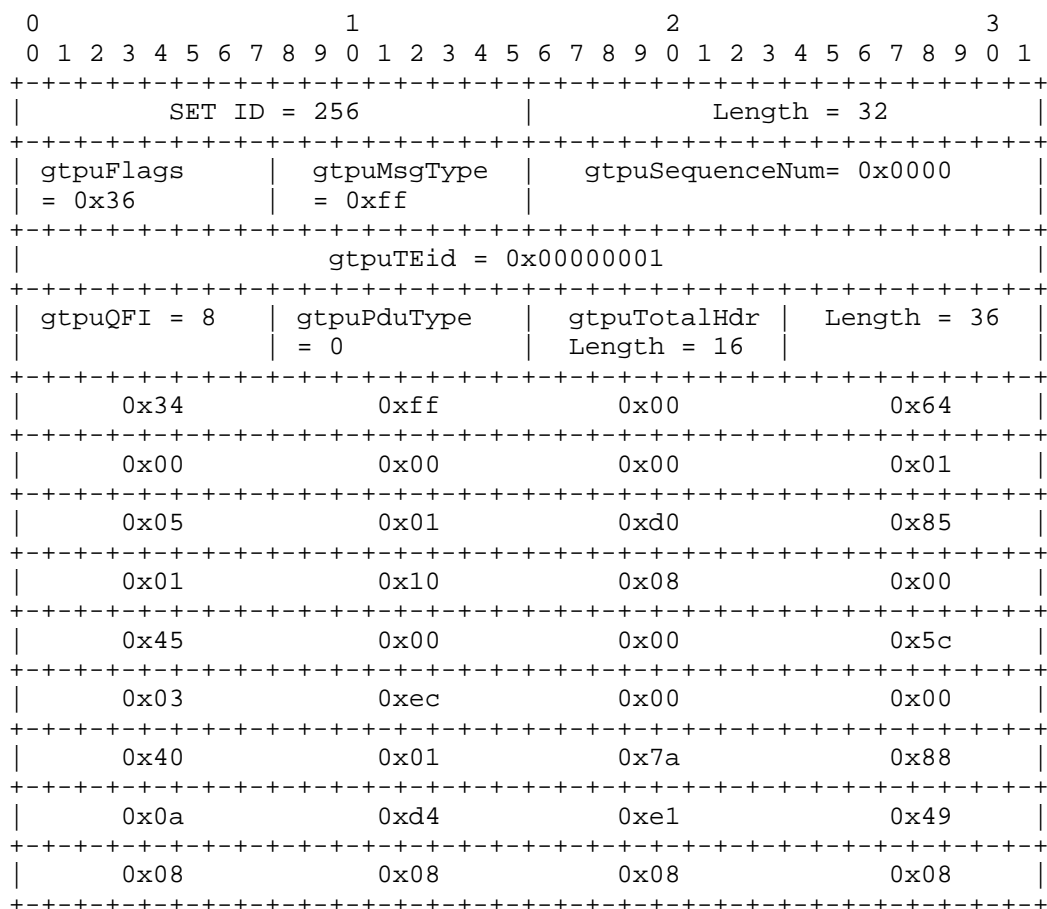


Figure 2: Data Set Encoding Format

The gtpuHeaderSection octets in this example are:

```
0x34 0xff 0x00 0x64 0x00 0x00 0x00 0x01
0x05 0x01 0xd0 0x85 0x01 0x10 0x08 0x00
0x45 0x00 0x00 0x5c 0x03 0xec 0x00 0x00
0x40 0x01 0x7a 0x88 0x0a 0xd4 0xe1 0x49
0x08 0x08 0x08 0x08
```

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