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SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Data over Transport – Generic aspects – General

SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

Internet protocol aspects – Transport

Generic framing procedure

Recommendation ITU-T G.7041/Y.1303

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ITU-T G-SERIES RECOMMENDATIONS

TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

INTERNATIONAL TELEPHONE CONNECTIONS AND CIRCUITS	G.100–G.199
GENERAL CHARACTERISTICS COMMON TO ALL ANALOGUE CARRIER-TRANSMISSION SYSTEMS	G.200–G.299
INDIVIDUAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON METALLIC LINES	G.300–G.399
GENERAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON RADIO-RELAY OR SATELLITE LINKS AND INTERCONNECTION WITH METALLIC LINES	G.400–G.449
COORDINATION OF RADIOTELEPHONY AND LINE TELEPHONY	G.450–G.499
TRANSMISSION MEDIA AND OPTICAL SYSTEMS CHARACTERISTICS	G.600–G.699
DIGITAL TERMINAL EQUIPMENTS	G.700–G.799
DIGITAL NETWORKS	G.800–G.899
DIGITAL SECTIONS AND DIGITAL LINE SYSTEM	G.900–G.999
MULTIMEDIA QUALITY OF SERVICE AND PERFORMANCE – GENERIC AND USER-RELATED ASPECTS	G.1000–G.1999
TRANSMISSION MEDIA CHARACTERISTICS	G.6000–G.6999
DATA OVER TRANSPORT – GENERIC ASPECTS	G.7000–G.7999
General	**G.7000–G.7099**
Transport network control aspects	G.7700–G.7799
PACKET OVER TRANSPORT ASPECTS	G.8000–G.8999
ACCESS NETWORKS	G.9000–G.9999

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Recommendation ITU-T G.7041/Y.1303

Generic framing procedure

Summary

Recommendation ITU-T G.7041/Y.1303 defines a generic framing procedure (GFP) to delineate octet-aligned, variable-length payloads from higher-level client signals for subsequent mapping into octet-synchronous paths, such as those defined in Recommendations ITU-T G.707/Y.1322, ITU-T G.8040/Y.1340 and ITU-T G.709/Y.1331. This Recommendation defines:

– frame formats for protocol data units (PDUs) transferred between GFP initiation and termination points;

– the mapping procedure for the client signals into GFP;

– responses to certain defect conditions.

This edition adds the information from Amendment 1 (2012), Amendment 2 (2012) and Amendment 3 (2015) to Recommendation ITU-T G.7041 (2011), in addition to new material and text enhancements from contributions to the February 2016 meeting.

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As of the date of approval of this Recommendation, ITU had received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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Table of Contents

		Page
1	Scope	1
2	References	1
3	Terms and definitions	3
4	Abbreviations and acronyms	4
5	Conventions	6
6	Aspects common to both frame-mapped and transparent-mapped modes of GFP	6
6.1	Basic signal structure for GFP client frames	7
6.2	GFP control frames	18
6.3	GFP frame-level functions	19
6.4	Management communications frame	24
7	Payload-specific aspects for frame-mapped GFP	24
7.1	Ethernet media access control payload	24
7.2	HDLC/PPP payload	27
7.3	Fibre channel payload via FC-BBW_SONET	28
7.4	Error handling in frame-mapped GFP	29
7.5	IEEE 802.17 resilient packet ring payload	29
7.6	Direct mapping of multiprotocol label switching into GFP-F frames	30
7.7	Direct mapping of IP and OSI network layer PDUs into GFP-F frames	31
7.8	DVB ASI payload	32
7.9	Transporting Ethernet 10GBASE-R payloads with preamble transparency and ordered set information	33
7.10	Precision time protocol	36
7.11	Synchronization status messages	37
8	Payload-specific aspects for transparent mapping of 8B/10B clients into GFP	38
8.1	Common aspects of GFP-T	38
8.2	Running disparity in 64B/65B codes	42
8.3	Client-specific signal fail aspects	44
8.4	Synchronous full-rate transparent mapping of 8B/10B clients into GFP	47
8.5	Asynchronous (full- or sub-rate) mapping of 8B/10B clients into GFP	50
Appendix I – Examples of functional models for GFP applications		51
Appendix II – Sample GFP payload types		53
Appendix III – GFP frame example illustrating transmission order and CRC calculation		54
III.1	Worked example for a GFP-F frame	54
III.2	Worked example for a GFP-T superblock CRC calculation	57
III.3	Worked example for a GFP-F encapsulated MPLS frame	57

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Page

Appendix IV – Number of superblocks used in transparent GFP 59
IV.1 Introduction 59
IV.2 Calculation of spare bandwidth 59
IV.3 Calculation of available bandwidth for CMFs and MCFs 60
Appendix V – Bandwidth requirements for Ethernet transport 62
Appendix VI – Ethernet physical layer defect signals 65
Appendix VII – Ethernet throughput of ODUflex for GFP-F mapped client signals 67
Bibliography 69

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Introduction

A generic framing procedure (GFP) provides a generic mechanism to adapt traffic from higher-layer client signals over a transport network. Client signals may be protocol data unit- (PDU)-oriented [such as Internet protocol/point-to-point protocol (IP/PPP) or Ethernet media access control (MAC)] or block-code oriented constant bit rate stream [such as fibre channel or enterprise systems connection/single-byte command code sets connection (ESCON/SBCON)].

The GFP specification consists of both common and client-specific aspects. Common aspects of GFP apply to all GFP-adapted traffic and they are specified in clause 6. Client-specific aspects of GFP are specified in clauses 7 and 8. Currently, two modes of client signal adaptation are defined for GFP.

– A PDU-oriented adaptation mode, referred to as frame-mapped GFP (GFP-F), is specified in clause 7.

– A block-code oriented adaptation mode, referred to as transparent GFP (GFP-T), is specified in clause 8.

Figure 1 illustrates the relationship between the higher-layer client signals, GFP and GFP transport paths.

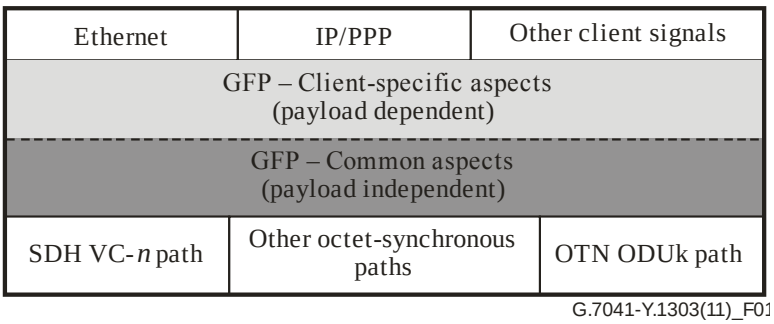

Figure 1 – GFP relationship to client signals and transport paths

Figure 2 illustrates the environment in which GFP operates.

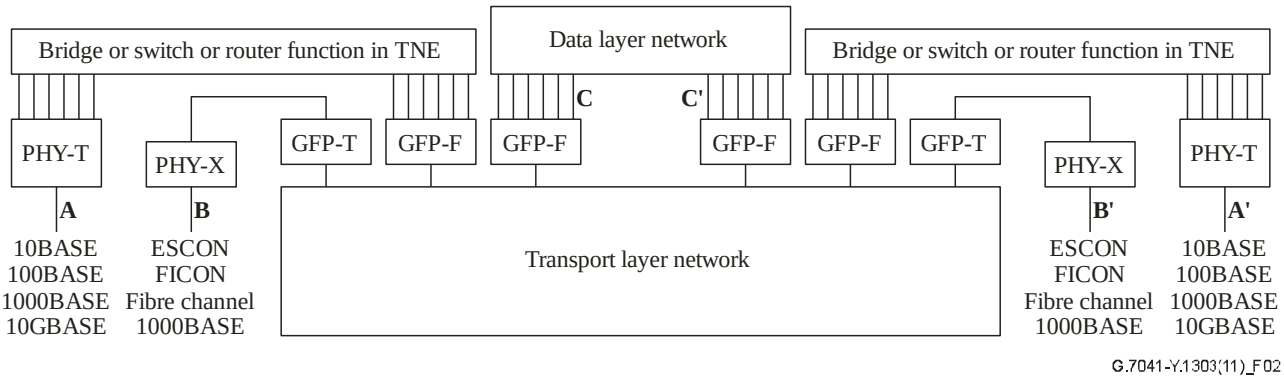

Figure 2 – GFP functional model (single client)

In the frame-mapped adaptation mode, the client/GFP adaptation function may operate at the data link layer (or higher layer) of the client signal. Client PDU visibility is required. This visibility is obtained when the client PDUs are received from either the data layer network [e.g., Internet protocol (IP) router fabric or Ethernet switch fabric (C/C' in Figure 2)] or, e.g., a bridge, switch or router function in a transport network element (TNE). In the latter case, the client PDUs are received via, e.g., an Ethernet interface (A/A' in Figure 2).

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For the transparent adaptation mode, the client/GFP adaptation function operates on the coded character stream rather than on the incoming client PDUs. Thus, processing of the incoming codeword space for the client signal is required (B/B' in Figure 2).

Typically, interconnections can be set up between ports A and A', B and B', C and C', A and C', and C and A'. Note that the physical port type of B and B' must be the same to support an interconnection, while the physical port type of A and A' may be different.

Some high-level functional models associated with the above GFP processing can be found in Appendix I.

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Recommendation ITU-T G.7041/Y.1303

Generic framing procedure

1 Scope

This Recommendation defines a generic framing procedure (GFP) to encapsulate variable-length payload of various client signals for subsequent transport over synchronous digital hierarchy (SDH), plesiochronous digital hierarchy (PDH) and optical transport network (OTN) networks as defined in [ITU-T G.707], [ITU-T G.8040] and [ITU-T G.709]. This Recommendation defines the:

– frame formats for protocol data units (PDUs) transferred between GFP initiation and termination points;

– mapping procedure for the client signals into GFP.

The framing procedure described in this Recommendation can be applied to both the encapsulation of entire client frames (frame-mapped GFP), in which a single client frame is mapped into a single GFP frame, and to character-mapped transport (transparent GFP), in which a number of client data characters are mapped into efficient block codes for transport within a GFP frame.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T G.707] Recommendation ITU-T G.707/Y.1322 (2007), *Network node interface for the synchronous digital hierarchy (SDH)*.

[ITU-T G.709] Recommendation ITU-T G.709/Y.1331 (2016), *Interfaces for the optical transport network (OTN)*.

[ITU-T G.781] Recommendation ITU-T G.781 (2008), *Synchronization layer functions*.

[ITU-T G.783] Recommendation ITU-T G.783 (2006), *Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks*.

[ITU-T G.798] Recommendation ITU-T G.798 (2012), *Characteristics of optical transport network hierarchy equipment functional blocks*.

[ITU-T G.806] Recommendation ITU-T G.806 (2012), *Characteristics of transport equipment – Description methodology and generic functionality*.

[ITU-T G.8021] Recommendation ITU-T G.8021/Y.1341 (2016), *Characteristics of Ethernet transport network equipment functional blocks*.

[ITU-T G.8040] Recommendation ITU-T G.8040/Y.1340 (2005), *GFP frame mapping into plesiochronous digital hierarchy (PDH)*.

[ITU-T G.8264] Recommendation ITU-T G.8264/Y.1364 (2013), *Distribution of timing information through packet networks*.

[ITU-T G.8275.1] Recommendation ITU-T G.8275.1/Y.1369.1 (2016), *Precision time protocol telecom profile for phase/time synchronization with full timing support from the network*.

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[ITU-T H.222.0] Recommendation ITU-T H.222.0 (2014)|ISO/IEC 13818-1:2015, *Information technology – Generic coding of moving pictures and associated audio information: Systems*.

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[IETF RFC 1661] IETF RFC 1661 (1994), *The Point-to-Point Protocol (PPP)*.

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[IETF RFC 2460] IETF RFC 2460 (1998), *Internet Protocol, Version 6 (IPv6) Specification*.

[IETF RFC 3032] IETF RFC 3032 (2001), *MPLS Label Stack Encoding*.

[IEEE 802.3] IEEE 802.3-2015, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications*.

[IEEE 802.17] IEEE 802.17-2011, *IEEE standard for information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 17: Resilient packet ring (RPR) access method and physical layer specifications*.

[ISO 9542] ISO 9542:1988, *Information processing systems – Telecommunications and information exchange between systems – End system to Intermediate system routeing exchange protocol for use in conjunction with the Protocol for providing the connectionless-mode network service (ISO 8473)*.

[ISO/IEC 10589] ISO/IEC 10589:2002, *Information technology – Telecommunications and information exchange between systems – Intermediate System to Intermediate System intra-domain routeing information exchange protocol for use in conjunction with the protocol for providing the connectionless-mode network service (ISO 8473)*.

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[ISO/IEC 13239] ISO/IEC 13239:2002, *Information technology – Telecommunications and information exchange between systems – High-level data link control (HDLC) procedures*.

[ISO/IEC 13818-9] ISO/IEC 13818-9:1996, *Information technology – Generic coding of moving pictures and associated audio information – Part 9: Extension for real time interface for systems decoders*.

[ISO/IEC 14165-241] ISO/IEC 14165-241:2005, *Information technology – Fibre Channel – Part 241: Backbone 2 (FC-BB-2)*.

3 Terms and definitions

This Recommendation defines the following terms:

3.1 channel identifier (CID): An 8-bit binary number used to indicate one of 256 communication channels at a generic framing procedure (GFP) initiation/termination point.

3.2 client data frame: A generic framing procedure (GFP) frame that contains payload data from a client signal.

3.3 client defect clear indication (DCI): A fast explicit indication from the client that a client signal fail, reverse defect or forward defect event has cleared. The DCI allows the generic framing procedure (GFP) sink adaptation function to respond to the fault clearing immediately rather than detecting the clearing through a time out in the arrival of Client Signal Fail (CSF), reverse defect indication (RDI) or forward defect indication (FDI) frames.

3.4 client forward defect indication (FDI): A generic framing procedure (GFP) client management frame (CMF) used to communicate client forward defect information from the GFP-F source to the sink adaptation functions. Some clients transmit an indication of local faults affecting the forward signal direction, with the indication encoded into the client physical layer signal.

3.5 client management frame (CMF): A generic framing procedure (GFP) frame containing information associated with the management of the GFP connection between the GFP source and sink.

3.6 client reverse defect indication (RDI): A generic framing procedure (GFP) client management frame (CMF) used to communicate this client reverse defect information from the GFP-F source to the sink adaptation functions. Some clients transmit an indication of faults in the reverse signal direction, with the indication encoded into the client physical layer signal.

3.7 control frame: A generic framing procedure (GFP) frame used to control the GFP connection. The only control defined at this time is the idle frame.

3.8 frame-mapped GFP: A type of generic framing procedure (GFP) mapping in which a client signal frame is received and mapped in its entirety into one GFP frame.

3.9 management communications frame (MCF): A generic framing procedure (GFP) frame used to provide a management communications channel (MCC) capability across the GFP link. The definition of this channel and its applications are beyond the scope of this Recommendation.

3.10 maximum transmission unit (MTU): Maximum size of the generic framing procedure (GFP) payload area, in octets.

3.11 running disparity (RD): A procedure used by block line codes, such as 8B/10B, to balance the total of number of 1s and 0s transmitted over time. The running disparity at the end of a line code sub-block is positive if more 1s than 0s have been sent up to that point, and negative if more 0s than 1s have been sent. The encoder uses the running disparity value to choose which of the two possible codes to transmit for the next character mapping in order to balance the number of transmitted 1s and 0s.

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3.12 source port/destination port (SP/DP): A logical addressable entity on a physical interface.

3.13 superblock: A transparent generic framing procedure (GFP) structure that combines multiple 64B/65B codes along with a CRC-16 for the purposes of providing payload octet alignment and error control over the bits in the superblock.

NOTE – See Figure 8-3.

3.14 transparent GFP: A type of generic framing procedure (GFP) mapping in which block-coded client characters are decoded and then mapped into a fixed-length GFP frame and may be transmitted immediately without waiting for the reception of an entire client data frame.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

1GbE	1 Gbit/s Ethernet
ACFC	Address-and-Control-Field-Compression
AIS	Alarm Indication Signal
ASI	Asynchronous Serial Interface
ATM	Asynchronous Transfer Mode
BBW	Backbone WAN
cHEC	core Header Error Check
CID	Channel Identifier
CLNP	Connectionless Network Protocol
CMF	Client Management Frame
CoS	Class of Service
CRC	Cyclic Redundancy Check
CSF	Client Signal Fail
DCI	Defect Clear Indication
DE	Discard Eligibility
DP	Destination Port
DVB	Digital Video Broadcast
eHEC	extension Header Error Check
ES-IS	End System-to-Intermediate System
EOF	End of Frame
ESCON	Enterprise Systems Connection
EXI	Extension header Identifier
FC	Fibre Channel
FCS	Frame Check Sequence
FDI	Forward Defect Indication
FEFI	Far-End Fault Indication
FICON	Fibre Connection

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FIFO	First-In, First-Out
GFP	Generic Framing Procedure
GFP-F	Generic Framing Procedure, Frame-mapped
GFP-T	Generic Framing Procedure, Transparent
HDLC	High-level Data Link Control
HEC	Header Error Check
IFG	Inter-Frame Gap
IP	Internet Protocol
IPG	Inter-Packet Gap
ISDN	Integrated Services Digital Network
IS-IS	Intermediate System-to-Intermediate System
LCC	Last Control Character
LCP	Link Control Protocol
LF	Local Fault
LOL	Loss of Light
LOS	Loss of Signal
LSB	Least Significant Bit
MAC	Media Access Control
MAPOS	Multiple Access Protocol Over Synchronous optical network/synchronous digital hierarchy
MCC	Management Communications Channel
MCF	Management Communications Frame
MPEG	Moving Picture Expert Group
MPLS	Multiprotocol Label Switching
MSB	Most Significant Bit
MTU	Maximum Transmission Unit
NE	Network Element
OSI	Open Systems Interconnection
OTN	Optical Transport Network
PCS	Physical Coding Sublayer
PDH	Plesiochronous Digital Hierarchy
PDU	Protocol Data Unit
pFCS	payload Frame Check Sequence
PFI	Payload Frame check sequence Indicator
PLI	Payload Length Indicator
PLL	Phase-Locked Loop
PPP	Point-to-Point Protocol
PTI	Payload Type Identifier

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PTP	Precision Time Protocol
RD	Running Disparity
RDI	Reverse Defect Indication
RF	Remote Fault
RPR	Resilient Packet Ring
RS	Reed-Solomon
SBCON	Single-Byte command code sets Connection
SBW	Spare Bandwidth
SDH	Synchronous Digital Hierarchy
SFD	Start of Frame Delimiter
SOF	Start of Frame
SONET	Synchronous Optical Network
SP	Source Port
SSF	Server Signal Failure
SSM	Synchronization Status Message
tHEC	type Header Error Check
TS	Transport Stream
TSF	Trail Signal Fail
UPI	User Payload Identifier
VC-*n*	Virtual Container-*n*

5 Conventions

Transmission order: The order of transmission of information in all the figures in this Recommendation is first from left to right and then from top to bottom. Within each byte, the most significant bit (MSB) is transmitted first. The MSB is shown at the left of all the figures.

Undefined field values: The default value for any undefined header fields is 0, unless otherwise stated.

6 Aspects common to both frame-mapped and transparent-mapped modes of GFP

This clause discusses the common (protocol-independent) aspects of GFP for octet-aligned payloads. The mapping of the framed payloads into an SDH VC-*n* is specified in [ITU-T G.707]. The mapping of the framed payloads into an OTN ODUk payload is specified in [ITU-T G.709].

GFP uses a variation of the HEC-based frame delineation mechanism defined for asynchronous transfer mode (ATM) (see [ITU-T I.432.1]). Two kinds of GFP frames are defined: GFP client frames and GFP control frames. Frame formats for GFP client and control frames are defined in clauses 6.1 and 6.2. GFP also supports a flexible (payload) header extension mechanism to facilitate the adaptation of GFP for use with diverse transport mechanisms. Currently defined payload extension header types are specified in clause 6.1.2.1.3.

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6.1 Basic signal structure for GFP client frames

The format for GFP frames is shown in Figure 6-1. GFP frames are octet-aligned and consist of a GFP core header and, except for GFP idle frames, a GFP payload area.

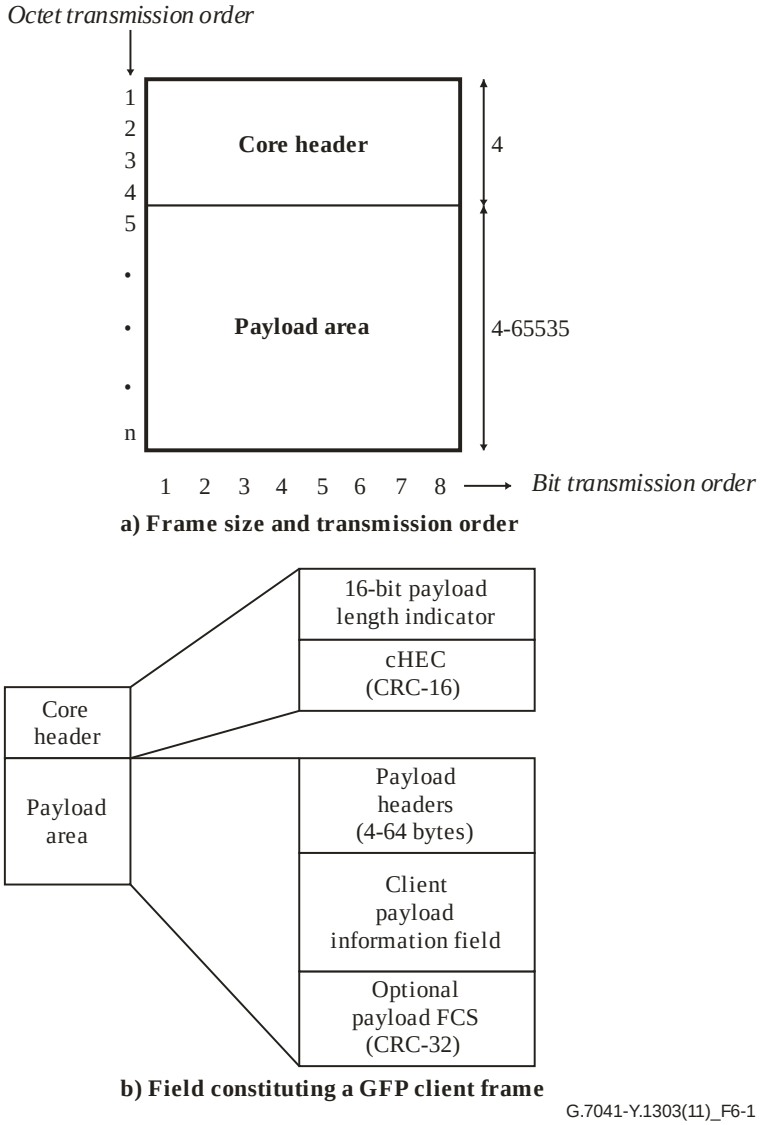

Figure 6-1 – Frame format for GFP client frames

6.1.1 GFP core header

The GFP core header format is shown in Figure 6-2. The four octets of the GFP core header consist of a 16-bit payload length indicator (PLI) field and a 16-bit core header error check (cHEC) field. This header allows GFP frame delineation independent of the content of the higher layer PDUs.

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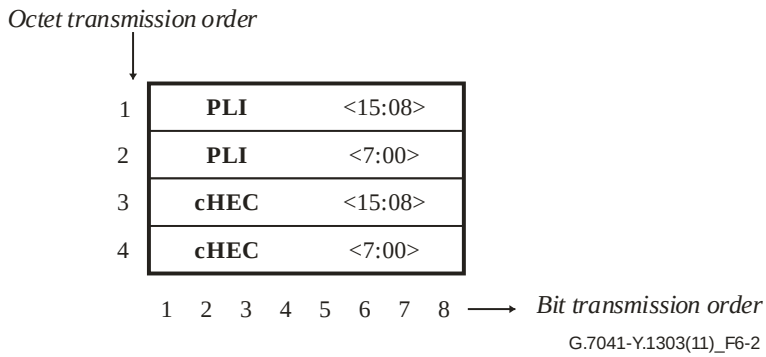

Figure 6-2 – GFP core header format

6.1.1.1 Payload length indicator field

The two-octet PLI field contains a binary number representing the number of octets in the GFP payload area. The absolute minimum value of the PLI field in a GFP client frame is four octets. PLI values 0–3 are reserved for GFP control frame usage (see clause 6.2).

6.1.1.2 Core header error control field

The two-octet cHEC field contains a cyclic redundancy check-16 (CRC-16) error control code that protects the integrity of the contents of the core header by enabling both single-bit error correction and multi-bit error detection. The cHEC sequence is calculated over the octets of the core header as specified in clause 6.1.1.2.1.

6.1.1.2.1 HEC processing

The header error check (HEC) generating polynomial is $G(x) = x^{16} + x^{12} + x^5 + 1$, with an initialization value of zero, where x^{16} corresponds to the MSB and x^0 corresponds to the least significant bit (LSB).

The cHEC field is generated by the source adaptation process using the following steps (see Appendix I of [b-ITU-T V.41]).

1) The first two octets of the GFP frame are taken in network octet order, MSB first, to form a 16-bit pattern representing the coefficients of a polynomial $M(x)$ of degree 15.
2) $M(x)$ is multiplied by x^{16} and divided (modulo 2) by $G(x)$, producing a remainder $R(x)$ of degree 15 or less.
3) The coefficients of $R(x)$ are considered to be a 16-bit sequence, where x^{15} is the MSB.
4) This 16-bit sequence is the CRC-16 where the first bit of the CRC-16 to be transmitted is the coefficient of x^{15} and the last bit transmitted is the coefficient of x^0.

The sink adaptation process performs steps 1)–3) in the same manner as the source adaptation process, except that here, the $M(x)$ polynomial of step 1) includes the CRC-16 bits in received order, and has degree 23. In the absence of bit errors, the remainder shall be 0000 0000 0000 0000.

This single error correction shall be performed on the core header. The GFP sink adaptation process shall discard any of those GFP frames where multi-bit errors are detected. The sink adaptation process also updates any relevant system records for performance monitoring purposes.

6.1.1.3 Core header scrambling

The core header is scrambled for DC balance by an exclusive-OR operation (modulo 2 addition) with the hexadecimal number B6AB31E0. This number is the maximum transition, minimum side-lobe, Barker-like sequence of length 32. The scrambling of the GFP core header improves the robustness of the GFP frame delineation procedure and provides a sufficient number of 0-1 and 1-0 transitions during idle transmission periods.

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6.1.2 GFP payload area

The GFP payload area, which consists of all octets in the GFP frame after the GFP core header, is used to convey higher-layer specific protocol information. This variable length area may include from 4 to 65 535 octets. As shown in Figure 6-3, the GFP payload area consists of two common components: a payload header and a payload information field. An optional payload frame check sequence (pFCS) field is also supported.

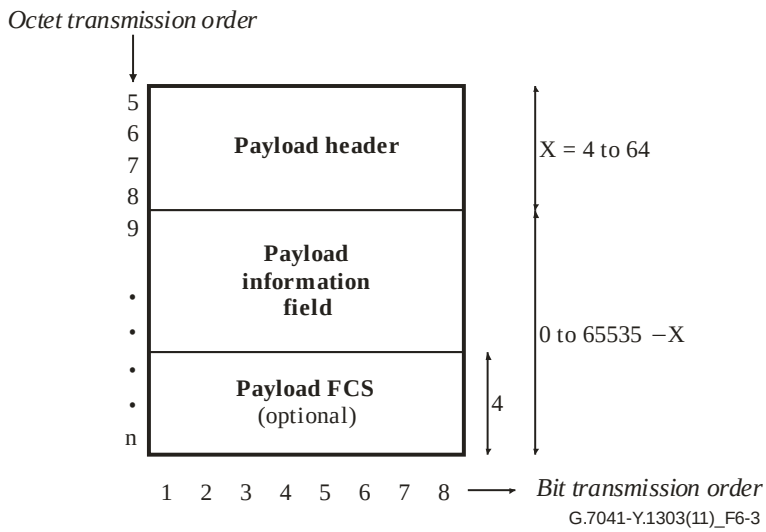

Figure 6-3 – GFP payload area format

Practical GFP maximum transmission unit (MTU) sizes for the GFP payload area are application specific. An implementation should support transmission and reception of GFP frames with GFP payload areas of at least 2 000 octets. By prior arrangement, consenting GFP implementations may use other MTU values. Implementations supporting frame-mapped fibre channel (FC) should support GFP payload areas of at least 2 156 octets.

6.1.2.1 Payload header

The payload header is a variable-length area, 4 to 64 octets long, intended to support data link management procedures specific to the higher-layer client signal. The structure of the GFP payload header is illustrated in Figure 6-4. The area contains two mandatory fields, the type and the type header error check (tHEC) fields, and a variable number of additional payload header fields. This group of additional payload header fields is referred to as the extension header. The presence of the extension header, and its format, and the presence of the optional pFCS are specified by the type field. The tHEC protects the integrity of the type field.

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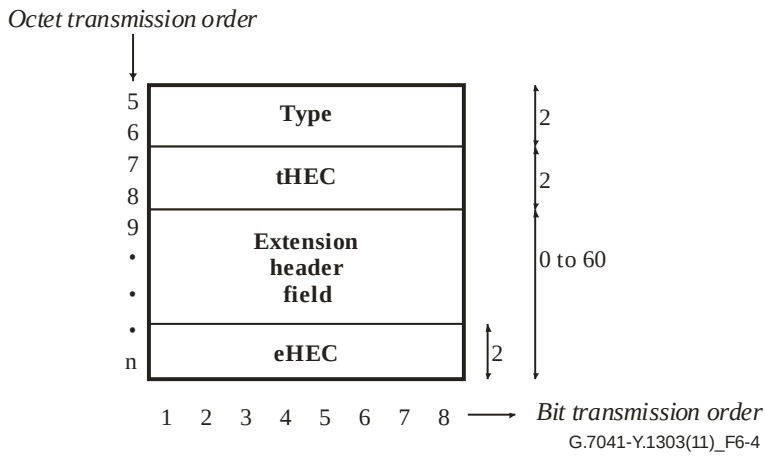

Figure 6-4 – GFP payload header format

An implementation shall support reception of a GFP frame with a payload header of any length in the range 4 to 64 octets.

6.1.2.1.1 GFP type field

The GFP type field is a mandatory two-octet field of the payload header that indicates the content and format of the GFP payload information field (see clause 6.1.2.2). The type field distinguishes between GFP frame types and between different services in a multi-service environment. As shown in Figure 6-5, the type field consists of a payload type identifier (PTI), a pFCS indicator (PFI), an extension header identifier (EXI) and a user payload identifier (UPI).

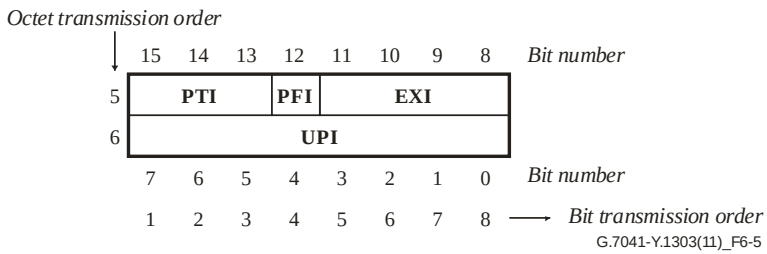

Figure 6-5 – GFP type field format

The interpretation of the UPI field for PTI values different from 000 or 100 is for further study. Sample type field values are illustrated in Appendix II.

6.1.2.1.1.1 Payload type identifier

This 3-bit subfield of the type field identifies the type of GFP client frame. Three kinds of client frames are currently defined, user data frames (PTI = 000), CMFs (PTI = 100) and management communication frames (PTI = 101). PTI codepoints are given in Table 6-1.

Table 6-1 – GFP payload type identifiers

Type bits <15:13>	Usage
000	User data
100	Client management
101	Management communications
Others	Reserved

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6.1.2.1.1.2 Payload frame check sequence indicator

This one-bit subfield of the type field indicates the presence (PFI = 1) or absence (PFI = 0) of the pFCS field.

6.1.2.1.1.3 Extension header identifier (EXI)

This 4-bit subfield of the type field identifies the type of extension header GFP. Three kinds of extension headers are currently defined: a null extension header; a linear extension header; and a ring extension header. EXI codepoints are given in Table 6-2.

Table 6-2 – GFP extension header identifiers

Type bits <11:8>	Usage
0000	Null extension header
0001	Linear frame
0010	Ring frame
Others	Reserved

6.1.2.1.1.4 User payload identifier

This 8-bit field identifies the type of payload conveyed in the GFP payload information field. Interpretation of the UPI field is relative to the type of GFP client frame as indicated by the PTI subfield. UPI values for client data frames are specified in clause 6.1.3.1 and UPI values for CMFs are specified in clause 6.1.3.2.

6.1.2.1.2 Type headererror control field

The two-octet tHEC field contains a CRC-16 error control code that protects the integrity of the contents of the type field by enabling both single-bit error correction and multi-bit error detection. The type header consists of the type field and the tHEC.

The content of the tHEC field is generated using the same steps as the cHEC (see clause 6.1.1.2.1) with the following exception:

– for the tHEC, step 1 is modified such that $M(x)$ is formed from all the octets in the type field, excluding the tHEC field itself at the source, but including the tHEC field at the sink.

The GFP sink adaptation process shall perform single-bit error correction on the type field, which is protected by a tHEC field. The GFP sink adaptation process shall discard any of those GFP frames where multi-bit errors are detected. The sink adaptation process also updates any relevant system records for performance monitoring purposes.

6.1.2.1.3 GFP extension headers

The payload extension header is a 0-to-60 octet extended field [including the extension header error check (eHEC)] that supports technology-specific data link headers such as virtual link identifiers, source/destination addresses, port numbers, class of service (CoS) and extension header error control. The type of the extension header is indicated by the content of the EXI bits in the type field of the payload header.

Three extension header variants are currently defined to support client-specific data over a logical ring or logical point-to-point (linear) configurations.

This clause describes the various fields in each extension header. The default value for any undefined fields is 0 unless otherwise stated.

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6.1.2.1.3.1 Null extension header

The payload header for a frame with a null extension header is shown in Figure 6-6. This extension header applies to a logical point-to-point configuration. It is intended for scenarios where the transport path is dedicated to one client signal.

Octet transmission order

5	**Type**	<15:08>
6	**Type**	<7:00>
7	**tHEC**	<15:08>
8	**tHEC**	<7:00>

1 2 3 4 5 6 7 8 → *Bit transmission order*

G.7041-Y.1303(11)_F6-6

Figure 6-6 – Payload header for a GFP frame with a null extension header

6.1.2.1.3.2 Extension header for a linear frame

The payload header for a linear (point-to-point) frame with an extension header, shown in Figure 6-7, is intended for scenarios where there are several independent links requiring aggregation on to a single transport path.

Octet transmission order

5	**Type**	<15:08>
6	**Type**	<7:00>
7	**tHEC**	<15:08>
8	**tHEC**	<7:00>
9	**CIDe**	<7:00>
10	**Spare**	<7:00>
11	**eHEC**	<15:08>
12	**eHEC**	<7:00>

1 2 3 4 5 6 7 8 → *Bit transmission order*

G.7041-Y.1303(11)_F6-7

Figure 6-7 – Payload header for a linear (point-to-point) frame including the extension header

6.1.2.1.3.2.1 Channel ID field

The CID is an 8-bit binary number used to indicate one of 256 communication channels at a GFP termination point.

6.1.2.1.3.2.2 Spare field

The 8-bit spare field is reserved for future use.

6.1.2.1.3.2.3 Extension header error check field

See clause 6.1.2.1.4.

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6.1.2.1.3.3 Extension header for a ring frame

For further study.

6.1.2.1.4 Extension header error check field

The two-octet eHEC field contains a CRC-16 error control code that protects the integrity of the contents of the extension headers by enabling both single-bit error correction (optional) and multi-bit error detection.

The content of the eHEC field is generated using the same steps as the cHEC (see clause 6.1.1.2.1) with the following exception:

– for the eHEC, step 1 is modified such that $M(x)$ is formed from all the octets in the extension header, but excluding the eHEC field itself.

The GFP sink adaptation process may perform single-bit error correction on all of the fields protected by a tHEC field. Single error correction is optional for the extension header. The GFP sink adaptation process shall discard any of those GFP frames where multi-bit errors are detected or where any error occurs in a header field that does not make use of single error correction. The sink adaptation process also updates any relevant system records for performance monitoring purposes.

6.1.2.2 Payload information field

The payload information field contains the framed PDU for frame-mapped GFP or, in the case of transparent GFP, a group of client signal characters. This variable-length field may include from 0 to 65 535 – X octets, where X is the size of the payload header. This field may include an optional pFCS field. The client PDU/signal is always transferred into the GFP payload information field as an octet-aligned packet stream.

6.1.2.2.1 Payload frame check sequence field

The GFP pFCS, as shown in Figure 6-8, is an optional, four-octet long, FCS. It contains a CRC-32 sequence that protects the contents of the GFP payload information field. The FCS generation process is defined in clause 6.1.2.2.1.1. A value of 1 in the PFI bit within the type field identifies the presence of the pFCS field.

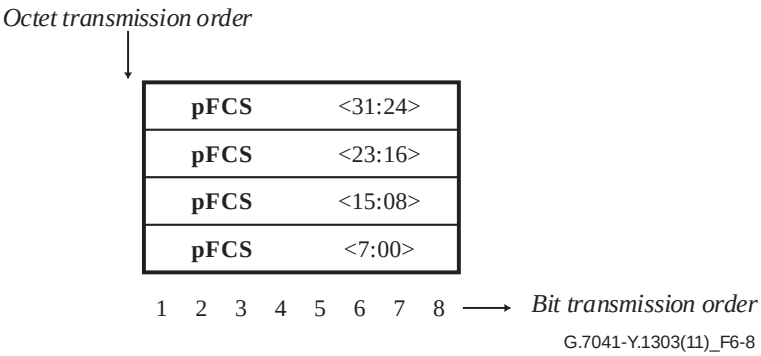

Figure 6-8 – GFP payload frame check sequence format

6.1.2.2.1.1 Payload frame check sequence generation

The pFCS is generated using the CRC-32 generating polynomial [ISO/IEC 13239] $G(x) = x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^{8} + x^{7} + x^{5} + x^{4} + x^{2} + x^{1} + 1$, where x^{32} corresponds to the MSB and x^{0} corresponds to the LSB.

The pFCS field is generated using the following steps.

1) The N octets from the GFP payload information field, excluding the FCS are taken in network octet order, MSB first, to form a $8N$-bit pattern representing the coefficients of a polynomial $M'(x)$ of degree $8N – 1$.

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2) $M'(x)$ is multiplied by x^{32}, added to the product of x^{8N} and the all-1s polynomial $U(x) = 1 + x^1 + x^2 + \ldots + x^{31}$, and divided (modulo 2) by $G(x)$, producing a remainder $R(x)$ of degree 31 or less.

NOTE – The addition of x^{8N} $[1 + x^1 + x^2 + \ldots + x^{31}]$ is equivalent to presetting the shift register to all-1s for typical shift register implementations using presets. Either method is equivalent to complementing the 32 MSBs of the GFP payload information field for the purpose of calculating the FCS.

3) The coefficients of $R(x)$ are considered to be a 32-bit sequence, where x^{31} is the MSB.

4) The complement of this 32-bit sequence is the CRC-32.

The sink adaptation process performs steps 1)–3) in the same manner as the source adaptation process. In the absence of errors, the remainder shall be 11000111_00000100_11011101_01111011, in the order x^{31} to x^0.

6.1.2.3 Payload area scrambling

Scrambling of the GFP payload area is required to provide security if the payload information happens to be the same as the scrambling word (or its inverse) from a frame-synchronous scrambler, such as those used in the SDH Reed-Solomon (RS) layer or in an OTN OPU*k* channel. Figure 6-9 illustrates the scrambler and descrambler processes.

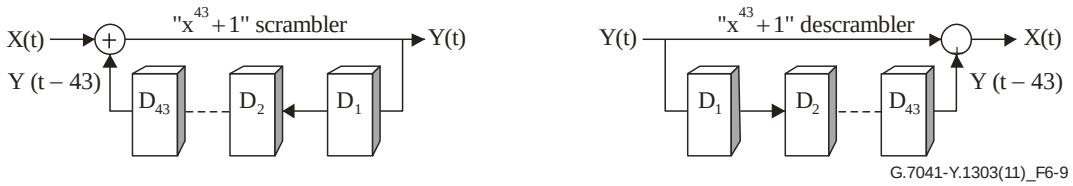

Figure 6-9 – x^{43}+1 scrambler and descrambler processes for GFP

All octets in the GFP payload area are scrambled using a $1 + x^{43}$ self-synchronous scrambler. Scrambling is done in network bit order.

At the source adaptation process, scrambling is enabled starting at the first transmitted octet after the cHEC field, and is disabled after the last transmitted octet of the GFP frame. When the scrambler or descrambler is disabled, its state is retained. Hence, the scrambler or descrambler state at the beginning of a GFP frame payload area will thus be the last 43 payload area bits of the GFP frame transmitted in that channel immediately prior to the current GFP frame.

The activation of the sink adaptation process descrambler also depends on the present state of the cHEC check algorithm:

a) in the HUNT and PRESYNC states, the descrambler is disabled;

b) in the SYNC state, the descrambler is enabled only for the octets between the cHEC field and the end of the candidate GFP frame.

NOTE – The GFP sink adaptation process can reliably forward GFP frames to the higher-layer entity only when the sink adaptation process is in the SYNC state.

6.1.3 GFP client frames

Two types of GFP client frames are currently defined, client data and client management. GFP client data frames are used to transport data from the client signal. GFP CMFs are used to transport information associated with the management of the client signal or GFP connection.

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6.1.3.1 Client data frames

Client data is transported over GFP using client data frames. Client data frames are GFP client frames consisting of a core header and a payload area. The type field of the client data frames uses the following Type subfield values:

– PTI = 000

– PFI = Payload specific

– EXI = Payload specific

– UPI = Payload specific

The PFI shall be set as required depending on whether FCS is enabled or not. The EXI shall be set consistently with the frame multiplexing and topology requirements for the GFP connection. The UPI shall be set according to the transported client signal type. Defined UPI values for client data frames are given Table 6-3.

Table 6-3 – User payload identifiers for GFP client frames

PTI = 000 and 101 (See Notes 2 and 3)	
Type bits <7:0>	**GFP frame payload area**
0000 0000 and 1111 1111	Reserved and not available
0000 0001	Frame-mapped Ethernet
0000 0010	Frame-mapped PPP
0000 0011	Transparent fibre channel
0000 0100	Transparent FICON
0000 0101	Transparent ESCON/SBCON
0000 0110	Transparent Gbit Ethernet
0000 0111	Reserved for future use
0000 1000	Frame-mapped multiple access protocol over SDH (MAPOS)
0000 1001	Transparent DVB ASI
0000 1010	Framed-mapped IEEE 802.17 resilient packet ring
0000 1011	Frame-mapped fibre Channel FC-BBW
0000 1100	Asynchronous transparent fibre channel
0000 1101	Frame-mapped MPLS
0000 1110	See Note 6
0000 1111	Frame-mapped OSI network layer protocols (IS-IS, ES-IS, CLNP)
0001 0000	Frame-mapped IPv4
0001 0001	Frame-mapped IPv6
0001 0010	Frame-mapped DVB ASI
0001 0011	Frame-mapped 64B/66B encoded Ethernet, including the Ethernet frame preamble (see Note 4)
0001 0100	Frame-mapped 64B/66B encoded Ethernet ordered set information (see Note 5)
0001 0101	Transparent transcoded FC-1200 (see clause 17.8.2 of [ITU-T G.709])

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Table 6-3 – User payload identifiers for GFP client frames

PTI = 000 and 101 (See Notes 2 and 3)	
Type bits <7:0>	**GFP frame payload area**
0001 0110	Precision time protocol (PTP) message
0001 0111	Synchronization status message (see clause 7.11 and Note 7)
0001 1000 through 1110 1111	Reserved for future standardization
1111 0000 through 1111 1110	Reserved for proprietary use (See Note 1)
NOTE 1 – The use of proprietary code values is described in Annex A of [ITU-T G.806]. NOTE 2 – The UPI value applies to the PDU in the payload area of that GFP frame. NOTE 3 – Not all of these UPI types are applicable with PTI = 101. NOTE 4 – The former [b-ITU-T G-Sup.43] description of this mapping recommended using UPI = 1111 1101. NOTE 5 – The former [b-ITU-T G-Sup.43] description of this mapping recommended using UPI = 1111 1110. NOTE 6 – This UPI value had been assigned to multicast MPLS frames, which is a mapping that is no longer applicable. This UPI value should not be used. NOTE 7 – The same UPI is used for the both types of messages in 7.11. Both include a synchronization status message (SSM) octet, with the extended SSM appending additional message fields.	

6.1.3.2 GFP client management frames

CMFs provide a generic mechanism for the GFP client-specific source adaptation process to optionally send CMFs to the GFP client-specific sink adaptation process. As illustrated in Figure 6-10, the CMFs are GFP client frames consisting of a core header and a payload area. The type field of the client data frames uses the following Type subfield values:

– PTI = 100

– PFI = Payload specific

– EXI = Payload specific

– UPI = Payload specific

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