Generic Framing Procedure

- Preamble
- Packet over SDH (POS)
- GFP Functional Model and Frame Format
- GFP Advantages

Sistemas de Telecomunicações *Rui Lopes Campos*

Preamble

- Telecom operators/carriers major need → reduce OPEX
- OPEX reduction
  - number of different technologies used in the network has to be reduced
  - evolving toward convergence of all the services over the same network
- Network convergence over IP
  - data is prominent type of traffic to be transmitted
  - real-time services like TV and voice can be reduced to data flows
  - reasonable to converge on the Internet model

OPEX – *Operation Expenditure*

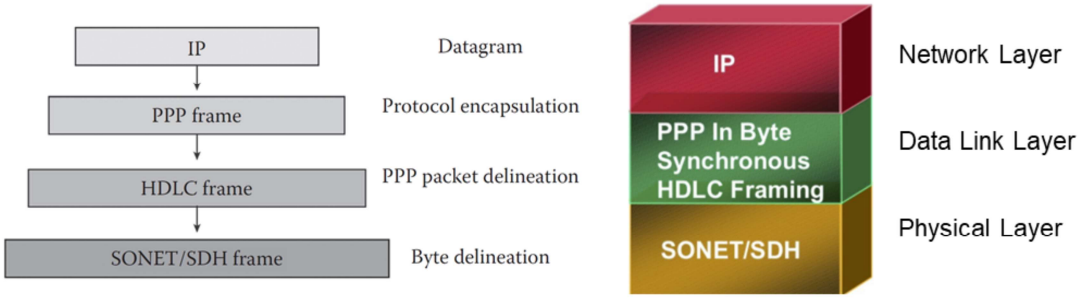
CAPEX – *Capital Expenditure*

Preamble

- Carrier network generally evolving from SDH transport
- Lots of SDH machines deployed in the field
  - some last generation machines, with long operating lifetime in front
- It is desirable to reuse these most modern SDH machines, at least for an important part of their lifetime → reduce CAPEX

Packet over SDH – POS

- Layer 2 technology using PPP and HDLC to encapsulate IP packets into a frame
- Standardized, widely deployed way to map IP packets into SDH frames – RFC 2615
- By adopting POS
  - reuse last generation SDH machines and management and survivability mechanisms well-known/appreciated by carriers

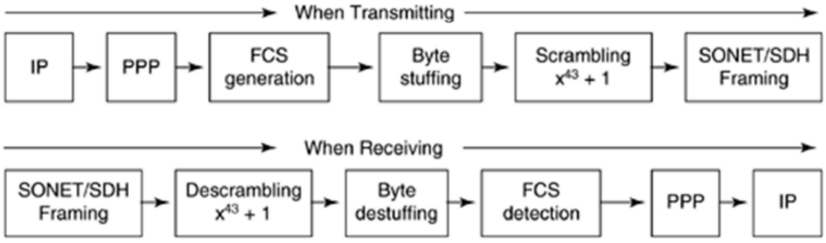


Sistemas de Telecomunicações *Generic Framing Procedure*

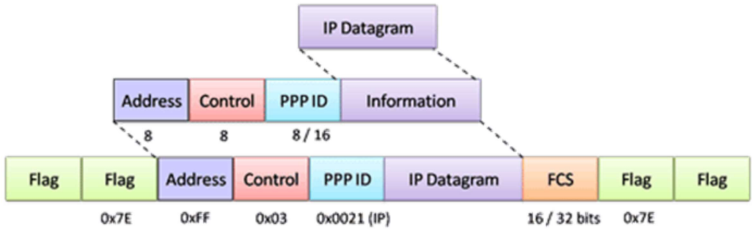
O protocolo PPP (*Point-to-Point Protocol*) é tipicamente usado para encapsulamento e transporte de pacotes IP sobre ligações ponto-a-ponto (e.g. acesso ADSL, ligação entre dois *routers* IP). O protocolo PPP usa o formato das tramas HDLC (*High-Level Data Link Control*) como base (RFC 1549).

Packet over SDH – POS

- Packet Flow for Transmission and Reception of IP over PPP over SDH



- POS Framing



Sistemas de Telecomunicações *Generic Framing Procedure*

Na transmissão de pacotes são feitas as seguintes operações:

- Encapsulamento dos pacotes IP em tramas PPP;
- Cálculo do FCS (*Frame Check Sequence*);
- *Byte stuffing* (assunto abordado em Redes de Computadores – garantia de transparência)
- *Scrambling* (randomização dos dados para garantir transições frequentes entre 0s e 1s e com isso garantir a sincronização do recetor com o emissor).

Na receção são realizadas as operações inversas.

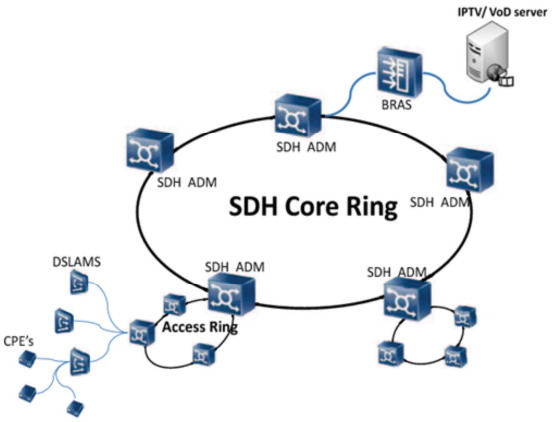
Na figura a cores está representado o encapsulamento dos datagramas IP numa trama PPP, cujo formato é baseado na trama HDLC. Este formato de trama é equivalente ao que foi usado no protocolo de ligação dados desenvolvido na UC de Redes de Computadores.

Packet over SDH – POS

- Transport is carried out through an SDH network
- POS improves network survivability at the expense of inefficiency
  - capacity (bit/s) provided by SDH frequently not needed
  - stuffing abundantly used, loading SDH layer with void load transported
- For these reasons, a more effective adaptation layer was defined
  - the **General Framing Procedure (GFP)**

Generic Framing Procedure – GFP

- Tool for integrating packet networks over SDH transport
  - increase exploitation efficiency of the physical layer resources
- Does not rely only on use of monolithic SDH frames
  - defines flexible adaptation to exploit at best the SDH transport
- Designed for application in high capacity networks and transport of multiple data traffic – e.g., IP and Ethernet



Generic Framing Procedure – GFP

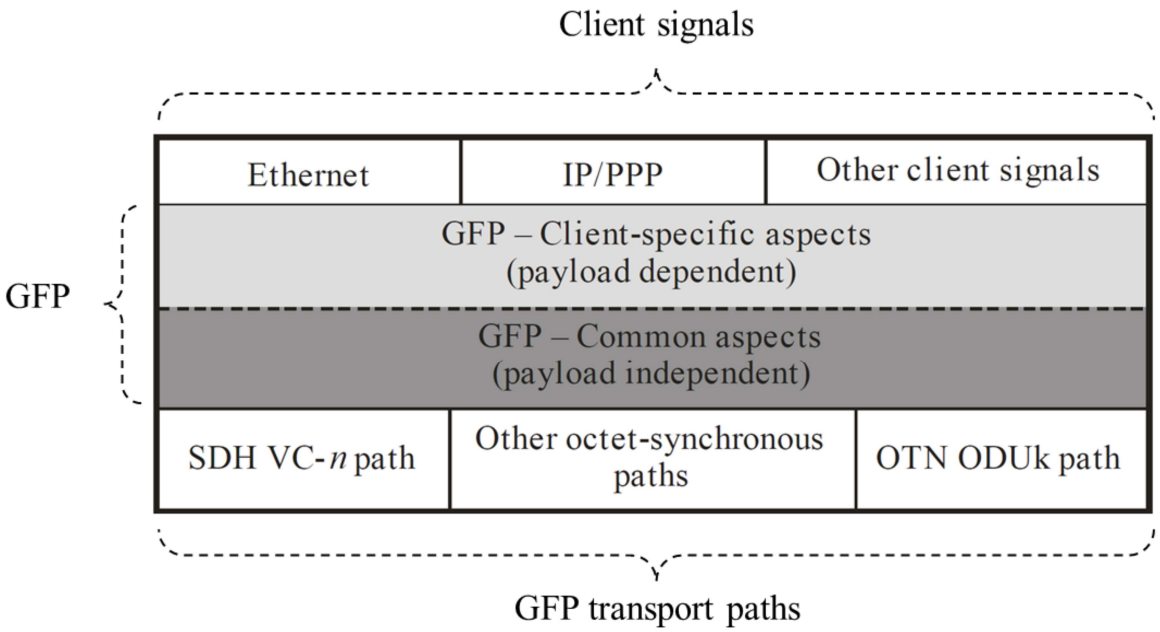
- Simple and scalable
  - proven technology at 1 Gbit/s, 2.5 Gbit/s and 10 Gbit/s
  - scalable beyond 40 Gbit/s
- Supports both Layer 1 and Layer 2 traffic
  - alternative transport mechanism to POS (RFC 2615)
- Standards based
  - ANSI T1.105.02 (2002)
  - Endorsed by IETF (RFC 2823)
  - ITU-T G.7041/Y.1303 (2016)

Sistemas de Telecomunicações *Generic Framing Procedure*

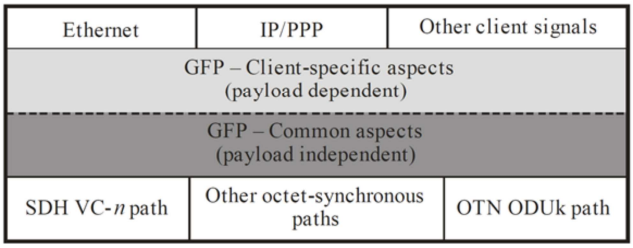
O RFC 2823 define um novo encapsulamento para o PPP designado de *Simple Data Link* (SDL). O SDL introduz *overhead* de encapsulamento muito inferior ao encapsulamento baseado em HDLC usado no POS e pode ser igualmente usado sobre ligações SDH.

Generic Framing Procedure – GFP

Relationship between higher-layer client signals, GFP and GFP transport paths



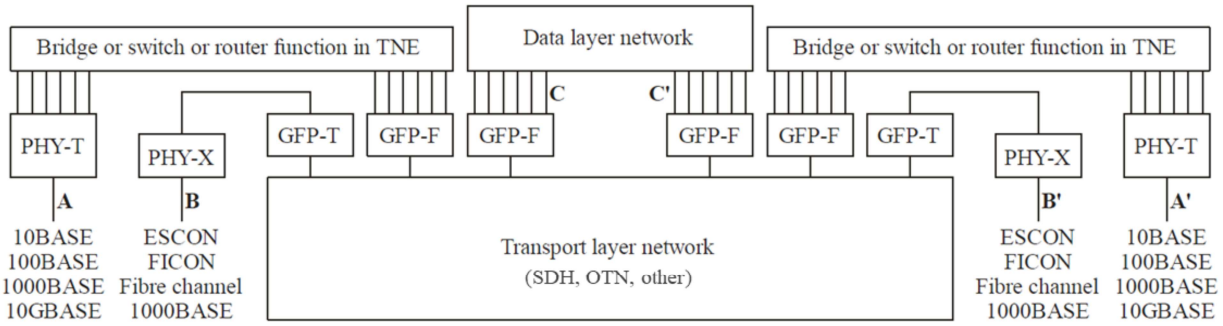
Generic Framing Procedure – GFP



- Consists of both **client-specific** and **common** aspects
  - Common aspects apply to all GFP-adapted traffic
- **Two modes** of client signal adaptation defined (can coexist in the same frame)
  - PDU-oriented adaptation mode → frame-mapped GFP (GFP-F)
  - Block-code oriented adaptation mode → transparent-mapped GFP (GFP-T)

Generic Framing Procedure – GFP

GFP functional model



TNE – Terminal Network Equipment

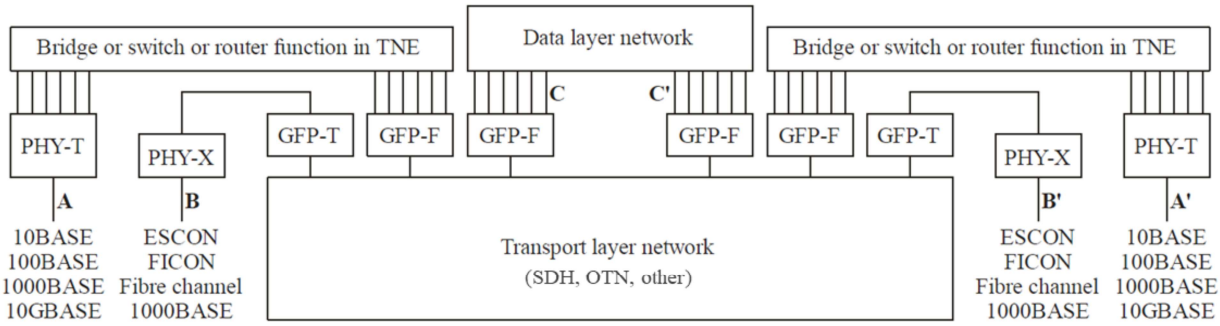
- Frame-mapped → optimized for packet-based applications
  - adaptation function operates at data link (or higher) layer of client signal
  - client PDU visibility required
  - client PDUs received from data layer network (C/C') or from TNE (A/A')

O **modo GFP-F** tem, entre outras, as seguintes características:

- Tramas de tamanho variável;
- Multiplexagem ao nível do pacote;
- Débito variável;
- Requer *buffering* de pacotes, introduzindo portanto latência.

Generic Framing Procedure – GFP

GFP functional model



- Transparent-mapped → optimized for applications sensitive to delay/real-time
  - adaptation function operates on coded character stream rather than on client PDUs
  - processing of incoming codeword space for client signal is required (B/B')

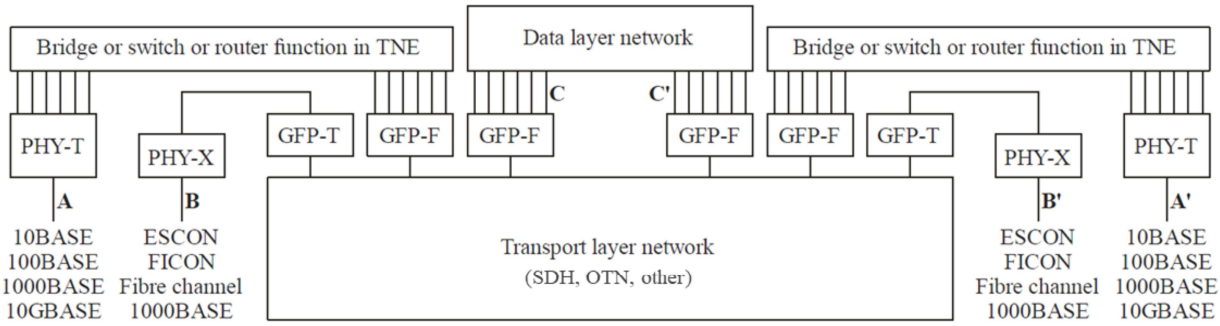
Sistemas de Telecomunicações *Generic Framing Procedure*

O **modo GFP-T** tem, entre outras, as seguintes características:

- Tramas de tamanho constante;
- Sem buffering (sem latência)
- Multiplexagem ao nível do *bit stream*;
- Eficiência inferior ao modo GFP-F na utilização da largura de banda disponível.

Generic Framing Procedure – GFP

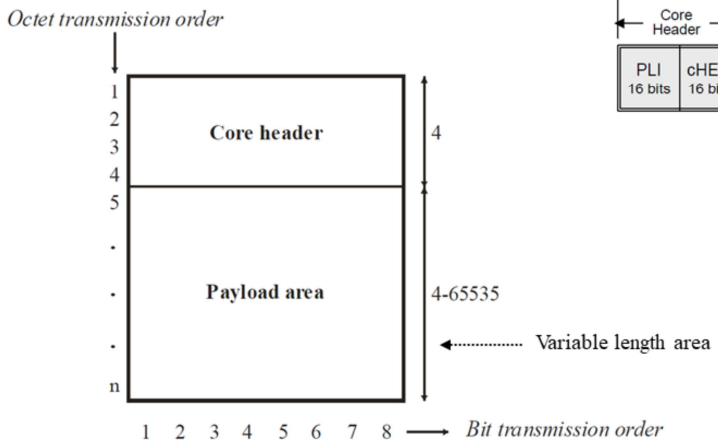
GFP functional model

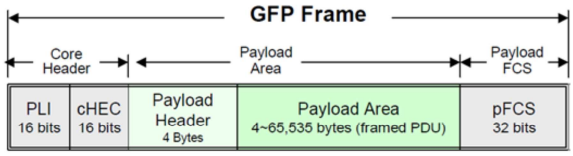


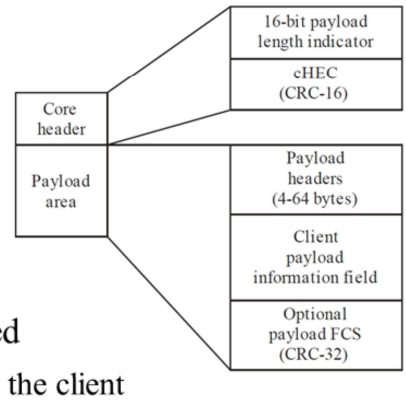
- Typically, interconnections can be set up between A and A', B and B', C and C', A and C', and C and A'
- Physical port type of B and B' must be the same to support interconnection
- Physical port type of A and A' may be different

Generic Framing Procedure – GFP

Frame format for GFP client frames







- Two types of GFP client frames are currently defined
  - **client data** – data frames used to transport data from the client
  - **client management** – used to transport info associated with management of client signal or GFP connection

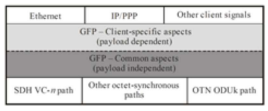
Sistemas de Telecomunicações *Generic Framing Procedure*

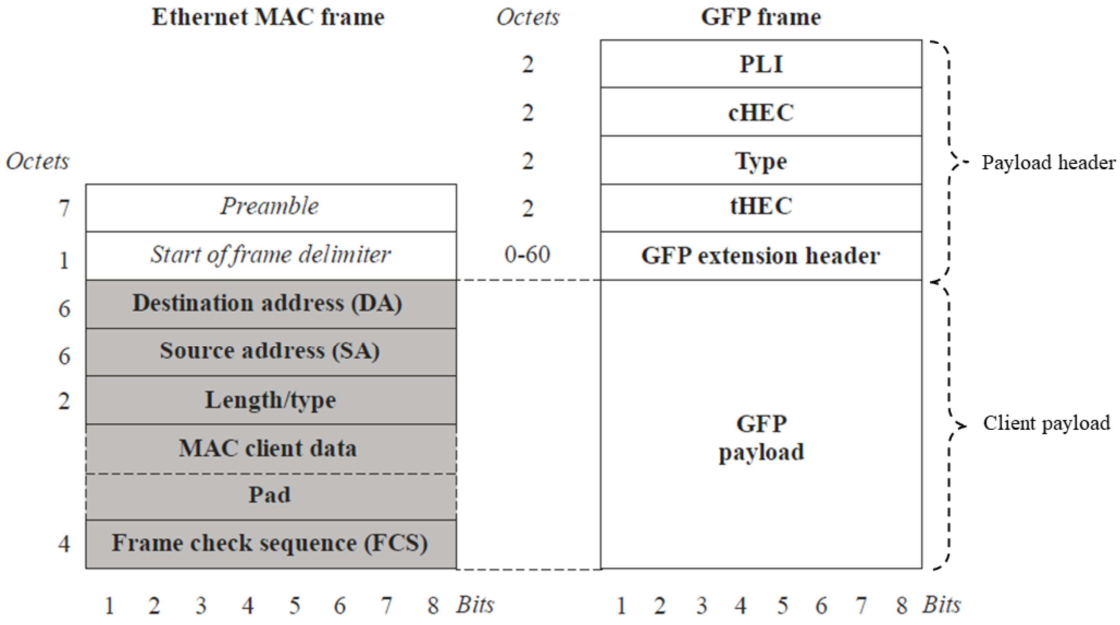
Estão definidos dois tipos de tramas GFP: GFP *client frames* e GFP *control frames*. As *client frames* são por sua vez subdivididas em dois subtipos: *client data* e *client management*. Mais detalhes são apresentados no documento de especificação da ITU – ver referências no último slide.

Generic Framing Procedure – GFP

Payload-specific aspects for frame-mapped GFP

Ethernet and GFP frame relationships

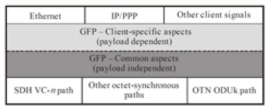


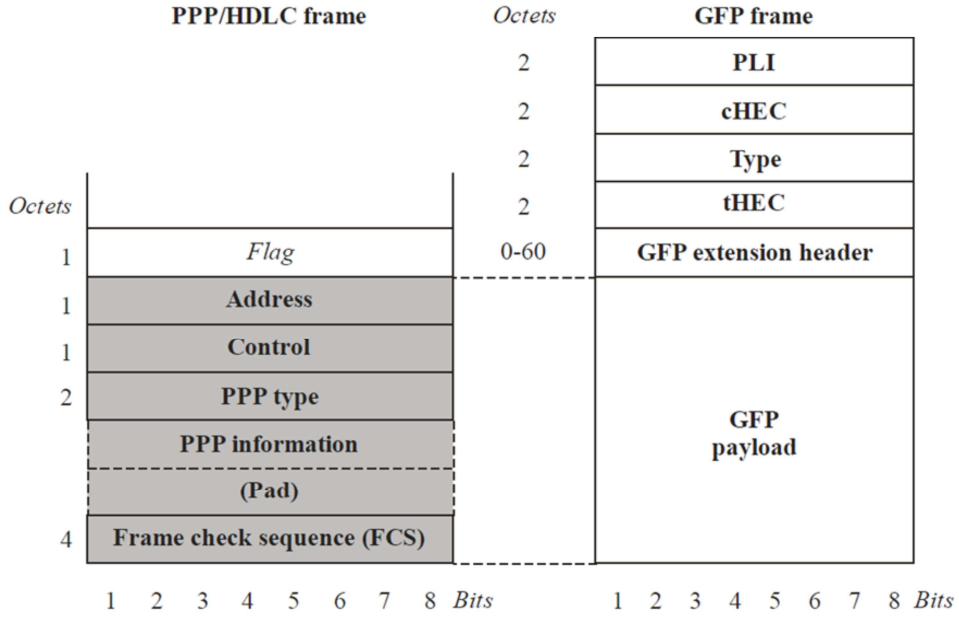


Generic Framing Procedure – GFP

Payload-specific aspects for frame-mapped GFP

HDLC/PPP and GFP frame relationships

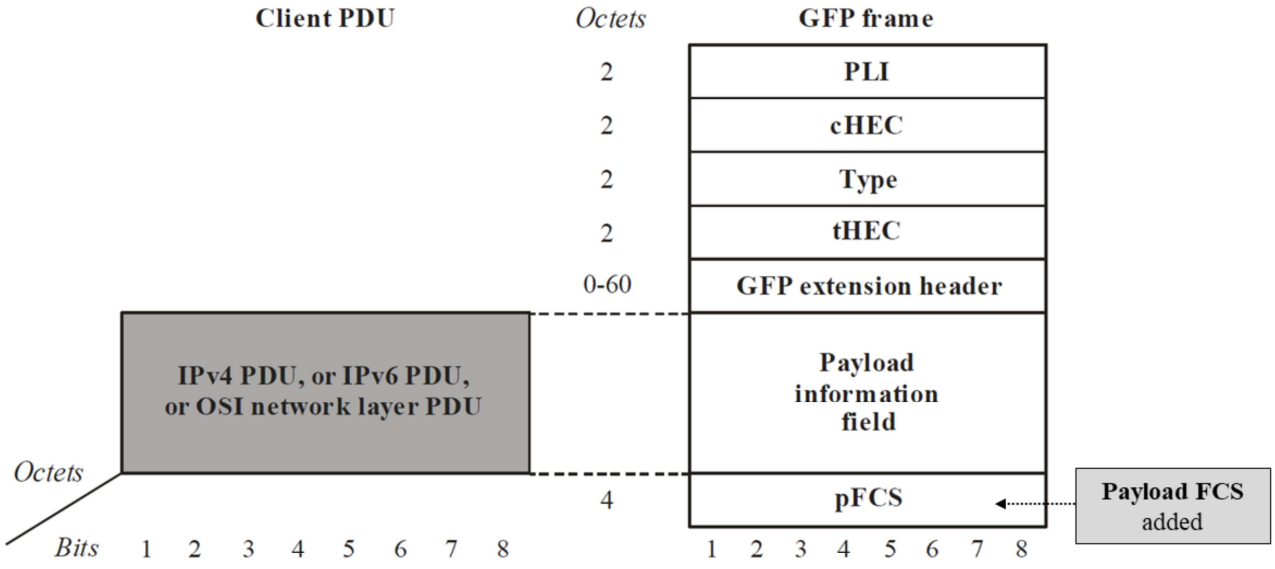




Generic Framing Procedure – GFP

Payload-specific aspects for frame-mapped GFP

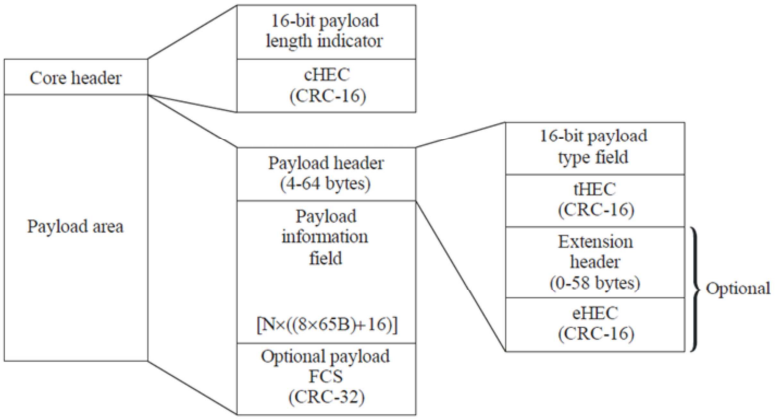
IPv4/IPv6/OSI network layer PDUs and GFP frame relationships



Generic Framing Procedure – GFP

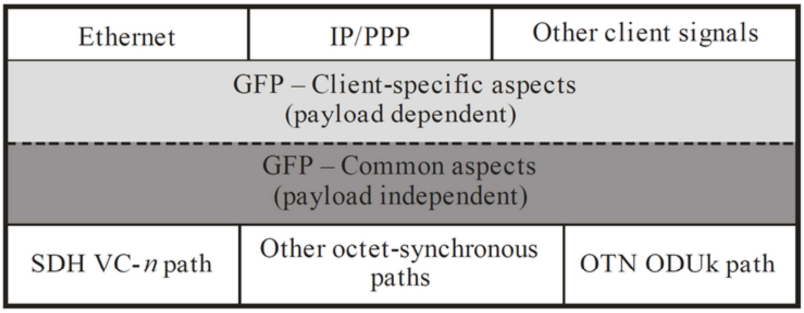
Payload-specific aspects for transparent-mapped GFP

- Individual characters of client signal mapped into periodic, fixed-length GFP frames, rather the buffering of the entire client frame into GFP frame used in GFP-F
- Transparent GFP frame uses same frame structure as GFP-F



Generic Framing Procedure – GFP

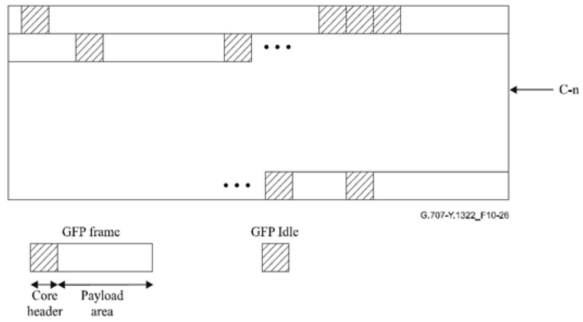
Mapping of framed payloads into Transport Layer Network



- Mapping into SDH VC-n specified in ITU-T G.707
- Mapping into OTN ODUk payload specified in ITU-T G.709

Generic Framing Procedure – GFP

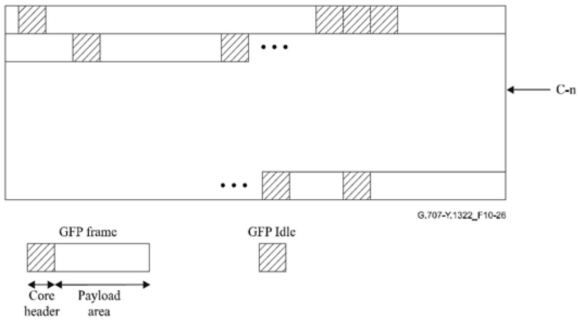
Mapping into SDH VC-n



- GFP frame stream is mapped into a container-n
  (n = 11, 12, 2, 3, 4, 4-Xc, 11-Xv/12-Xv/2-Xv/3-Xv/4-Xv)
- Container-n then mapped into VC-n together with associated POH
- GFP frame boundaries aligned with VC-n byte boundaries
- Since container-n capacity is not integer multiple of variable length GFP Frame, a GFP frame may cross a container-n frame boundary

Generic Framing Procedure – GFP

Mapping into SDH VC-n



- GFP frames arrive as continuous byte stream with a capacity identical to VC payload, due to the insertion of GFP Idles at GFP adaptation stage
- Takes advantage of:
  - **Virtual Concatenation** technique to increase efficiency
    - allows custom-sized SDH pipes that are any multiple of the basic rates
  - **Link Capacity Adjustment Scheme (LCAS)**
    - dynamically change amount of bandwidth used for the virtual concatenation

Generic Framing Procedure – GFP

GFP + Virtual Concatenation + LCAS – Transport Efficiency

Traffic Type	SONET		SDH	
	Contiguous	Virtual	Contiguous	Virtual
10Mbps Ethernet	STS-1 (20%)	VT-1.5-7v (89%)	VC-3 (20%)	VC-12-5v (92%)
100Mbit/s Fast Ethernet	STS-3c (67%)	STS-1-2v (100%)	VC-4 (67%)	VC-3-2v (100%) VC-12-46v (100%)
200Mbit/s (ESCON)	STS-6c (66%)	STS-1-4v (100%)	VC-4-4c (33%)	VC-3-4v (100%) VC-4-2v (66%)
1Gbps Fibre Channel	STS-21c (85%)	STS-1-18v (95%)	VC-4-16c (35%)	VC-4-6v (95%)
1Gbit/s Ethernet	STS-24c (83%)	STS-1-21v (92%)	VC-4-16c (42%)	VC-4-7v (95%)

GFP Advantages

- **Versatility**
  - Transport services for either Layer 1 or Layer 2 payloads
    - PPP, IP, MPLS, Ethernet, etc.
    - Fibre Channel, FICON, DVB ASI at Layer 1
    - Endorsed by multiple communities including IETF and ITU
- **Scalability**
  - Transport capabilities at rates from 10Mbps to beyond 40Gbps
- **Simplicity**
  - Eliminates need for ATM/HDLC networking for simple connectivity services
  - More efficient, lower-risk component designs
- **Component availability**
  - Broader user demand expected to drive future applications, feature maturity, interface commonality, and lower cost

GFP Advantages

- **Support of variable and fixed length packets**
  - IP/Ethernet datagrams, block codes, ATM cells
- **High data link efficiency**
  - scalable to 40Gbps and beyond
- **Flexible traffic adaptation modes**
  - Frame-Mapped GFP (GFP-F)
    - Suitable for **elastic applications** (e.g., streaming)
  - Transparent-Mapped GFP (GFP-T)
    - Suitable for **in-elastic applications** (e.g., VoIP)

References

- A. Malis and W. Simpson, “PPP over SONET/SDH”, IETF RFC 2615, Jun. 1999.
- Iannone, E. (2012). Telecommunication Networks. CRC Press.
- ITU-T, “Generic framing procedure”, Rec. G.7041/Y.1303, Aug. 2016.
- ITU-T, “Network node interface for the synchronous digital hierarchy (SDH)”, Rec. G.707/Y.1322, Jan. 2007