Generic framing procedure

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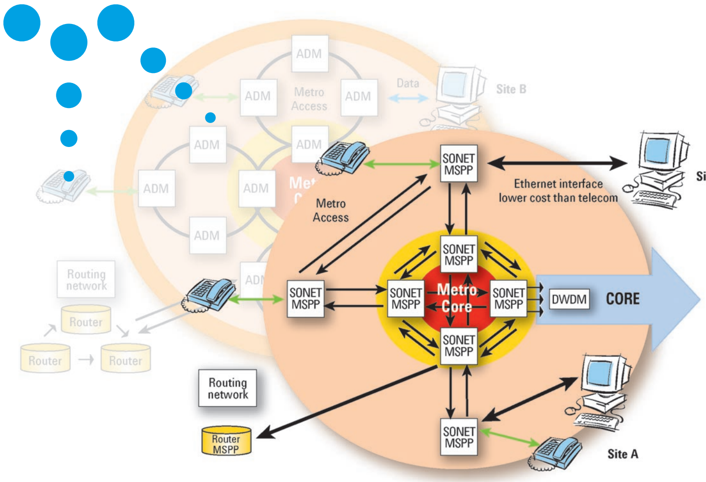
White paper



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Abstract

Unlike synchronous SONET/SDH, Ethernet has a bursty traffic pattern. To compensate for its idle times and bring it up to the required data rate, encapsulation (or a wrapper) is needed to enable Ethernet traffic to be transported over the SONET/SDH network. One of the most flexible encapsulation mechanisms is Generic Framing Procedure (GFP). This paper examines the GFP framing structure and its flexibility towards multi-service environments, demonstrating that GFP has the potential of becoming the dominant encapsulation technique in next-generation SONET/SDH networks.

Drivers for Ethernet in the metropolitan network

Internet access and video conferencing have transformed the way companies across the globe conduct business, both within their organizations and with their customers. The transformation is partly due to the emergence of new network technologies, such as Ethernet, to provide the necessary support services and ensure sufficient quality and cost-effectiveness. Ethernet is the dominant technology in local area networks (LANs), and it is expected to find its way into metropolitan area networks (MANs) and wide area networks (WANs), along with protocols such as Fiber Channel, enterprise system connection (ESCON) and fiber connection (FICON). The reason is that as a universal service interface, Ethernet is capable of providing the characteristics of a range of standard voice and data services, it can deliver broadband, it costs less than traditional SONET/SDH interfaces, and offers point-to-point and multipoint service options.

In addition, today's networks need to be flexible to support a multi-user environment where the usage pattern and usage time of the end user can vary greatly. For example, bandwidth allocated for a remote office connection and for employee Internet access can be reduced after working hours, but bandwidth for connections to a Website host server must be available constantly. Ethernet, in association with evolving technologies, will be able to provide usage pattern flexibility as well as ease of expansion.

Nevertheless, while Ethernet is used extensively in the enterprise network, the long-haul and metro networks use predominantly SONET/SDH-based circuit technology. For Service Providers to take advantage of Ethernet flexibility and cost efficiency, Ethernet over the legacy network requires an additional mechanism if the SONET/SDH networks are to transport packet-based traffic effectively. And this is where GFP plays a significant role. GFP encapsulates frame/packet-based protocols within SONET/SDH, acting as a rate-adapting bridge layer between Ethernet and SONET/SDH. It also allows individual Ethernet streams to be switched and groomed, and provides header error correction and channel identifiers for port multiplexing. This gives Service Providers the flexibility and granularity required to transport packet-based traffic within the basic SONET/SDH framing structure.

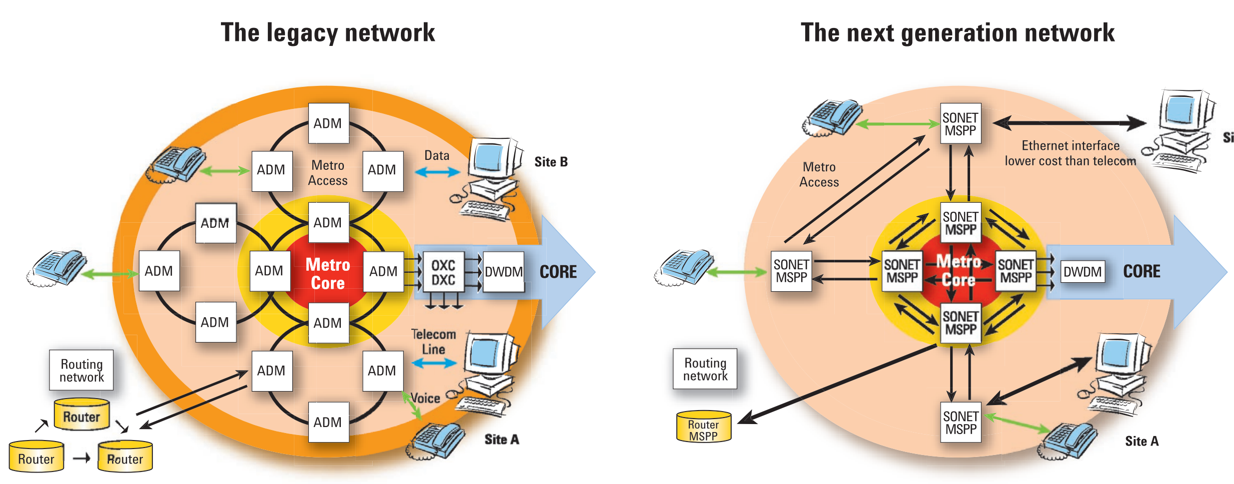

Figure 1.
From legacy to next-generation networks

Introduction to GFP

GFP is defined as a generic mechanism to transport any client signal over fixed data-rate optical channels. Any client signal like IP/PPP, Ethernet MAC, Fiber Channel, ESCON or FICON can be mapped over the transport network using GFP. As such, GFP provides a single, flexible mechanism to map any client signal into SONET/SDH and the optical transport network (OTN).

GFP supports both point-to-point and ring applications and eliminates the need for byte/bit stuffing. This avoids payload specific frame expansion, which saves bandwidth. GFP utilizes a length/HEC-based frame delineation mechanism that is more robust than that used by HDLC (High-level Data Link Control) which is single octet flag based.

To cater for all mapping requirements, two mapping modes are currently defined for GFP:

- Frame-mapped GFP (GFP-F)
- Transparent-mapped GFP (GFP-T)

Frame-mapped GFP

This mode maps the entire client frame into one GFP frame. It also describes a single client frame that is mapped into a single GFP frame, for example, an Ethernet frame mapped into a GFP frame.

Transparent-mapped GFP

This mode facilitates the transport of block-coded client signals (for example Fiber Channel, ESCON or FICON) that require very low transmission latency. The individual characters of a client signal are de-mapped from the client signal and then mapped into GFP frames. This process helps avoid buffering an entire client frame before it is mapped into the GFP frame.

In the transparent mapping mode, the GFP frame contains groups of 8B/10B code-groups mapped into a 64B/65B code with a cyclic redundancy check (CRC). The GFP frame structure remains the same whether it is frame-mapped GFP or transparent-mapped GFP.

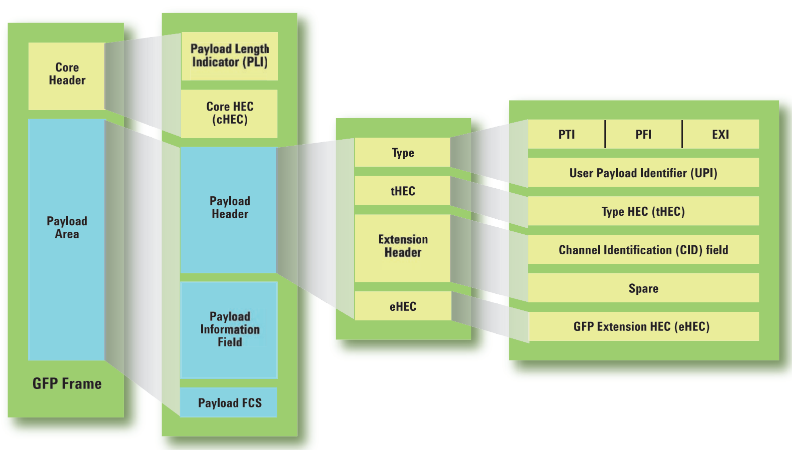

Figure 2.
The fields used to describe the GFP frame

In general, there are two types of GFP frames, GFP client frames and GFP control frames:

GFP client frames
These can be further classified into two types:

- Client data frames, used to transport data from the client signal
- Client management frames, used to transport management information about client signals between source and sink, for example Loss of Client signal. These frames comprise the core header and payload area only and have the value of PTI as 100

GFP control frames (GFP idle frames)
These frames are used for the management of the GFP connection, and consist of only the Core Header field (no payload area). These frames are used to compensate for the gaps between the client signal where the transport medium has a higher capacity than the client signal.

GFP frames from multiple ports or multiple client types are multiplexed on a frame-by-frame basis. GFP idle frames are inserted if there are no GFP frames available for transmission. This provides a continuous stream of frames for mapping.

In the case of a Client Signal Fail (CSF) condition, the GFP source generates a client management frame every 100 ms. On receipt of a CSF indication, the GFP sink declares a client signal failure. This condition is cleared either by receipt of a valid GFP frame, or when no CSF indications are received for 1000 ms. GFP idle frames are sent during the CSF condition.

Structure of a GFP frame

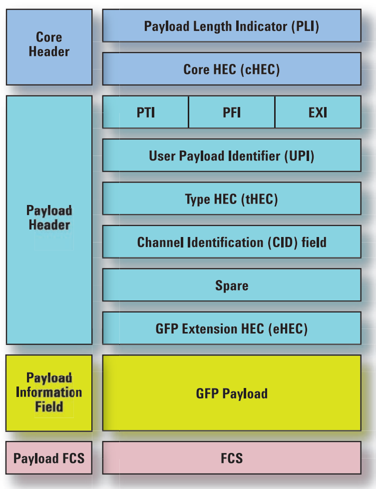

Figure 3.
Basic GFP client frame consists of a core header and a payload area

Core Header	This describes the GFP frame, independent of the content of higher layer Protocol Data Units (PDUs). The cHEC contains a CRC error control code for protection of Core Header contents. The scrambling of the Core Header provides additional robustness of the GFP frame delineation process.
Payload Header	**Payload Header** supports data link management procedures specific to client signal. **Type** field identifies the format and presence of the Extension Header and Payload FCS. This field also distinguishes between GFP frame types and between different services in a multi-service environment. **Payload Type** identifies the type of GFP client frames. **Payload FCS** Indicator identifies the presence or absence of the Payload FCS field. **Extension Header Identifier** is used to identify the GFP Extension Header. (null, linear or ring). **User Payload Identifier** is used to convey the type of payload carried in the GFP Payload Information field. **tHEC** field protects the integrity of the Type field **Channel Identification (CID)** field is used to identify the communication channel at a GFP termination point. **GFP Extension Header** support the technology specific headers, for example Virtual Link Identifiers, source/destination addresses, port numbers and class of service. ● **Null Extension Header** is intended for dedicated transport paths of one client signal ● **Linear Extension Header** is intended for several independent links requiring aggregation onto a single transport path ● **Ring Extension Header** is intended for use where a ring transport path is shared among multiple client signals **Extension HEC field** is used to protect the integrity of the contents of Extension Header.
Payload Information Field	In the case of Frame-mapped GFP, the GFP payload area contains the framed PDU; in the case of Transparent GFP it contains a group of client characters.
Payload FCS	**pFCS** is used toprotect the contents of the GFP payload

GFP encapsulation techniques

The relationship between an Ethernet MAC frame and GFP is shown in Figure 4. There is a one-to-one mapping between a higher layer PDU and a GFP PDU, with the boundaries aligned to each other.

Ethernet MAC encapsulation

In the case of Ethernet MAC's encapsulation into GFP, the fields from Destination Address to Frame Check Sequence (FCS) are placed in the GFP payload area. As the source adaptation process extracts the frame from the client bit stream, the GFP source adaptation process deletes the gaps between the packets, known as the Inter Packet Gaps (IPGs). Ethernet MAC is then forwarded for further encapsulation into the GFP frame. On the sink side, the sink adaptation process restores the IPGs, and Ethernet MAC is then forwarded to the client layer for further processing.

Error handling

In the source adaptation process, any PDUs received with errors from the client side are discarded before transmission. However, PDUs detected for errors during transmission are padded with appropriate bit sequence and FCS. This action ensures that the client end drops the errored PDU.

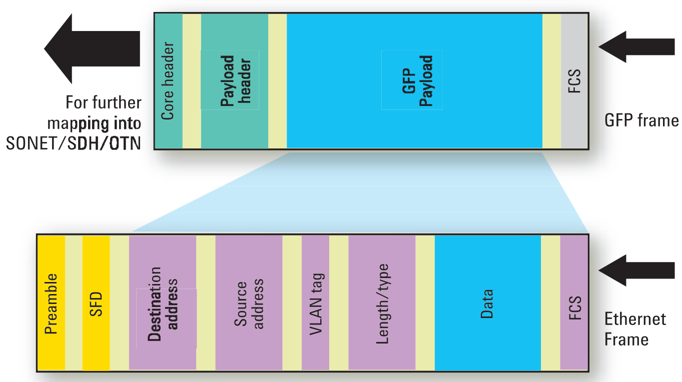

Figure 4. Ethernet MAC encapsulation into GFP using frame-mapped GFP

PPP/HDLC encapsulation

PPP/HDLC frame encapsulation into GFP is similar to the Ethernet MAC encapsulation procedure and is shown in Figure 5.

PPP frames are first encapsulated in an HDLC-like frame. Similar to Ethernet MAC, the boundaries of the GFP PDU are aligned with boundaries of the framed PPP/HDLC PDUs. The fields from Address to FCS (including the PPP information field padding) are placed in the GFP payload area. The GFP source adaptation process removes the flags and associated escape characters and forwards the PPP/HDLC frame for further encapsulation in GFP. On the sink side, the PPP/HDLC frame is extracted from the GFP frame and forwarded to the client layer for further processing, such as the addition of flags and escape characters.

ESCON/FICON encapsulation

In the case of ESCON/FICON encapsulation, the physical layer of the client signal is decoded and the decoded characters are mapped into a 64B/65B block code. The block code is then mapped into payload bytes of 64B/65B code in the order in which they were received.

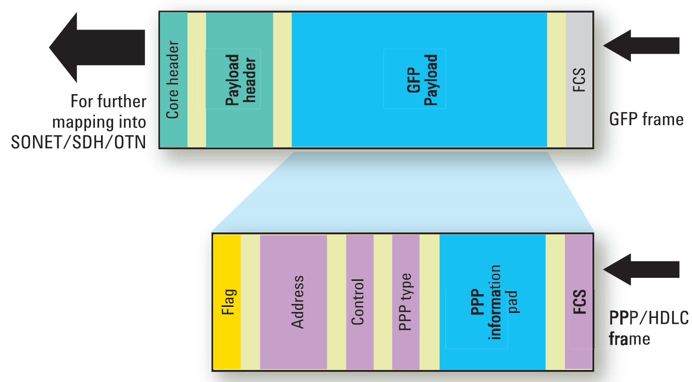

Figure 5.
PPP/HDLC encapsulation into GFP using transparent-mapped GFP

Advantages of GFP

Of the many advantages of GFP as an encapsulation mechanism, the most significant is that GFP minimizes the protocol-specific processing and protocol translation associated with Packet over SONET/SDH, and avoids the complex adaptation layer processing of ATM. Traditional encapsulation techniques such as Packet over SONET/SDH cannot guarantee bandwidth since the padding used inflates the frames size. GFP frame headers, on the other hand, are exactly the same size as the Preamble (which is dropped during encapsulation) which guarantees bandwidth.

GFP also provides one uniform mechanism to adapt any payload type to any transport media. In other words, GFP results in network flexibility, efficiency and robustness.

Conclusion

The key issue for Service Providers looking to adopt Ethernet over SONET/SDH as a transport mechanism is whether it is capable of dealing with data-oriented applications and synchronous traffic such as voice. Using GFP resolves this issue by providing an efficient, scalable and unified mode of transport for both synchronous TDM traffic and data applications such as those used in LANs, storage area networks (SANs), and the Internet. GFP is also the most economical way of adopting high-speed services in legacy metro and long-haul SONET/SDH networks, and can provide the basis for the evolving resilient packet ring (RPR) technology. In short, GFP has the potential to become the dominant encapsulation technique in the modern network.

Glossary of terms

ASP	Application service provider
cHEC	Core header error correction
CID	Channel identification
CMF	Client management frame
CSF	Client signal fail
eHEC	Extension header error correction
ESCON	Enterprise system connect
EXI	Extension header indicator
FICON	Fibre connection
GFP-F	Generic framing procedure framed
GFP-T	Generic framing procedure transparent
HDLC	High-level Data Link Control
LAN	Local area network
MAC	Media access control
PDU	Protocol data unit
pFCS	Payload Frame Check Sequence
PFI	Payload FCS indicator
PLI	Payload length indicator
PTI	Payload type identifier
RPR	Resilient packet ring
SAN	Storage area network
tHEC	Type header error correction
UPI	User payload identifier
VLAN	Virtual LAN

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