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Generic Framing Procedure (GFP) for NG-SONET/SDH: An Overview

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on*your*wavelength

Outline

- **What is GFP?**
- **Problem Statement**
- **GFP Value Proposition**
- **GFP Model**
  - Frame Structure
  - Procedures
- **GFP Performance**
- **Applications:**
  - Hybrid SONET/DATA NEs
- **Summary**

Generic Framing Procedure - GFP

A "generic" mechanism to adapt multiple client traffic types as either:

- *a physical link (Layer 1) client*
- *a logical data link (Layer 2) client*

into a bit synchronous or octet-synchronous transmission channel

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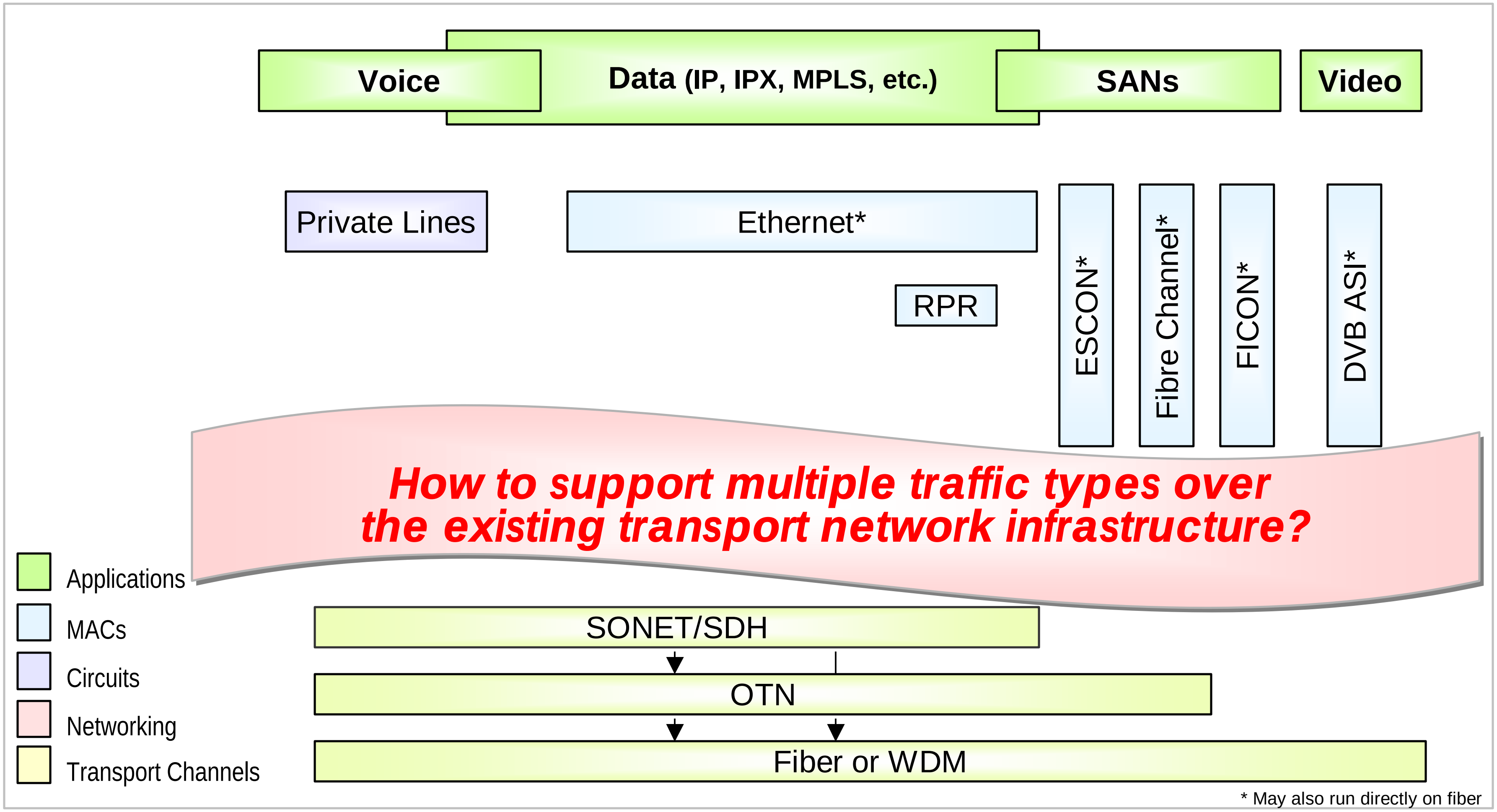
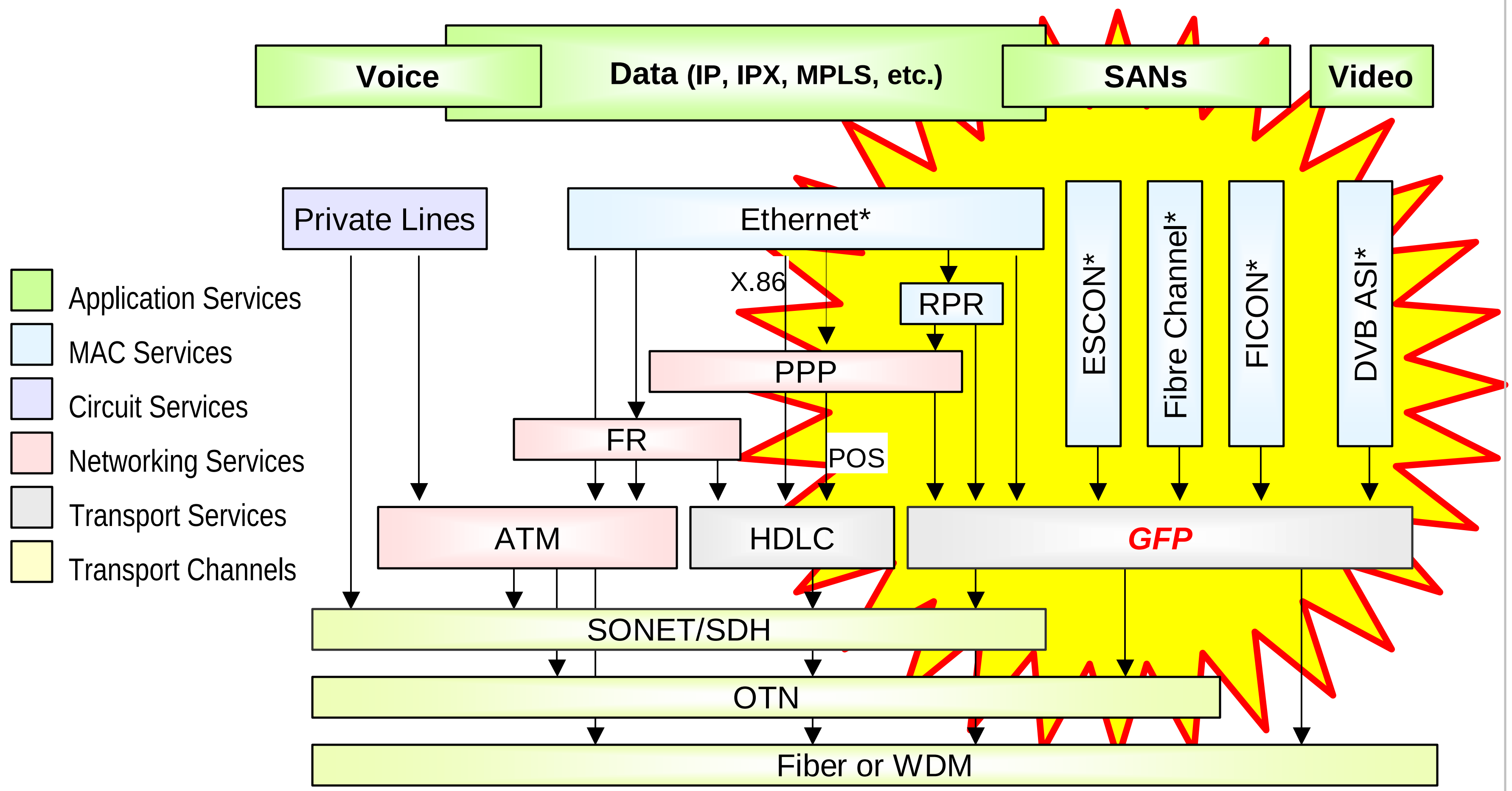
The Problem:
Public Multi-Service Transport

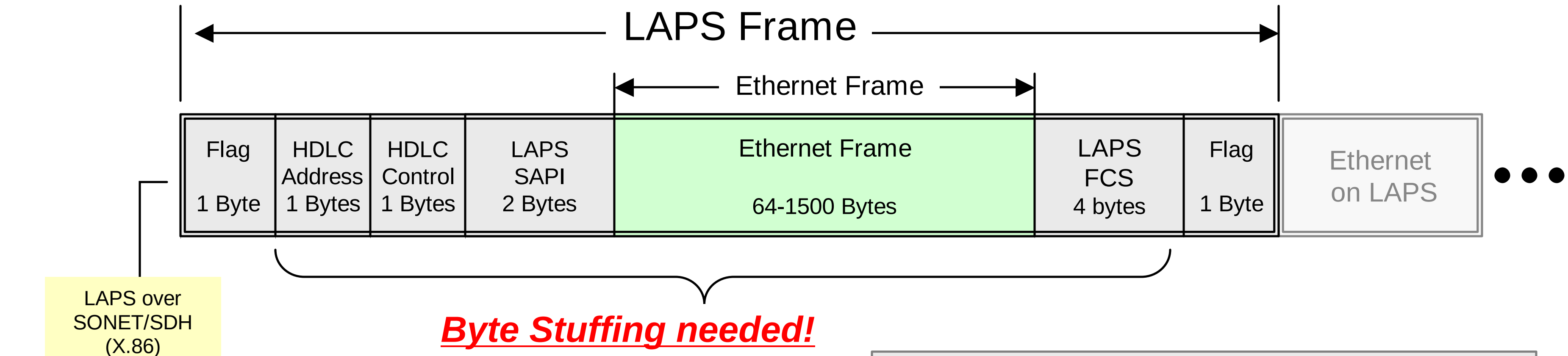


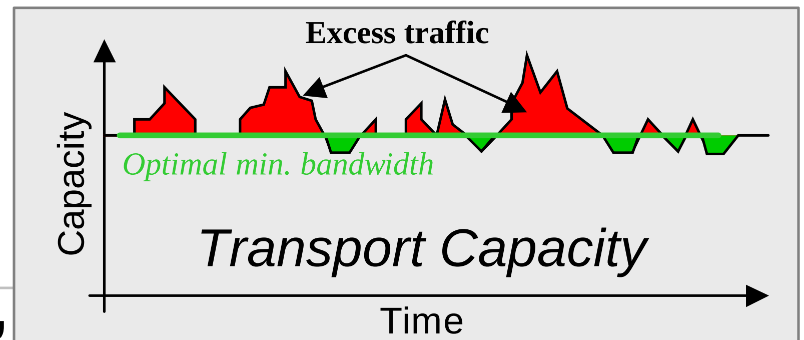
The Solutions:
A Fragmented Solution Space



* May also run directly on fiber

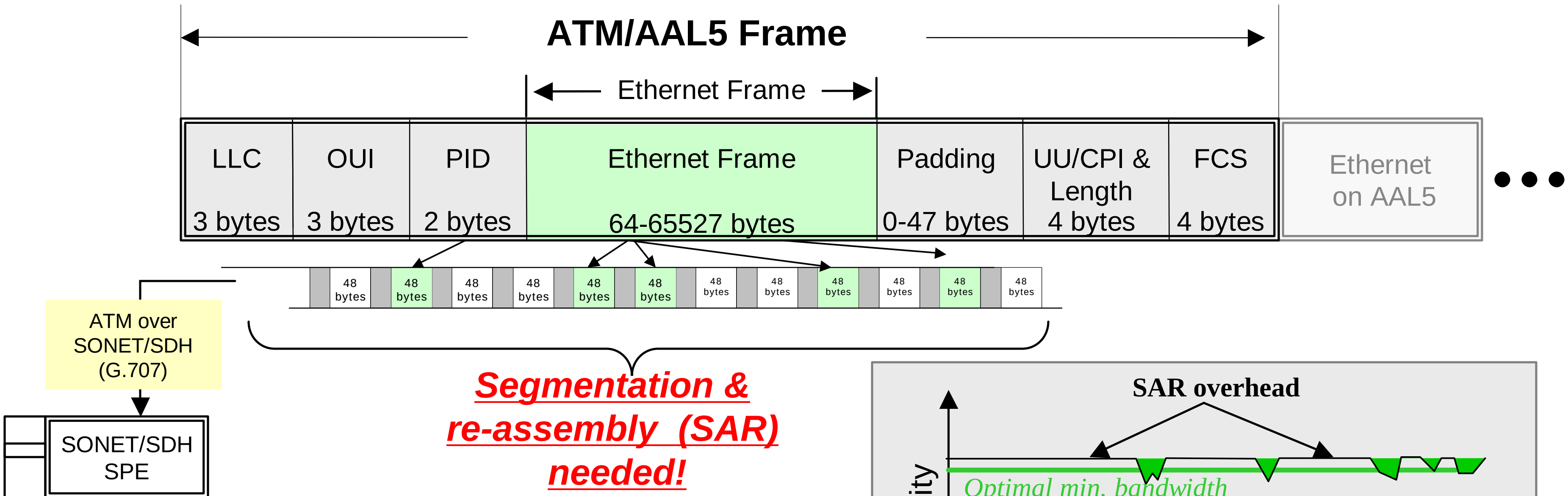
Example 1: Ethernet over LAPS (ITU-T X.86)

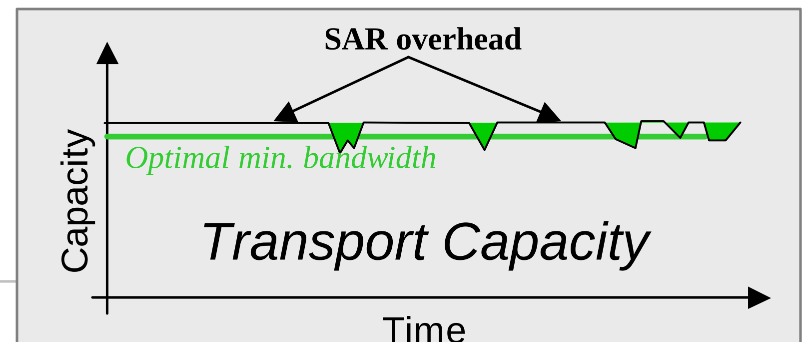




- **Ethernet in "HDLC-like Framing"**
  - Non-deterministic transport overhead
  - Byte stuffing interferes with QoS/bandwidth management
  - Flag-based delineation computationally expensive as speed increases

Example 2:
Ethernet over ATM (IETF RFC 1483)

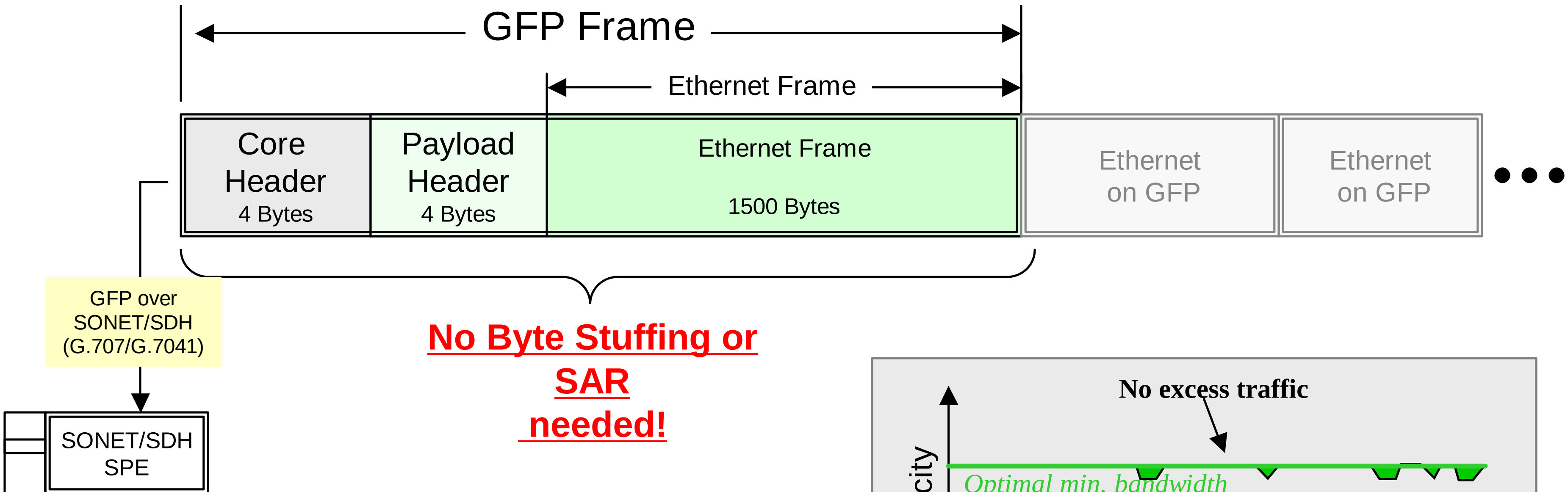


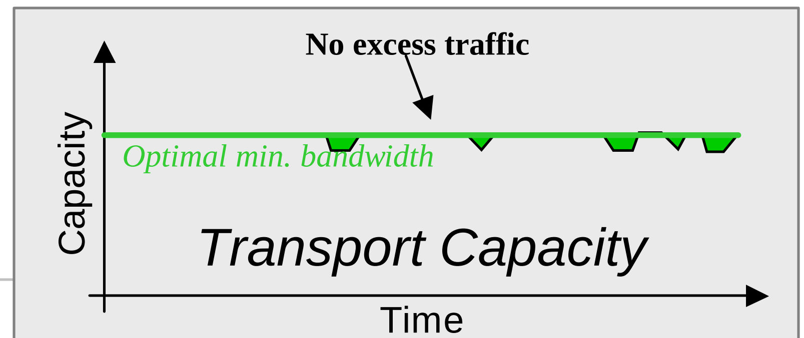


■ Ethernet over ATM

- Excellent QoS management capabilities
- Large transport overhead for small packets
- SAR expensive for simple connectivity services

Example 3: Ethernet over GFP-F (ITU-T G.7041)





- **Ethernet over GFP**
  - Deterministic transport overhead
  - No adaptation interference with QoS/bandwidth management
  - Low complexity frame delineation that scales ups as speed increases

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Why GFP?

- **Simple and scaleable**
  - Proven technology at 1G, 2.5G and 10G
  - Scalable beyond 40G
- **Supports both Layer 1 and Layer 2 traffic**
  - Alternative transport mechanism to ATM (ITU-T I.341.1/IETF RFC 1483)
  - Alternative transport mechanism to HDLC-framing (ISO-3309/IETF RFC 2615)
- **Standards based:**
  - ITU-T G.7041(2001) & ANSI T1.105.02 (2002)
  - Endorsed by IETF (RFC 2823)
  - Endorsed by RPR WG (IEEE 802.17)

Sample Applications

Channel Types:

- **Bit-Synchronous Channel:**
  - Dark Fiber
  - WDM
- **Octet-Synchronous Channel:**
  - SONET (T1.105.02)
  - SDH (ITU-T G.707)
  - OTN (ITU-T G.709)

Client Types:

- **Physical Coding (Layer 1):**
  - Fibre Channel
  - FICON
  - ESCON
  - Gigabit Ethernet
  - Infiniband
  - DVB ASI
- **Data Links (Layer 2):**
  - PPP/IP/MPLS
  - Ethernet
  - MAPOS
  - RPR

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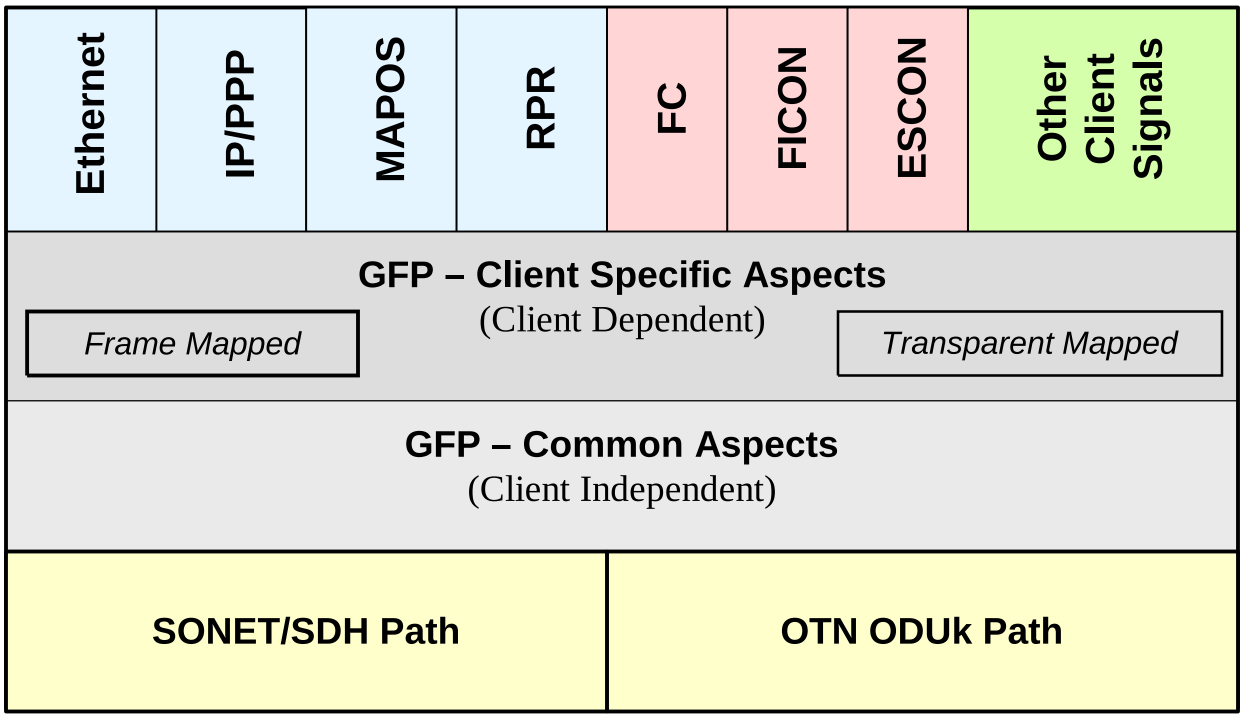
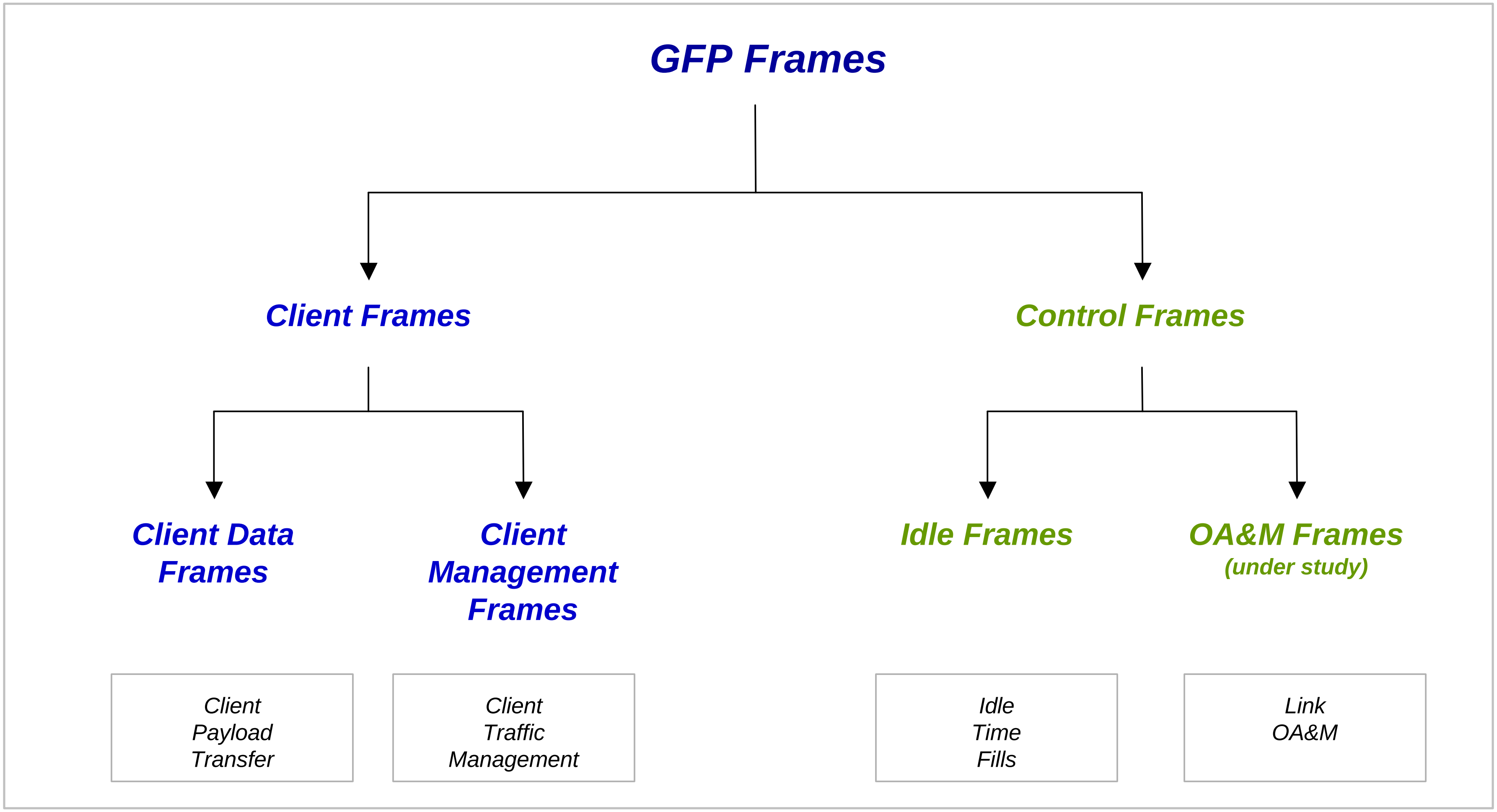
Functional Model

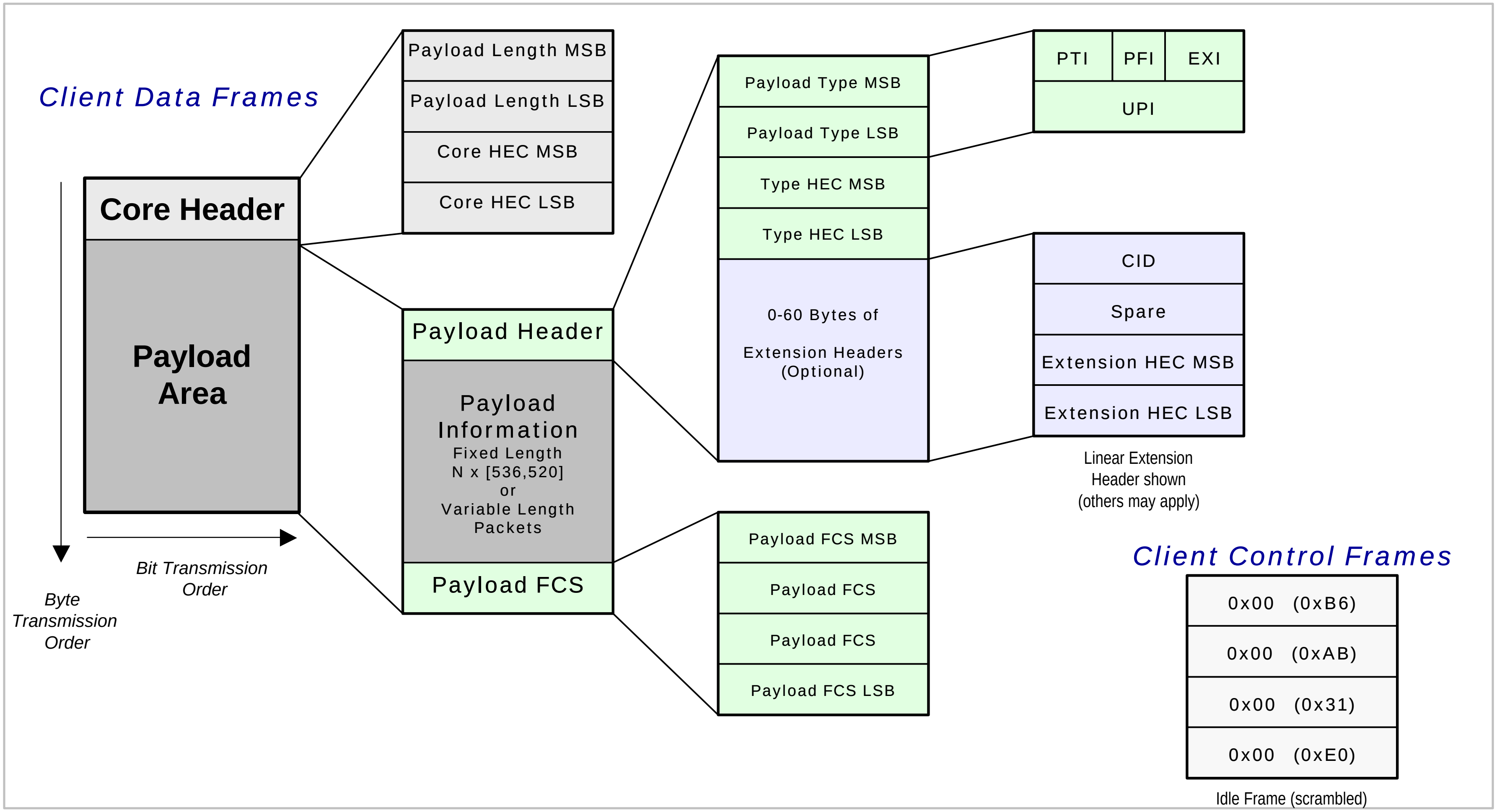


Frame Types

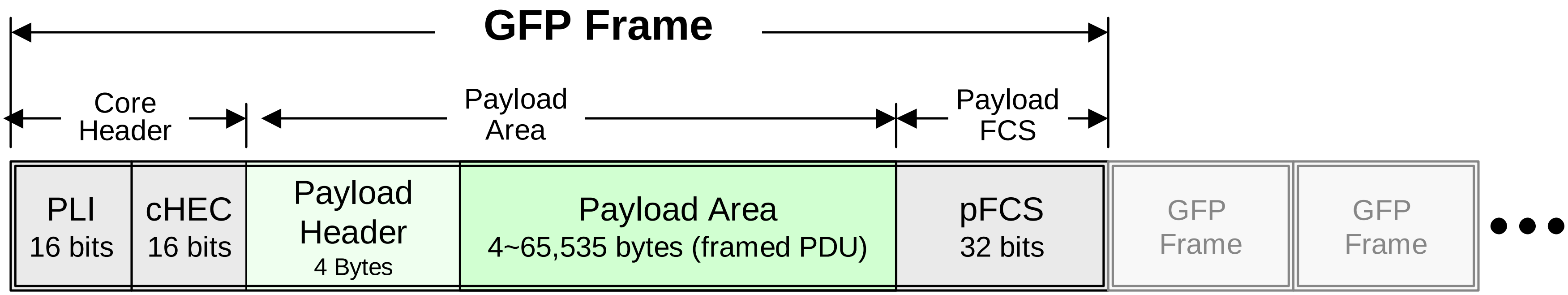


GFP Frames
Client Frames
Control Frames
Client Data Frames
Client Management Frames
Idle Frames
OA&M Frames
(under study)
Client Payload Transfer
Client Traffic Management
Idle Time Fills
Link OA&M

Generic Frame Structure



Basic GFP Frame Format



- **PLI** := Payload Length Indicator
- **cHEC** := Core Header CRC (ITU-T CRC-16)
- **Payload Area** := Framed PDU (PPP, IP, Ethernet, etc.)
- **Payload Header** := Client PDU management
- **pFCS** := *Optional* Payload FCS (ITU-T CRC-32)

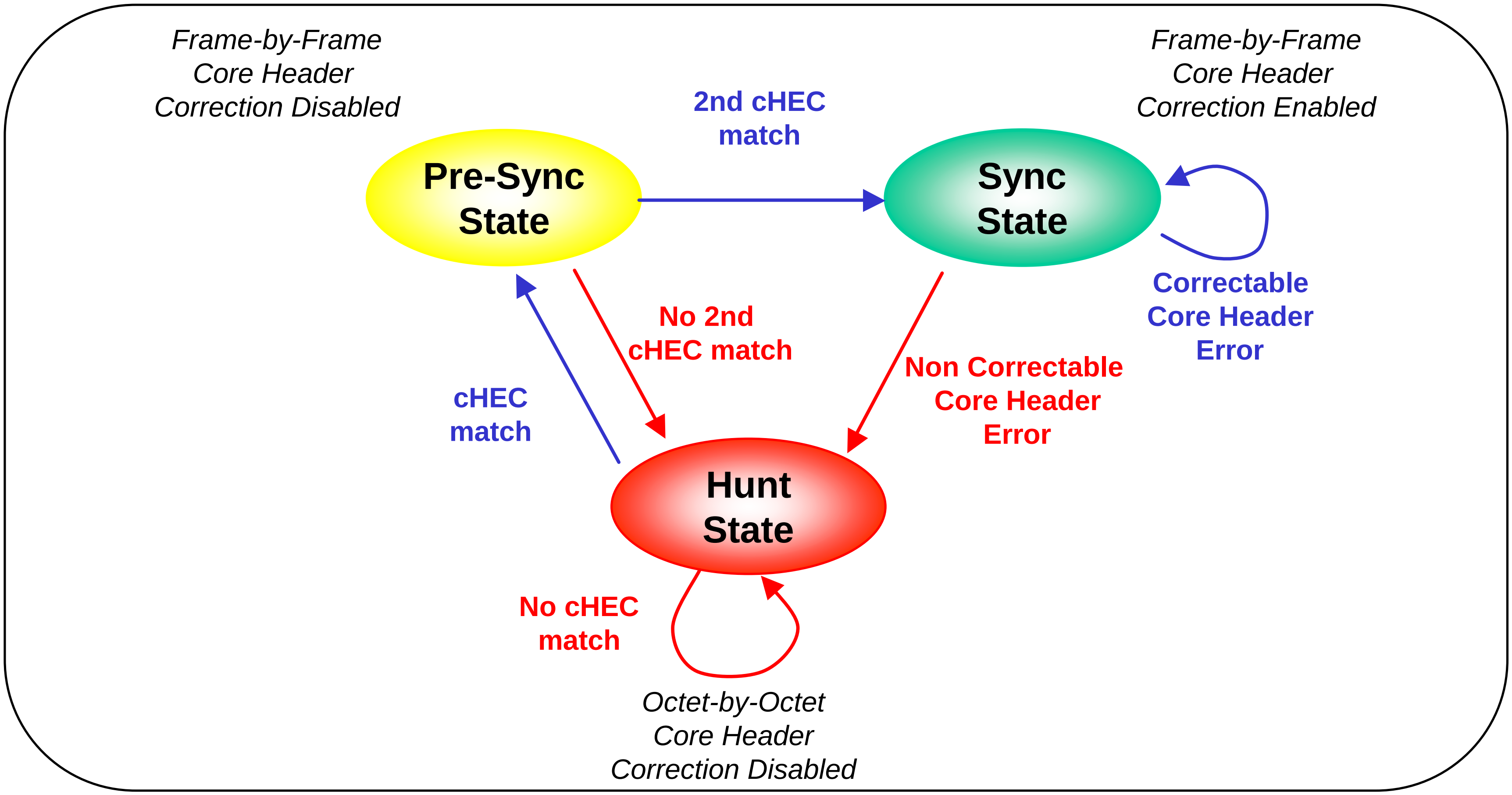
Frame Structure: Summary

- **All GFP OAM&P functions handled via the GFP Core Header**
- **Payload Header supports any payload specific adaptation functions**
  - Client types (Ethernet, IP, MPLS, Fibre Channel, etc.)
  - Client multiplexing (via Extension Headers)
  - Client link management (via Client Management Frames)
- **Optional Payload FCS on a per frame basis**
- **Asynchronous rate adaptation via Idle Frames**

GFP Procedures

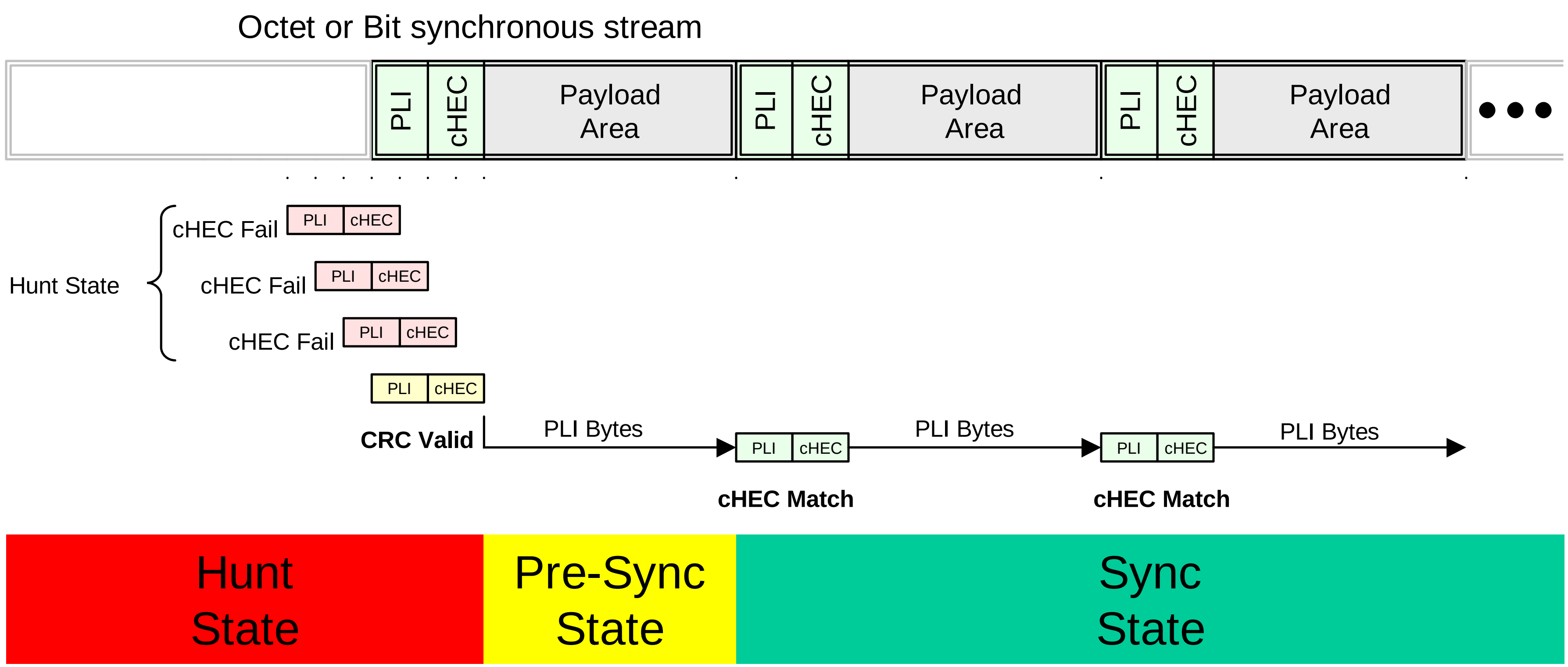
- **Frame Delineation**
- **Frame/Client Multiplexing**
- **Adaptation Modes**
- **Scrambling**
  - Core Header
  - Payload Area
- **Error Handling**
  - Headers
  - Payload
- **Client Management**

Frame Delineation: GFP State Machine



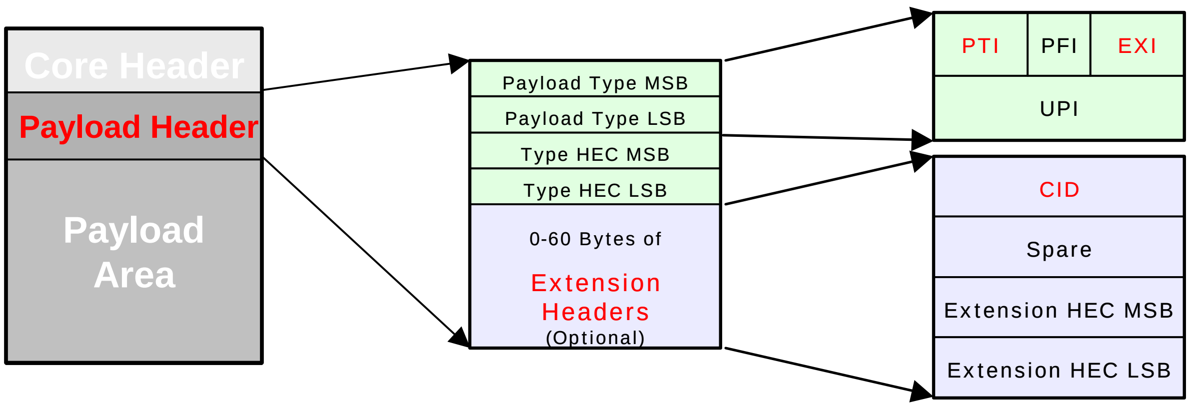
Frame Delineation
An Example

- Two consecutive cHEC field matches vs. computed CHEC
- Pointer-based (PLI field) offset to next incoming frame



Multiplexing

- **Frame Multiplexing via PTI field:**
  - Client Data Frames have priority over Client Mgmt. Fames
  - Client Management Frames have priority over Idle Frames
- **Client Multiplexing via Extension Headers:**
  - Null Extension Header on dedicated transport channels per client
  - Linear Extension Header (point-to-point configurations)
  - Ring Extension Header (ring configuration)

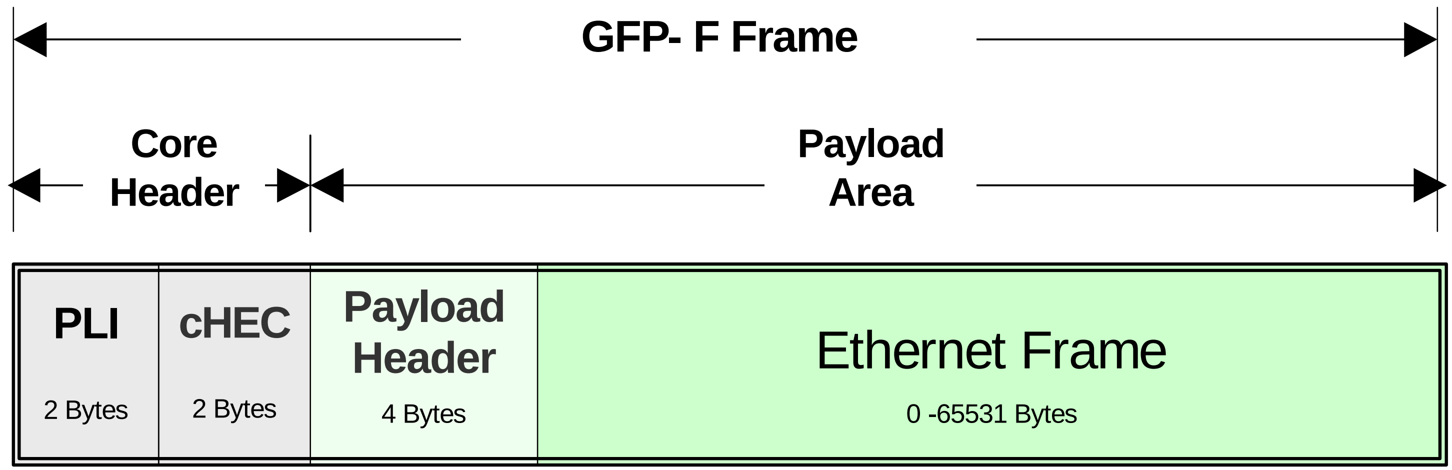


Frame Muxing:
PTI: Payload Type Id

Client Muxing:
EXI: Extension Hdr ID
CID: Customer ID

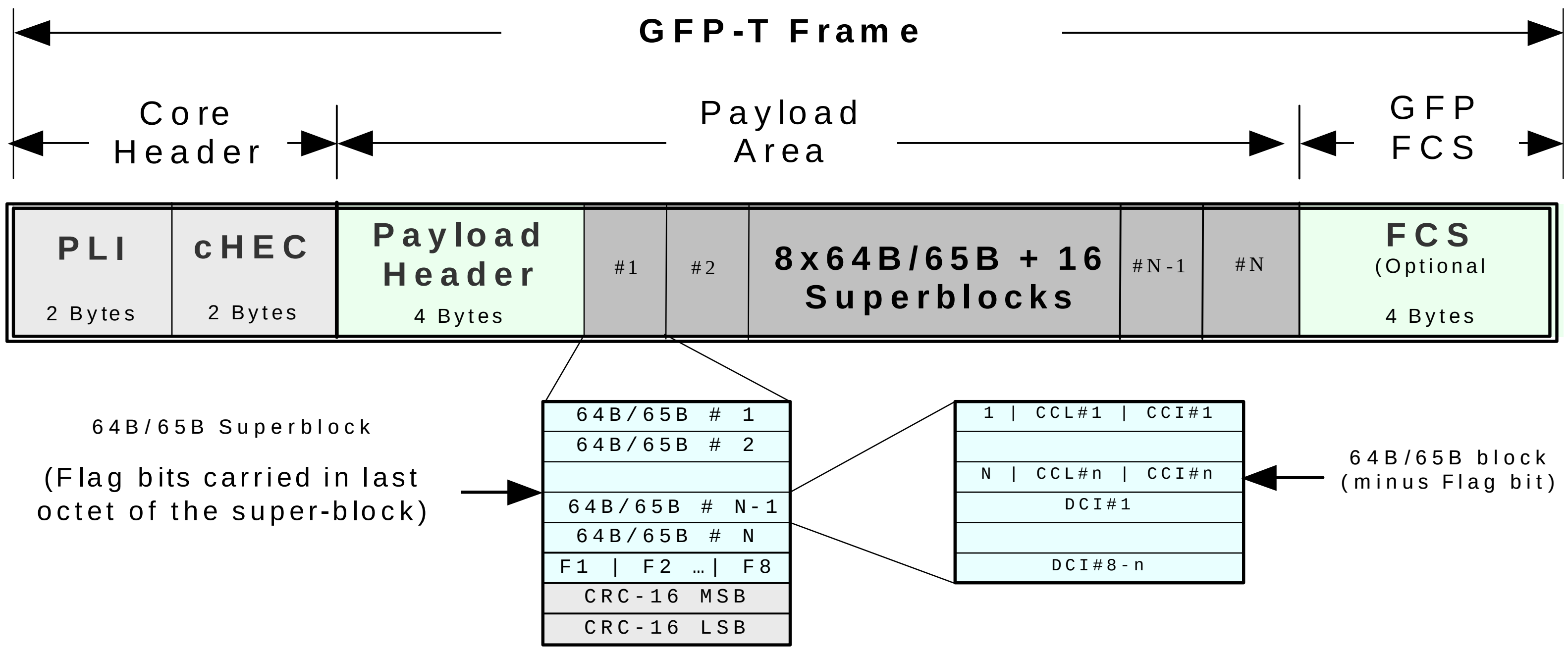
Adaptation Modes: Frame-Mapped GFP

- 1-to-1 mapping of L2 PDU to GFP payload
- UPI field indicates L2 PDU type
- Example: IEEE 802.3/Ethernet MAC frames



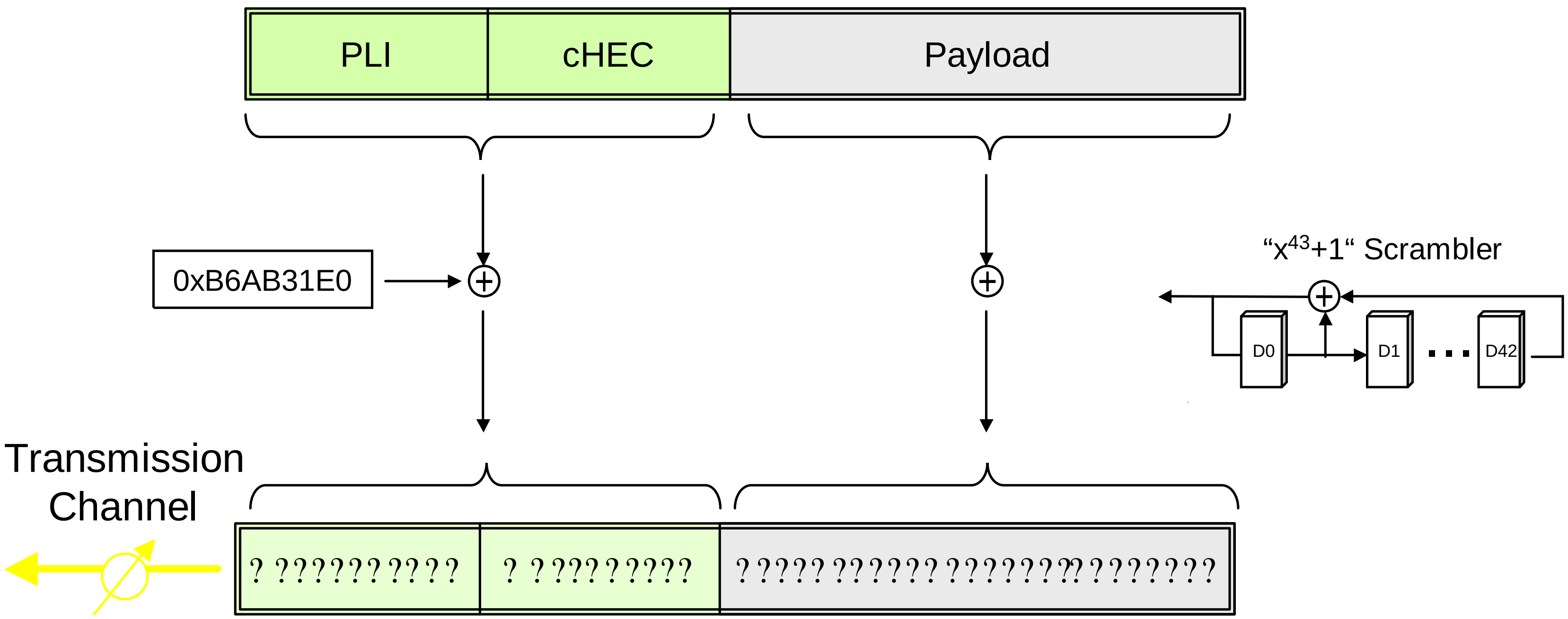
Adaptation Modes: Transparent-Mapped GFP

- N-to-1 mapping of L1 codewords to GFP payload
- Example: 8B/10B codewords



Scrambling:
DC Balance & Payload Scrambler

- **Header (PLI Field + CHEC) XOR'd with the 32 bit value *"0xB6AB31E0"* before transmission for DC balance.**
- **Payload scrambled with ATM-style self-synchronous scrambler**



Error Handling

- **Multi-bit Error Detection & Correction:**
  - Core Header – cHEC (ITU-T CRC-16):
  - Payload Type Field – tHEC (ITU-T CRC-16)
  - GFP-T payload (Optimized CRC-16)

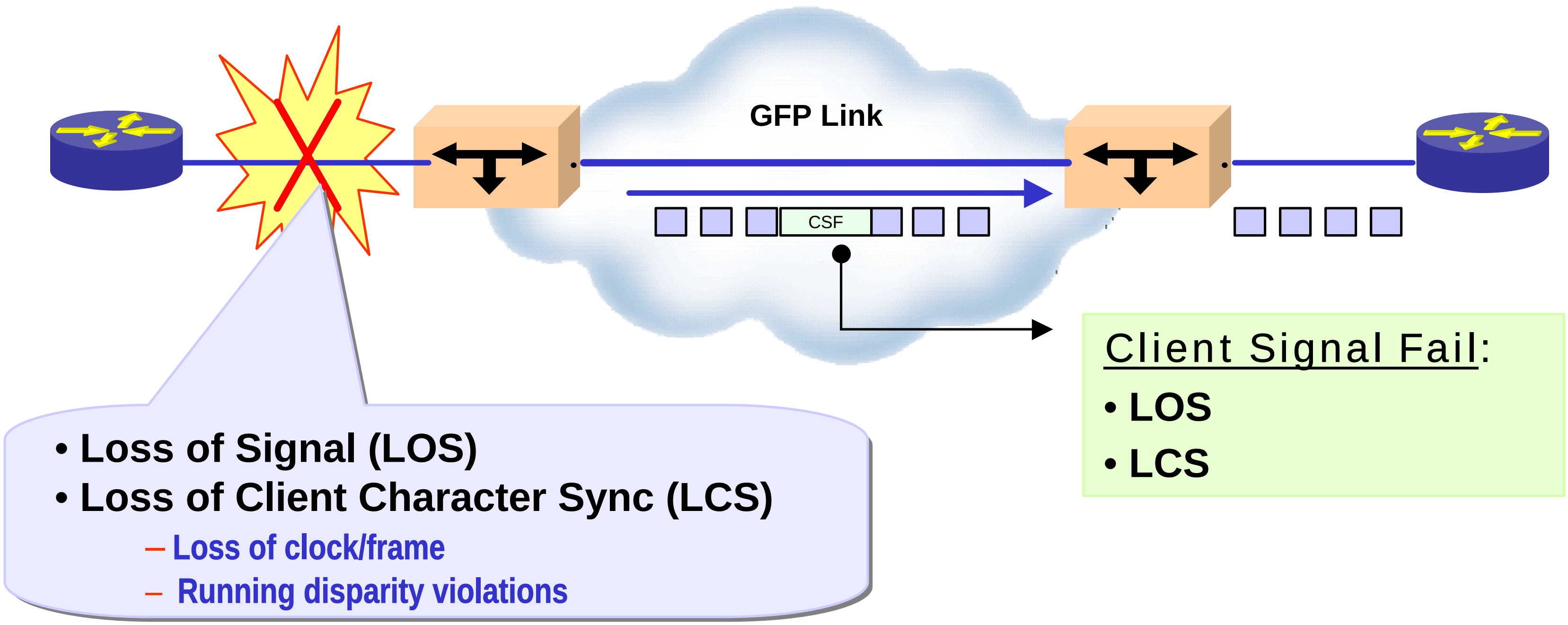
1-bit error correction

3-bit error correction

- **Multi-bit Error Detection:**
  - Payload Extension Header – eHEC (ITU-T CRC-16)
  - Payload Information Field – pFCS (ITU-T CRC-32)

Client Management

- Client Signal Fail (CSF) indications sent periodically upon detection of a failure/degradation event
- Cleared by new Client Data Frame or CSF timeout



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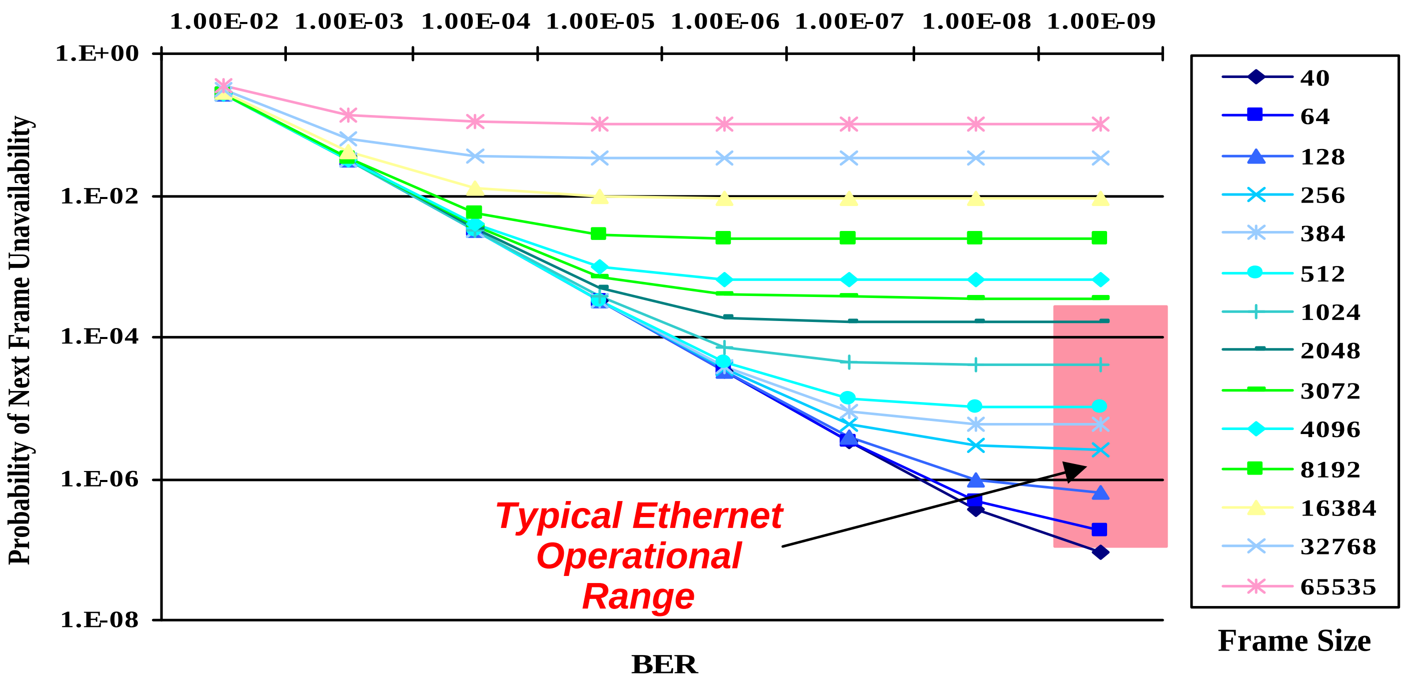
Performance: Synchronization Loss Events

- Re-sync required whenever cHEC test fails
- Low synchronization loss probability for typical fiber BER
- Example: 40Bytes PDU at 40G. Loss event frequency decreases with increasing PDU size or decreasing BER

BER	Prob [Sync Loss]	Frequency
10^{-7}	**5×10^{-12}**	**~ 48 min**
10^{-8}	**5×10^{-14}**	**~ 3.3 Days**
10^{-9}	**5×10^{-16}**	**~ 1 Year**
10^{-10}	**5×10^{-18}**	**~100 Years**

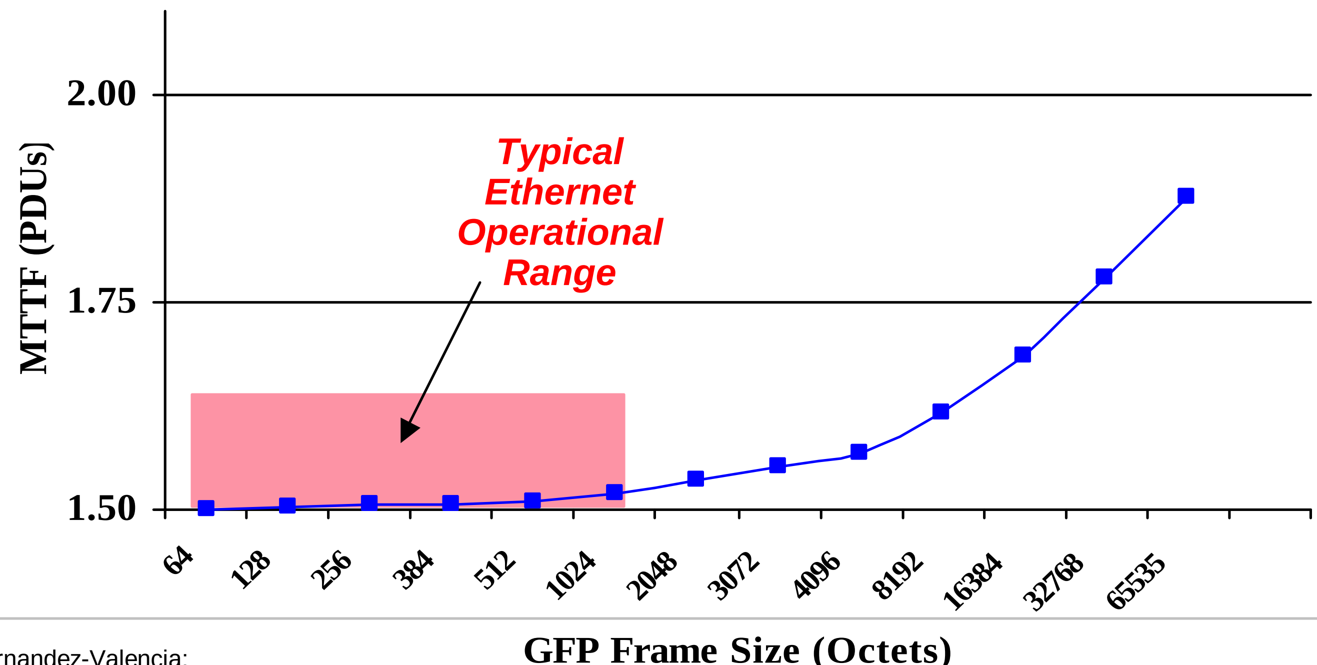
Performance:
Missed Frame Delineation Events

- Low probability of frame unavailability after LOF events
- Essentially insensitive to random errors for practical BERs



Performance: Mean Time To Frame

- Datalink syncs after 2 consecutive cHEC matches
- Fast Mean Time to Frame (MTTF) delineation
- Largely insensitive to BER & line rate over the region of interest for (first order approximation)



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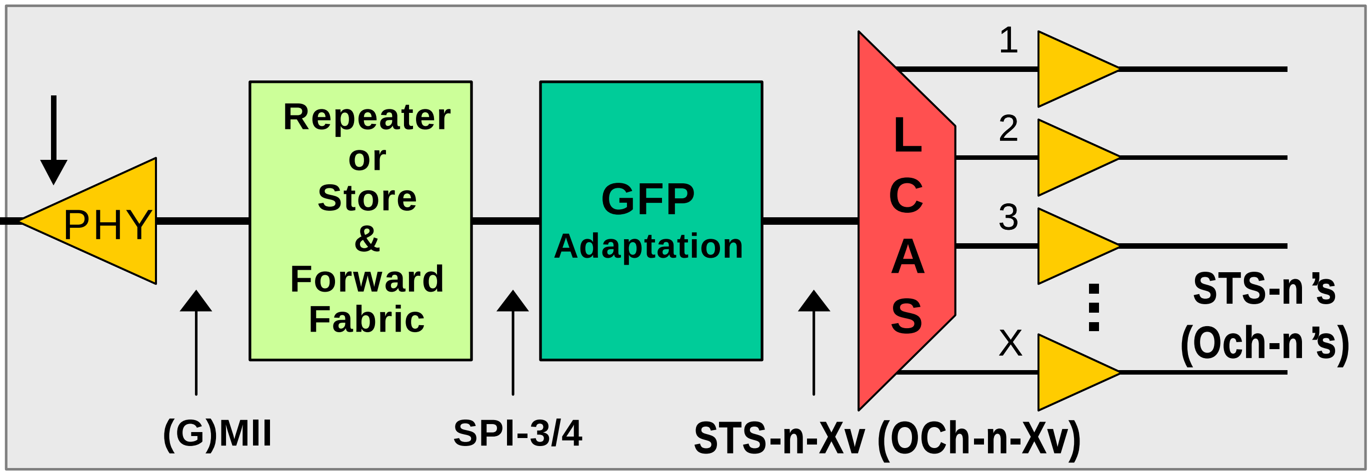
Hybrid Network Elements
NG SONET/Data Systems

- **Three basic building blocks**
  - GFP (ITU-T G.7041/ANSI T1.105.02)
  - Virtual Concatenation (ITU-T G.707/ANSI T1.105.02)
  - LCAS (ITU-T G.707/ANSI T1.105.02)

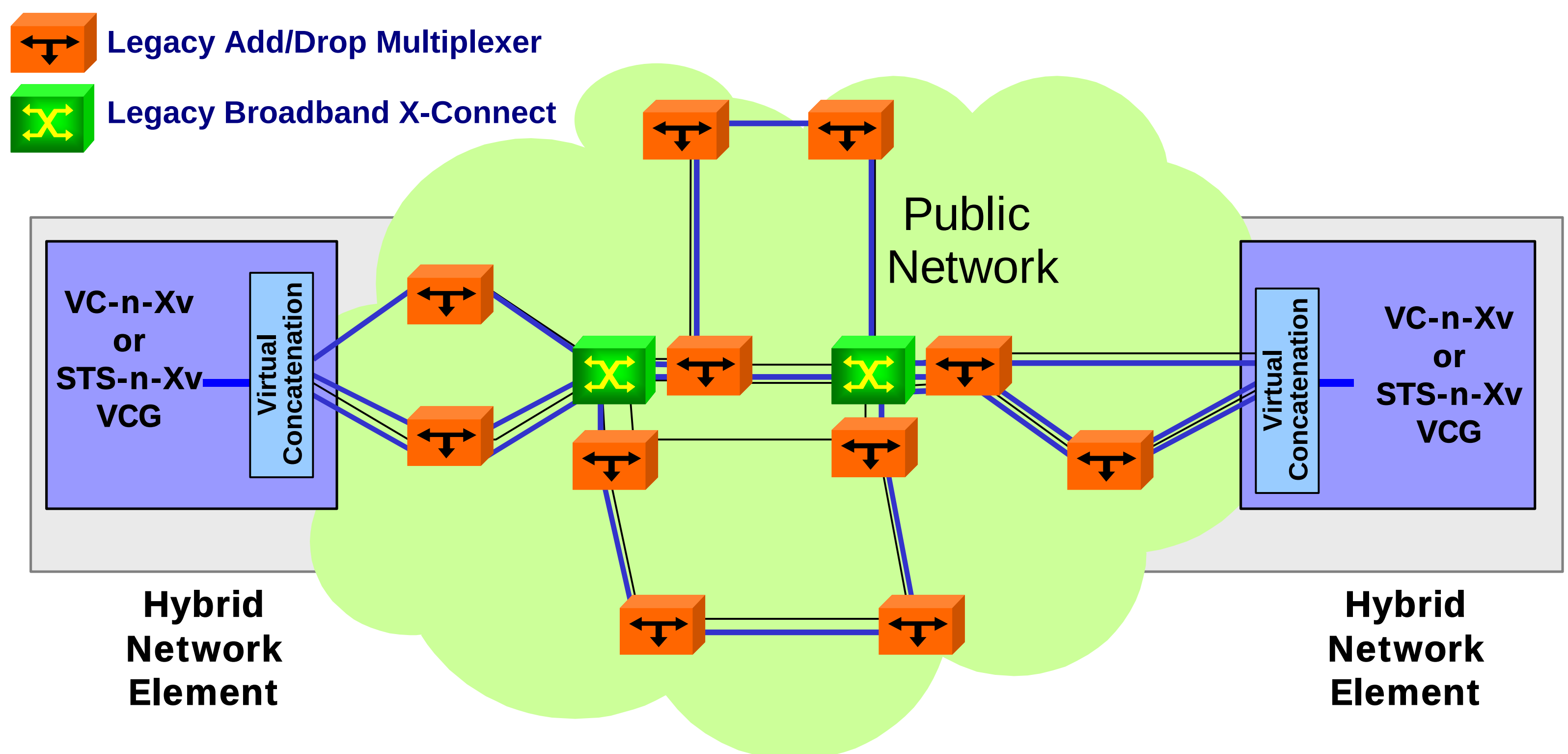
Native Interfaces:
- *FE*
- *GbE*
- *PPP/IP/MPLS*
- *Fibre Channel*
- *FICON*
- *ESCON*



Hybrid Network Elements Virtual Concatenation

- **Multiple SONET STS-Nc's (VC-n's) grouped into single STM-N-Xv Virtual Concatenation Group (VCG)**
  - Component STS-Nc's may be routed separately
  - Compensates differential network delays up to 32 ms
- **Network Operator provisions no. of channels (X) in VCG**
  - Solves SONET/SDH & OTN bandwidth "granularity problem"
- **Completely transparent to intermediate NEs.**
  - Only termination nodes need to support this feature

Hybrid Network Elements
Virtual Concatenation - Example



Hybrid Network Elements
Link Capacity Adjustment Scheme (LCAS)

- **Controls hitless addition/removal of STS-N's (VC-n's) to/from VCG under management control**
  - In-service hitless bandwidth modification
  - Address the dynamic management of bandwidth for data transport services over SONET/SDH
- **Manages automatic removal/addition of failed/repaired STS-N's from/to VCG**
- **Supports virtual channel protection through "load sharing" on STS-N's**
  - Works best on point-to-point links
- **ITU-T Recommendation G.7042 / ANSI T1.105.02**

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%)

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Summary
GFP Advantages

- ***Versatility:*** **Enables transport services for either Layer 1 or Layer payloads:**
  - PPP, IP, MPLS, Ethernet, HDLC & MAPOS at Layer 2
  - Fibre Channel, FICON, ESCON, Infiniband, DVB ASI at Layer 1
  - Endorsed by multiple communities including IEEE RPR WG & IETF
- ***Scalability:*** **Demonstrate transport capabilities at rates from 10Mbps to 10Gbps (and soon beyond)**
- ***Simplicity:*** **Eliminates need for ATM and HDLC networking for simple connectivity services resulting in more efficient, lower-risk component designs**
- ***Component availability:*** **Broader user demand expected to drive future applications, feature maturity, interface commonality and lower cost**

GFP Characteristics and Benefits

- **Simple Header Error Control (HEC) based synchronization:**
  - Generalizes ATM's HEC synchronization (inexpensive table lookup)
  - Supports variable or fixed length packets (IP/Ethernet datagrams, block codes or ATM cells)
- **Simple pointer-based frame delineation:**
  - Low processing complexity without payload expansion
  - Low (deterministic) adaptation overhead
  - High data link efficiency (scalable to 10Gbps and beyond)
  - Amenable to strict/loose QoS support, particularly for real-time services
- **Flexible traffic adaptation modes:**
  - Frame-Mapped GFP (GFP-F): *Suitable for elastic applications*
  - Transparent-Mapped GFP (GFP-T): *Suitable for in-elastic applications*