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Data Over SONET/SDH (DoS) Technologies - Standards, Structures & Design.

December 18, 2002

presented by:

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Data over SONET/SDH Seminar Series

Objective

- Comprehensive tutorial seminar series for engineers involved in the design, verification, manufacturing, deployment and maintenance of Data over (next generation) SONET/SDH equipment and networks.

Series Topics

- DoS Technologies - Standards, Structures & Design.
- DoS Equipment - Architectures & Test Challenges
- SONET/SDH Jitter Measurements & Standards
- DoS Client Signal Technologies

What is Data over SONET/SDH (DoS) ?

- Evolution of legacy SONET/SDH networks to transport a variety of data traffic services bandwidth-efficiently.
  - More than Packet over SONET/SDH (PoS)
  - More than Ethernet over SONET/SDH (EoS)
  - More than proprietary solutions.

"Legacy evolution not new network revolution"

Seminar 1: DoS Technologies

Technologies To Be Covered

- **VC** — Virtual Concatenation
  - optimum (bandwidth) sized pipe
- **LCAS** — Link Capacity Adjustment Scheme
  - dynamic pipe sizing on demand
- **GFP** — Generic Framing Procedure
  - standardized encapsulation for multiple services over SONET or SDH
- **LAPS** — Link Access Procedure for SDH
  - standardized encapsulation for Ethernet service over SDH

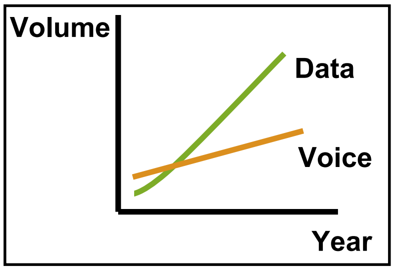
Plus references to Packet over SONET/SDH (PoS) and client signals such as Ethernet, GbE & Fibre Channel.

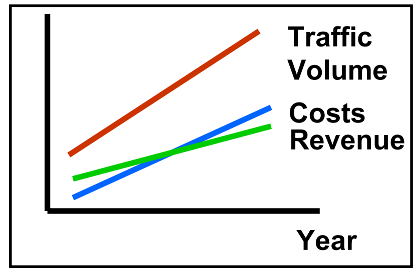
Seminar 1: DoS Technologies

Seminar Content

- DoS market, technology drivers, & standards
- Technology structures & implementation
  - GFP
  - Virtual Concatenation & LCAS
- DoS chipsets & equipment design
- DoS equipment design issues
- Wrap Up + question & answer session

DoS Market Drivers & Trends





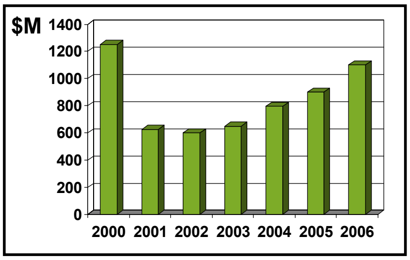
Increase Service Revenues

- New data services, eg. Ethernet private lines, flexible bandwidth TDM private lines, SAN services.
- Enhanced existing services - eg. faster provisioning

Lower CAPEX / OPEX

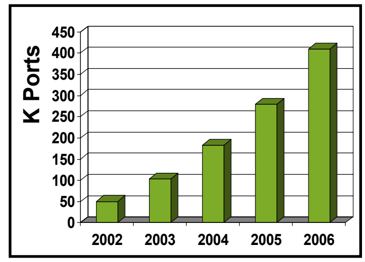
- Offer new services on existing legacy network ("*legacy compatibility*").
- Maximise network bandwidth efficiency
- Reduce maintenance costs

DoS Market Forecasts



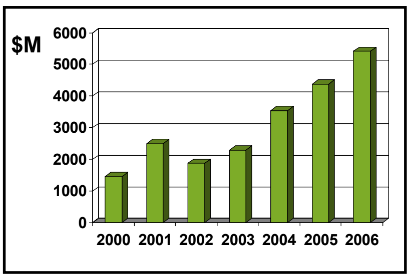
SONET/SDH Chipset Market (2000-2006)

Source: IDC 2002



Ethernet Ports By SONET/SDH Platform (2002-2006)

Source: RHK 2002



Data over SONET/SDH Aggregation Equipment Market (2000-2006)

Source: RHK 2002

DoS Equipment Evolution

Technology Layers & Purpose

Client Signals

Encapsulation Protocols

Concatenation Processes

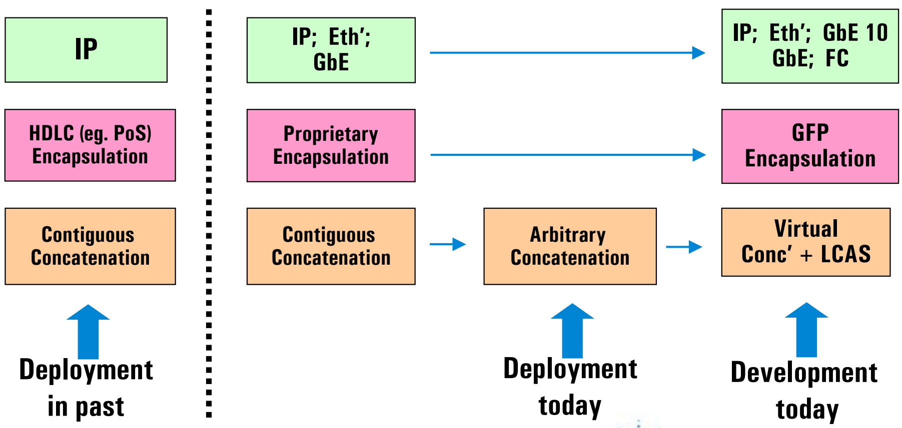
- SONET/SDH is synchronous, continuous byte stream. Data signals are generally asynchronous, bursty, variable frames. Encapsulation compensates for idle time between data stream bursts.
- Low cost transport does not generally have OAM functionality. Encapsulation layer provides support functions to enable reliable transport of services.

- Procedure whereby multiple SONET/SDH containers can be used as one enabling transport of higher capacity signals.

DoS Equipment Evolution

Technology Evolution (not revolution)

Evolution of SONET/SDH standards and equipment to more efficiently & effectively carry data traffic. *Legacy compatible*.



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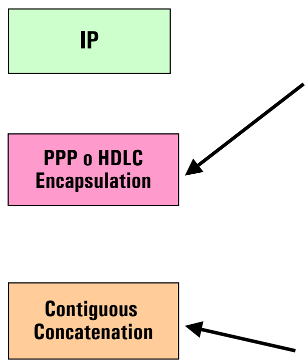
DoS Equipment Evolution - HDLC

bits	8	8	8/16			16/32	8
HDLC Frame	Flag	Address	Control		Data	FCS	Flag
PPP in HDLC Frame (PoS)	Flag	Address	Control	Protocol	Data	FCS	Flag
PPP in HDLC Frame (PoS)	0x7E	0xFF	0x03	0x0021	Data	FCS	0x7E
Cisco HDLC Frame (PoS)	0x7E	0x0F	0x00	0x0800	Data	FCS	0x7E
Ethernet over SDH using LAPS (X.86)	0x7E	0x04	0x03	0xFE	Data	FCS	0x7E

DoS Equipment Evolution - HDLC

PoS



- Single service - IP packets only.
- Ethernet services lose Level 2 intelligence, eg. multi-casting, VLAN filtering, prioritization.
- Undeterministic bandwidth utilization
- Not robust to bit errors.
- Not interoperable in all cases due to HDLC field variances.

- Bandwidth inefficient for data services.

DoS Equipment Evolution - HDLC

LAPS

Ethernet

HDLC Encapsulation

- Limited services - IP (X.85) and Ethernet (X.86) only.
- Undeterministic bandwidth utilization
- Not robust to bit errors.

Cont' or VC Concatenation

- Only defined for SDH.

LAPS Framing Structure

Flag
Address
Control
SAPI
Data
FCS
Flag

Flag: All frames start and end with a flag. Start flag (ie. Opening Flag) has value 01111110 (Hex).

Address: The address field has the constant value of 0x04 (Hex).

Control: The control field consists of sequence 0x03 (Hex), which is again a constant value

SAPI: Identifies the payload type, for example, Ethernet has the SAPI value 0xfe01 (Hex).

Data: IP or Ethernet packet content.

FCS: CRC calculation result is placed in this Frame Check Sequence field

DoS Equipment Evolution - GFP

GFP

IP; Eth'; GbE 10 GbE; FC

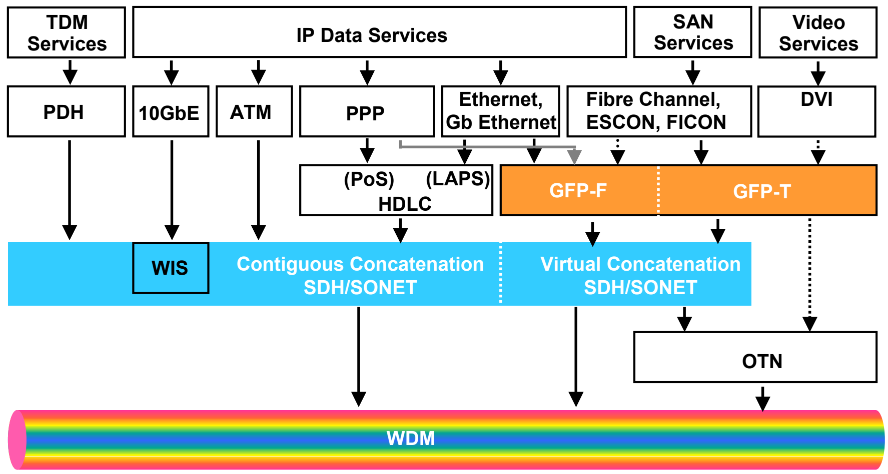
GFP Encapsulation

Virtual Conc' + LCAS

- Multiple service support
  - GFP-F for eg. Ethernet services;
  - GFP-T for eg. FC, FICON, ESCON
- Deterministic and efficient bandwidth utilization
- Robust to bit errors.

- Bandwidth efficient for data services.

GFP + VC Implementation Overview



DoS Technology Standards

GFP & LAPS Encapsulations

Existing (Fully Ratified)

- ITU-T G.7041/Y.1303 (Dec 2001) GFP (Framed & Transparent)
- ITU-T X.85/Y.1321 (Mar 2001) LAPS (IP over SDH)
- ITU-T X.86/ (Feb 2001) LAPS (Ethernet over SDH)

Virtual Concatenation & LCAS

Existing (Fully Ratified)

- ITU-T G.707/Y.1322 (Sep 2002) SDH VC
- ITU-T G.7042/Y.1305 (Nov 2001) LCAS
- ANSI T1.105a-2002 (2002) SONET VC & LCAS

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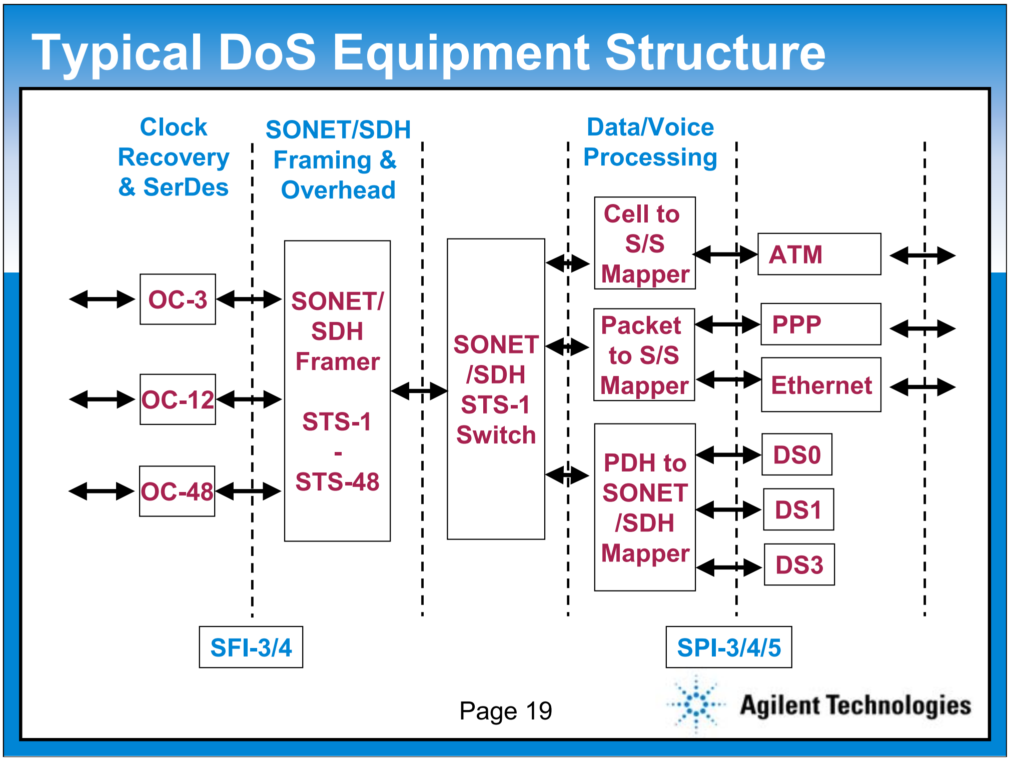

Typical DoS Equipment Structure
Clock Recovery & SerDes
SONET/SDH Framing & Overhead
Data/Voice Processing
OC-3
OC-12
OC-48
SONET/ SDH Framer
STS-1 - STS-48
SONET /SDH STS-1 Switch
Cell to S/S Mapper
Packet to S/S Mapper
PDH to SONET /SDH Mapper
ATM
PPP
Ethernet
DS0
DS1
DS3
SFI-3/4
SPI-3/4/5
Page 19
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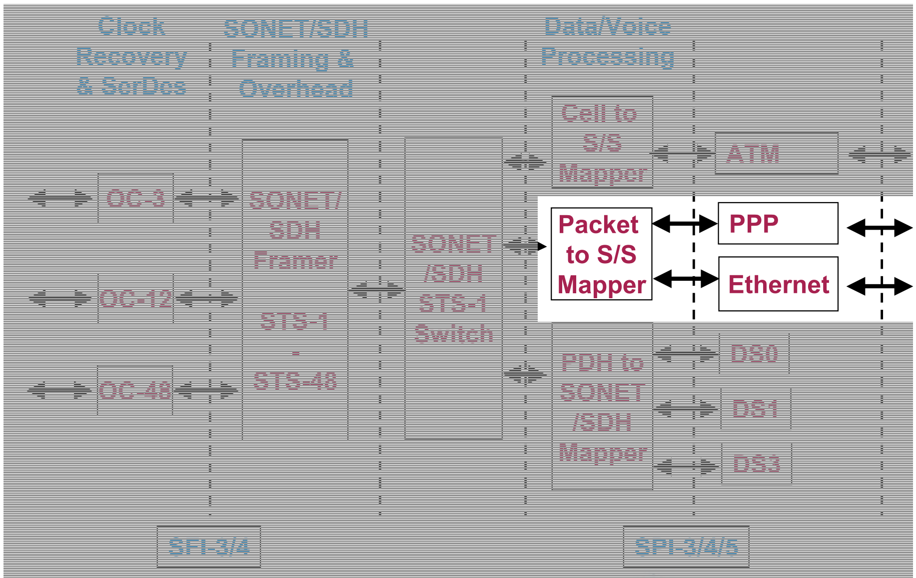
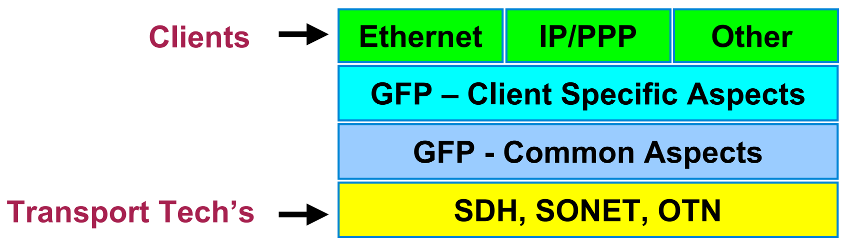
Data Client Encapsulation

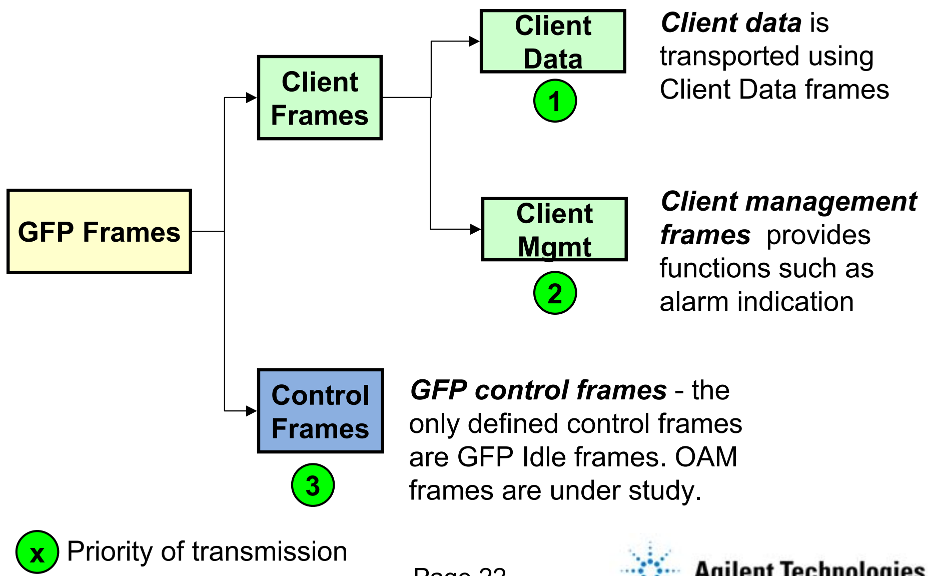


GFP

- G.7041 defines both common & client specific aspects
- Common aspects - apply to all GFP adapted traffic, irrespective of the payload being transported
  - eg. basic functions such as PDU delineation, scrambling and performance monitoring.
- Client specific aspects - payload dependent aspects such as the mapping of the client signal into GFP



GFP Common – The Muxing of Frames



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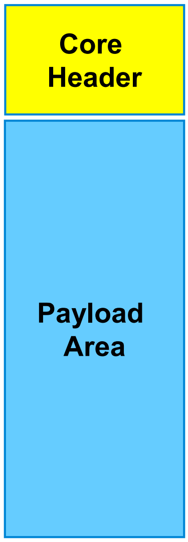
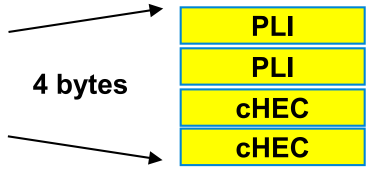
GFP – Common Aspects

4 bytes	Core Header	→ Responsible for frame delineation. Based on ATM mechanism.
4 bytes to 65535 bytes	Payload Area	

GFP Common Aspects - Core Header





PLI Payload area Length Indicator field. 2 bytes field of the number of bytes in the GFP Payload Area

cHEC Core Header Error Control field. 2 bytes containing CRC-16 error control. Single bit error corrections and multi-bit detection

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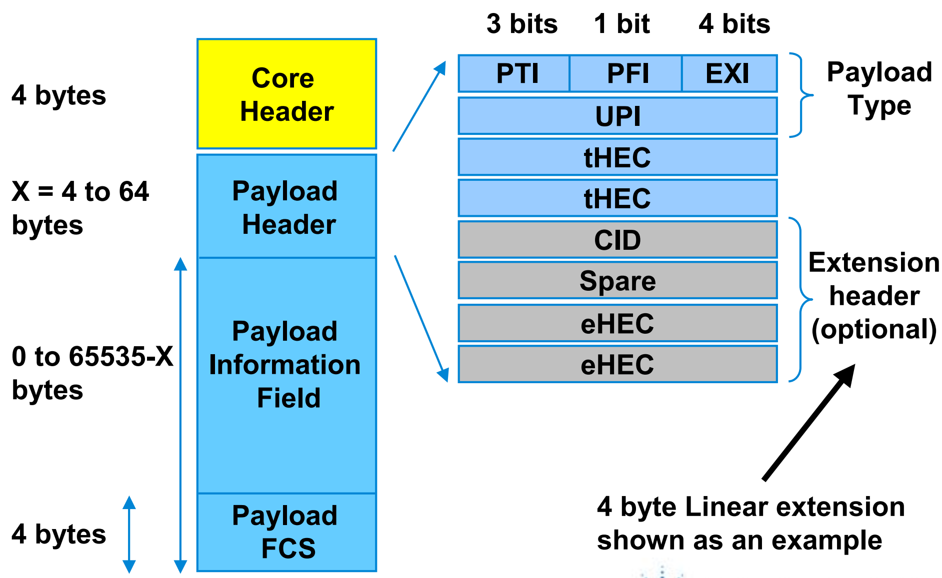
GFP Common Aspects – Payload Header



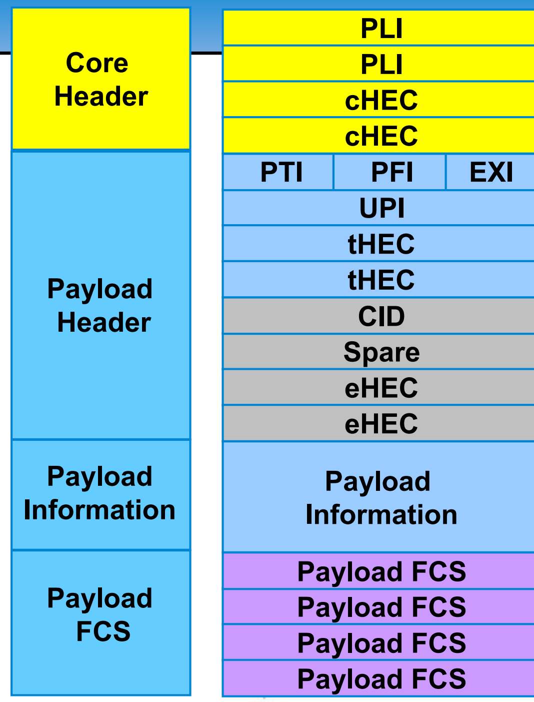
GFP Payload Header - More Detail

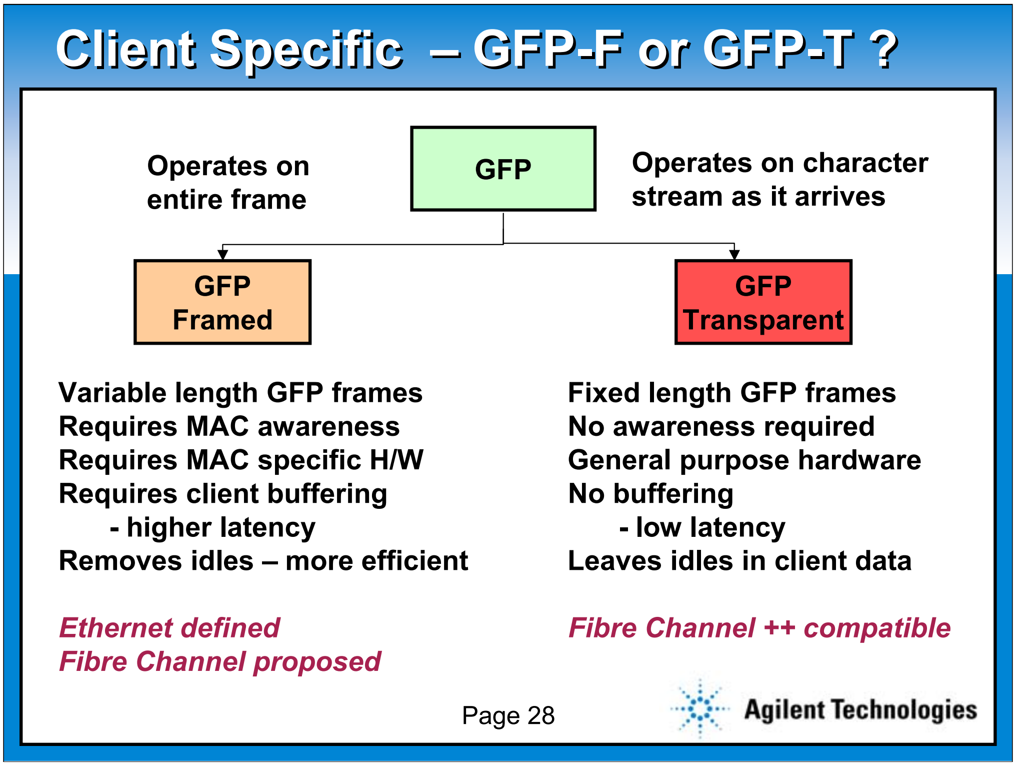
PTI	3 bits	PTI – Payload Type Identifier specifies client data or management frame
PFI	1 bit	PFI – Payload FCS Identifier indicates presence (1) or absence (0) of payload FCS
EXI	4 bits	EXI – Extension Header Identifier indicates NULL, Linear or Ring extension
UPI		User Payload Identifier set according to client signal
tHEC		2 byte Type HEC for single error correction over Type
tHEC		
CID		Optional Channel ID (Linear extension)
Spare		
eHEC		Extension HEC for single error correction
eHEC		

GFP Frame

The complete GFP frame.

Used for both GFP-Framed & GFP-Transparent modes of operation. (GFP-F and GFP-T respectively).





GFP supports both point-to-point and ring applications.

Currently two modes of GFP encapsulation are defined which are

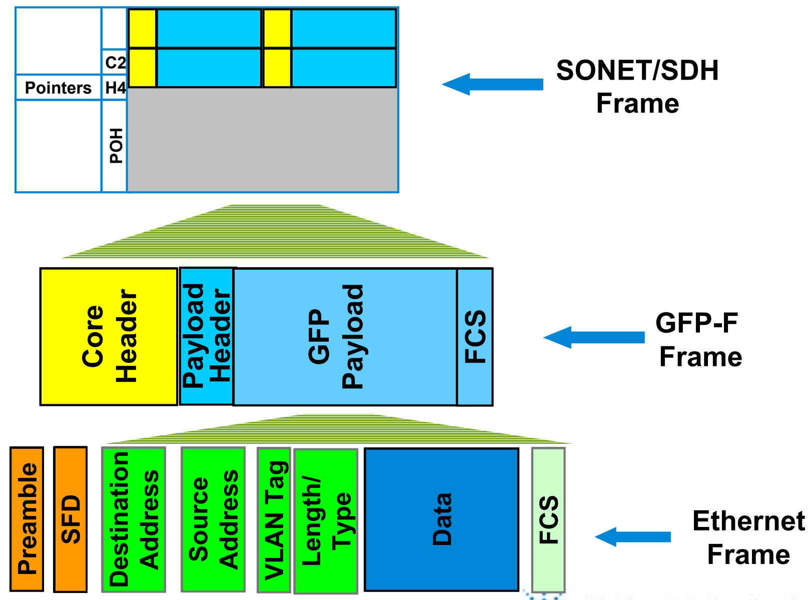
1- Frame-Mapped GFP (GFP-F) and

2- Transparent GFP (GFP-T)

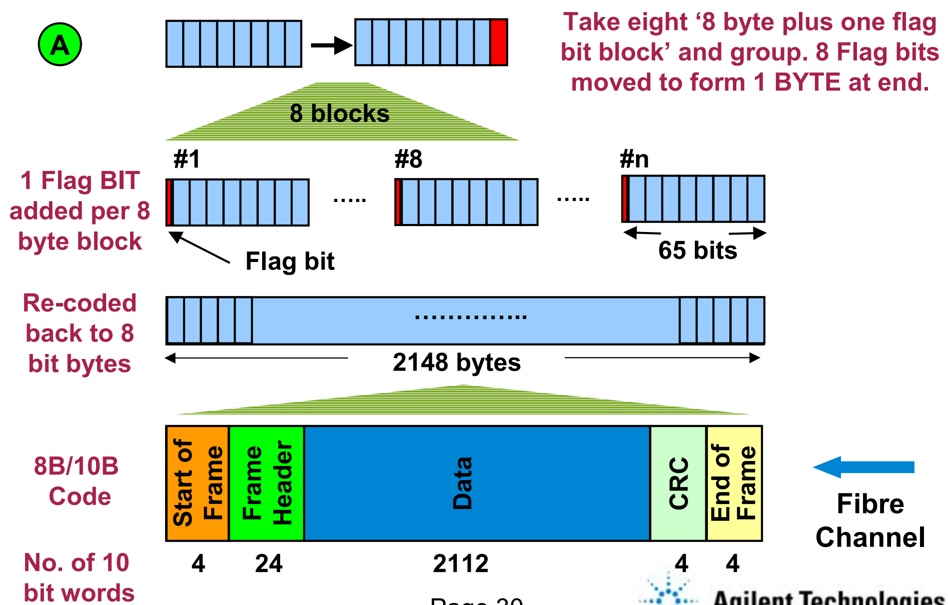
Frame-Mapped GFP maps a client frame in its entirety into one GFP frame or we can also say that a single client frame is mapped into a single GFP frame. For example an Ethernet Frame mapped into a GFP Frame.

Transparent GFP is intended to facilitate the transport of block coded client signals like Fiber Channel, ESCON, FICON or even Gigabit Ethernet. The individual characters of a client signal are de-mapped from the client signal and then mapped into fixed length GFP frames. This process avoids buffering of an entire client frame for further processing into a GFP frame.

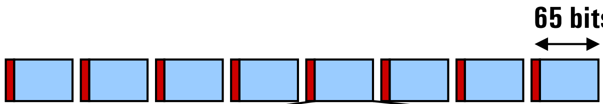
GFP-F Example - Ethernet Client



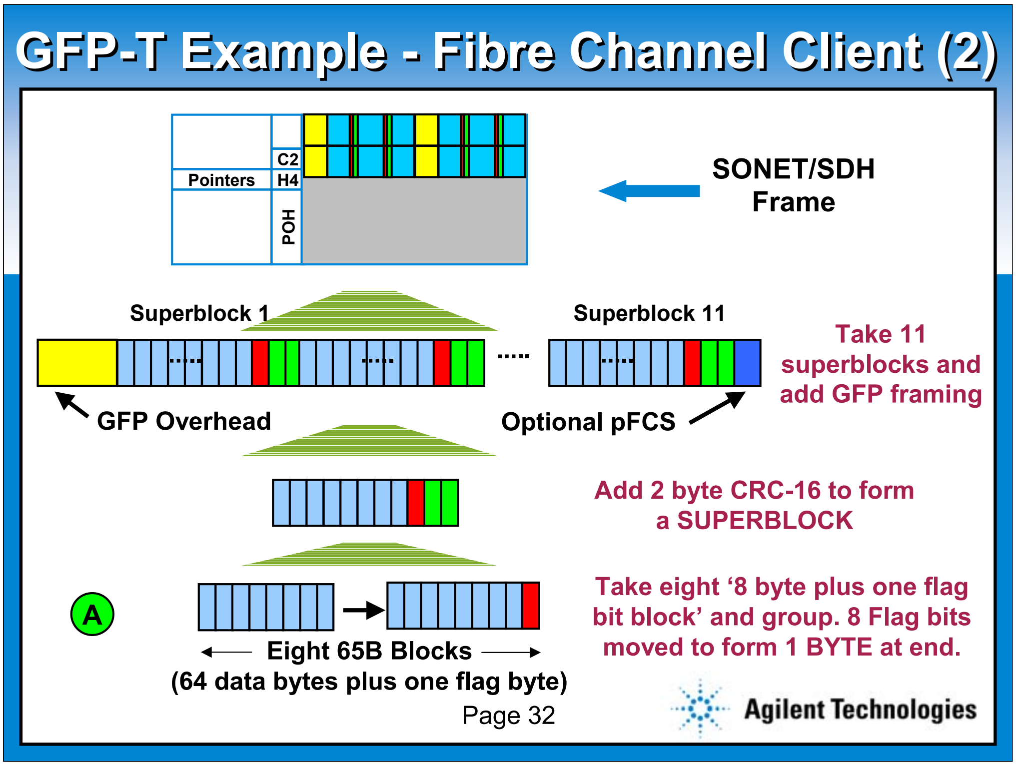
GFP-T Example - Fibre Channel Client (1)



GFP-T Block



Client Input	Flag Bit	64-Bit (8-Octet) Field							
All Data	0	D1	D2	D3	D4	D5	D6	D7	D8
7 data 1 control	1	0 aaa C1	D1	D2	D3	D4	D5	D6	D7
6 data 2 control	1	1 aaa C1	0 bbb C2	D1	D2	D3	D4	D5	D6
5 data 3 control	1	1 aaa C1	1 bbb C2	0 ccc C3	D1	D2	D3	D4	D5
4 data 4 control	1	1 aaa C1	1 bbb C2	1 ccc C3	0 ddd C4	D1	D2	D3	D4
3 data 5 control	1	1 aaa C1	1 bbb C2	1 ccc C3	1 ddd C4	0 eee C5	D1	D2	D3
2 data 6 control	1	1 aaa C1	1 bbb C2	1 ccc C3	1 ddd C4	1 eee C5	0 fff C6	D1	D2
1 data 7 control	1	1 aaa C1	1 bbb C2	1 ccc C3	1 ddd C4	1 eee C5	1 fff C6	0 ggg C7	D1
8 control	1	1 aaa C1	1 bbb C2	1 ccc C3	1 ddd C4	1 eee C5	1 fff C6	1 ggg C7	0 hhh C8



GFP-T Example - Fibre Channel Client (2)
C2
Pointers
H4
POH
SONET/SDH
Frame
Superblock 1
Superblock 11
Take 11
superblocks and
add GFP framing
GFP Overhead
Optional pFCS
Add 2 byte CRC-16 to form
a SUPERBLOCK
A
Take eight '8 byte plus one flag
bit block' and group. 8 Flag bits
moved to form 1 BYTE at end.
Eight 65B Blocks
(64 data bytes plus one flag byte)
Page 32
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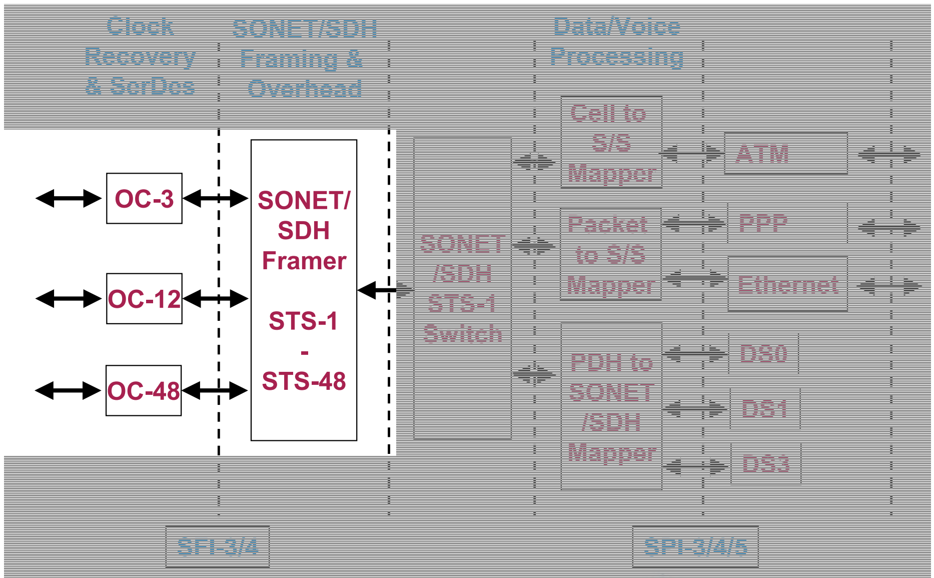
SONET/SDH Concatenation



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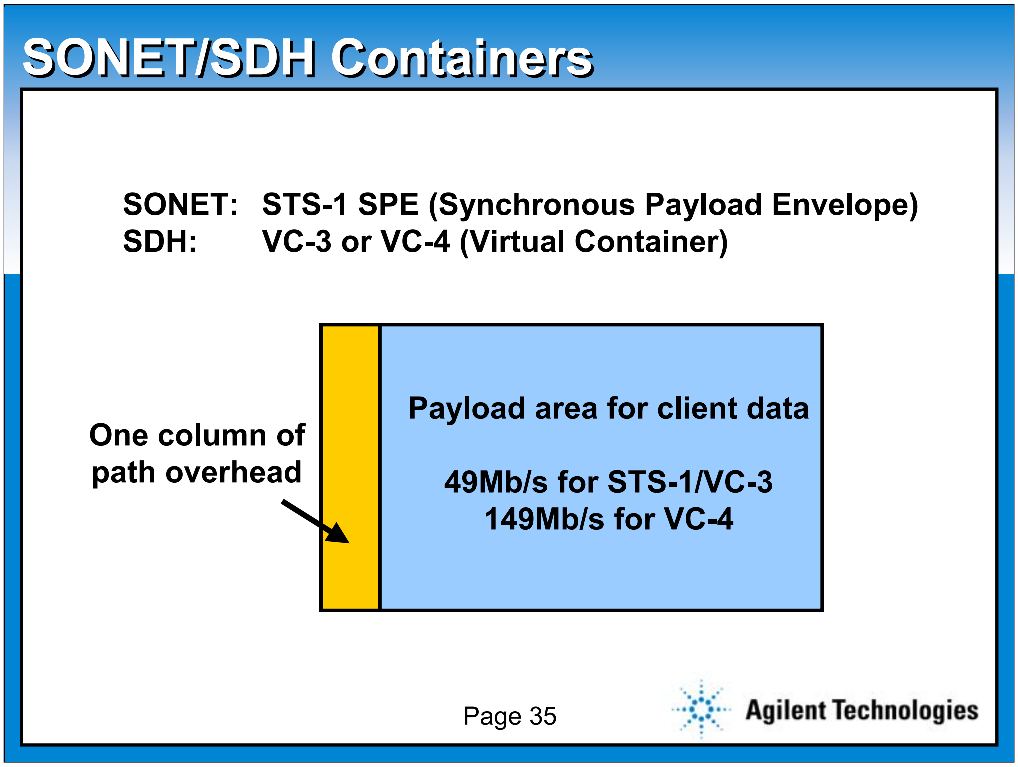
Concatenation Terminology

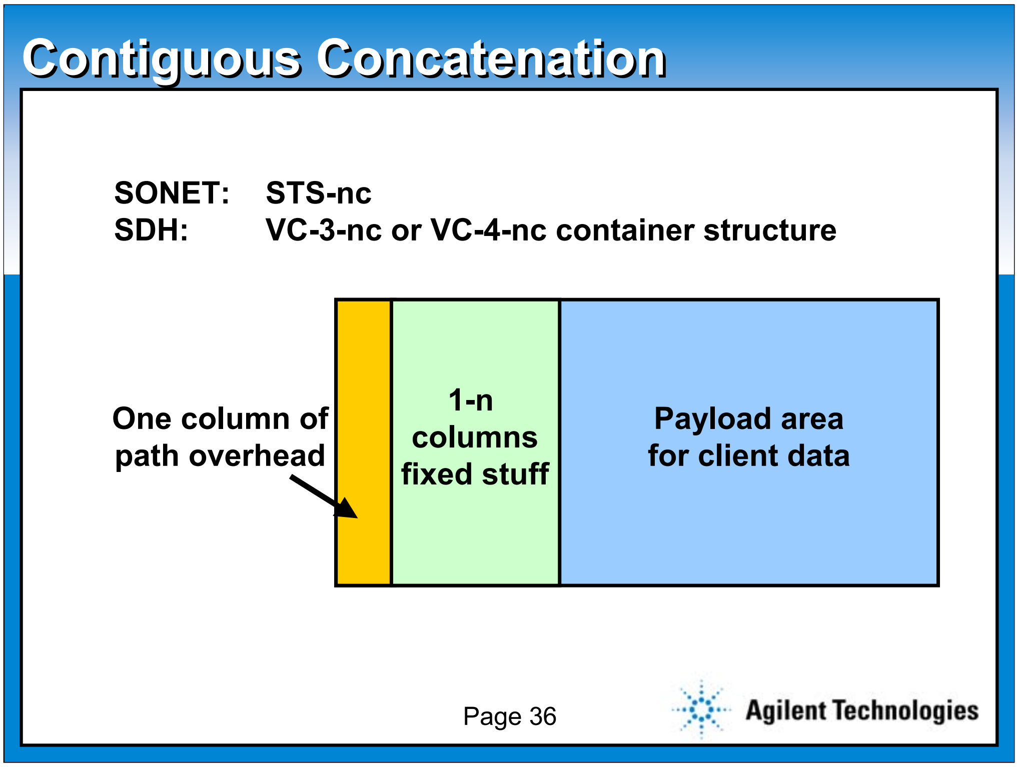
- **Containers**
  - The fundamental building blocks of SONET/SDH
- **Contiguous Concatenation**
  - A way of ‘sticking’ together multiple containers to make one large container for carrying a larger payload
- **Virtual Concatenation**
  - A methodology of using multiple containers to carry a larger payload, but each container is independent when transported across the network



Containers are the fundamental building blocks for virtual concatenation. This is the container structure for an STS-1 or VC-3.

One column of path overhead which is used to manage the container from transmitter to receiver, the path end points, and a payload area used to carry the client data.

One STS-1 or VC-3 has approximately 49Mb/s of bandwidth for client data.



Contiguous concatenation already exists in many parts of the network and this diagram illustrates the structure of a container using contiguous concatenation.

If this were an STS-3c, we would have 1 column of path overhead, 2 columns of fixed stuff bytes and a payload area three times the size of a single STS-1.

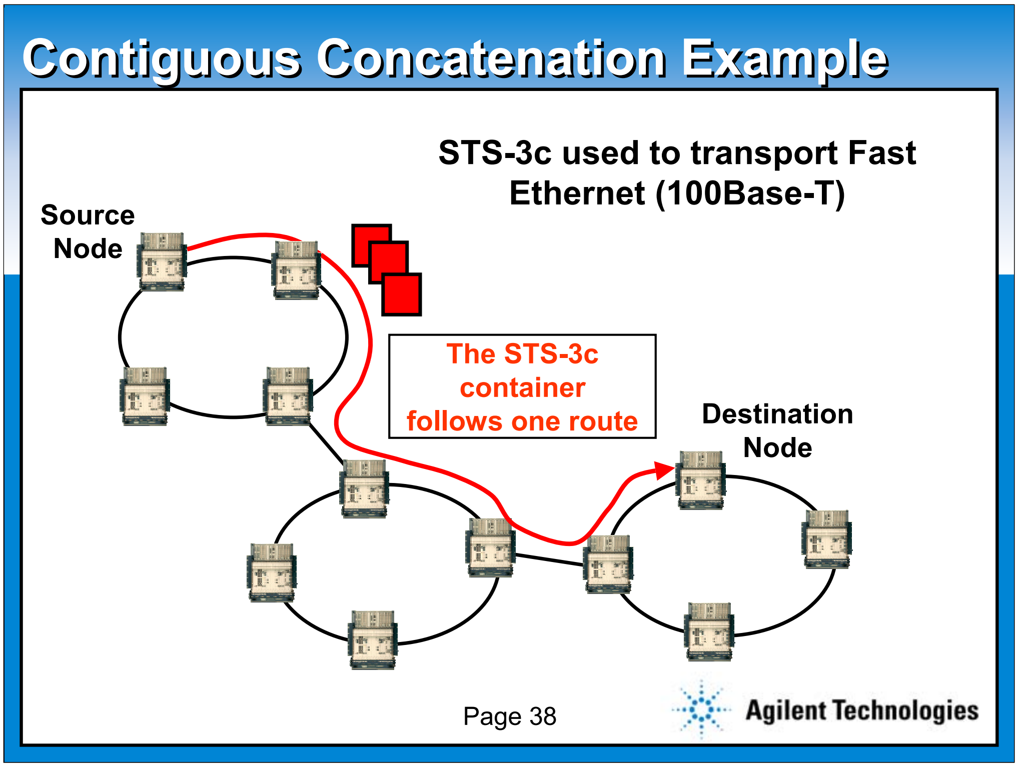
This size of container provides approximately 147 Mb/s of bandwidth for client data and is typically used to transport fast Ethernet signals of 100 Mb/s.

Contiguous Concatenation

- One payload travels one way through network
- Each element must recognize contiguous structure
- Payload sizes not efficient for data payloads …

Service	Data Rate	Contiguous Concatenation		Efficiency
		SONET	SDH	
Ethernet	10Mb/s	STS-1	VC-3	20%
ATM	25Mb/s	STS-1	VC-3	50%
Fast Ethernet	100Mb/s	STS-3c	VC-4	67%
Fiber Channel	200Mb/s	STS-12c	VC-4-4c	33%
Gbit Ethernet	1000Mb/s	STS-48c	VC-4-16c	42%

A STS-1/VC-4 has 149Mb/s of capacity



As the STS-3c is transported across the network, all the containers follow the same route, and all of the network equipment must be compatible with the STS-3c container structure.

Let's now look in more detail at virtual concatenation...

What is 'Virtual Concatenation (VC)' ?

- Uses groups of independent SONET/SDH containers.
- Containers take different routes to destination.
  Different route have different delays
- Destination must remove (buffer) delay, and re-align arriving containers

	SDH	SONET
Low Order	VC groups Tributary Units VC-1/2-Xv (e.g. VC-12-5v)	VC groups Virtual Tributaries VTn-Xv (e.g. VT-1.5-7v)
High Order	VC groups Virtual Containers VC-n-Xv (e.g. VC-4-7v)	VC groups SPEs STSn-Xv (e.g. STS-1-2v)

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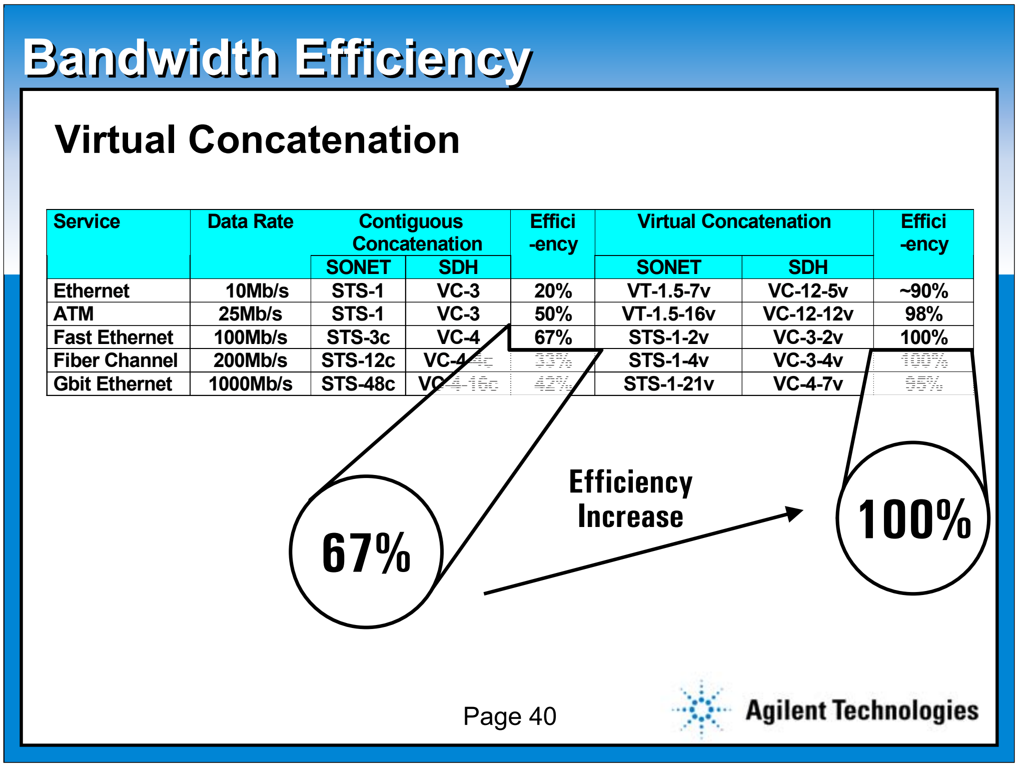
For any network equipment in the transit path that does NOT support virtual concatenation, this causes no problem whatsoever as the container is passed through transparently with no processing of the path overhead. This is a significant point when considering a migration to Virtual concatenation since only the path end points need to be Vcat 'aware'.

A major benefit of allowing the containers to follow different routes, it is easier to utilize 'stranded' bandwidth. However, the downside of this is the need to buffer data at the receiver to re-align the incoming data.



Bandwidth Efficiency

Virtual Concatenation

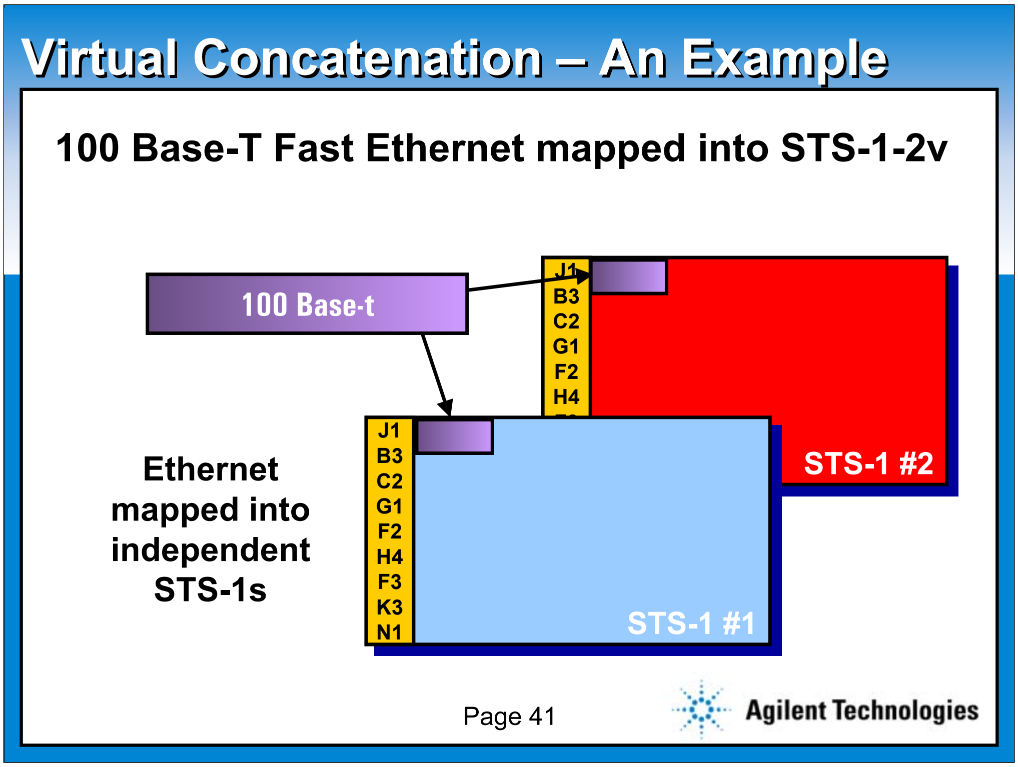
Service	Data Rate	Contiguous Concatenation		Efficiency	Virtual Concatenation		Efficiency
		SONET	SDH		SONET	SDH	
Ethernet	10Mb/s	STS-1	VC-3	20%	VT-1.5-7v	VC-12-5v	~90%
ATM	25Mb/s	STS-1	VC-3	50%	VT-1.5-16v	VC-12-12v	98%
Fast Ethernet	100Mb/s	STS-3c	VC-4	67%	STS-1-2v	VC-3-2v	100%
Fiber Channel	200Mb/s	STS-12c	VC-4-4c	33%	STS-1-4v	VC-3-4v	100%
Gbit Ethernet	1000Mb/s	STS-48c	VC-4-16c	42%	STS-1-21v	VC-4-7v	95%

This table shows the improvements in bandwidth efficiency that can be made by using virtual concatenation instead of contiguous concatenation.

I mentioned that an STS-3c is often used to transport 100 Mb/s fast Ethernet services. This results in a bandwidth efficiency of 67%.

By using virtual concatenation, we can use 2 STS-1s to carry the same service and the bandwidth efficiency rockets to 100%!

Even larger efficiency improvements can be made with other data services.



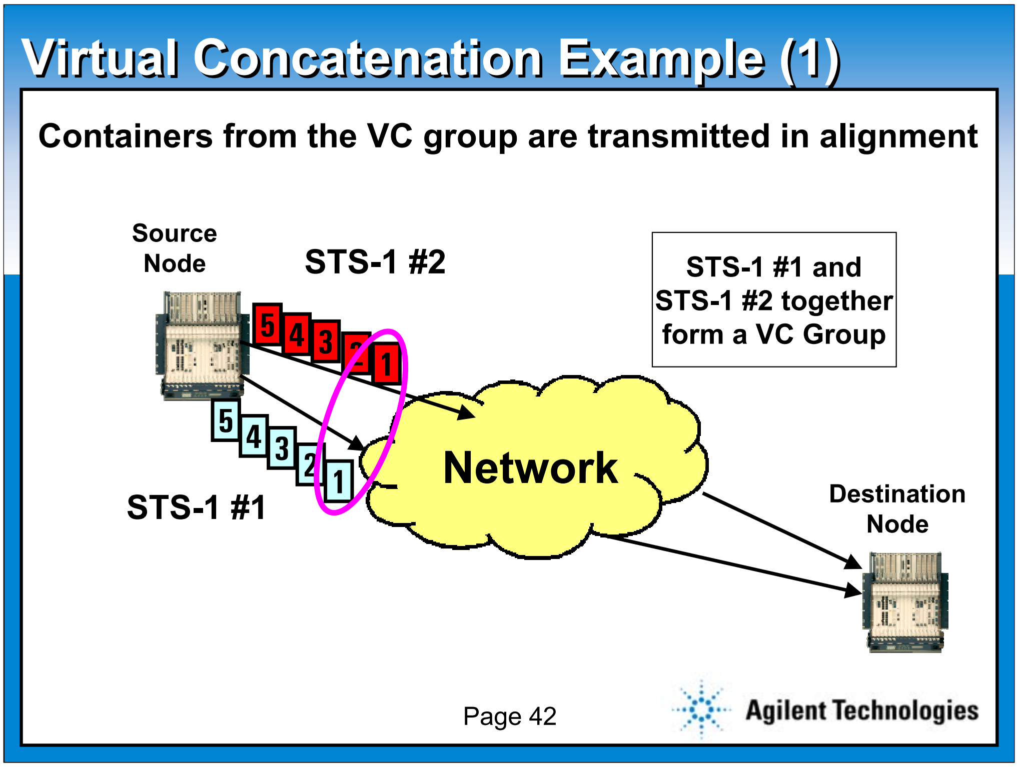
Let's look at an example of transporting a 100 Base-t, fast Ethernet service using virtual concatenation.

Two STS-1s are generally sufficient to provide enough client bandwidth to carry a 100 Base-t data stream. This is a virtual container group of size 2, and the correct term for this is an STS-1-2v.

The two STS-1s are numbered STS-1 number 1 and STS-1 number 2.

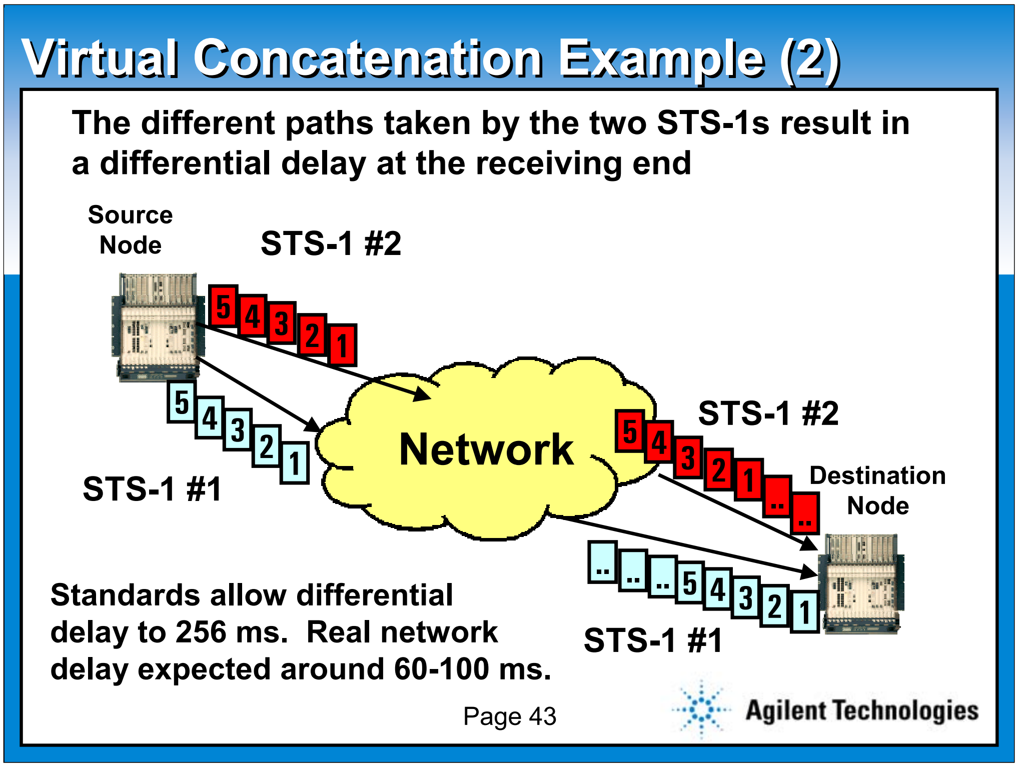
Each virtual container is filled a byte at a time, and the containers transmitted simultaneously on two different ports of a network element.

Note that in this diagram STS-1 number one is colored pale blue and STS-1 number 2 is colored red.



The pale blue boxes represent the SONET frames carrying the containers for STS-1 number 1 while the red boxes represent the SONET frames carrying the containers for STS-1 number 2.

You should note that the numbers in the boxes signify that frames with the same number on the different paths are transmitted at the same time. So, frame 1 of STS-1 number 1 is transmitted at the same time as frame 1 of STS-1 number 2 and so on.



The two STS-1s in our virtually concatenated signal have taken different routes through the network and you will see that at the destination node, frame 1 of STS-1 number 1 arrives 2 frames sooner than frame 1 of STS-1 number 2.

In order for the network element to correctly re-create the original 100 Base-t data stream, it needs to buffer Frame 1 of STS-1 number 1 until frame 1 of STS-1 number 2 arrives. When this happens, the original signal can be re-created and the process continues so long as data is sent across the network.

From this example, it can be seen that there are two key things that need to be achieved.

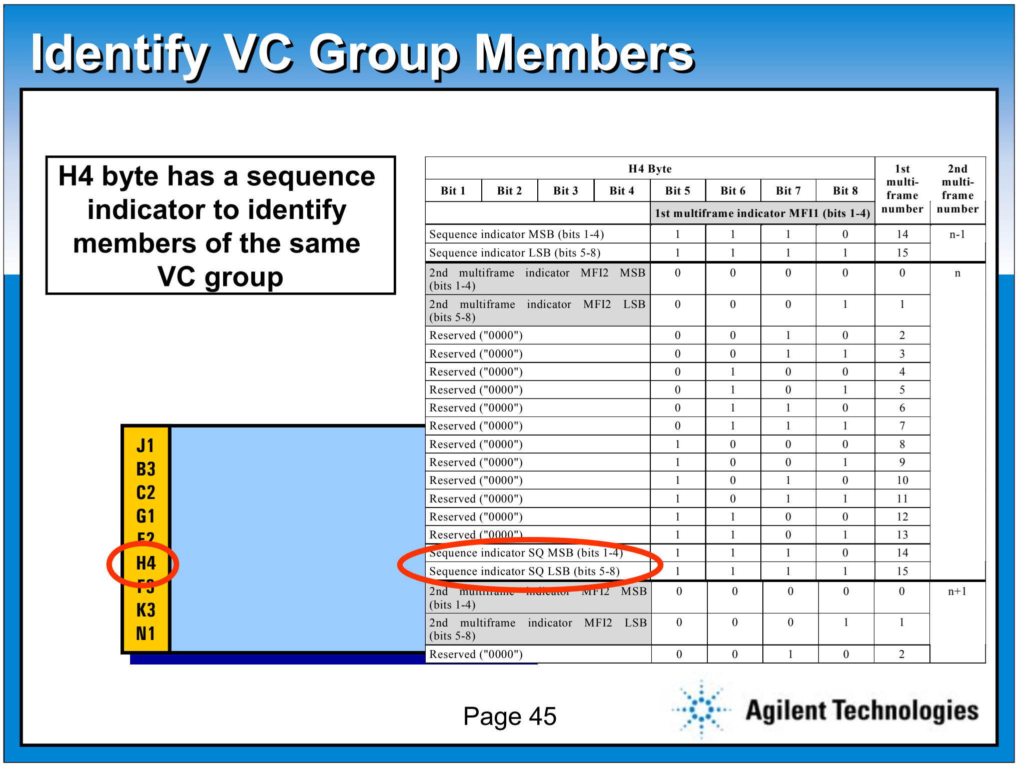
Firstly, the receiving equipment needs some method of re-aligning the containers arriving on the different paths.

Secondly, some storage area, or buffer memory, is required to compensate for the differential delay between the two paths.

It can also be seen that as the delay, or the number of members of the Vcat group increases, more data needs to be stored. It is likely that the buffer memory size in real equipment will result in some trade-off between delay compensation and Vcat group size.

Removing VC Differential Delay

- The receiving equipment must re-align the arriving SONET/SDH containers.
- This is accomplished by
  - buffering the incoming data.
  - using a sequence indicator in the H4 byte in the path overhead of all members of the high order VC group to put containers into the correct order.
- A similar frame and multi-frame indicator scheme is implemented in the K4 byte for low order VC groups.

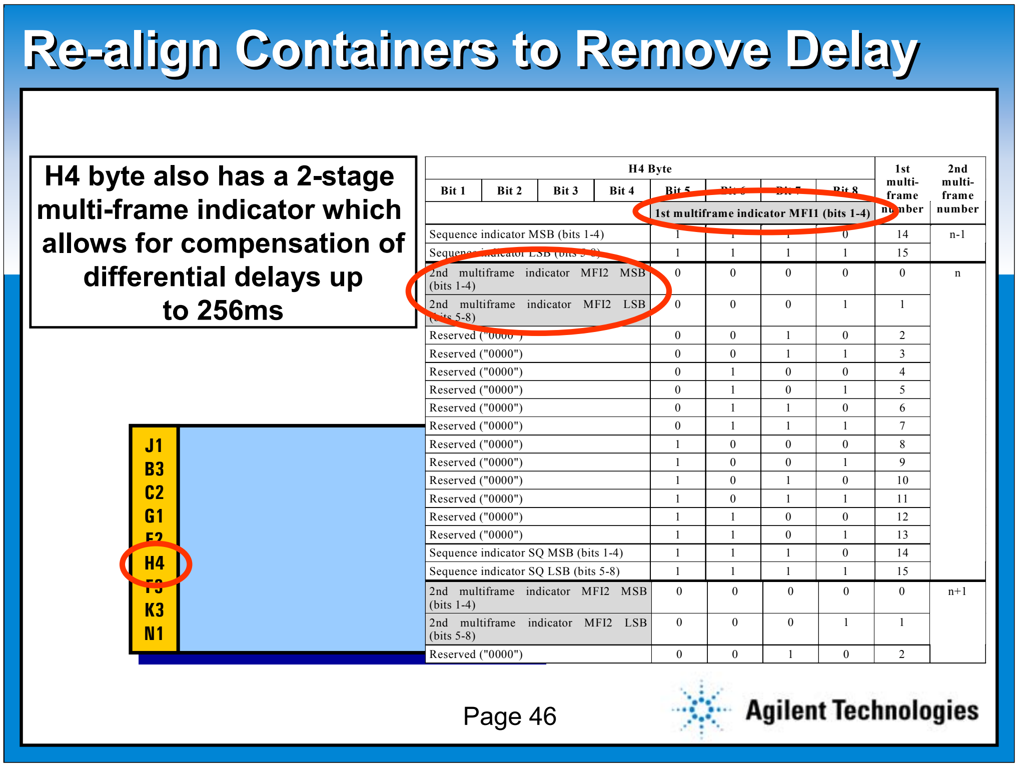


H4 Byte									1st multi-frame number	2nd multi-frame number
Bit 1	Bit 2	Bit 3	Bit 4		Bit 5	Bit 6	Bit 7	Bit 8		
					1st multiframe indicator MFI1 (bits 1-4)					
Sequence indicator MSB (bits 1-4)					1	1	1	0	14	n-1
Sequence indicator LSB (bits 5-8)					1	1	1	1	15	
2nd multiframe indicator MFI2 MSB (bits 1-4)					0	0	0	0	0	n
2nd multiframe indicator MFI2 LSB (bits 5-8)					0	0	0	1	1	
Reserved ("0000")					0	0	1	0	2	
Reserved ("0000")					0	0	1	1	3	
Reserved ("0000")					0	1	0	0	4	
Reserved ("0000")					0	1	0	1	5	
Reserved ("0000")					0	1	1	0	6	
Reserved ("0000")					0	1	1	1	7	
Reserved ("0000")					1	0	0	0	8	
Reserved ("0000")					1	0	0	1	9	
Reserved ("0000")					1	0	1	0	10	
Reserved ("0000")					1	0	1	1	11	
Reserved ("0000")					1	1	0	0	12	
Reserved ("0000")					1	1	0	1	13	
Sequence indicator SQ MSB (bits 1-4)					1	1	1	0	14	
Sequence indicator SQ LSB (bits 5-8)					1	1	1	1	15	
2nd multiframe indicator MFI2 MSB (bits 1-4)					0	0	0	0	0	n+1
2nd multiframe indicator MFI2 LSB (bits 5-8)					0	0	0	1	1	
Reserved ("0000")					0	0	1	0	2	

How virtual concatenation is implemented in SONET and SDH is by using a special sequence in the H4 byte of the path overhead. This is used by all containers that are a member of a Vcat group. The table shown here is taken directly from the ITU-T standard.

Part of the information contained in the H4 byte is a sequence indicator. This is used to identify members of the Vcat group and is circled in RED on the table in front of you.

In our previous example, ALL containers sent on the path STS-1 number one would have the value of 0, and all the containers sent on the path STS-1 number 2 would have the value 1.



H4 Byte								1st multi-frame number	2nd multi-frame number
Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8		
				1st multiframe indicator MFI1 (bits 1-4)					
Sequence indicator MSB (bits 1-4)				1	1	1	0	14	n-1
Sequence indicator LSB (bits 5-8)				1	1	1	1	15	
2nd multiframe indicator MFI2 MSB (bits 1-4)				0	0	0	0	0	n
2nd multiframe indicator MFI2 LSB (bits 5-8)				0	0	0	1	1	
Reserved ("0000")				0	0	1	0	2	
Reserved ("0000")				0	0	1	1	3	
Reserved ("0000")				0	1	0	0	4	
Reserved ("0000")				0	1	0	1	5	
Reserved ("0000")				0	1	1	0	6	
Reserved ("0000")				0	1	1	1	7	
Reserved ("0000")				1	0	0	0	8	
Reserved ("0000")				1	0	0	1	9	
Reserved ("0000")				1	0	1	0	10	
Reserved ("0000")				1	0	1	1	11	
Reserved ("0000")				1	1	0	0	12	
Reserved ("0000")				1	1	0	1	13	
Sequence indicator SQ MSB (bits 1-4)				1	1	1	0	14	
Sequence indicator SQ LSB (bits 5-8)				1	1	1	1	15	
2nd multiframe indicator MFI2 MSB (bits 1-4)				0	0	0	0	0	n+1
2nd multiframe indicator MFI2 LSB (bits 5-8)				0	0	0	1	1	
Reserved ("0000")				0	0	1	0	2	

With the Vcat group members identified, the next step is to re-align the incoming frames. This is accomplished using a 2 stage multiframe indicator, which is highlighted in RED on the table. This is effectively a counter running continuously from 0 to 4095 in the H4 byte.

The multiframe runs across 4,096 SONET or SDH frames, thus taking 512 ms for one complete cycle. This cycle is enough to compensate for differential delay up to 256ms.

Again using our previous example, the receiving equipment would see a 2 frame offset between the multiframe indicator values running in STS-1 number 1 and STS-1 number 2. This is all the information required to tell the network equipment what needs to be buffered in order to re-construct the original client data.

Contiguous vs Virtual Concatenation

Contiguous

- Poor granularity of container size
- Container travels along same path
- Requires all elements in path to understand concatenation indication
- Independent of network management system
- No differential delay

Virtual

- Flexible granularity (high order and low order)
- Individual containers can take separate paths
- Only the end elements need understand the concatenation arrangement
- Requires control from the network management system
- Individual containers may experience differential delay

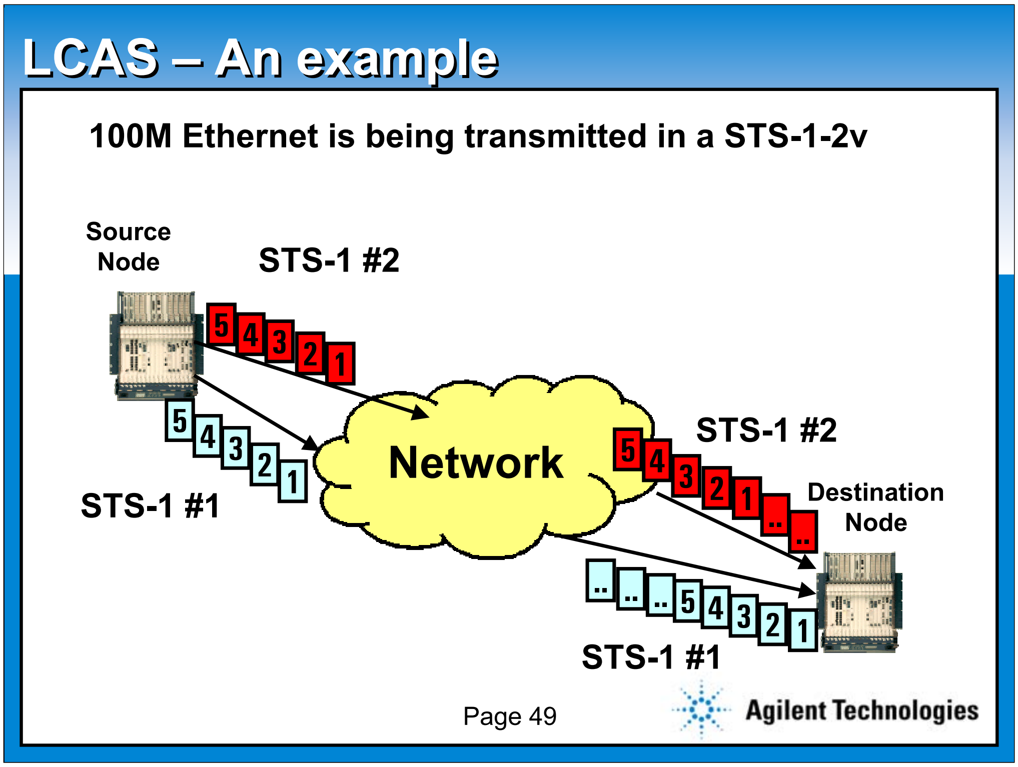
Link Capacity Adjustment Scheme

Requirement

- Allows containers to be added/removed from a group as the data bandwidth requirement changes
- Also provides ability to remove links that have failed
- Addition and removal of containers must be hitless

Operation

- A control packet is used to configure the path between source and destination
- The control packet is transmitted in the H4 byte for high order and K4 byte for low order virtual concatenation
- The control packet describes the link status during the next control packet
- Changes are sent in advance so the receiver can switch as soon as the new configuration arrives

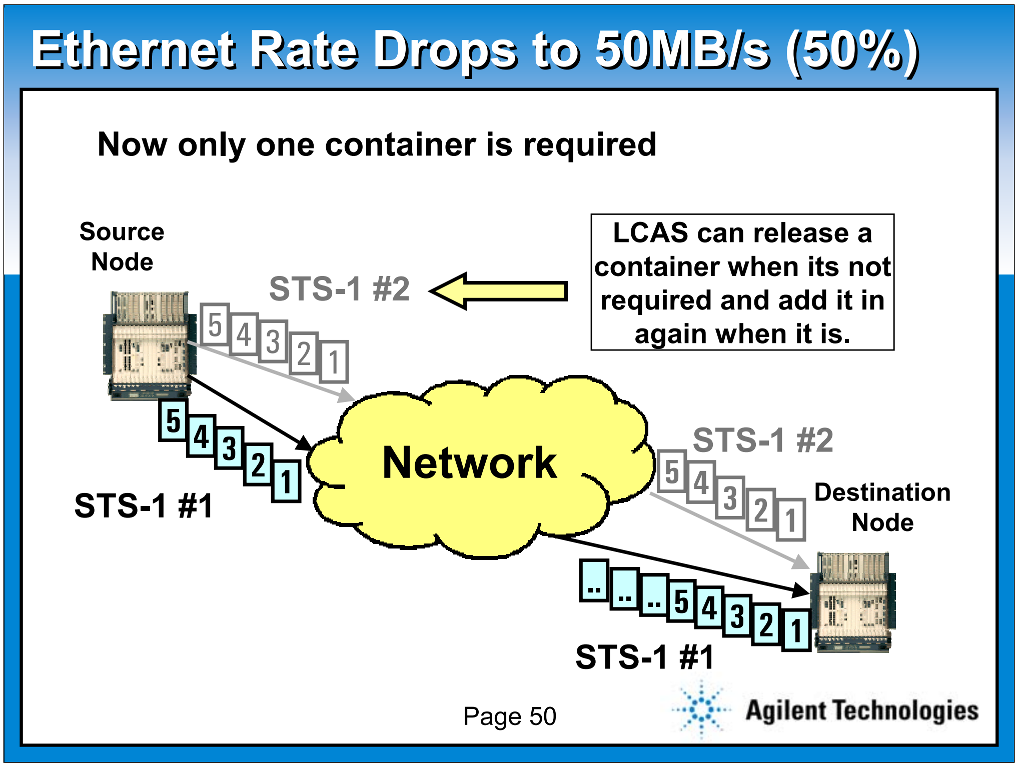


The two STS-1s in our virtually concatenated signal have taken different routes through the network and you will see that at the destination node, frame 1 of STS-1 number 1 arrives 2 frames sooner than frame 1 of STS-1 number 2.

In order for the network element to correctly re-create the original 100 Base-t data stream, it needs to buffer Frame 1 of STS-1 number 1 until frame 1 of STS-1 number 2 arrives. When this happens, the original signal can be re-created and the process continues so long as data is sent across the network.

From this example, it can be seen that the receiving equipment need some method of re-aligning the incoming containers, and storing containers for re-alignment.

It can also be seen that as the delay increases, or the number of members of the Vcat group increases, the larger the buffer memory required to compensate for the differential delay.



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It can also be seen that as the delay increases, or the number of members of the Vcat group increases, the larger the buffer memory required to compensate for the differential delay.

The LCAS Control Packet in H4 byte

H4 Byte								1st multi-frame number	2nd multi-frame number
Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8		
				1st multi-frame indicator (bits 1-4)					
Sequence indicator MSB (bits 1-4)				1	1	1	0	14	n-1
Sequence indicator LSB (bits 5-8)				1	1	1	1	15	
2nd multi-frame indicator MSB (bits 1-4)				0	0	0	0	0	N
2nd multi-frame indicator LSB (bits 5-8)				0	0	0	1	1	
CTRL				0	0	1	0	2	
GID ("000x")				0	0	1	1	3	
Reserved ("0000")				0	1	0	0	4	
Reserved ("0000")				0	1	0	1	5	
CRC-8				0	1	1	0	6	
CRC-8				0	1	1	1	7	
Member status				1	0	0	0	8	
Member status				1	0	0	1	9	
RS-ACK				1	0	1	0	10	
Reserved ("0000")				1	0	1	1	11	
Reserved ("0000")				1	1	0	0	12	
Reserved ("0000"), to extend Seq. Ind.				1	1	0	1	13	
Sequence indicator MSB (bits 1-4)				1	1	1	0	14	
Sequence indicator LSB (bits 5-8)				1	1	1	1	15	
2nd multi-frame indicator MSB (bits 1-4)				0	0	0	0	0	n+1
2nd multi-frame indicator LSB (bits 5-8)				0	0	0	1	1	
CTRL				0	0	1	0	2	
GID ("000x")				0	0	1	1	3	
Reserved ("0000")				0	1	0	0	4	
Reserved ("0000")				0	1	0	1	5	
CRC-8				0	1	1	0	6	
CRC-8				0	1	1	1	7	
Member status				1	0	0	0	8	

LCAS control packet

New LCAS functions

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The New LCAS fields

- The LCAS Control nibble carries instructions from source to destination:

- FIXED	(0000)	indicates non LCAS mode
- ADD	(0001)	this member will be added to group
- NORM	(0010)	steady state transmission no change
- EOS	(0011)	end of sequence
- IDLE	(0101)	not part of group/will be removed
- DNU	(1111)	Do Not Use failure detected

- Group ID (GID) every member of group has same GID
- Member status (MST) from source to destination either OK or failed
- RS-Ack from source to destination changes requested are accepted
- CRC protects each control packet

Seminar 1: DoS Technologies

Seminar Content

- DoS market, technology drivers & standards
- Technology structures & implementation
  - GFP
  - Virtual Concatenation & LCAS
- DoS chipsets & equipment design
- DoS equipment design issues
- Wrap Up + question & answer session

DoS Chipsets Trends

Industry Shift

- Recent years have seen a significant move away from application specific ICs (ASICs) to application specific standard products (ASSPs).

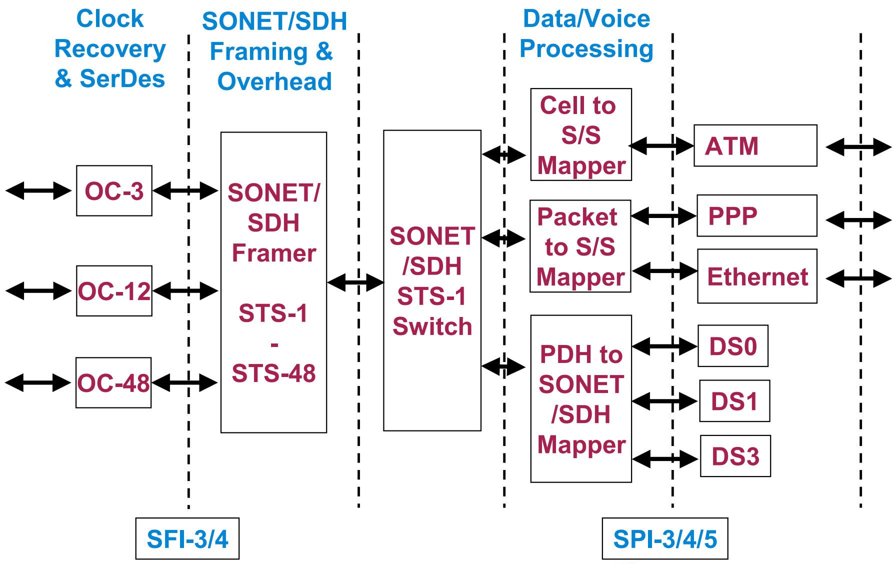
Smaller Silicon Technology (0.18 -> 0.13 micron)

- Lower power devices with more ports per device.
- Higher integration of devices such as framers, mappers and Ethernet MACs in a single device.

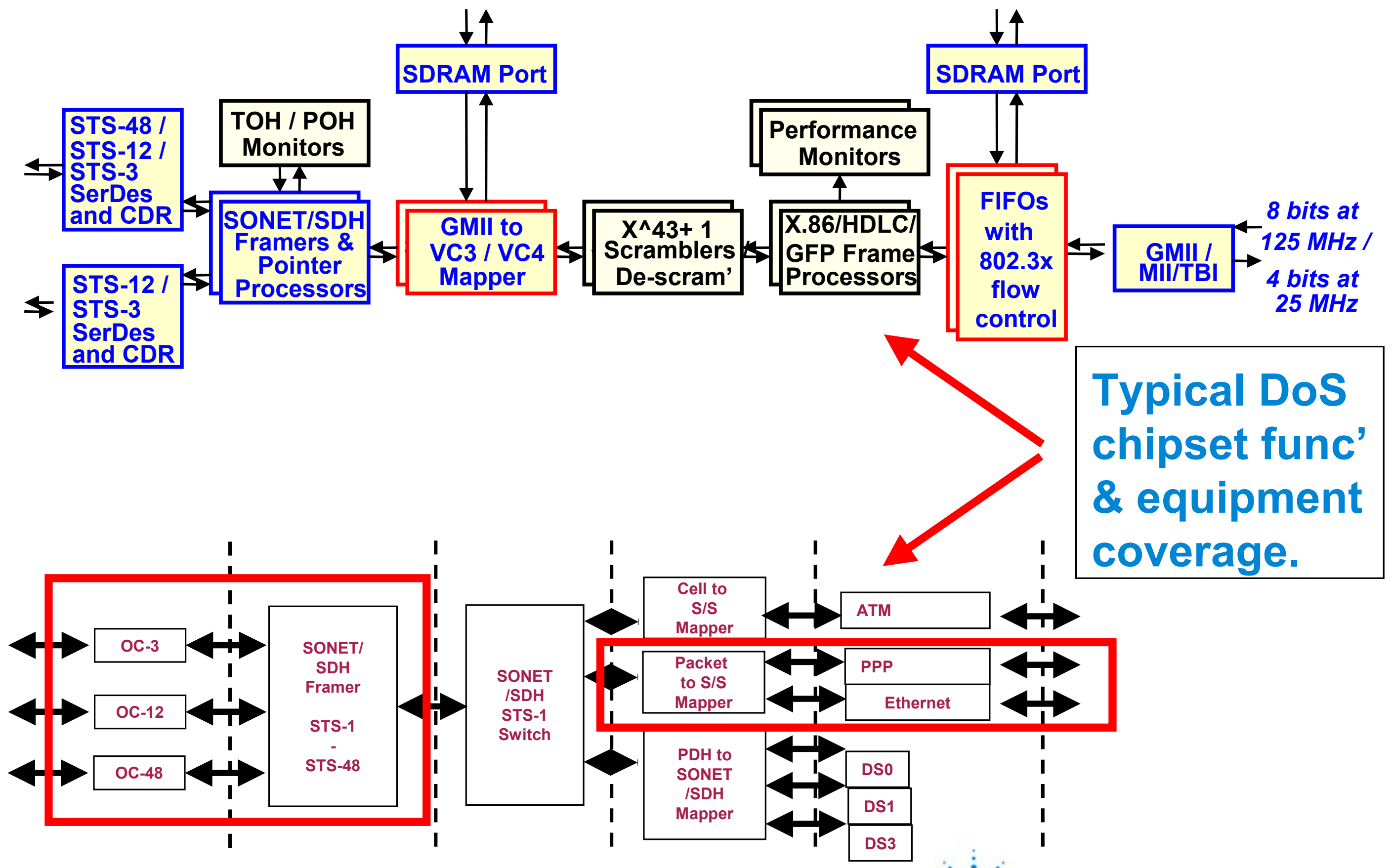
DoS Chipset Evolution (FPGA + Discrete Framers; ASSPs)

- 1st generation: GFP/LAPS (2001)
- 2nd generation: GFP/LAPS + VC (2002)
- 3rd generation: GFP/LAPS + VC/LCAS (2003)

Typical DoS Equipment Structure



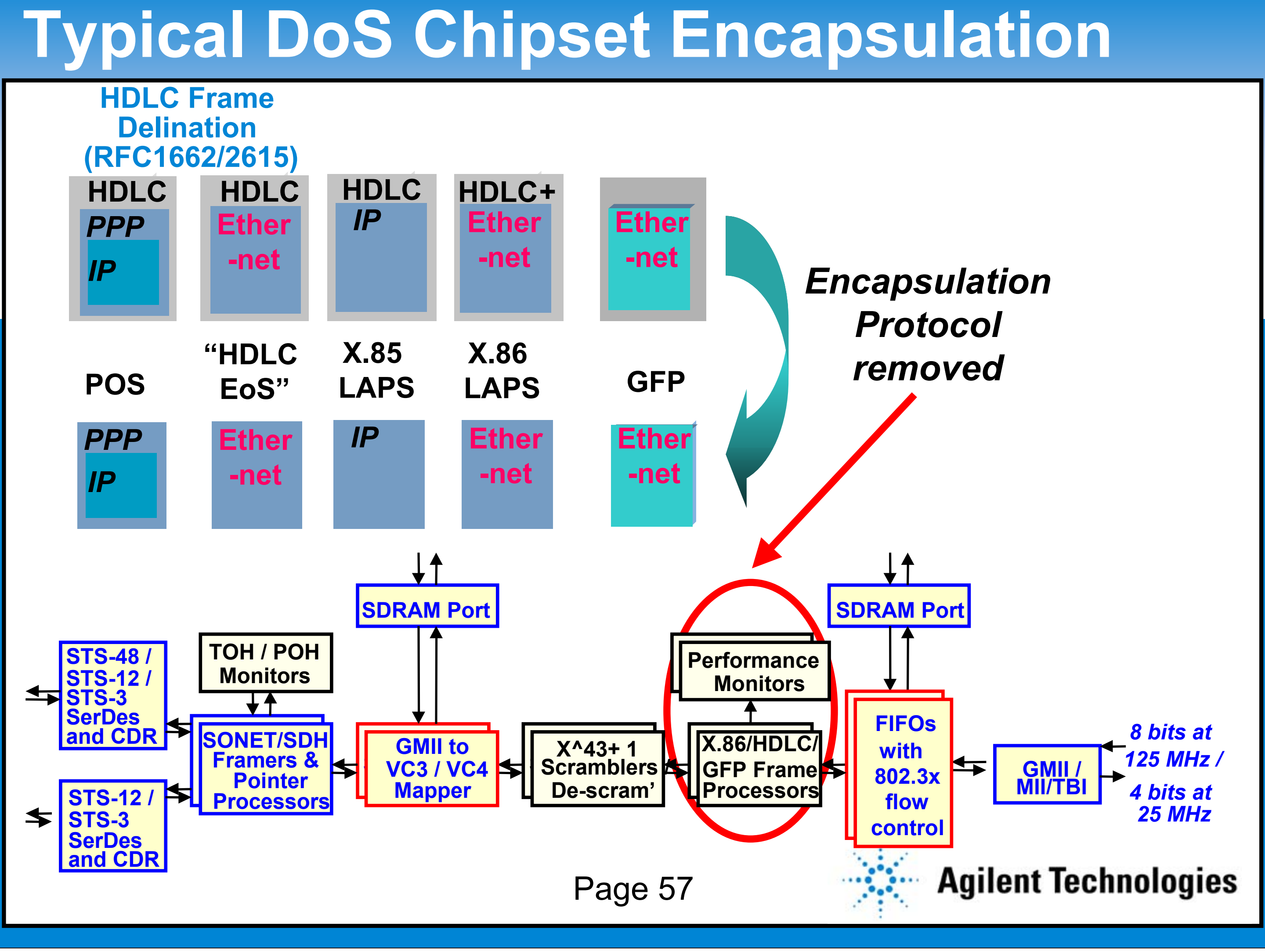
DoS Chipset Features/Block Diagram



Why GFP is a Better Option

GP offers several significant advantages when compared to other PDU-oriented framing mechanisms, such as LAPS [ITU-T X.86]. These include:

1. **GFP is more efficient than LAPS. It has no inflation factor and maintains a fixed overhead almost equal to the minimum overhead in LAPS. Traffic management and QoS control are significantly easier.**
2. **GFP is more robust than LAPS. A single bit-error in the PLI and the cHEC field does not cause loss of alignment, while with LAPS, a single bit-error in the flag causes misalignment. The HEC framing ensures a single bit-error correction in the PLI.**



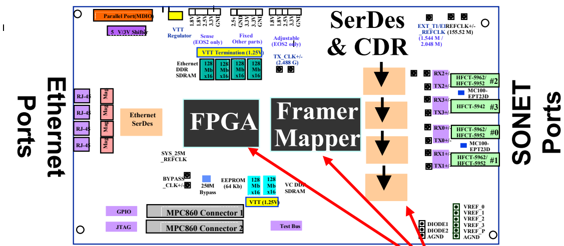
RFC 1662, "PPP in HDLC-like framing", specifies how to put a PPP frame into an HDLC frame for delineation and error checking. RFC 2615, "PPP over SONET/SDH", specifies which options in RFC 1662 to use when the link is a SONET fiber. RFC 1661, "The Point-to-Point Protocol", PPP frames carries both packets for link parameter negotiations as well as the IP packets.

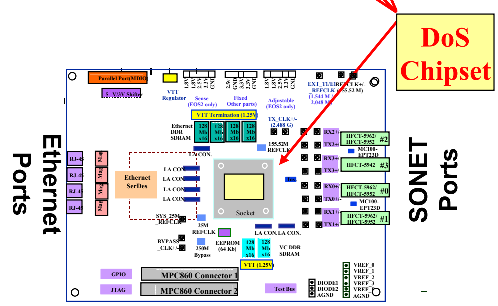
RFC 1662, "PPP in HDLC-like framing", specifies how to put a PPP frame into an HDLC frame for delineation and error checking. RFC 2615, "PPP over SONET/SDH", specifies which options in RFC 1662 to use when the link is a SONET. There is no standard on how to use HDLC to carry Ethernet frames across a SONET, but it doesn't take much imagination to replace each occurrence of "PPP frame" with "Ethernet frame" in RFC 1662, and EoS mappers normally use that scheme. But since there is no standardized name many confusing terms are in use like "Layer 2 POS", "POS mapped Ethernet", and sometimes even just "POS" is used. The most accurate (and maybe least used) is "HDLC delineated Ethernet".

POS is used for transmission of IP data over SONET frames via PPP has read advantages,.. But in the past required the bandwidth be predetermined in a rigid and constrained manner,.. A GbE stream in POS stream would need a full OC-48 pipe with standard contiguous concatenation. EoS allows for the bandwidth to be shared among several ports..STS-1 21v's, while the other portion can be deployed for other Ethernet applications. POS also

DoS Chipsets vs Discrete Components

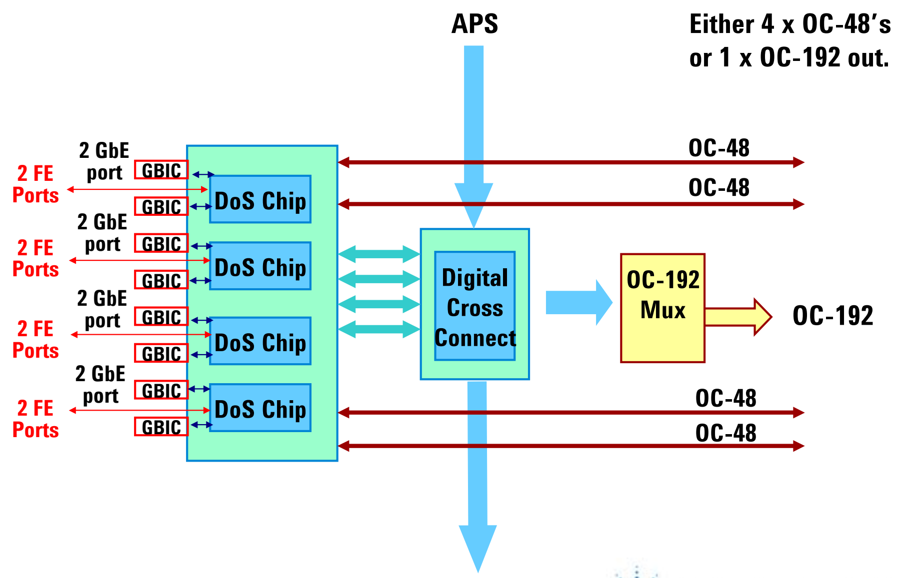
- **FPGA's, Discrete Mappers & SONET/SDH CDR/SerDes**





- **Typical DoS chipset.**

GbE to OC-192 Application Example



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Seminar 1: DoS Technologies

Seminar Content

- DoS market, technology drivers & standards
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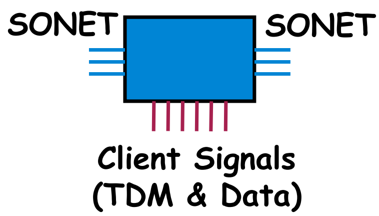
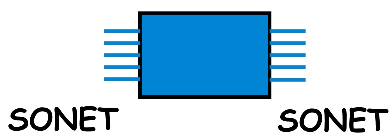
DoS Equipment Evolution

Network Equipment (NE) Architecture Evolution

Next generation (data over) SONET/SDH network equipment is undergoing significant architectural changes, including integration of multiple NE functionality in a single NE.



Next Generation SONET/SDH Multi-Service Provisioning Platform (MSPP)



Next Generation SONET/SDH Multi-Service Switching Platform (MSSP)

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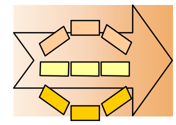
DoS Equipment Design Issues

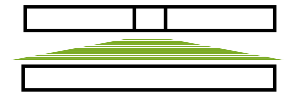
Concatenation Technology Related
- ie. for VC & LCAS:



- **Verify the addition and removal of VC group members:**
  - under normal conditions;
  - under network fault conditions
- **Ensure frame re-formation functions operate over the appropriate differential delay range, and over all payload types.**
- **Verify the bandwidth efficiency of DUT**
- **Verify the error and alarm handling functions of VC and LCAS.**

DoS Equipment Design Issues

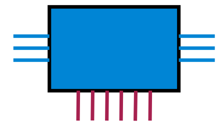
Encapsulation Technology Related
- eg. for GFP encapsulation:



- In the case of GFP-F , ensure the frame delineation algorithms are functioning correctly.
- Ensure HEC algorithms can correct a single bit error.
- Verify that the scrambling/de-scrambling mechanism is correctly defined as per ITU-T G.7041
- In the case of GFP-T, verify correct operation in the presence of underflow.
- Verify throughput and latency of the client signal (eg. Ethernet) stream.

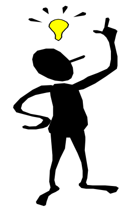
DoS Equipment Design Issues

Architecture Related
- eg. MSPP multi-ring support:



- **NE response (all SONET/SDH ports and channels) to error flooding conditions.**
- **NE response (all SONET/SDH ports and channels) to alarm flooding conditions.**
- **Implementation of new APS schemes to support multiple rings and mesh SONET/SDH network architectures.**

DoS Equipment Design Issues



Data over SONET/SDH Seminar 2, 15th January ‘03, … THE ANSWERS !

This seminar will review the new data over SONET/SDH network elements - Multi-Service Provisioning Platforms (MSPPs) and Multi-Service Switching Platforms (MSSPs) - from an architecture & test challenges perspective.

In particular, the seminar will address the need for multi-channel testing of switch matrices, the benefits of multi-port testing, and the critical design issues requiring verification associated with GFP, LAPS and Virtual concatenation.

Seminar 1: DoS Technologies

Seminar Content

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- DoS equipment design issues

- Wrap Up + question & answer session

Question & Answer Session

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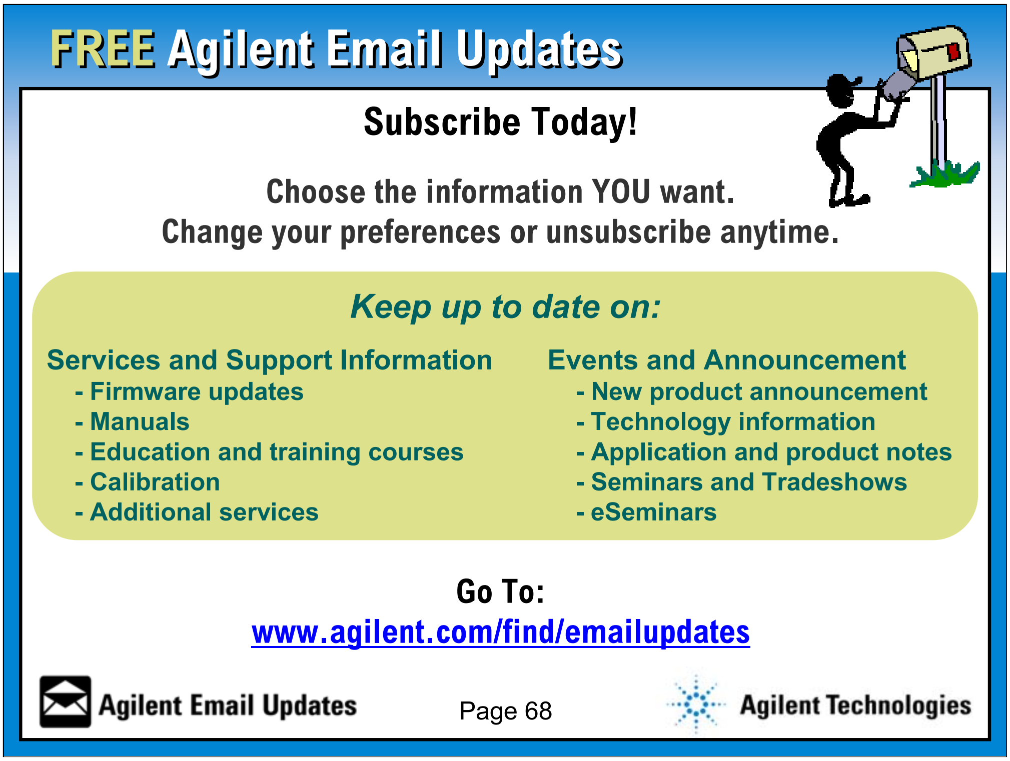

In a moment we will begin with the Q&A but 1st, for those of you who have enjoyed today's broadcast, Agilent Technologies is offering a new service that allows you to receive customized Email Updates. Each month you'll receive information on:

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Now on to the feedback form then to Q&A……..