Computer Networks II

SDH

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References

- ITU-T Recommendations.
- ANSI documents.
- SDH Pocket Guide, on line available: http://www.acterna.com/technical_resources/pocket_guides/sdh_guide1.html
- I.E.C. Synchronous Digital Hierarchy (SDH) Tutorial, on line available: http://www.iec.org/online/tutorials/sdh/index.html
- SONET Pocket Guide, on line available: http://www.acterna.com/commex/commex_pdf_win/index.html?PDF=/united_states/technical_resources/downloads/brochures/sonet.pdf
- I.E.C. Synchronous Optical Network (SONET) Tutorial, on line available: http://www.iec.org/online/tutorials/sonet/

Introduction

- SDH and SONET are standards for communicating large quantities of digital information over optical fibers.
- Both SDH and SONET emerged between 1988 and 1992.
- ITU coordinates the development of SDH standards.
- SONET is the United States version of the standard published by the American National Standards Institutue (ANSI).
- They were developed to replace the Plesiochronous Digital Hierarchy (PDH) system for transporting large amounts of telephone and data traffic.

The Original Goals of SONET/SDH Standardization

- Vendor Independence & Interoperability
- Elimination of All Manual Operations Activities
- Reduction of Cost of Operations
- Protection from Cable Cuts and Node Failures
- Faster, More Reliable, Less Expensive Service to the Customer

SDH standards

- Several ITU recommendations are related to SDH
  - » ITU-T G.707: Network Node Interface for the Synchronous Digital Hierarchy (SDH);
  - » ITU-T G.781: Structure of Recommendations on Equipment for the Synchronous Digital Hierarchy (SDH);
  - » ITU-T G.782: Types and Characteristics of Synchronous Digital Hierarchy (SDH) Equipment;
  - » ITU-T G.783: Characteristics of Synchronous Digital Hierarchy (SDH) Equipment Functional Blocks;
  - » ITU-T G.803: Architecture of Transport Networks Based on the Synchronous Digital Hierarchy (SDH);

SONET standards

- Several ANSI documents are related to SONET:
  - » ANSI T1.105: SONET - Basic Description including Multiplex Structure, Rates and Formats
  - » ANSI T1.105.01: SONET - Automatic Protection Switching
  - » ANSI T1.105.02: SONET - Payload Mappings
  - » ANSI T1.105.03: SONET - Jitter at Network Interfaces
  - » ANSI T1.105.03a: SONET - Jitter at Network Interfaces - DS1 Supplement
  - » ANSI T1.105.03b: SONET - Jitter at Network Interfaces - DS3 Wander Supplement
  - » ANSI T1.105.04: SONET - Data Communication Channel Protocol and Architectures
  - » ANSI T1.105.05: SONET - Tandem Connection Maintenance
  - » ANSI T1.105.06: SONET - Physical Layer Specifications
  - » ANSI T1.105.07: SONET - Sub-STS-1 Interface Rates and Formats Specification
  - » ANSI T1.105.09: SONET - Network Element Timing and Synchronization
  - » ANSI T1.119: SONET - Operations, Administration, Maintenance, and Provisioning (OAM&P) - Communications
  - » ANSI T1.119.01: SONET: OAM&P Communications Protection Switching Fragment

SDH Signals (1/2)

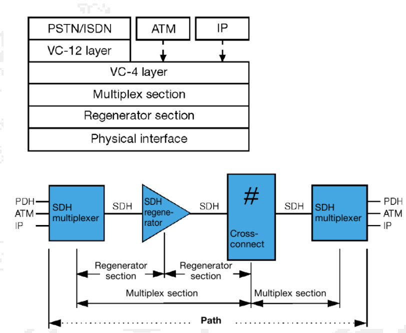
- SDH was initially developed to support telephone networks.
- The basic unit of transmission in SDH is at 155,520kbps.
- This value is direct consequence of the Nyquist-Shannon theorem:
  - » telephone signals are sampled at 8 kHz;
  - » the duration of a basic SDH frame (STM-1 frame) was chosen equal to the time between two samples 125µs
  - » the resulting bit rate is equal to: 8 bits/byte * 9 * 270 bytes / 125µs = 155,520 kbps (each STM-1 frame is composed of 9*270 bytes)

SDH Signals (2/2)

- SDH supports transmission rates higher than the basic one (155.52Mbps).
- These higher rates as defined as integer multiples of 155.52Mbps in a nx4 sequence:
  - » 622.08Mbps (STM-4)
  - » 2488.32Mbps (2.5Gbps) (STM-16)
  - » ...
- The upper limits of the supported rates is set by technology limits and not by standard lacks.
- The duration of an STM-N frame is always equal to125µs.

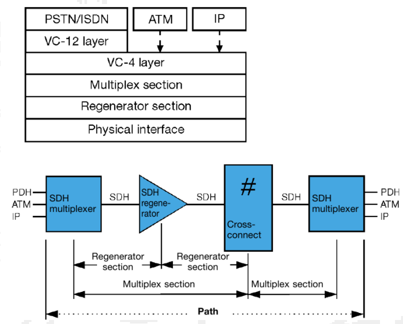
SDH Layer Structure (1/3)

- SDH networks are subdivided into various layers that are directly related to the network topology.
- The lowest layer is the physical layer,which represents the transmission medium.
- Transmission medium is usually a glass fiber or possibly a radio-link or satellite link.



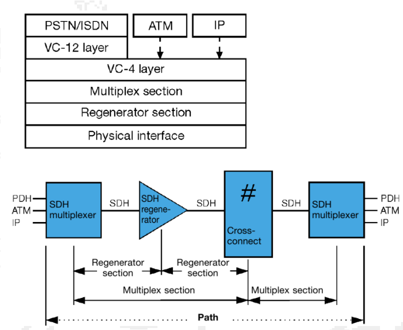
SDH Layer Structure (2/3)

- The regenerator section is the path between regenerators.
- Part of the overhead (RSOH, regenerator section overhead) is available for the signaling required within this layer.
- The multiplex section covers the part of the SDH link between multiplexers.
- The remainder of the overhead (MSOH, multiplex section overhead) is used for the needs of the multiplex section.



SDH Layer Structure (3/3)

- The carriers (VC, virtual containers) are available as payload at the two ends of the Multiplex Section.
- The two VC layers represent a part of the mapping process.
- Mapping is the procedure whereby the tributary signals, such as PDH and ATM signals are packed into the SDH transport modules.
- VC-4 mapping is used for 140 Mbit/s or ATM signals and VC-12 mapping is used for 2 Mbit/s signals.

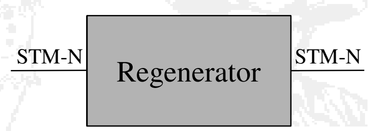


SDH Components

- SDH must be able to transmit different tributary signals:
  - plesiochronous signals;
  - ATM signals;
  - etc.
- This requires the use of various different network elements.
- Current SDH networks are basically made up from four different types of network element.

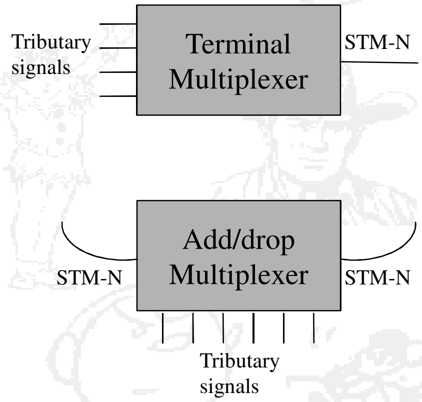
SDH Components: Regenerators

- Regenerators have the job of regenerating the clock and amplitude relationships of the incoming data signals
- They derive their clock signals from the incoming data stream.
- Messages are received by extracting various 64 kbit/s channels in the RSOH (regenerator section overhead).
- Messages can also be output using these channels.

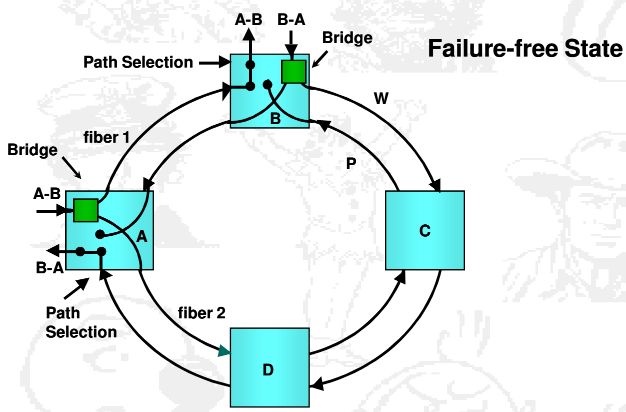


SDH Components: Multiplexers

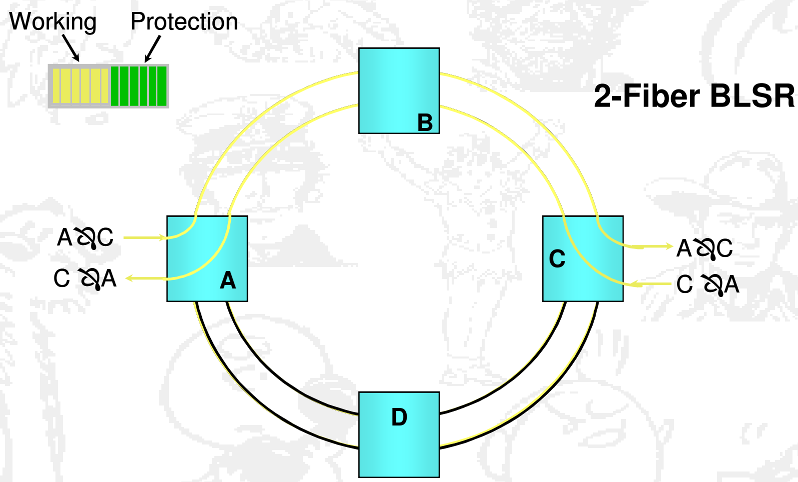
- Terminal multiplexers (TMs) multiplexes a number of tributary signals into one aggregate signals.
- Add/drop multiplexers (ADMs) terminate two agregate signals.
- ADMs are usually used in a ring configuration.



Unidirectional Path Switched Ring

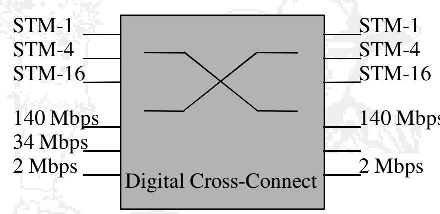


Bidirectional Line Switched Ring



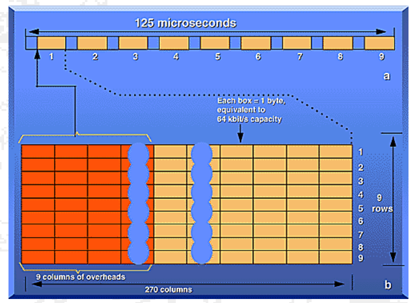
SDH Components: Digital Cross-Connect

- This network element has the widest range of functions.
- It allows mapping tributary signals into virtual containers as well as switching of various containers up to and including VC-4.



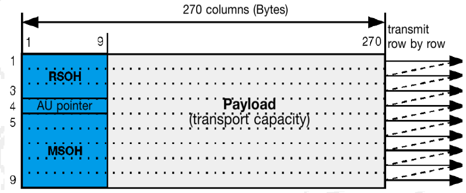
SDH Frame Structure (1/2)

- The basic SDH frame format is the Synchronous Transport Module [STM]
- STM-1 is the base-level.
- The SDH frame is formed by 9 rows by 270 bytes with a duration of 125µs.



SDH Frame Structure (2/2)

- The first 9 bytes of each row contains the Section Overhead.
- Section Overhead is used for transport-support features (framing, error monitoring, etc.).
- The remaining 270 bytes form the Synchronous Transport Module payload.
- The payload may be assigned in many ways to carry lower bit rate signals.
- Each lower bit rate signals has its own overhead.



STM-1 Section Overhead (1/2)

	A1	A1	A1	A2	A2	A2	J0	x	x
RSOH ←	B1	*	*	E1	*		F1	x	x
	D1	*	*	D2	*		D3		
					AU Pointer				
	B2	B2	B2	K1			K2		
MSOH ←	D4			D5			D6		
	D7			D8			D9		
	D10			D1			D12		
	S1					M1	E2		

x Reserved for national use
* Media-dependent use (Satellite, Radio-link)

STM-1 Section Overhead (2/2)

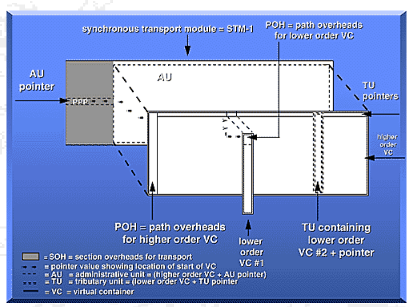
Overhead byte	Function
A1, A2	Frame alignment
B1, B2	Quality monitoring, parity bytes
D1 . . . D3	Q_{ECC} network management
D4 . . . D12	Q_{ECC} network management
E1, E2	Voice connection
F1	Maintenance
J0 (C1)	Trace identifier
K1, K2	Automatic protection switching (APS) control
S1	Clock quality indicator
M1	Transmission error acknowledgment

STM Payload Allocation (1/2)

- The 261 STM-payload columns can be assigned in many ways to carry lower bit-rate signals.
- Each signal has its own overhead.
- The administrative unit (AU) is the unit of provision for bandwidth in the main network.
- AU is the first level of division.
- Its capacity can be used to carry a high bit-rate signal, such as 45 Mbps or 140 Mbps (for the two sizes of AU, AU-3 and AU-4, respectively).

STM Payload Allocation (2/2)

- The figure at right shows an AU-4, which occupies all of the payload capacity of an STM-1.
- An AU can be further divided to carry lower-rate signals, each within a tributary unit (TU), of which there are several sizes.
- For example, a TU-12 carries a single 2Mbps signal, and a TU-2 carries a North American or Japanese 6-Mbps signal.



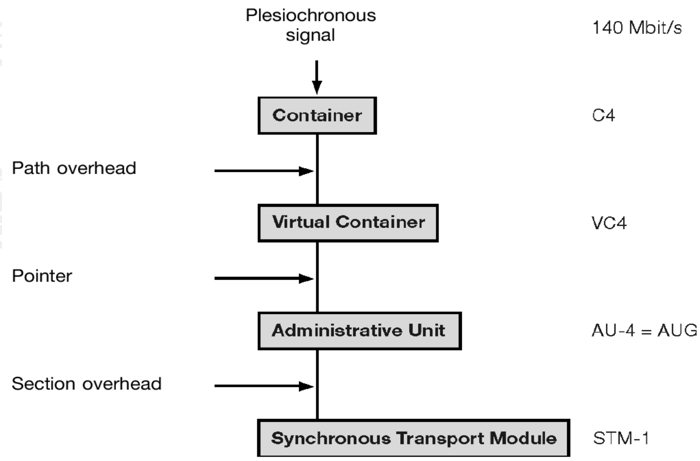
Container and Virtual Container

- Container is the basic package unit for tributary channels.
- Containers are always much larger than the payload to be transported. The remaining capacity is used partly for justification (stuffing) in order to equalize out timing inaccuracies.
- A Virtual Container VC is the payload entity that travels across the network, being created and dismantled at or near the service termination point.
- AVC is made up from the container thus formed together with the path overhead (POH)-

PDH and VC (1/2)

- PDH traffic signals are mapped into containers of appropriate size for the bandwidth required, using single-bit justification to align the clock rates where necessary.
- POHs are then added for management purposes, creating a VC, and these overheads are removed later where the VC is dismantled and the original signal is reconstituted.
- Each PDH signal is mapped into its own VC, and several VCs of the same nominal size are then multiplexed by byte interleaving into the SDH payload.

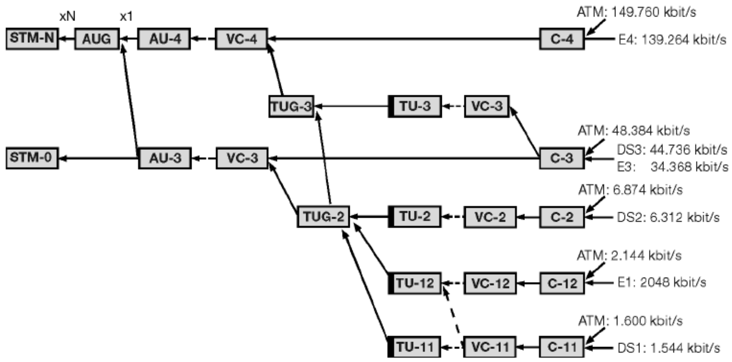
PDH and VC (2/2)



ATM and VC

- ATM signals can be transported in the SDH network in C11, C12, C3 and C4 containers.
- Since the container transport capacity may not meet the ATM bandwidth requirement, methods have been developed for transmitting the ATM payload in a multiple (n) C-4 (virtual or contiguous concatenation).
- Possible ATM mappings are defined in ITU-T Recommendation G.707 and the ATM mapping recommendations.

ATM and VC



Differences between SONET and SDH

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Differences between SONET and SDH

- The differences between SONET and SDH are based primarily on the different asynchronous bit rates that must be mapped into them.
- In developing these two technologies, there was a need to integrate existing transmission techniques in order to enable network operators to gradually introduce SONET and SDH.
- In the United State the highest-order commonly used multiplex signal is 45 Mbit/s, 51 Mbit/s was a sufficient synchronous primary rate for virtually any SONET application.
- However in the rest of the world, where 140 Mbit/s mux signals are very common, 155 Mbit/s (STM-1) was chosen as the primary synchronous mux rate.

Convergence of SONET and SDH Hierarchies

- SONET and SDH converge at SONET's 52-Mbps base level, defined as synchronous transport module-0 (STM-0).
- The base level for SDH is STM-1, which is equivalent to SONET's STS-3 (3 x 51.84 Mbps = 155.5 Mbps).
- Adaptation is relatively simple since gateway problems were taken into account in specifying SDH and SONET.
- Just a few overhead bytes need to be adapted.

SONET Signal	Bit Rate (Mbps)	SDH Signal	SONET Capacity	SDH Capacity
STS-1, OC-1	51,84	STM-0	28 DS-1s or 1 DS-3	21 E1s
STS-3, OC-3	155,52	STM-1	84 DS-1s or 3 DS-3s	63 E1s or 1 E4
STS-12, OC-12	622,08	STM-4	336 DS-1s or 12 DS-3s	252 E1s or 4 E4s
STS-48, OC-48	2488,32	STM-16	1,344 DS-1s or 48 DS-3s	1,008 E1s or 16 E4s
STS-192, OC-192	9953,28	STM-64	5,376 DS-1s or 192 DS-3s	4,032 E1s or 64 E4s

two signals contain different frame structures. STM = synchronous transport module (ITU-T) STS = synchronous transfer signal (ANSI) OC = optical carrier

ANSI Rate			ITU-T Rate		
Signal	**Bit Rate**	**Channels**	**Signal**	**Digital Bit Rate**	**Channels**
DS-0	64 kbps	1 DS-0	64-kbps	64 kbps	1 64-kbps
DS-1	1.544 Mbps	24 DS-0s	E1	2.048 Mbps	1,00E+001
DS-2	6.312 Mbps	96 DS-0s	E2	8.45 Mbps	4 E1s
DS-3	44.7 Mbps	28 DS-1s	E3	34 Mbps	16 E1s
	not defined		E4	144 Mbps	64 E1s