Transmission and Multiplexing Synchronous Digital Hierarchy Asynchronous Transfer Mode

ETSF05
Internet Protocols
Kaan Bür
(Jens Andersson)

Previously on ETS05

- **Point-to-point protocol, PPP** §11.7
- Circuit-switched and datagram networks §8.1-2
- **Routing algorithms** §22.3
- IPv4 and **IPv6 addresses, NAT** §19.1-2
- Internetworking §20.1
- Address mapping, ARP §21.1

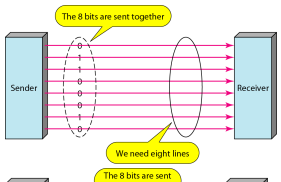
One minute statements and questions...

Today's lecture

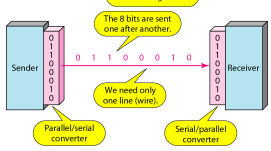
- **Transmission modes** §4.3
- **Time-division multiplexing** §6.1
- **Synchronous Optical Networks, SONET** §17.1-6
- **Asynchronous Transfer Mode, ATM** §18.2-3

Transmission modes

- Parallel



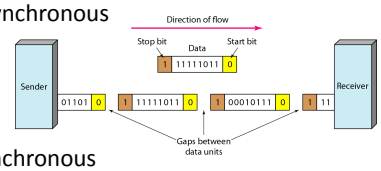
- Serial



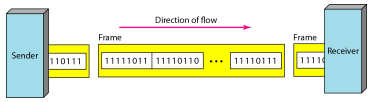
2011-10-10 4

Transmission modes

- Asynchronous



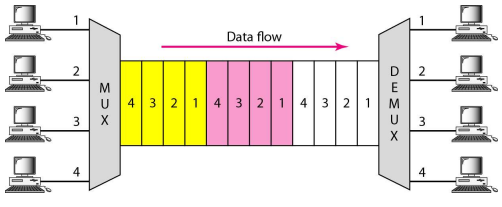
- Synchronous



2011-10-10 5

Time-division multiplexing (TDM)

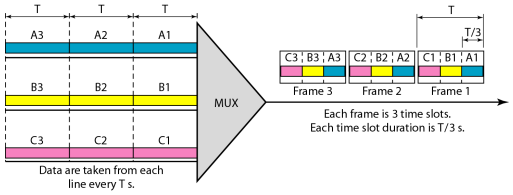
- Sharing available bandwidth
  - Actually, time-sharing available bit rate



2011-10-10 6

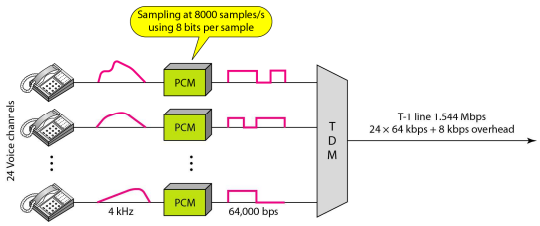
Synchronous TDM

- Outgoing link faster than incoming links
  - At least *n* times



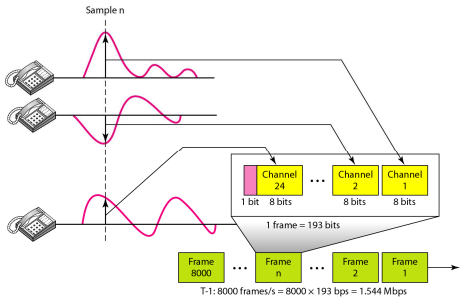
2011-10-10 7

STDM for digital telephony (T-1)



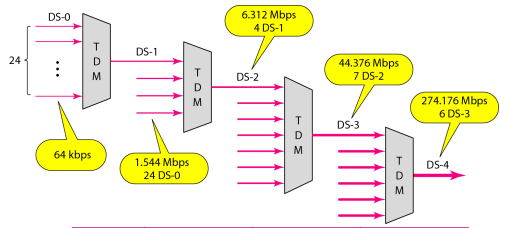
2011-10-10 8

STDM frame structure (T-1)



2011-10-10 9

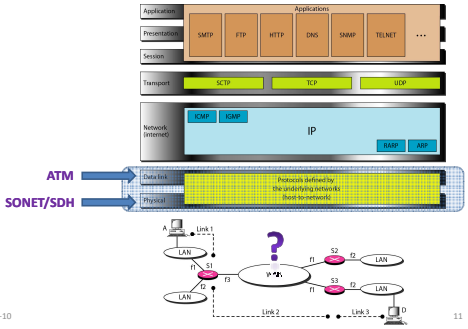
Digital hierarchy



Service	Line	Rate (Mbps)	Voice Channels
DS-1	T-1	1.544	24
DS-2	T-2	6.312	96
DS-3	T-3	44.736	672
DS-4	T-4	274.176	4032

2011-10-10 10

Wide area networks (WAN)



2011-10-10 11

Synchronous Optical Networks

- SONET, developed by ANSI
- Same as Synchronous digital hierarchy
  - SDH, developed by ITU-T

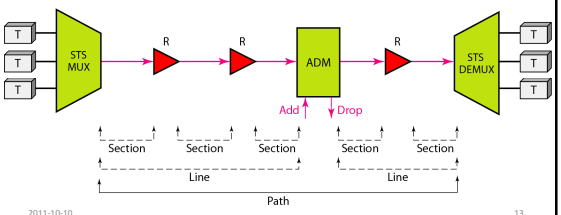
STS	OC	Rate (Mbps)	STM
STS-1	OC-1	51.840	
STS-3	OC-3	155.520	STM-1
STS-9	OC-9	466.560	STM-3
STS-12	OC-12	622.080	STM-4
STS-18	OC-18	933.120	STM-6
STS-24	OC-24	1244.160	STM-8
STS-36	OC-36	1866.230	STM-12
STS-48	OC-48	2488.320	STM-16
STS-96	OC-96	4976.640	STM-32
STS-192	OC-192	9953.280	STM-64

2011-10-10 12

Network architecture

- Devices and connections

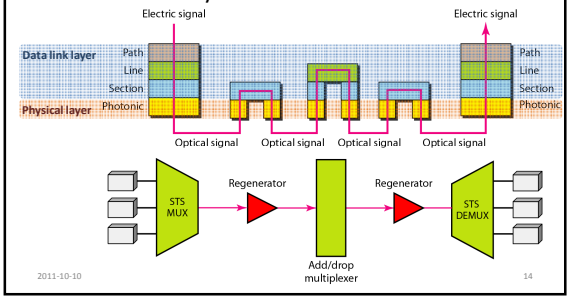
ADM: Add/drop multiplexer
STS MUX: Synchronous transport signal multiplexer
STS DEMUX: Synchronous transport signal demultiplexer
R: Regenerator
T: Terminal



2011-10-10 13

Network architecture

- Devices and layers

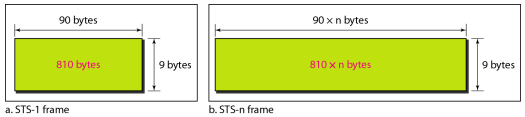


2011-10-10 14

SONET frames

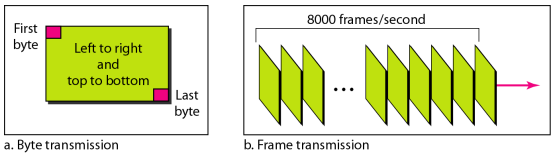
- Proportional to data rates

STS	OC	Rate (Mbps)	STM
STS-1	OC-1	51.840	
STS-3	OC-3	155.520	STM-1
STS-9	OC-9	466.560	STM-3
STS-12	OC-12	622.080	STM-4
STS-18	OC-18	933.120	STM-6
STS-24	OC-24	1244.160	STM-8
STS-36	OC-36	1866.230	STM-12
STS-48	OC-48	2488.320	STM-16
STS-96	OC-96	4976.640	STM-32
STS-192	OC-192	9953.280	STM-64

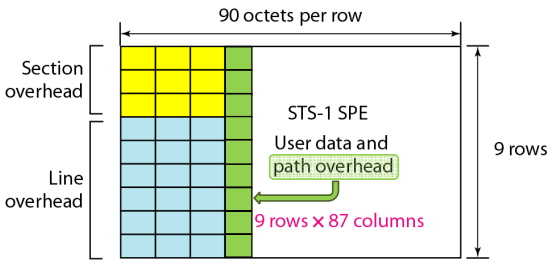


2011-10-10 15

SONET frames in transmission



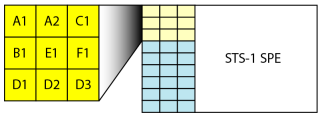
SONET frame structure (STS-1)



SONET frame structure (STS-1)

- Section overhead

A1, A2: Alignment
B1: Parity byte
C1: Identification
D1, D2, D3: Management
E1: Order wire byte
F1: User

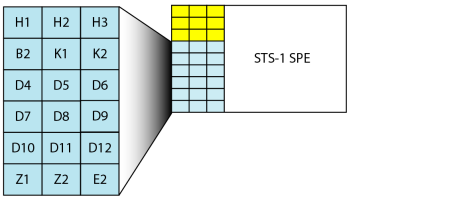


SONET frame structure (STS-1)

- Line overhead

B2: Line parity byte
D4-D12: Management bytes
E2: Order wire byte

H1, H2, H3: Pointers
K1, K2: Automatic protection switching bytes
Z1, Z2: Growth bytes (reserved)



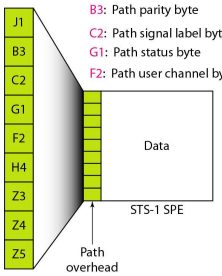
2011-10-10 19

SONET frame structure (STS-1)

- Path overhead

B3: Path parity byte
C2: Path signal label byte
G1: Path status byte
F2: Path user channel byte

H4: Virtual tributary indicator
J1: Path trace byte
Z3, Z4, Z5: Growth bytes (reserved)



2011-10-10 20

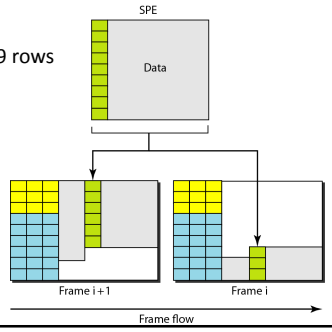
SONET overhead summary

Byte Function	*Section*	*Line*	*Path*
Alignment	A1, A2		
Parity	B1	B2	B3
Identifier	C1		C2
OA&M	D1–D3	D4–D12	
Order wire	E1	E2	
User	F1		F2
Status			G1
Pointers		H1– H3	H4
Trace			J1
Failure tolerance		K1, K2	
Growth (reserved for future)		Z1, Z2	Z3–Z5

2011-10-10 21

Encapsulation and offsetting

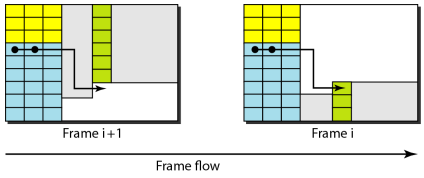
- STS-1
  - 90 bytes x 9 rows



2011-10-10 22

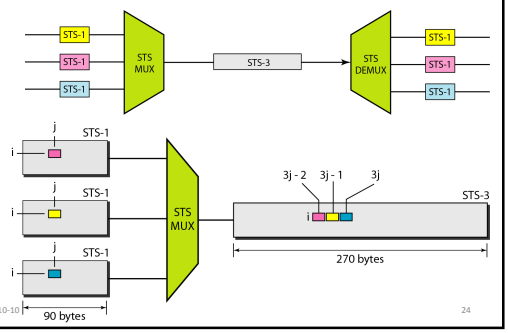
Pointers H1+H2

- Where does the next frame start?
  - 2 bytes to address 774 possibilities



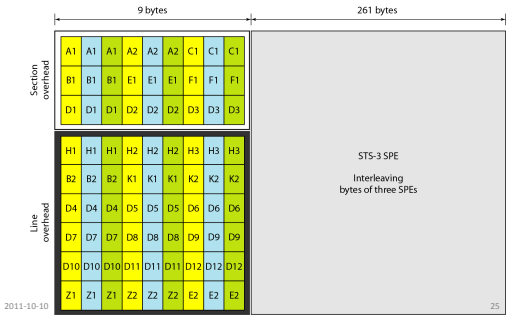
2011-10-10 23

Multiplexing and byte interleaving



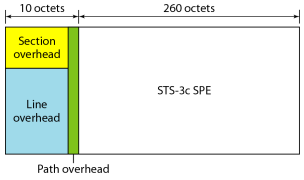
2011-10-10 24

Multiplexed SONET frame (STS-3)



Concatenated signal (STS-*n*c)

- Data rate > STS-1
  - Put in an STS-*n* signal
  - Not demultiplexable
  - Path overhead in single column

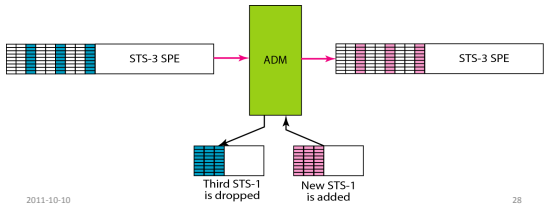


See you in 15' :)

- After the break
  - SONET topologies
  - Asynchronous Transfer Mode (ATM)

SONET add/drop multiplexer

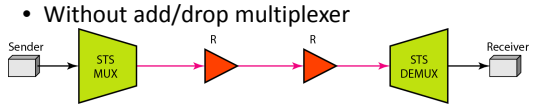
- Replaces a signal with another one
- Operates at line layer
- Similar to a switch



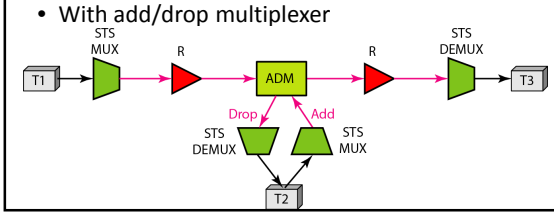
2011-10-10 28

Linear SONET topology

- Without add/drop multiplexer

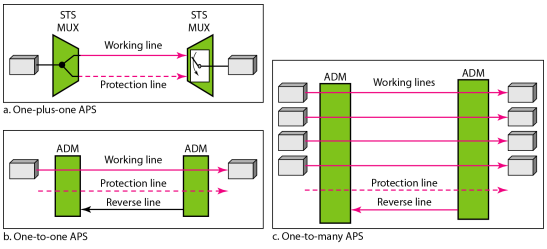


- With add/drop multiplexer



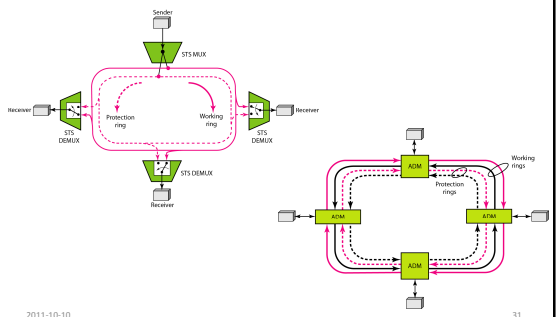
Automatic protection switching

- Failure protection through line redundancy



2011-10-10 30

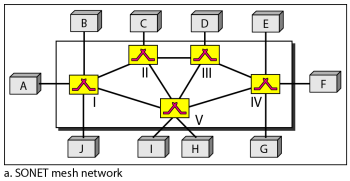
Ring SONET topology



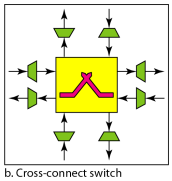
2011-10-10 31

Mesh SONET topology

- Better scalability
  - Multiplexing/demultiplexing at switches



a. SONET mesh network

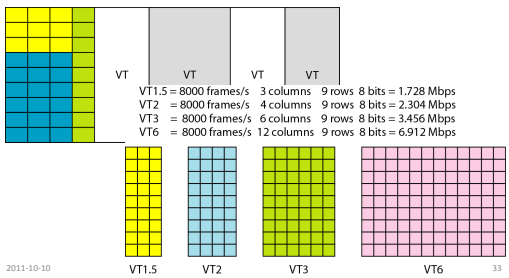


b. Cross-connect switch

2011-10-10 32

Virtual tributaries

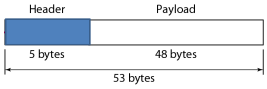
- Backward compatibility with DS-1 and DS-3



2011-10-10 33

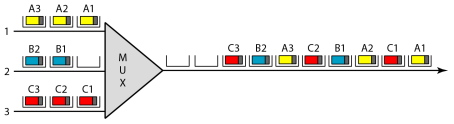
Asynchronous Transfer Mode (ATM)

- Developed by ATM Forum
  - Optimised for high-data rates
  - Wide area interconnectivity
  - Connection-oriented
  - Hardware implementation
- Adopted by ITU-T
- Uses fixed-size ”cells” as data unit

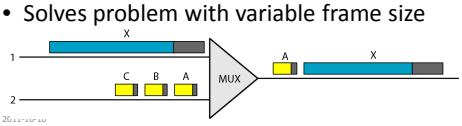


ATM multiplexing

- Asynchronous TDM = Statistical multiplexing

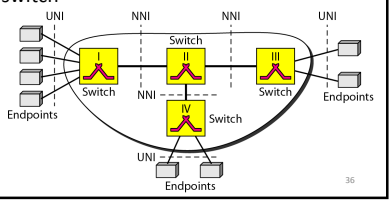


- Solves problem with variable frame size



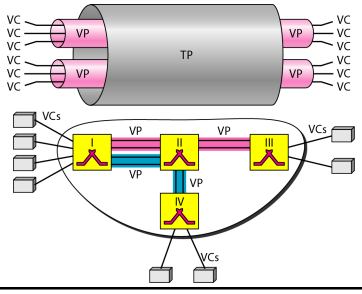
ATM network architecture

- User-to-network interface (UNI)
  - Endpoint ↔ switch
- Network-to-network interface (NNI)
  - Switch ↔ switch



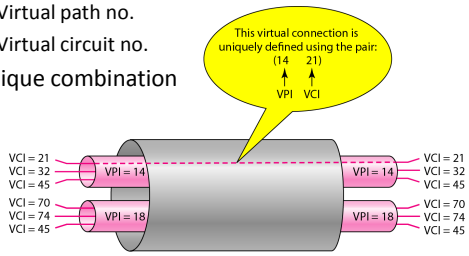
Virtual paths, virtual circuits

- Logical subunits of a physical transmission path

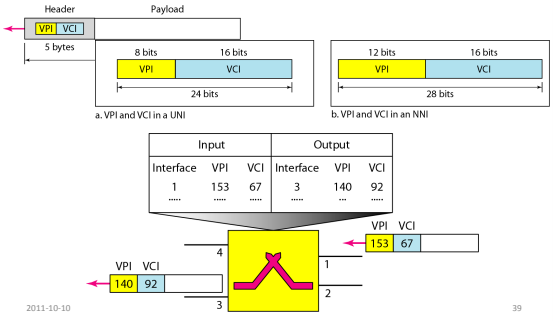


Virtual connections

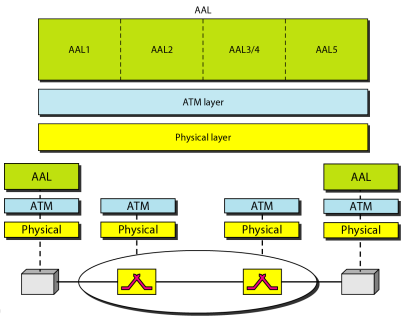
- Identified by
  - Virtual path no.
  - Virtual circuit no.
- Unique combination



Routing with VPI, VCI at ATM switch



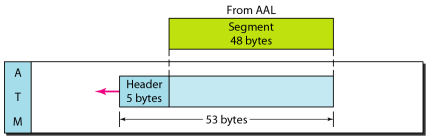
ATM layers



2011-10-10 40

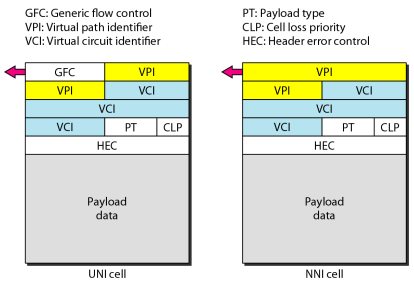
ATM layer

- Routing
- Traffic management
- Switching
- Multiplexing



2011-10-10 41

ATM headers

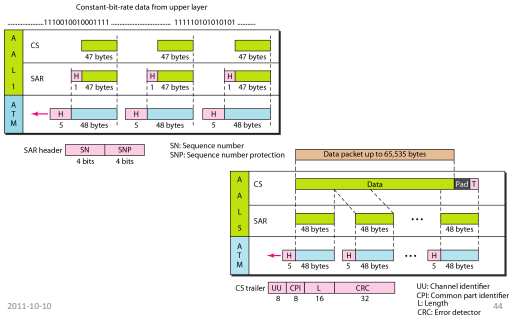


2011-10-10 42

Application adaptation layer (AAL)

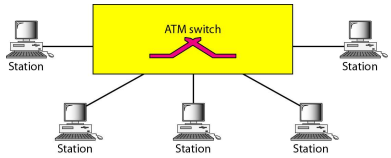
- Support for any type of payload
  - Convergence sublayer (CS)
  - Segmentation and reassembly (SAR)
- AAL1 for constant bit rate
- AAL2 for low bit rate
- AAL3/4 for sequencing and error control
- AAL5 for services with simpler demands

AAL1 and AAL5



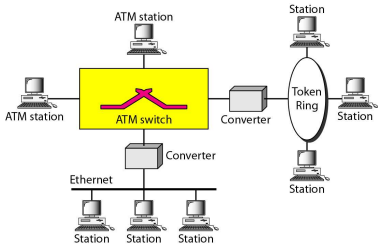
ATM LAN

- Attractive
  - High data rates
  - Multimedia services
  - Scalability



Hybrid ATM LAN solutions

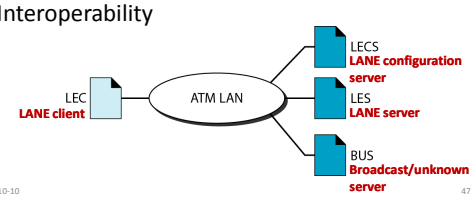
- Cost-effective alternative



2011-10-10 46

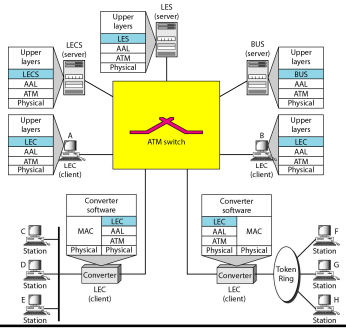
ATM LAN emulation (LANE)

- Connectionless vs. connection-oriented
- Physical vs. virtual addresses
- Multicast and broadcast
- Interoperability



2011-10-10 47

Mixed ATM architecture



2011-10-10 48

Summary: One minute statements

- PPP
  - Direct one-to-one connection
  - Subprotocols
- Routing
  - Table initiation
  - Updates
  - Tree formation
  - Relativity of shortest path

Summary: One minute questions

- PPP
  - Why address field if unused? → *HDLC inheritance*
- IPv6
  - Address categories
  - Transition from IPv4 → *ETSF05.2*
- IPv4
  - What happened to class A addresses? → *reused*
    Wikipedia: List of assigned /8 IPv4 address blocks
  - Use of address mask → *repetition*
  - NAT implementation and improvements → ***NOW***

Coming up next week

- Short (2 h) exam
  - Wednesday, 19/10, 09:00, E:3308 + E:3336
- Check last year's questions & answers
  - http://www.eit.lth.se/index.php?id=241&ciuid=463&coursepage=2387
- Course part 2 starts in study week 9, HT2
  - Monday, 24/10, 10:00, E:1406!