ETSF05 – Internet Protocols

Asynchronous Transfer Mode Synchronous Optical Networks

2012, Part 1, Lecture 3

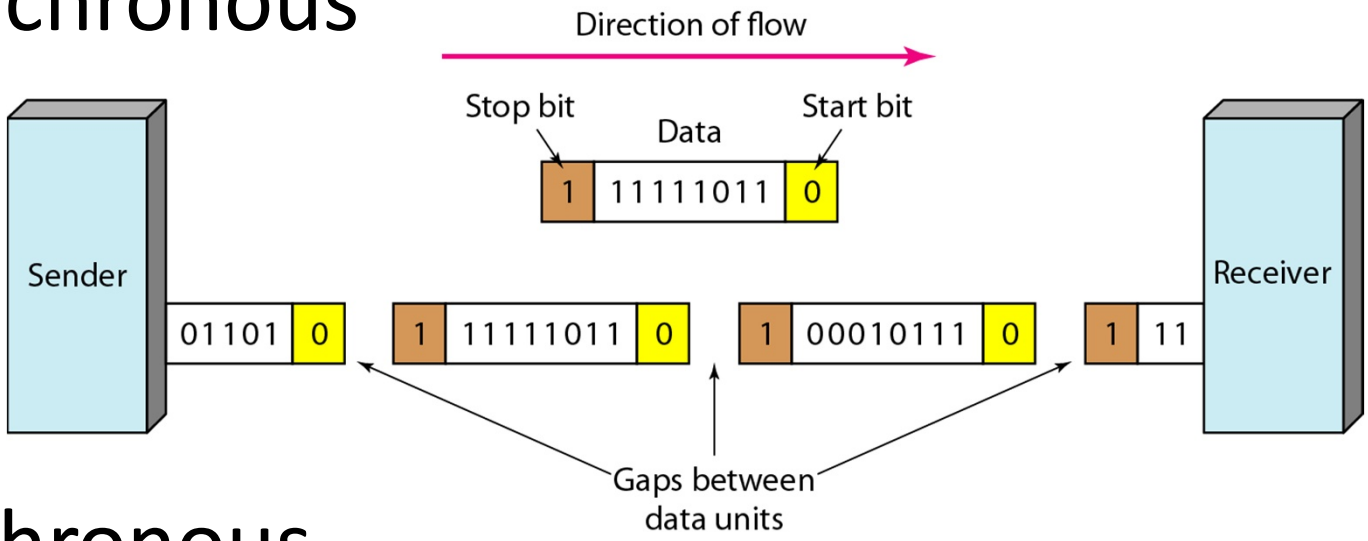
Kaan Bür, Jens Andersson

Today's lecture

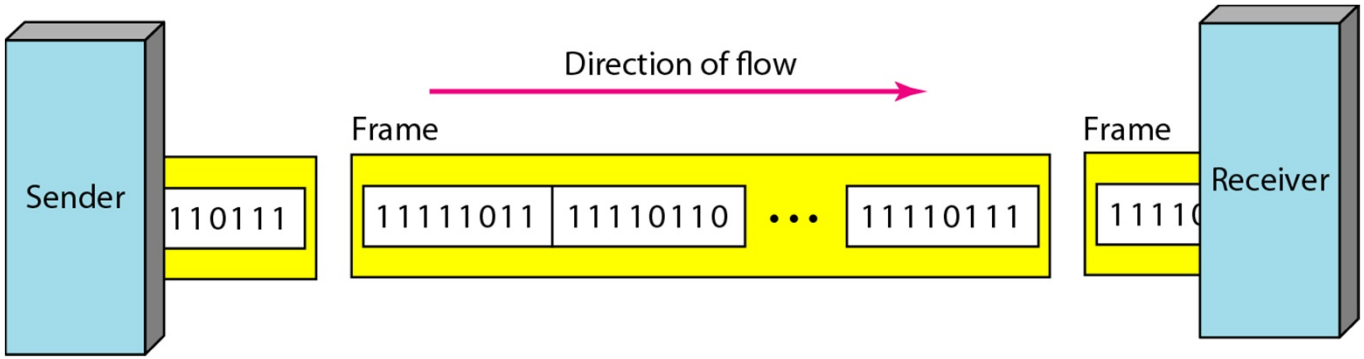
- Time division multiplexing
  [ed.4 ch.6.1] [ed.5 ch.6.1]
- Asynchronous transfer mode, ATM
  [ed.4 ch.18.2] [ed.5 ch.14.4]
- Virtual circuit networks
  [ed.4 ch.8.3] [ed.5 ch.8.3.2]
- Synchronous optical networks, SONET/SDH
  [ed.4 ch.17] [ed.5 ch.14.3]

Transmission modes

- Asynchronous

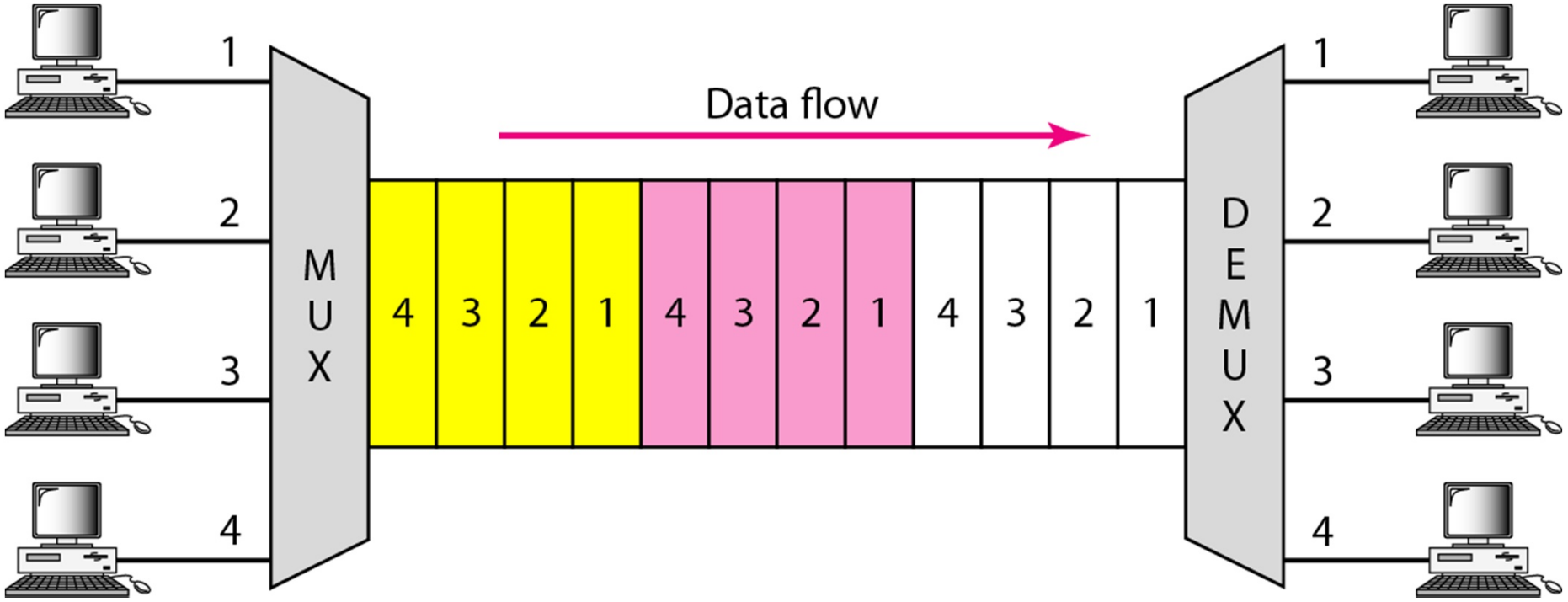


- Synchronous



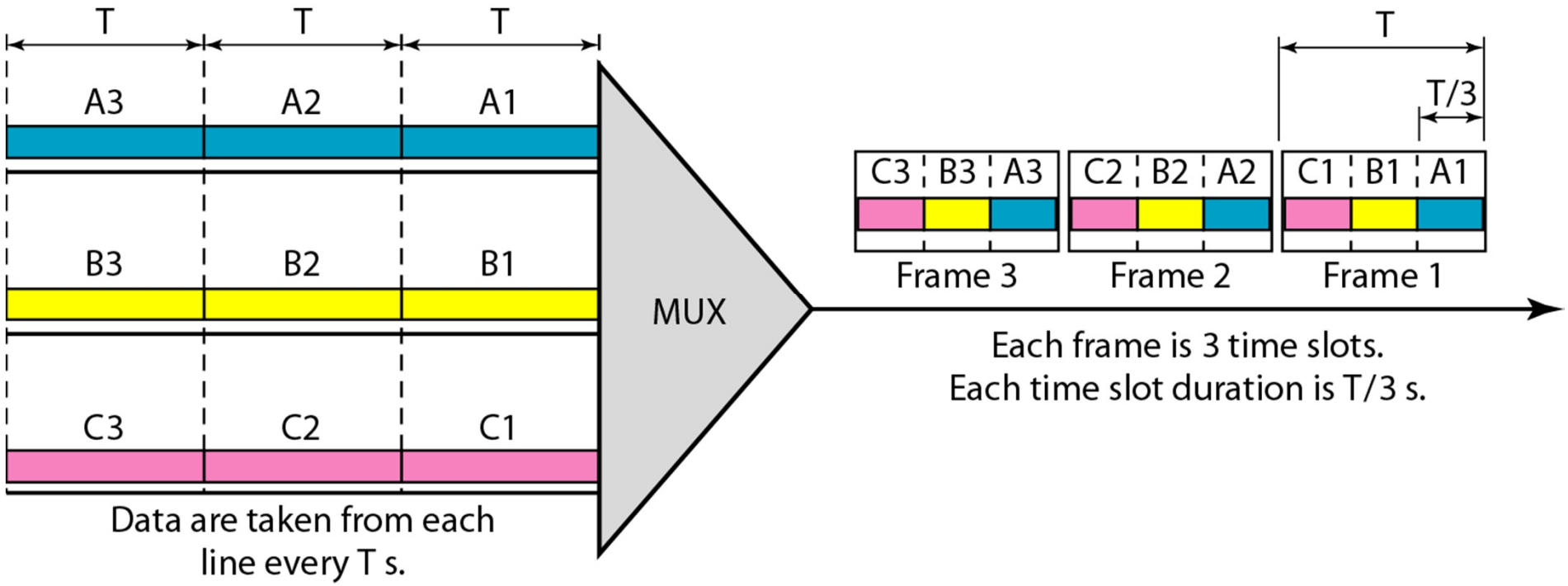
Time-division multiplexing (TDM)

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

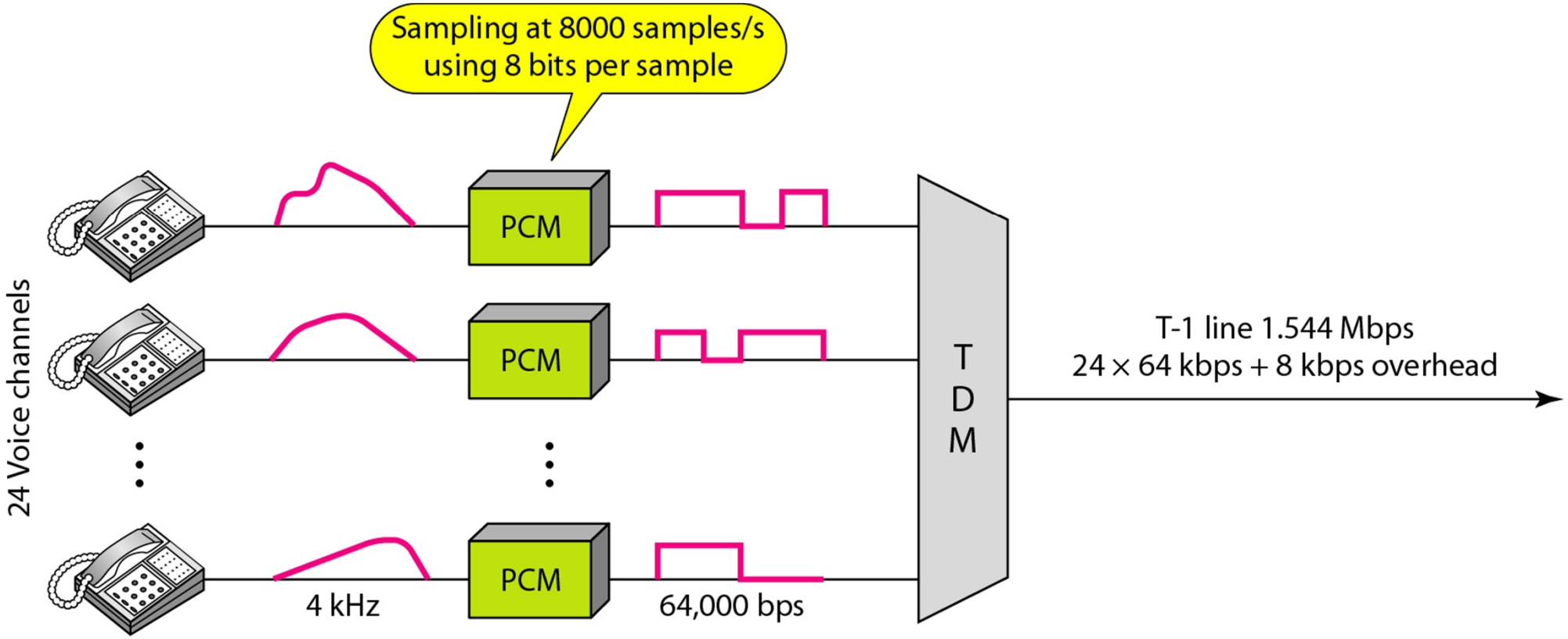


Synchronous TDM

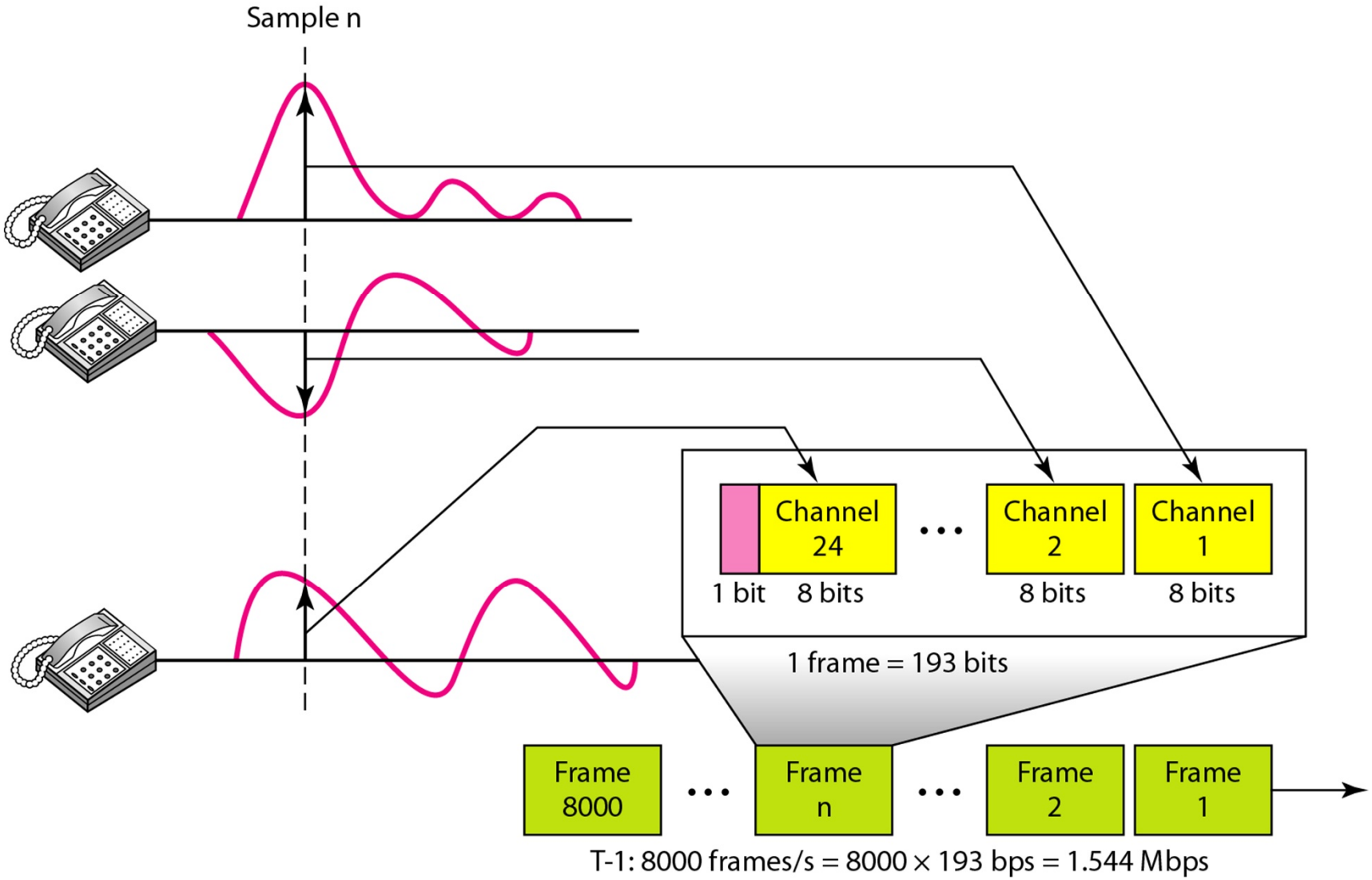
- Outgoing link faster than incoming links
  - At least *n* times



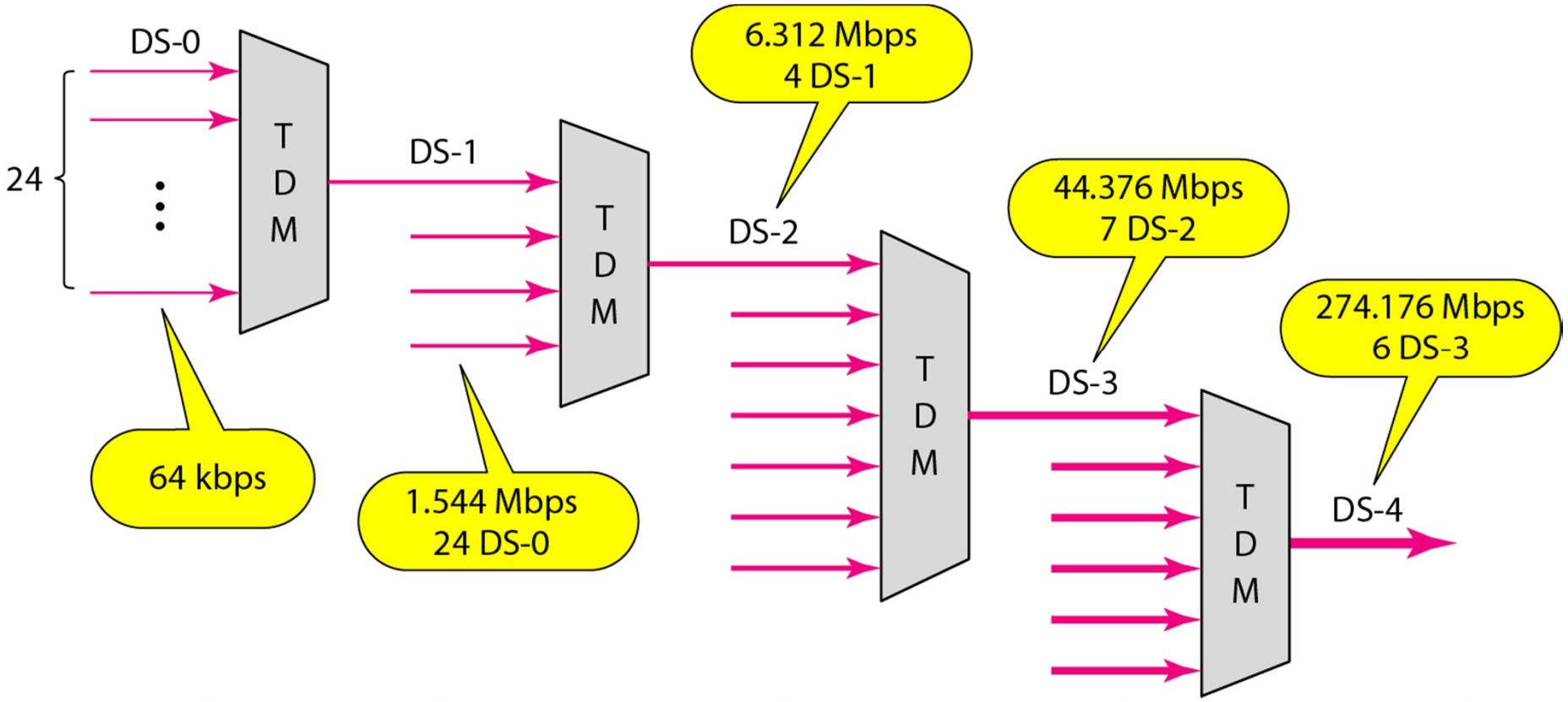
STDM for digital telephony (T-1)



STDM frame structure (T-1)

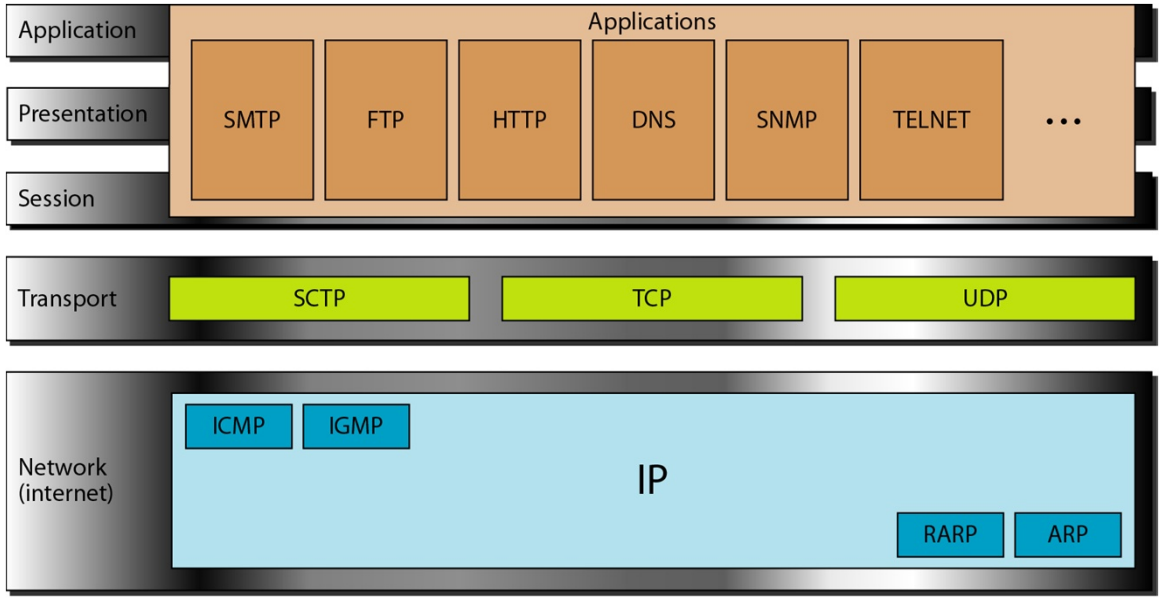


Digital hierarchy



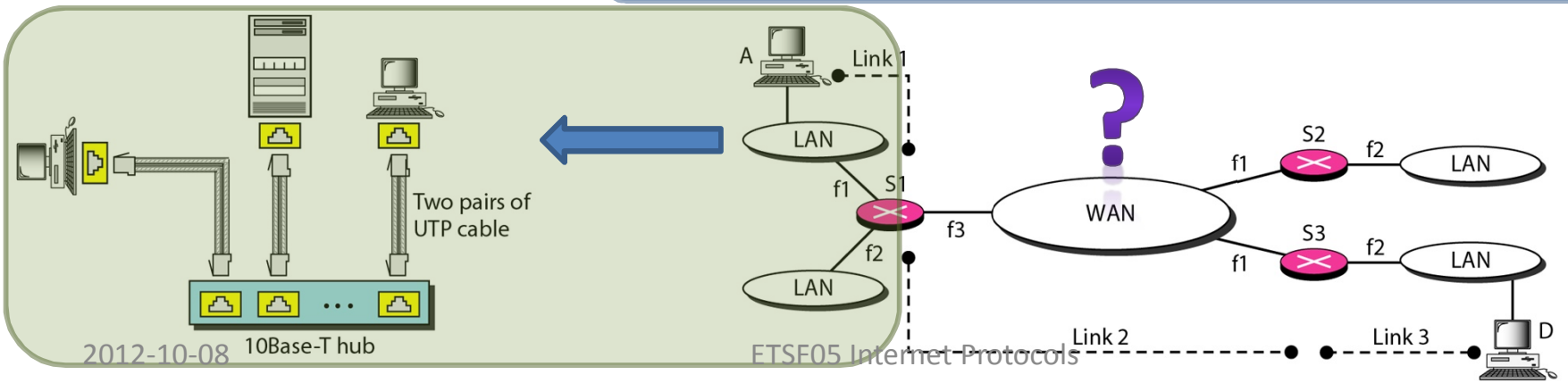
Service	*Line*	*Rate (Mbps)*	*Voice Channels*
DS-1	T-1	1.544	24
DS-2	T-2	6.312	96
DS-3	T-3	44.736	672
DS-4	T-4	274.176	4032

Wide area networks (WAN)



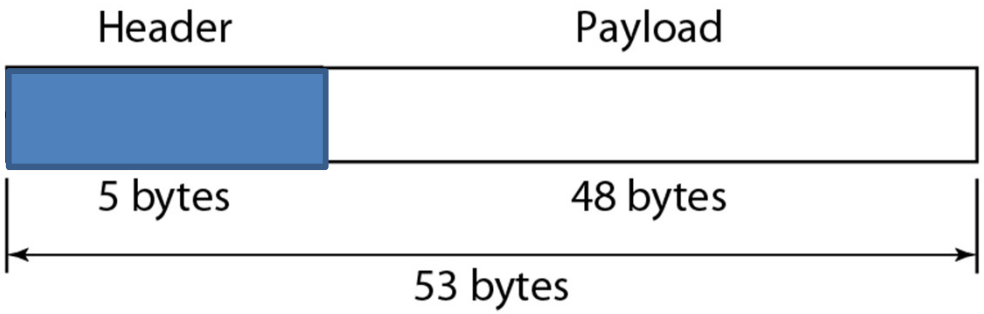
ATM

SONET/SDH



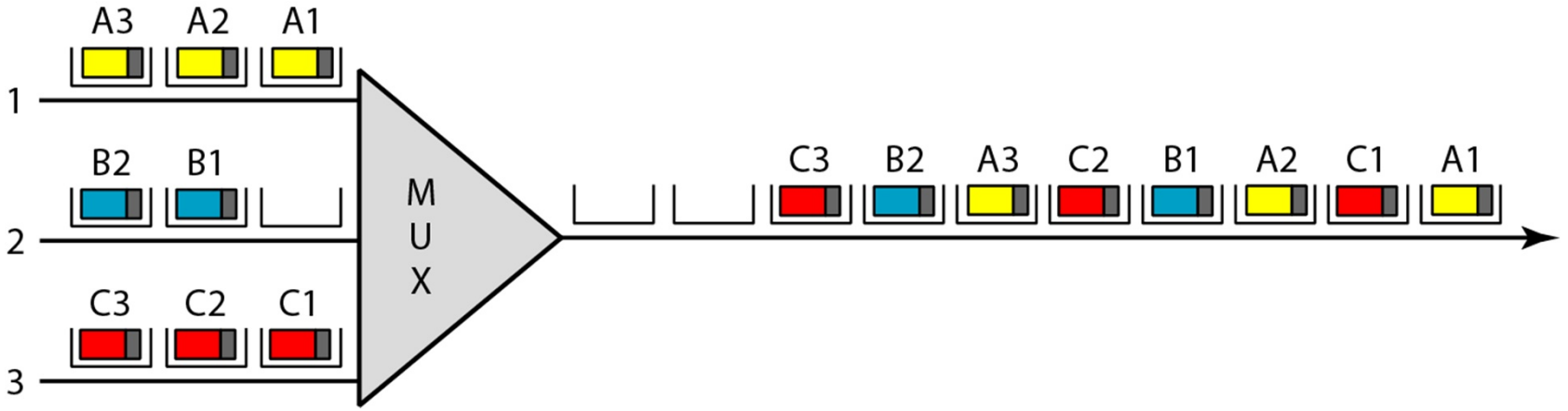
Asynchronous Transfer Mode (ATM)

- Developed by ATM Forum, adopted by ITU-T
  - Wide area interconnectivity
  - Connection-oriented
- Uses fixed-size ”cells” as data unit
  - Hardware implementation
  - High-data rates

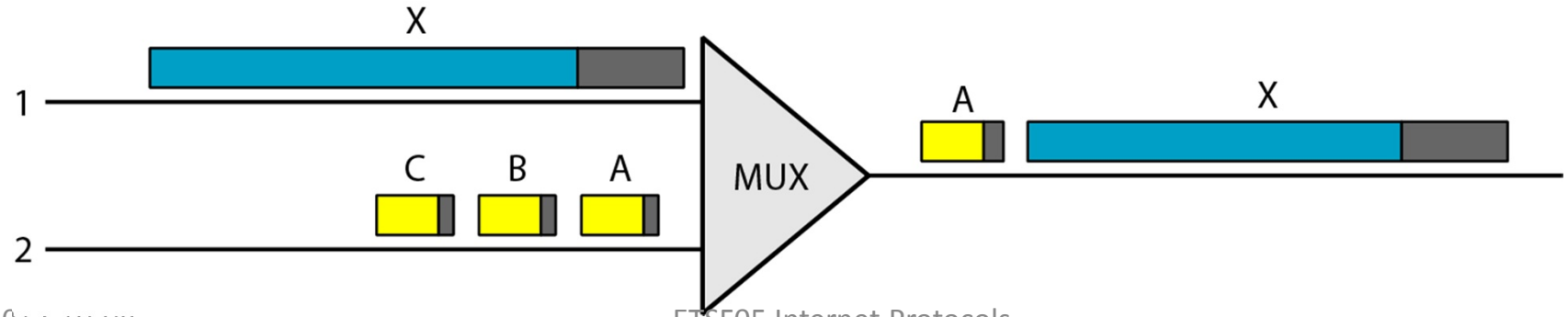


Asynchronous TDM

- Statistical multiplexing

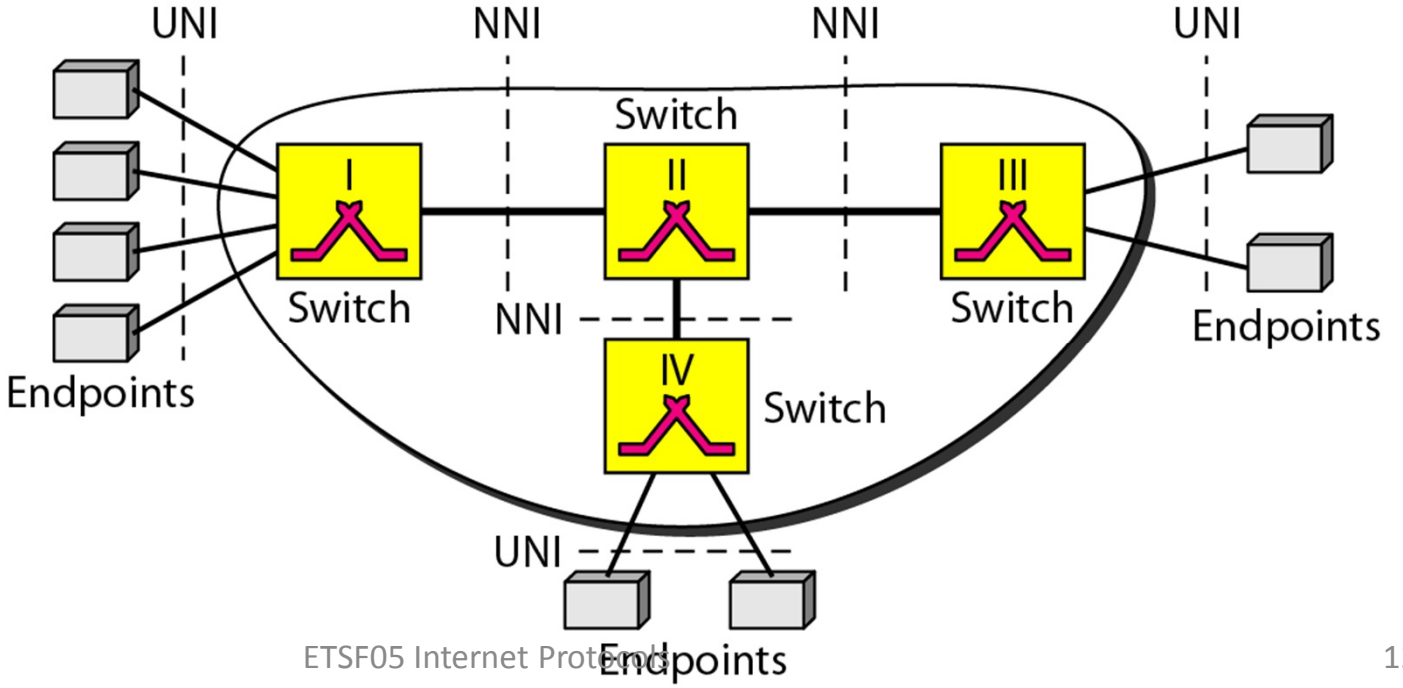


- Solves problem with variable frame size



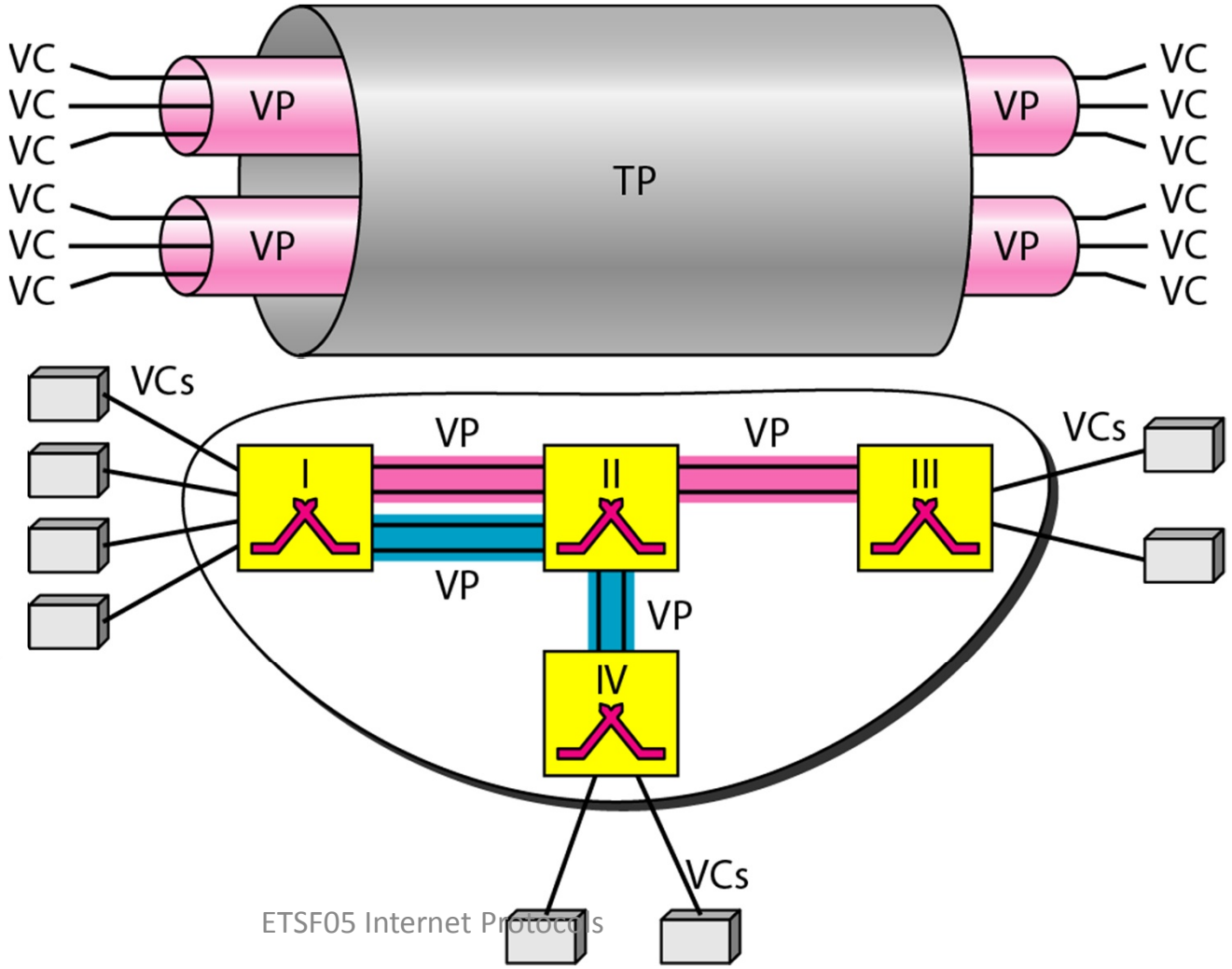
ATM network architecture

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



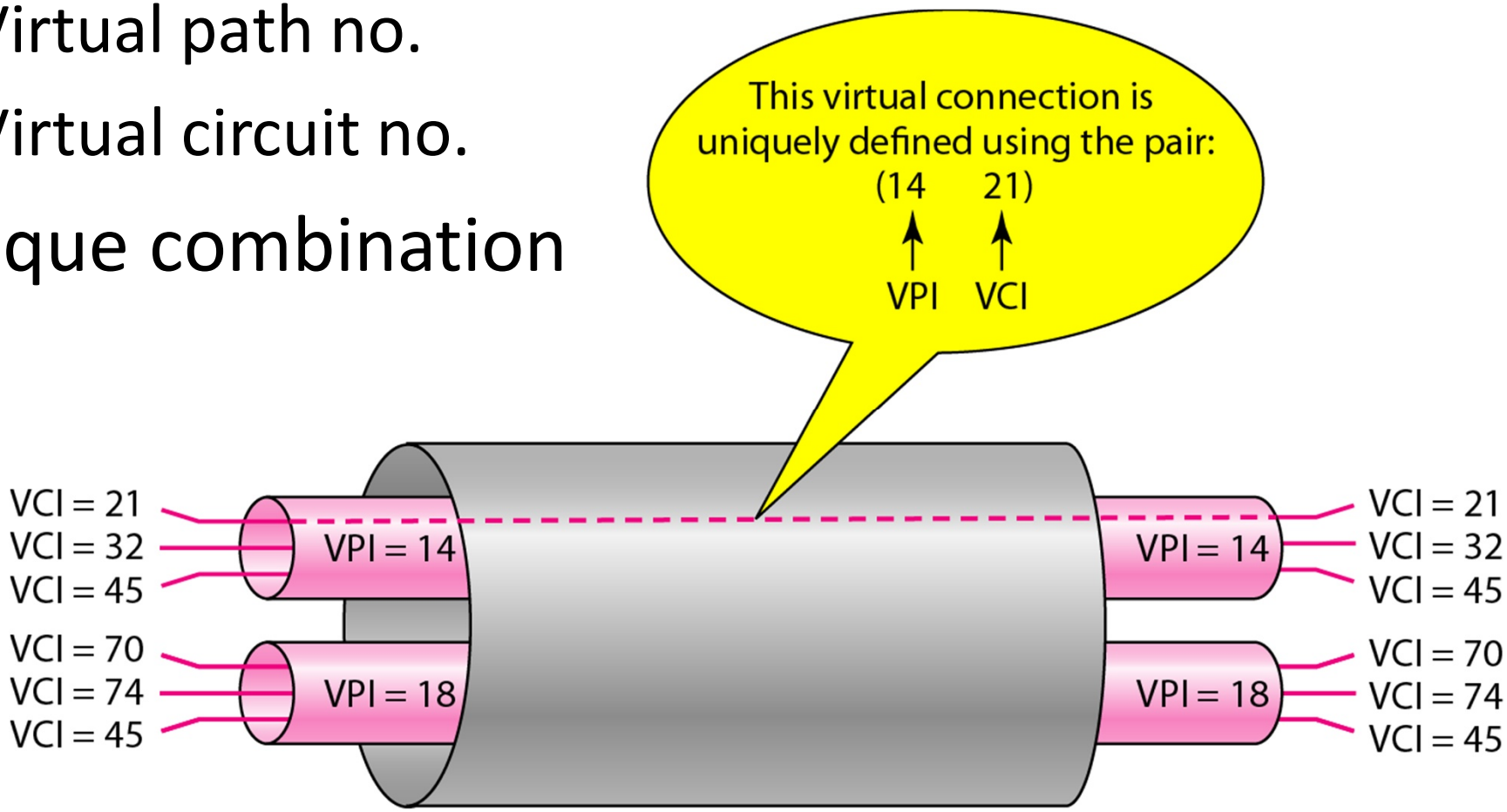
Virtual paths, virtual circuits

- Logical subunits of a physical transmission path

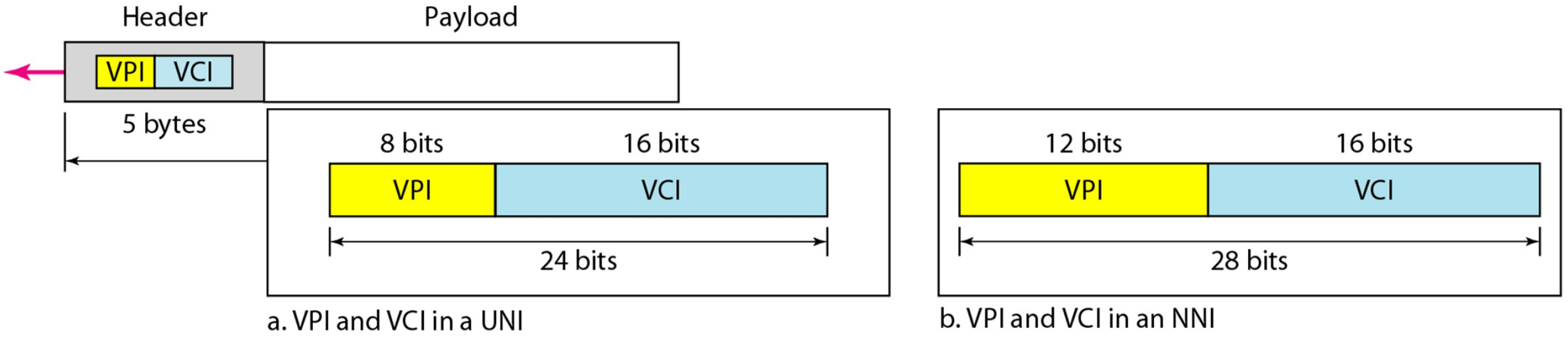


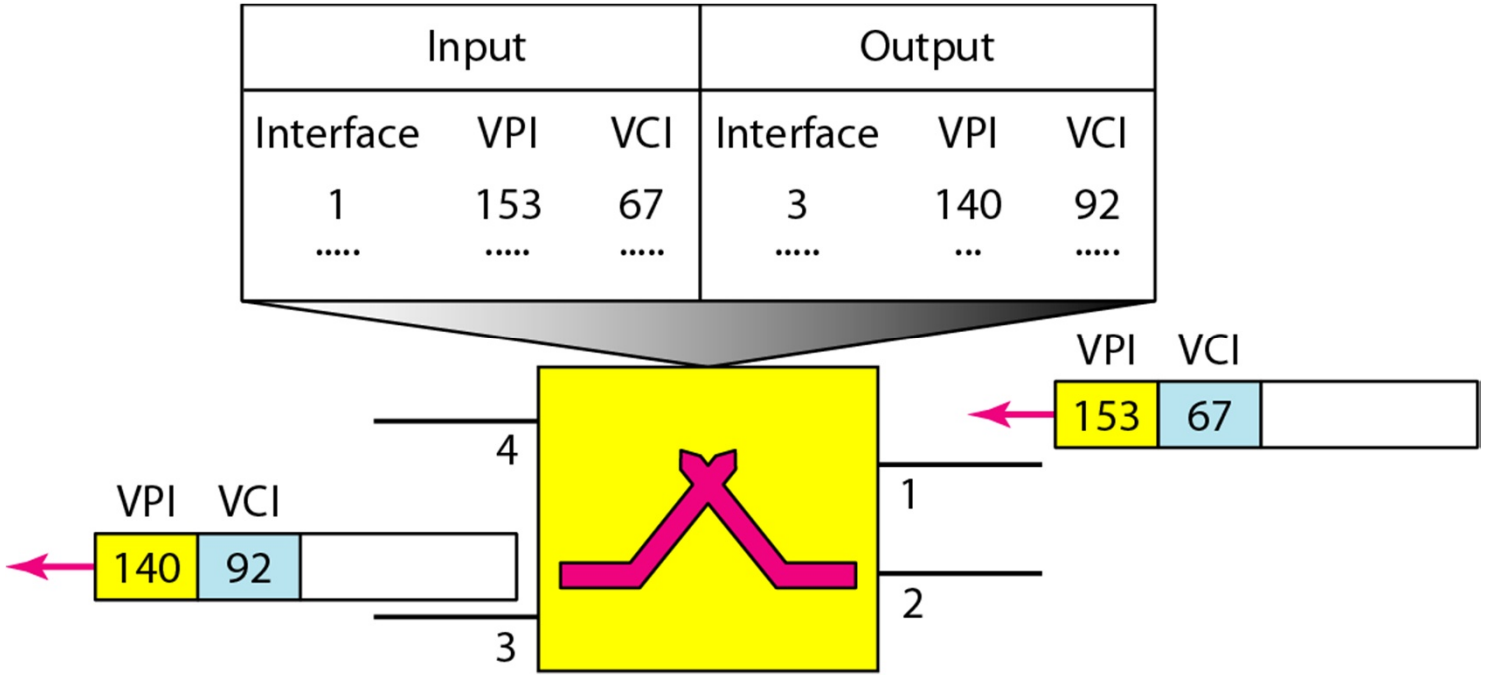
Virtual connections

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



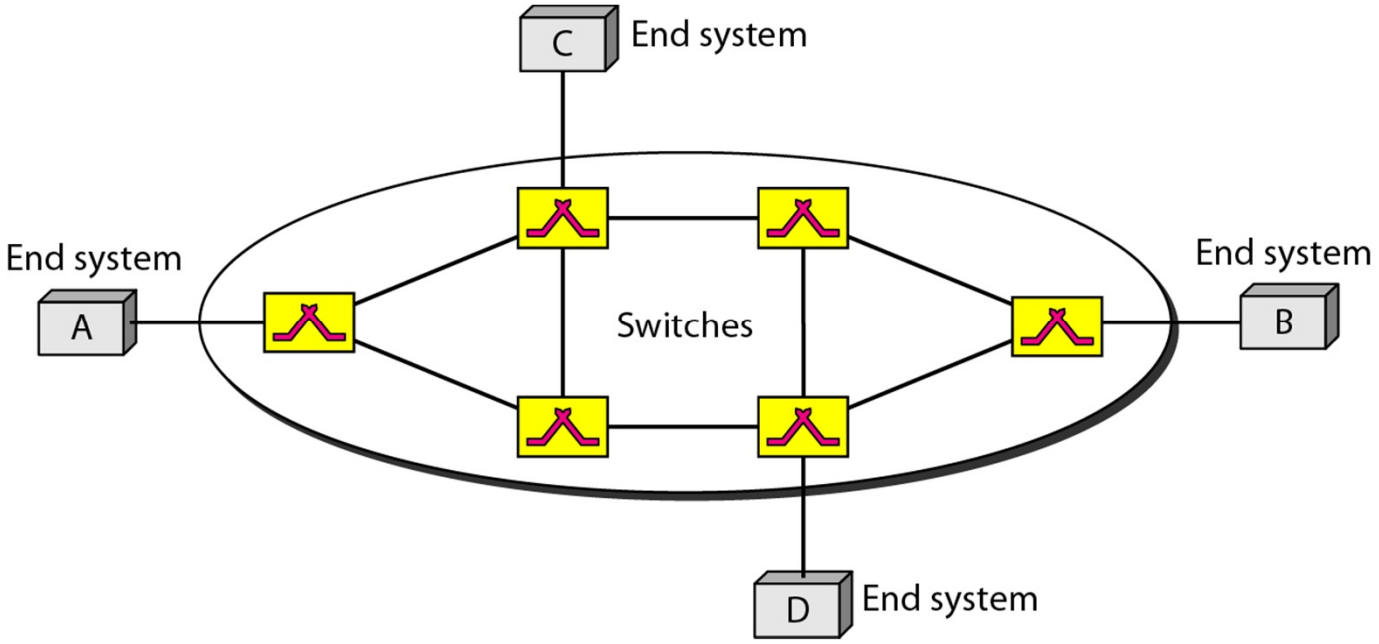
Routing with VPI, VCI at ATM switch



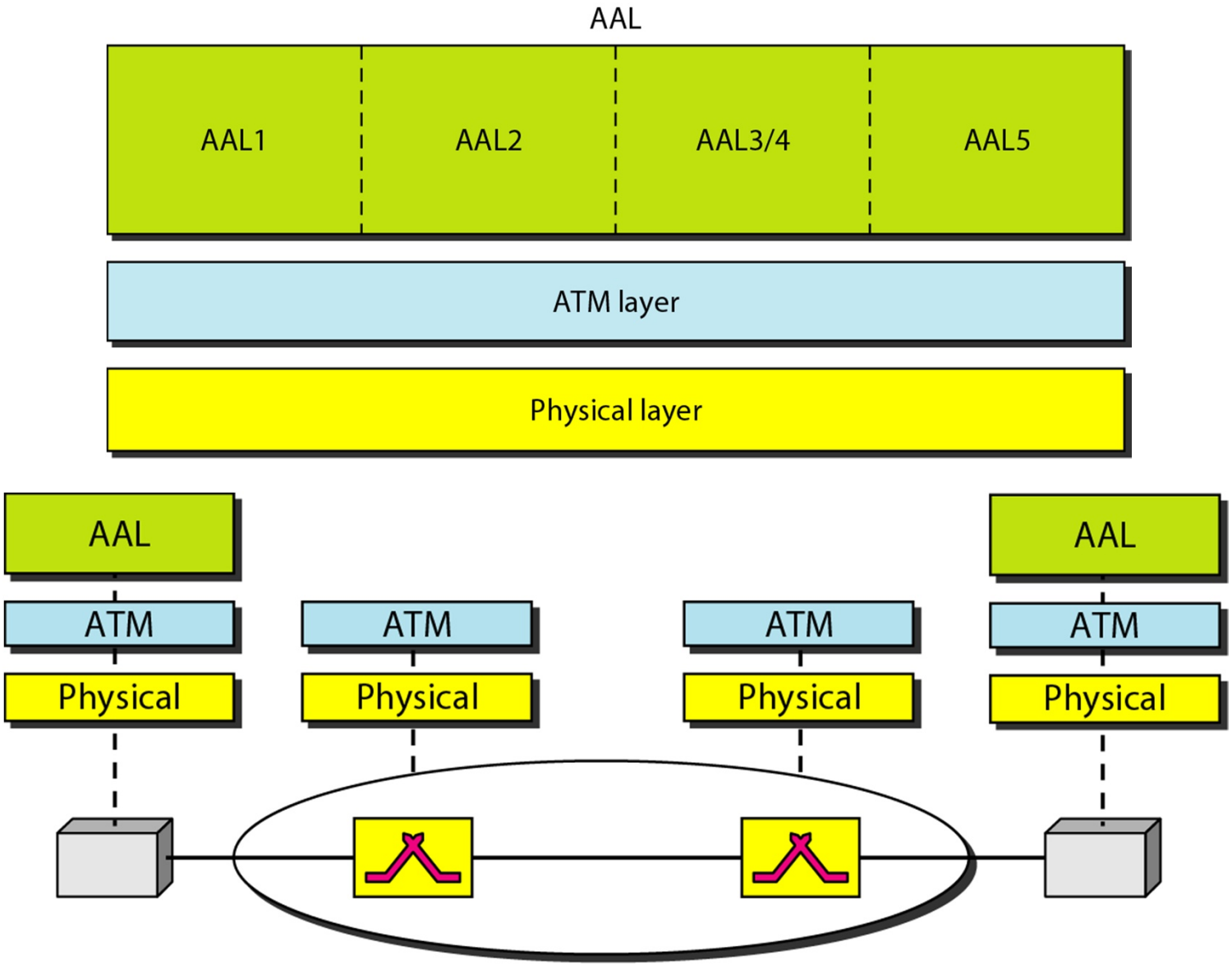


Virtual Circuit Networks

- Packet switching infrastructure
- Circuit switching logic

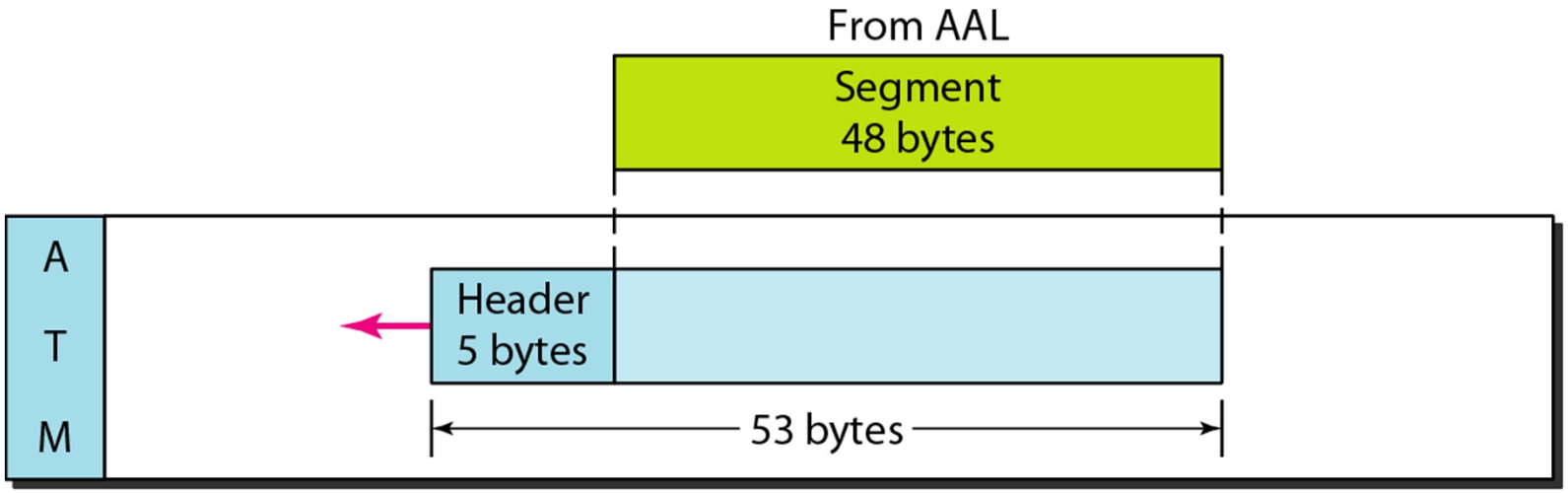


ATM layers


AAL
AAL1
AAL2
AAL3/4
AAL5
ATM layer
Physical layer
AAL
ATM
Physical
ATM
Physical
ATM
Physical
AAL
ATM
Physical

ATM layer

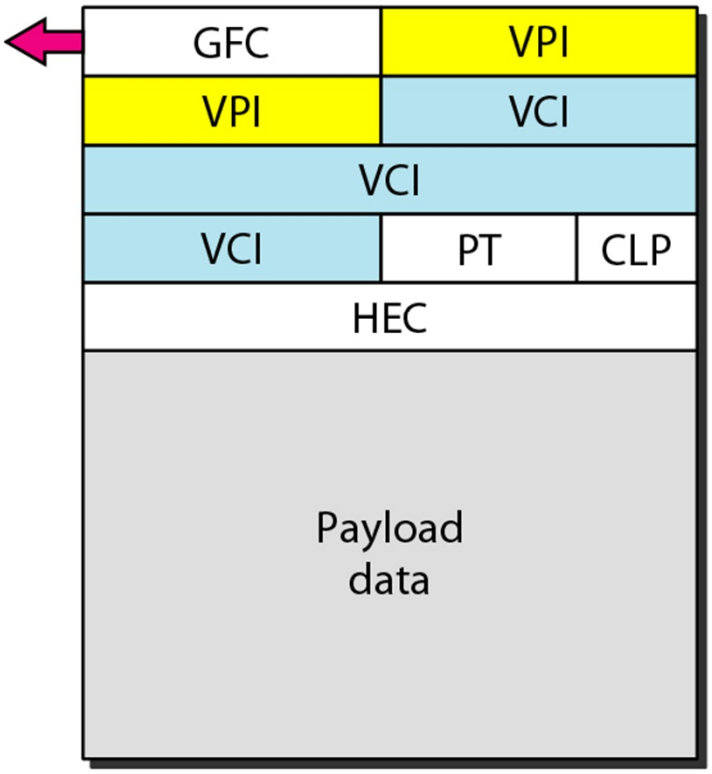
- Routing
- Traffic management
- Switching
- Multiplexing



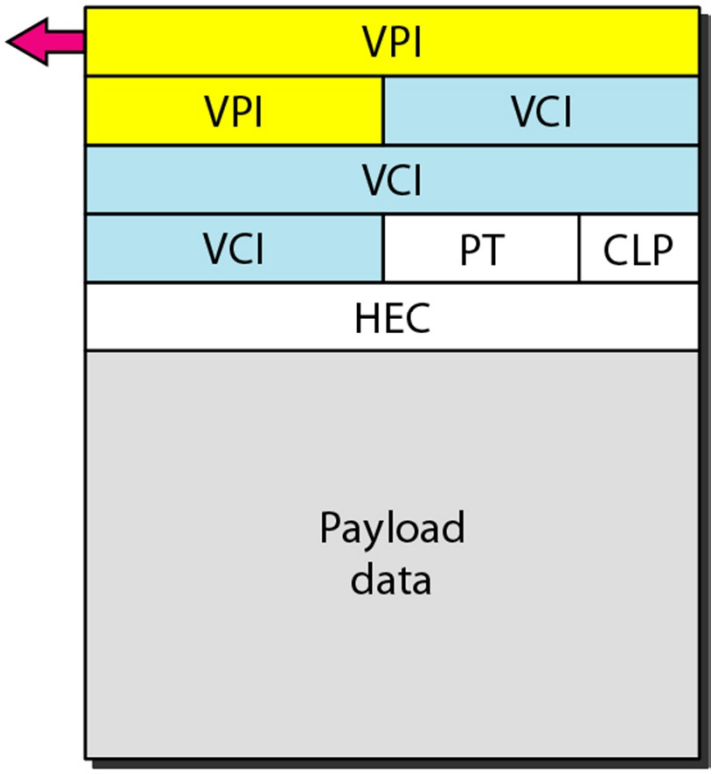
ATM headers

GFC: Generic flow control
VPI: Virtual path identifier
VCI: Virtual circuit identifier

PT: Payload type
CLP: Cell loss priority
HEC: Header error control



UNI cell

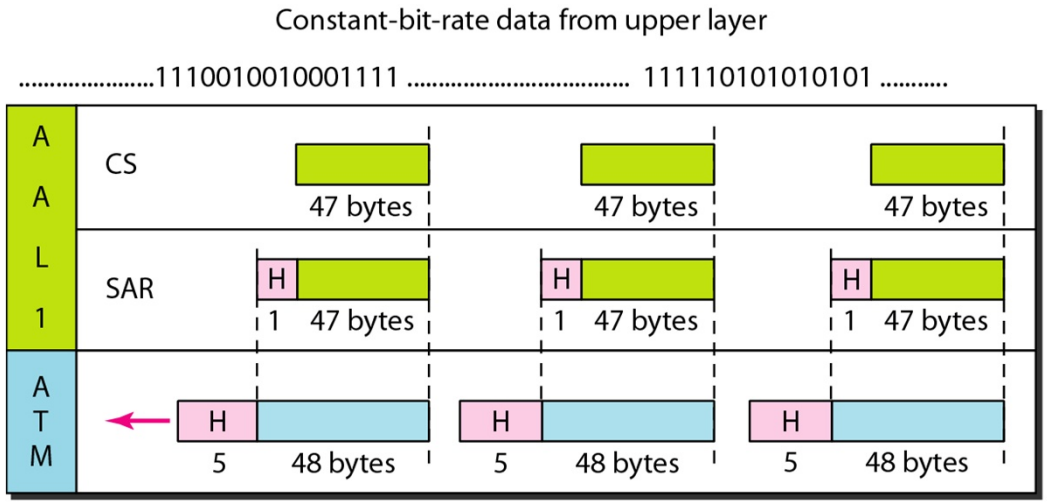


NNI cell

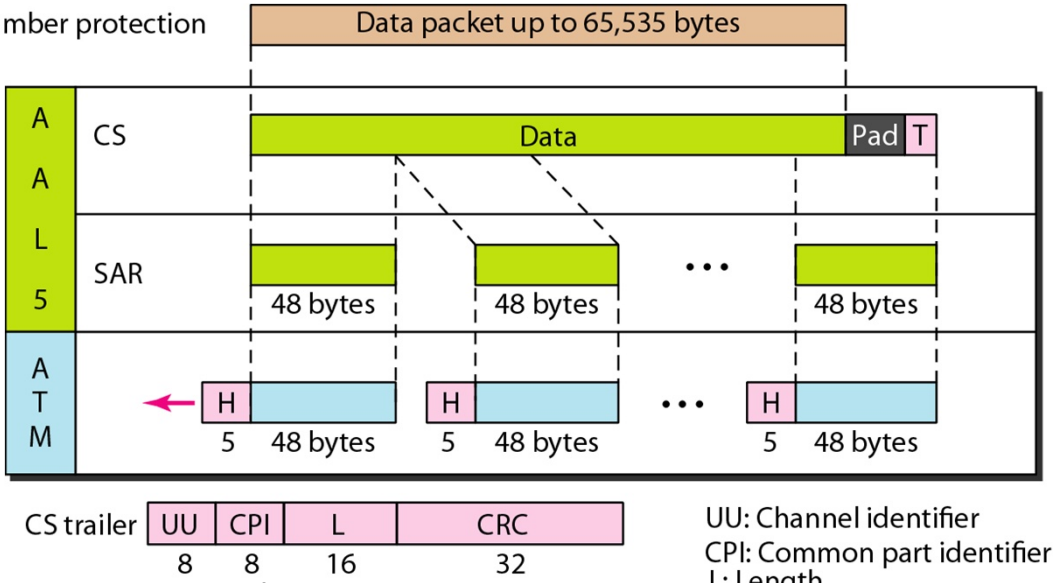
Application adaptation layer (AAL)

- 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 data services
- AAL5 when error control not needed

AAL1 and AAL5



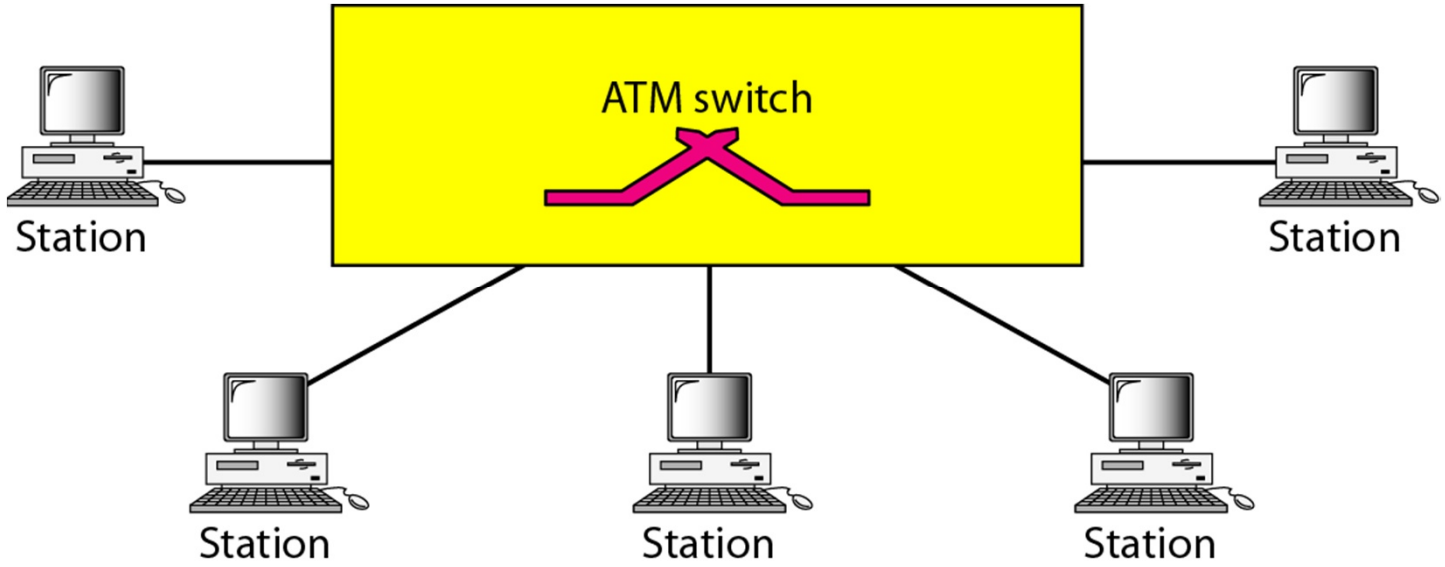
SN: Sequence number
SNP: Sequence number protection



UU: Channel identifier
CPI: Common part identifier
L: Length
CRC: Error detector

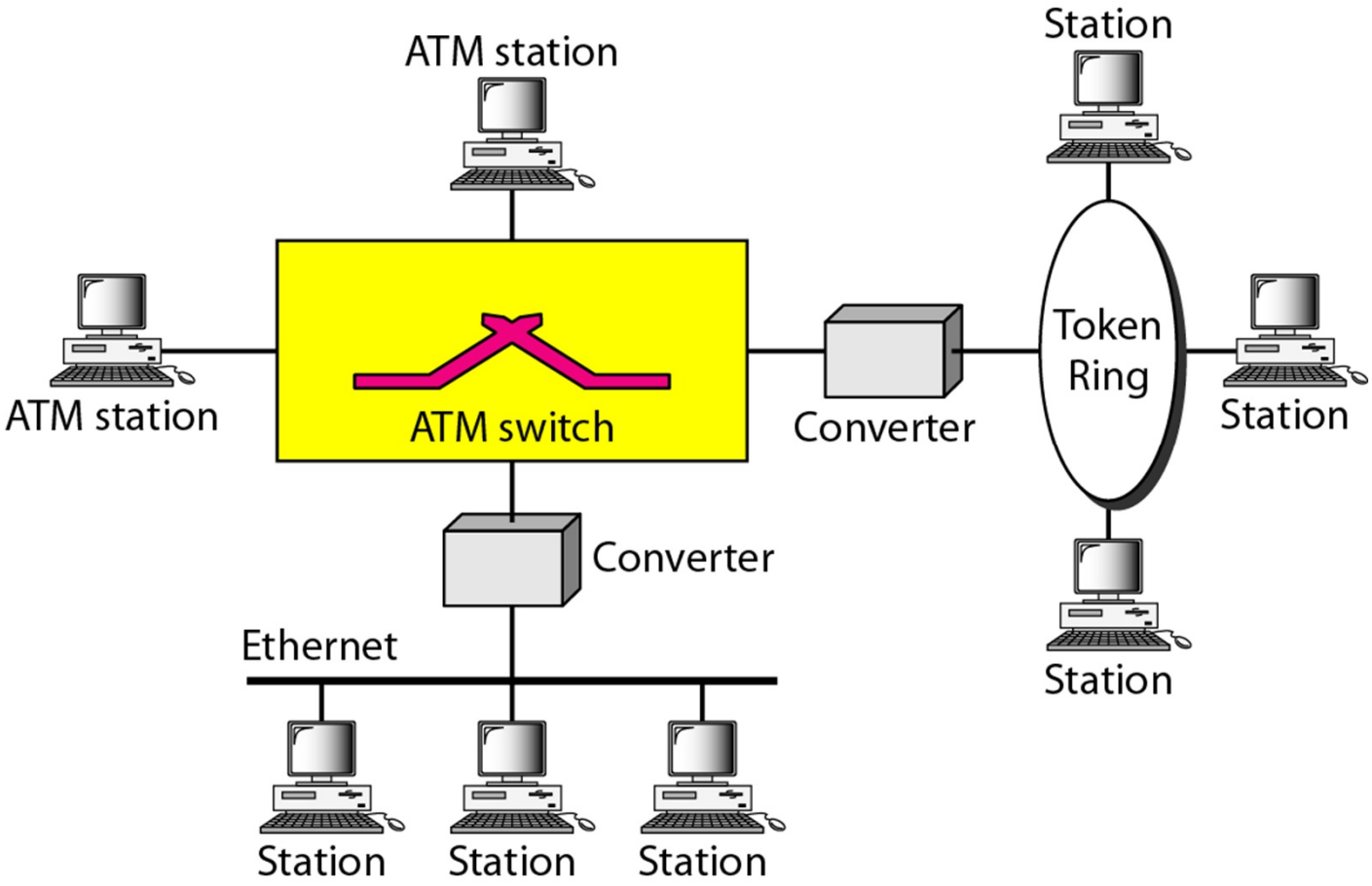
ATM LAN

- Attractive
  - High data rates
  - Multimedia services
  - Scalability



Hybrid ATM LAN solutions

- Cost-effective alternative



See you in 15’ :)

- After the break
  - SONET/SDH

Announcements

- Some subjects moved to Part 2
  - Wireless local area networks (WLAN)
    [ed.4 §14.1][ed.5 §15.1]

- Exercise sessions this week
  - Routing (Tuesday)
  - SONET/SDH, ATM (Thursday)

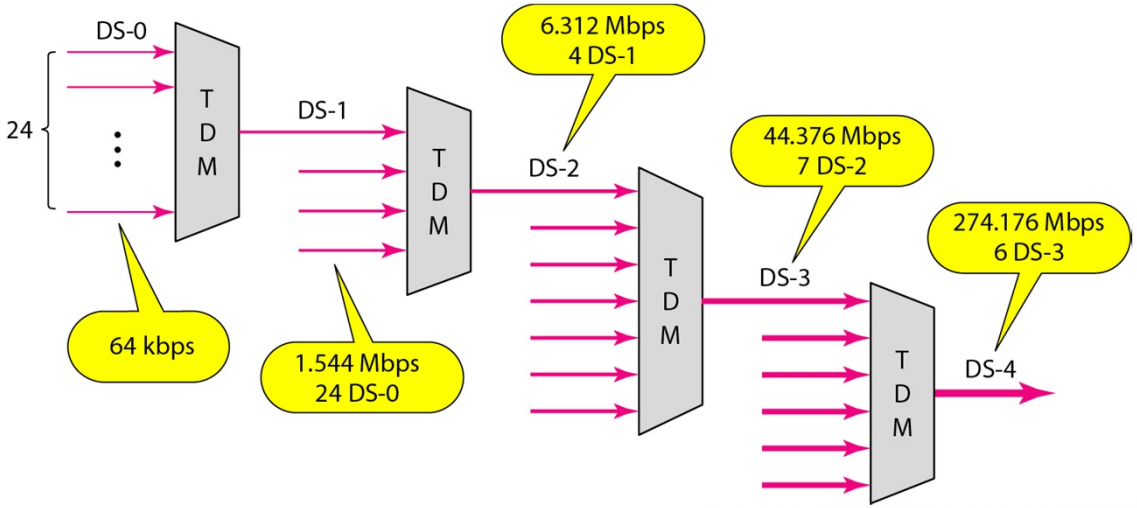
Synchronous Optical Networks

- SONET, developed by ANSI

Synchronous Digital Hierarchy

- SDH, developed by ITU-T

Digital hierarchy on optical links



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**

Network architecture

- Devices and connections

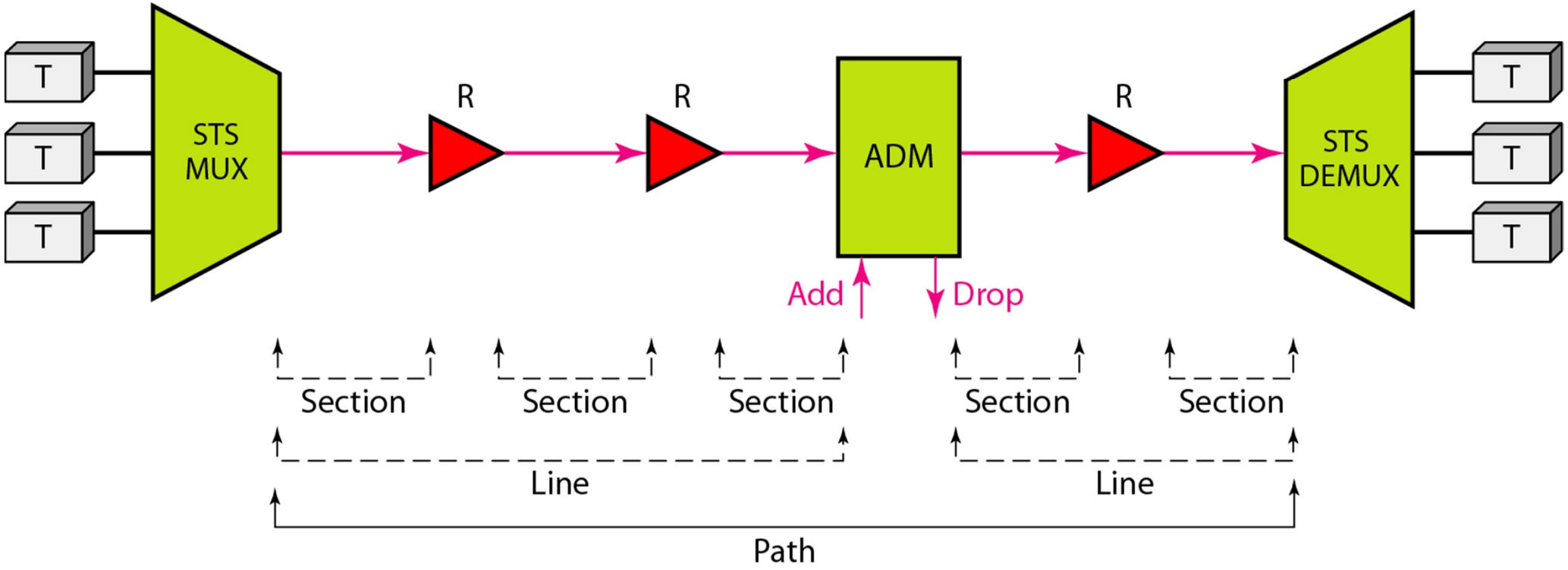
ADM: Add/drop multiplexer

STS MUX: Synchronous transport signal multiplexer

STS DEMUX: Synchronous transport signal demultiplexer

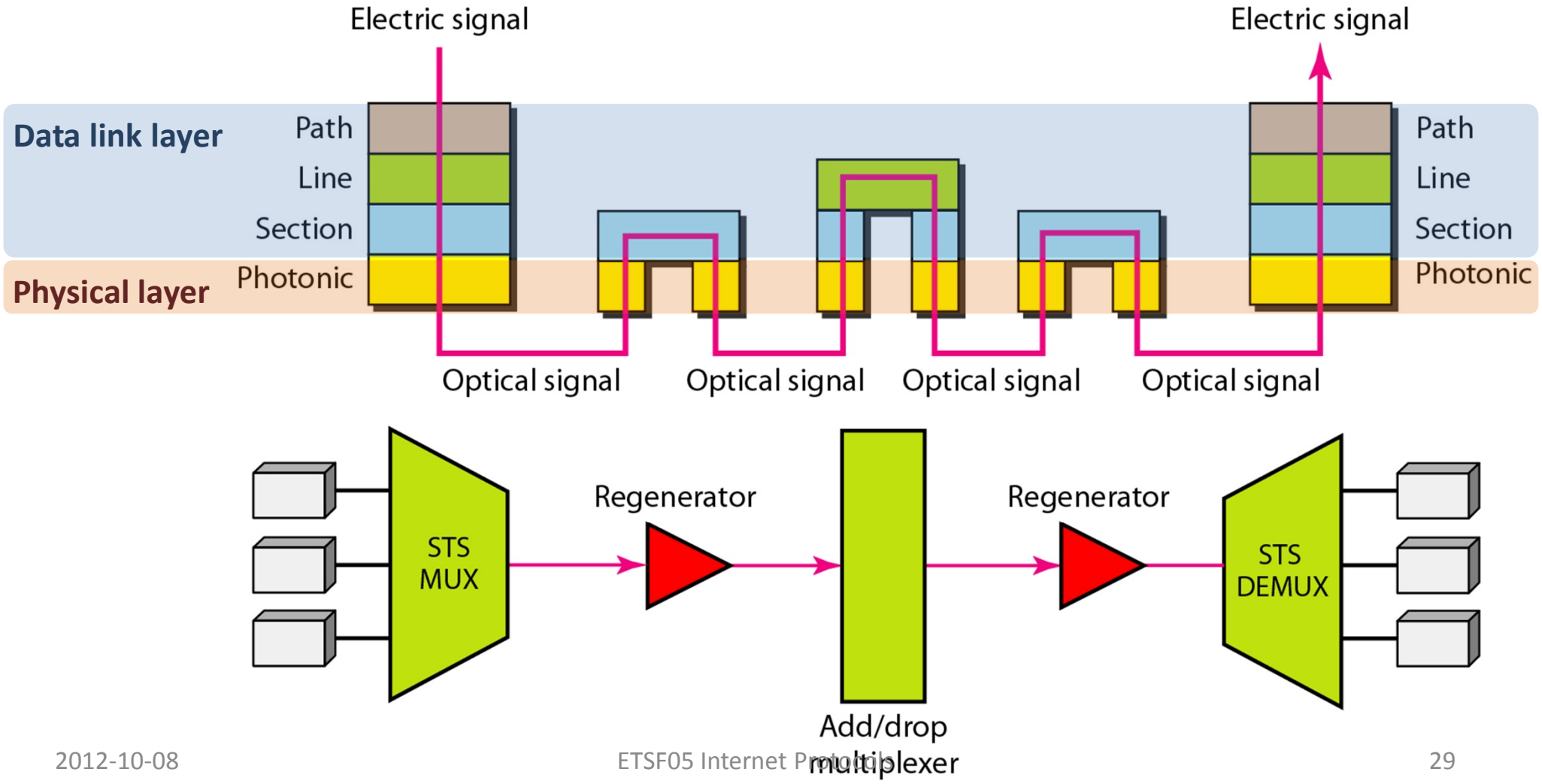
R: Regenerator

T: Terminal



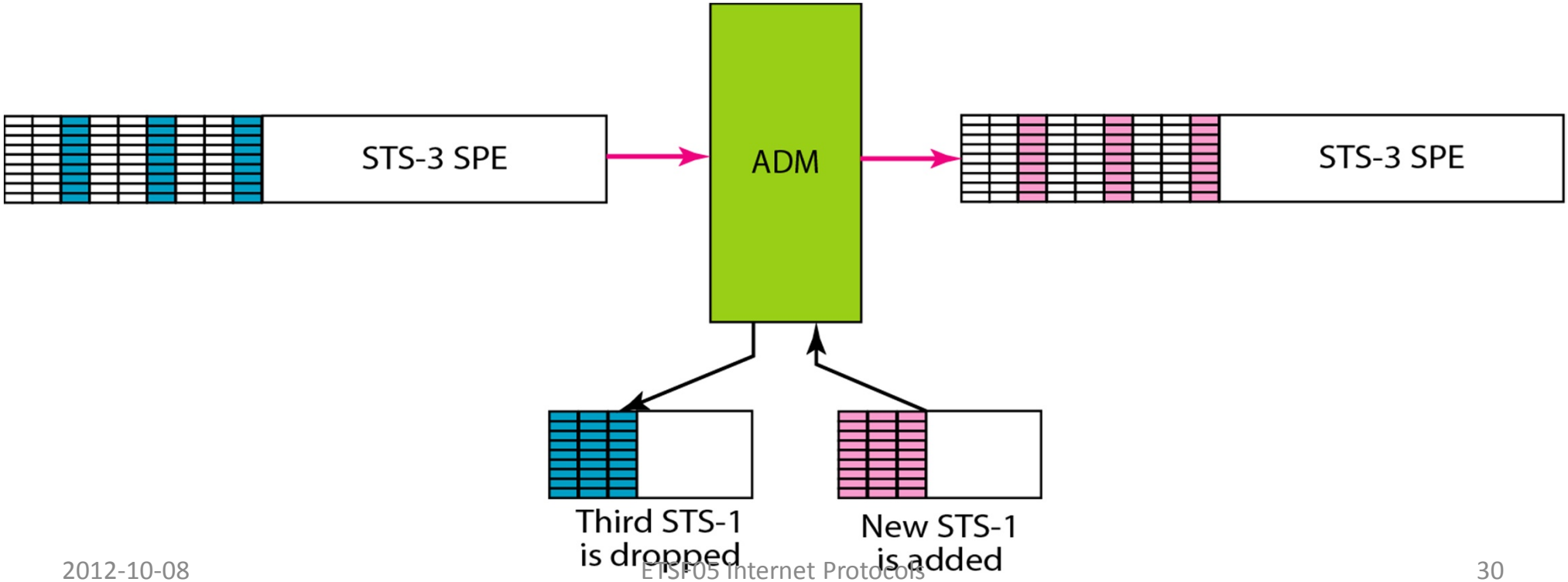
Network architecture

- Devices and layers



SONET add/drop multiplexer

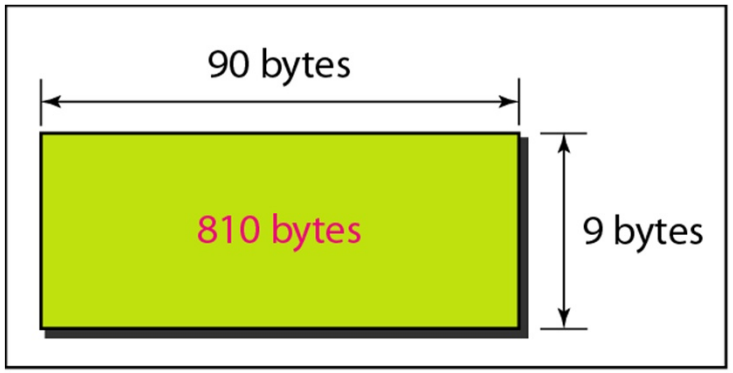
- Replaces a signal with another one
- Operates at line layer
- Similar to a switch



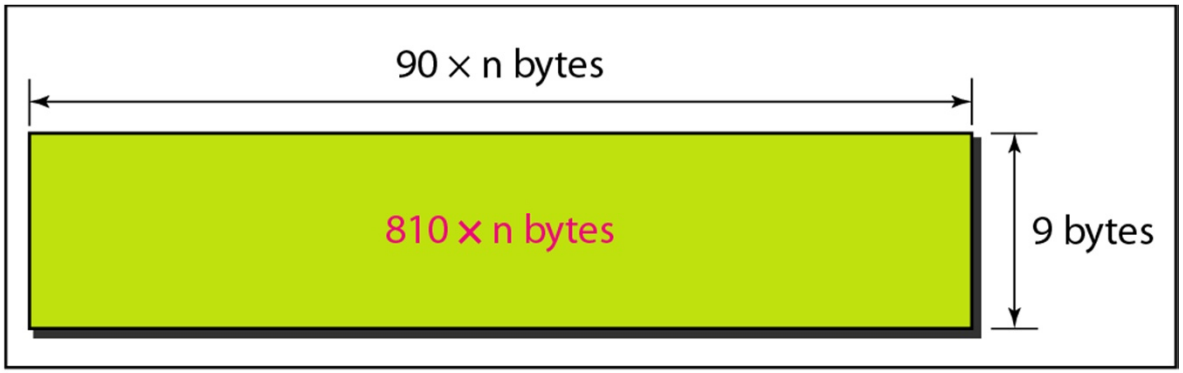
SONET frames

- 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

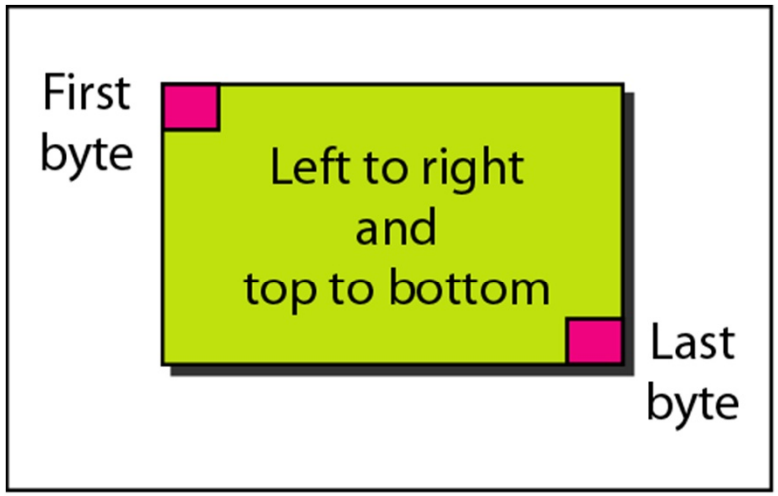


a. STS-1 frame

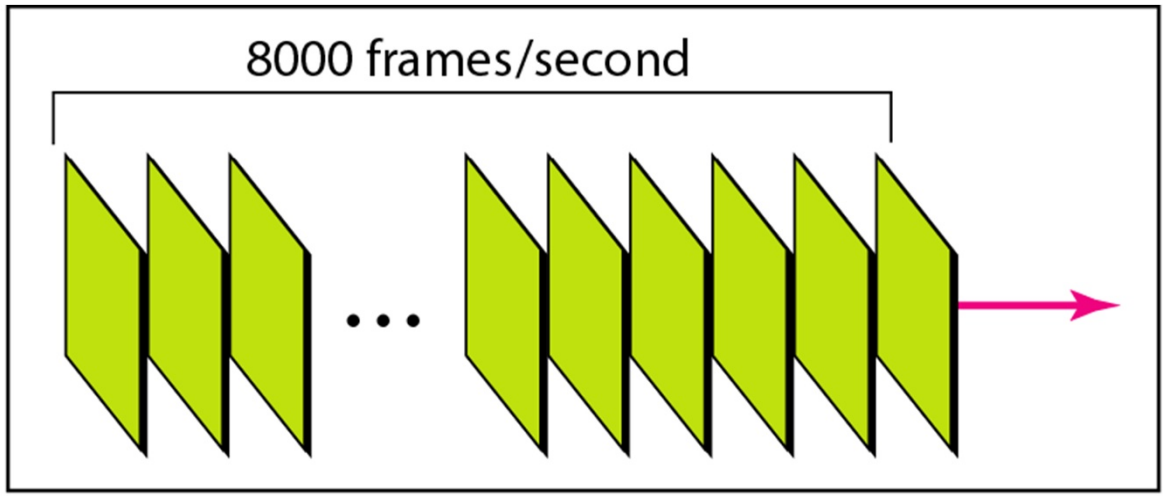


b. STS-n frame

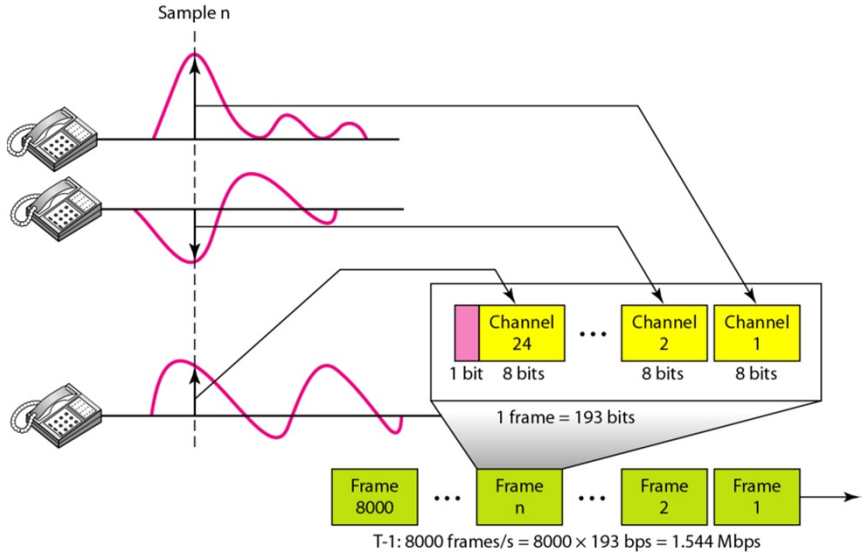
SONET frames in transmission



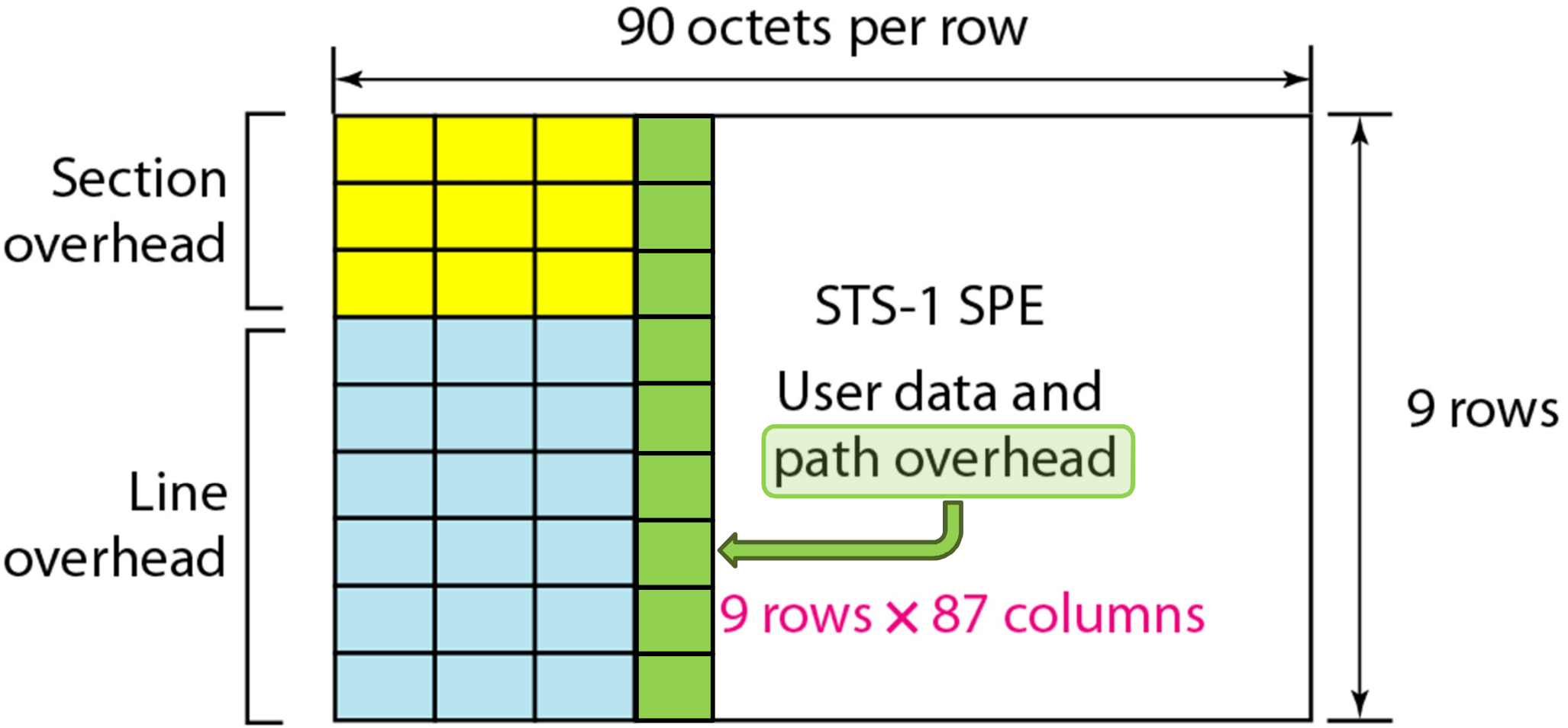
a. Byte transmission



b. Frame transmission

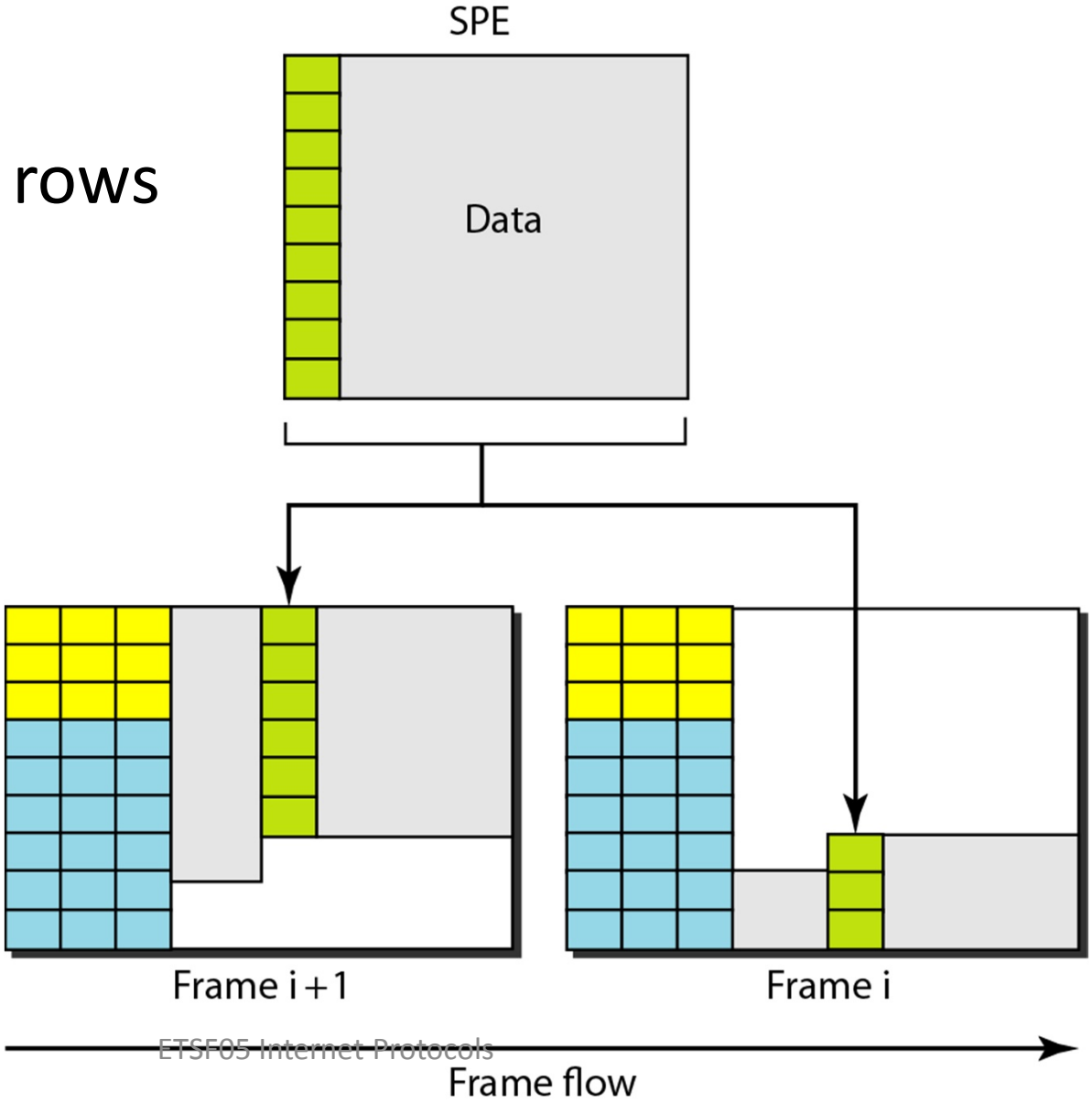


SONET frame structure (STS-1)



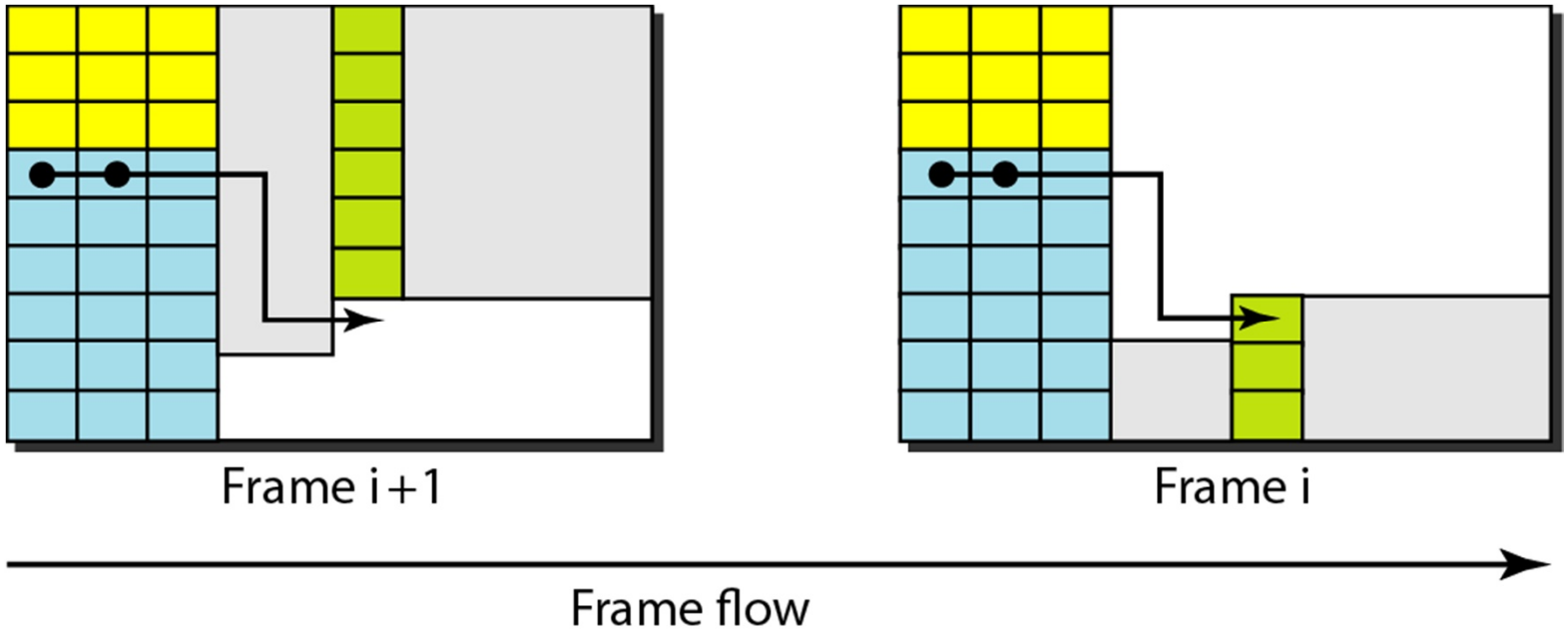
Encapsulation and offsetting

- STS-1
  - 90 bytes x 9 rows

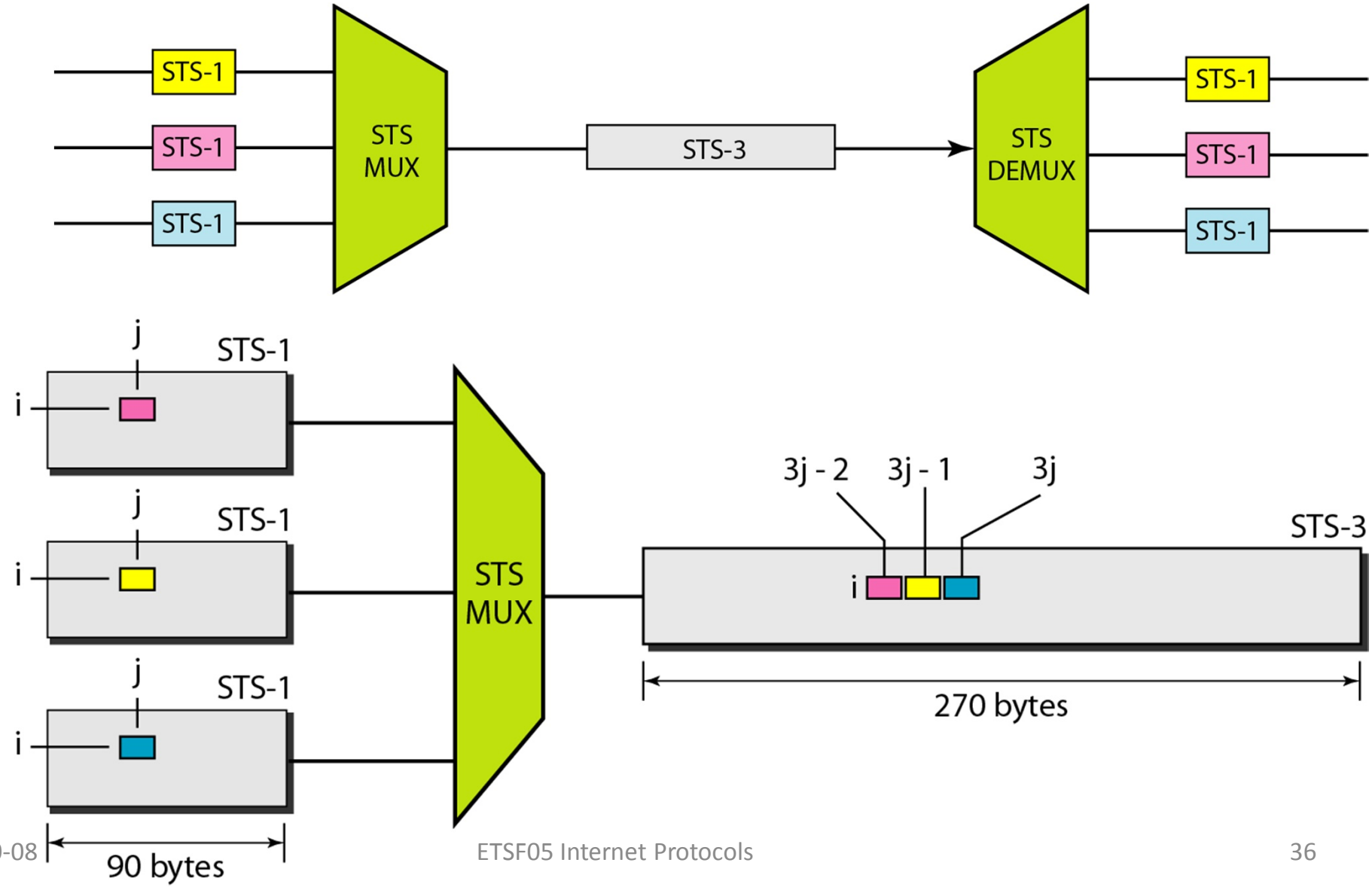


Pointers H1+H2

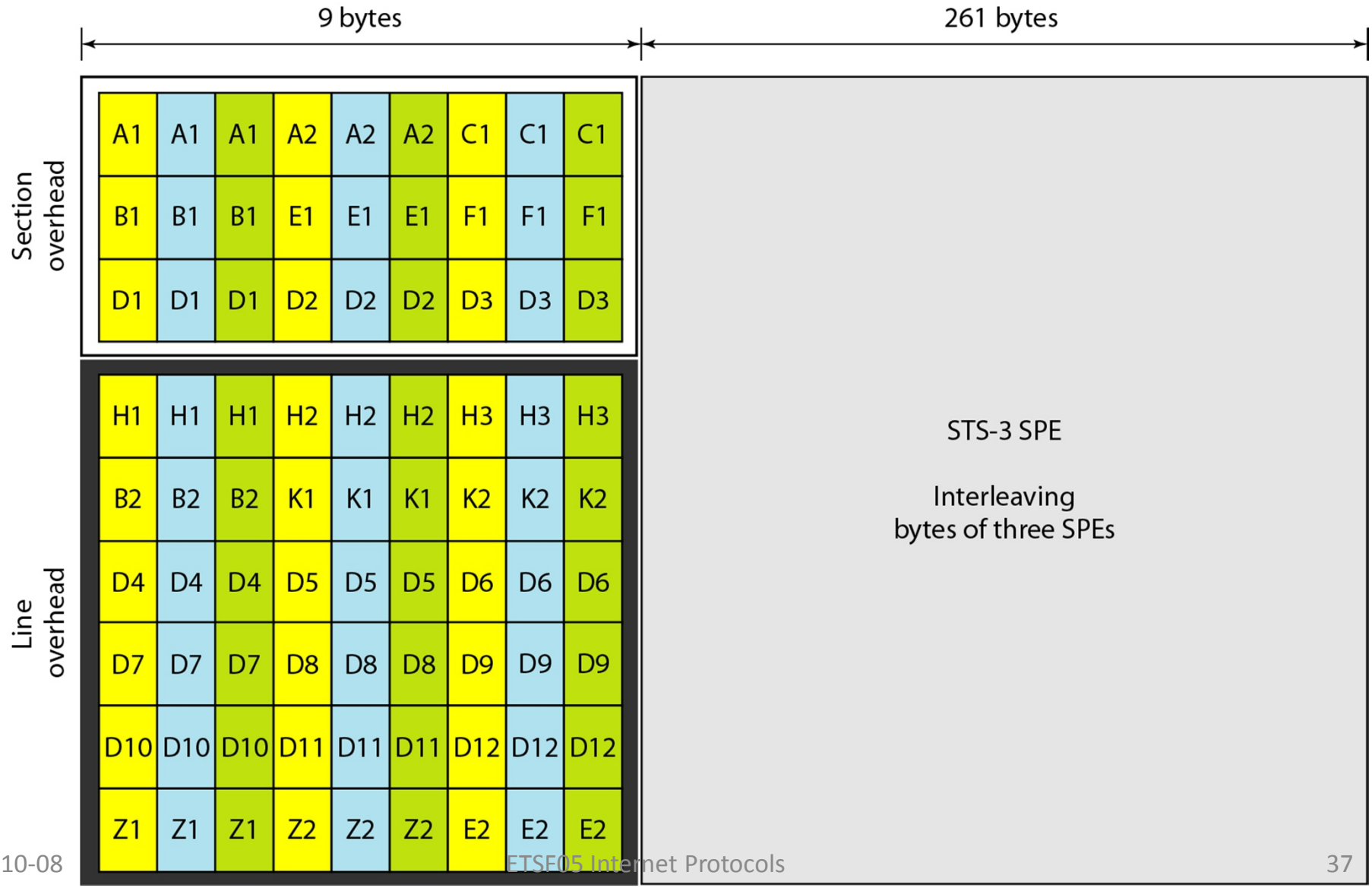
- Where does the next frame start?
  - 2 bytes to address 774 possibilities



Multiplexing and byte interleaving

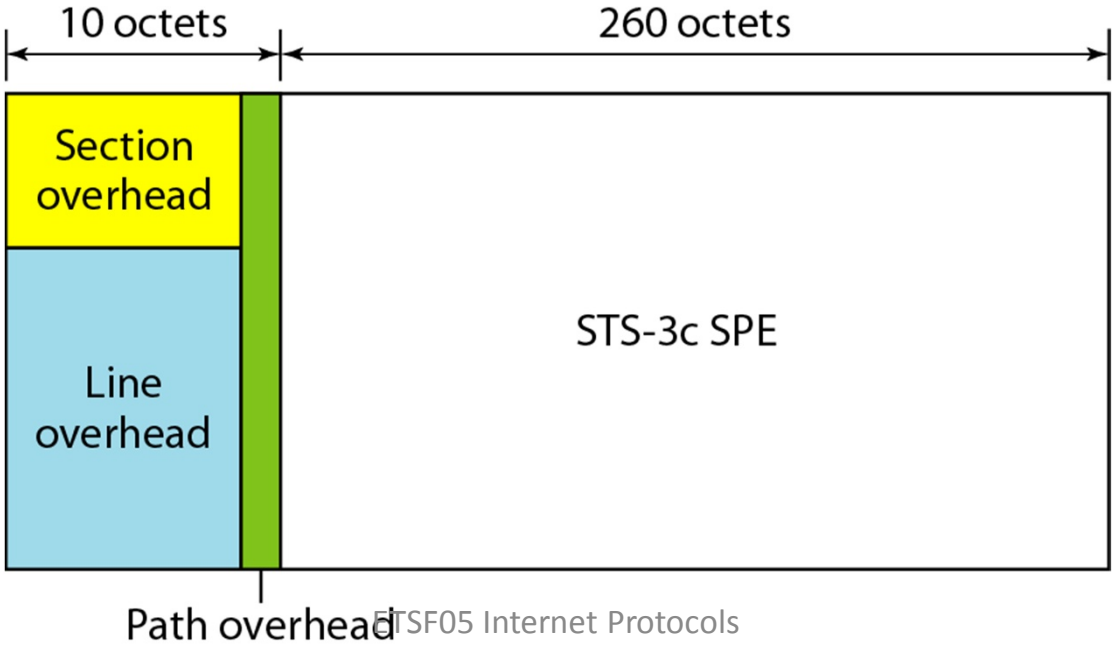


Multiplexed SONET frame (STS-3)



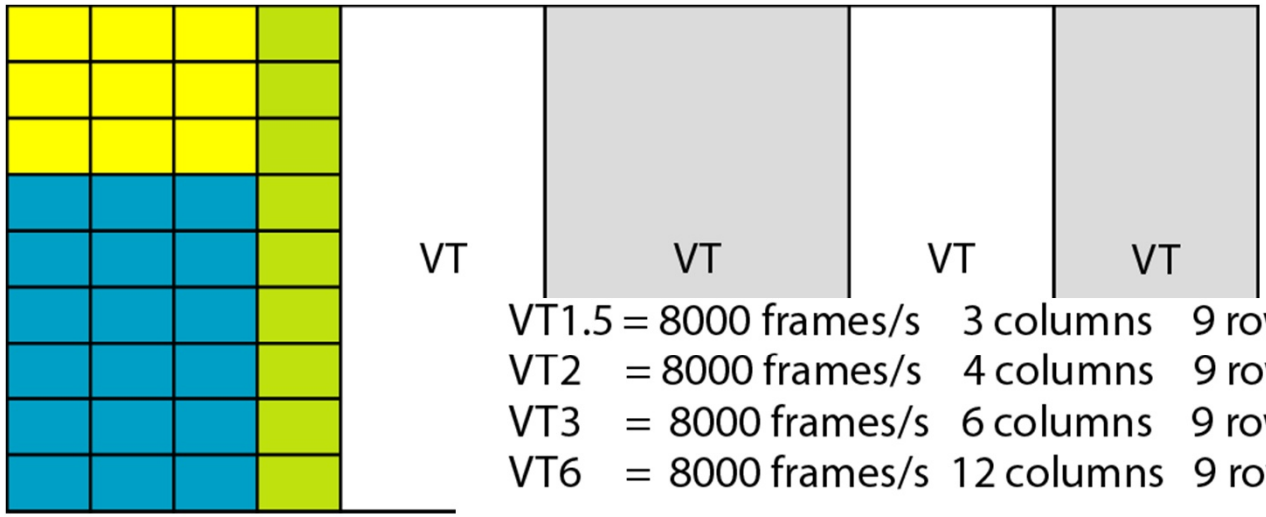
Concatenated signal (STS-*n*c)

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

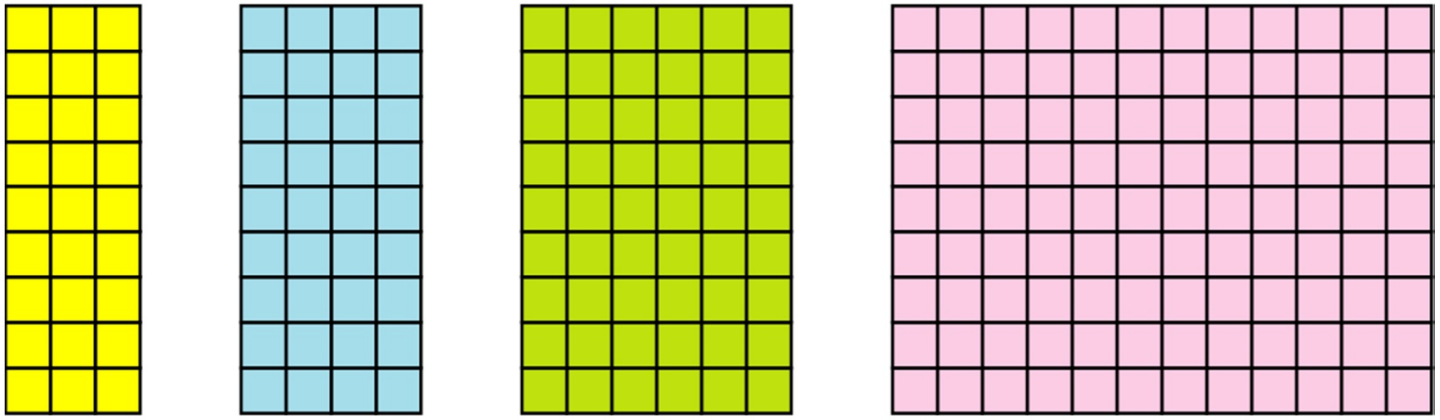


Virtual tributaries

- Backward compatibility with DS-1 and DS-3

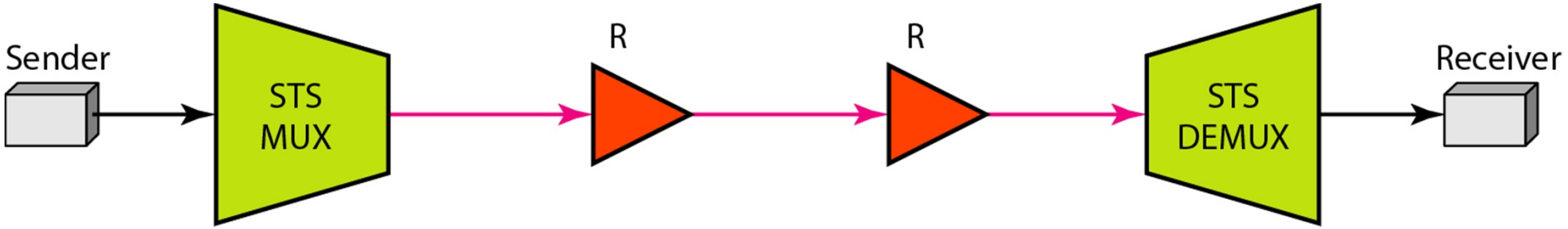


VT1.5 = 8000 frames/s 3 columns 9 rows 8 bits = 1.728 Mbps
VT2 = 8000 frames/s 4 columns 9 rows 8 bits = 2.304 Mbps
VT3 = 8000 frames/s 6 columns 9 rows 8 bits = 3.456 Mbps
VT6 = 8000 frames/s 12 columns 9 rows 8 bits = 6.912 Mbps

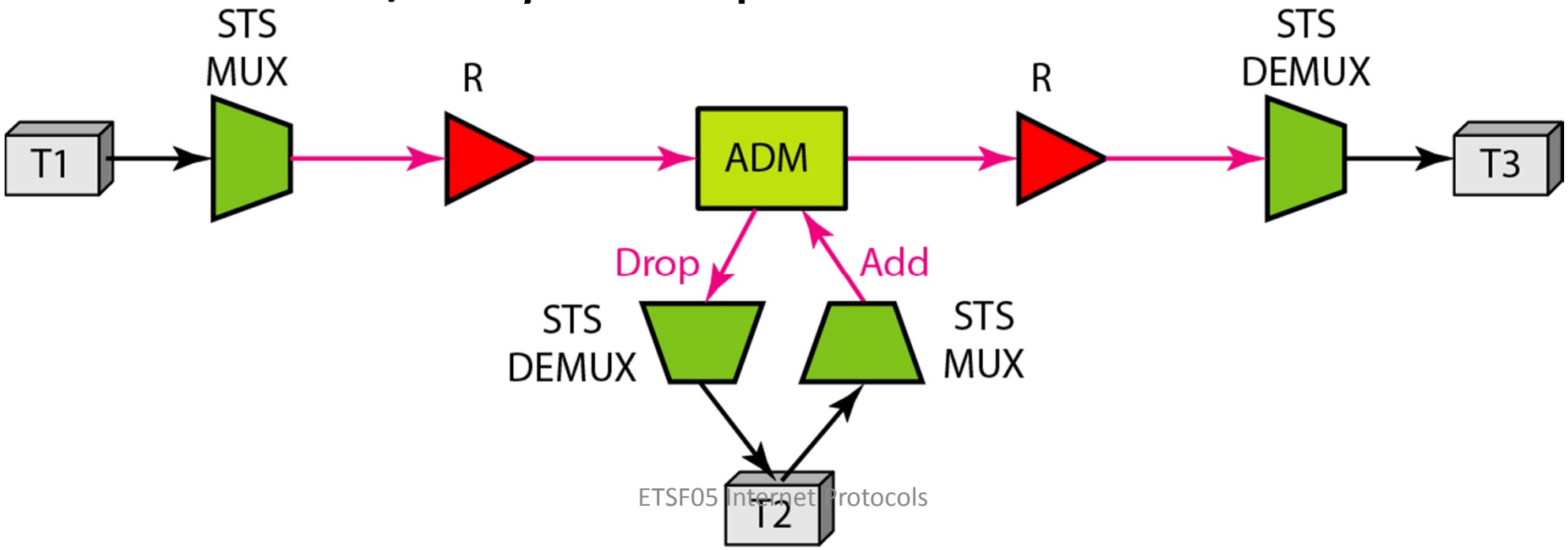


Linear SONET topology

- Without add/drop multiplexer

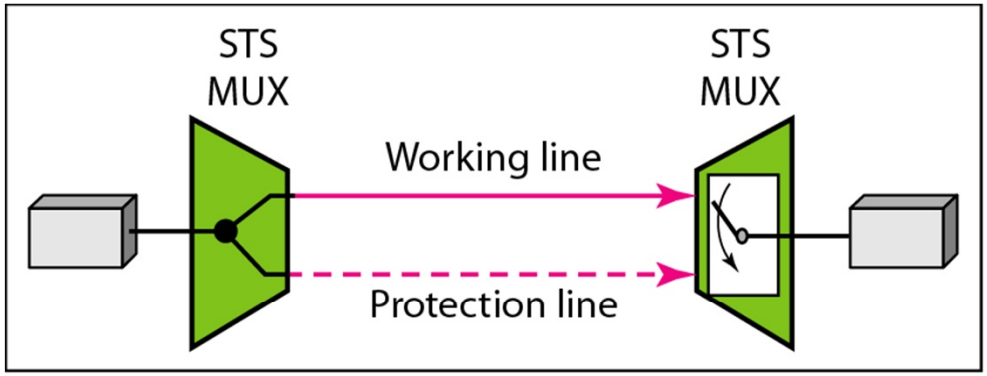


- With add/drop multiplexer

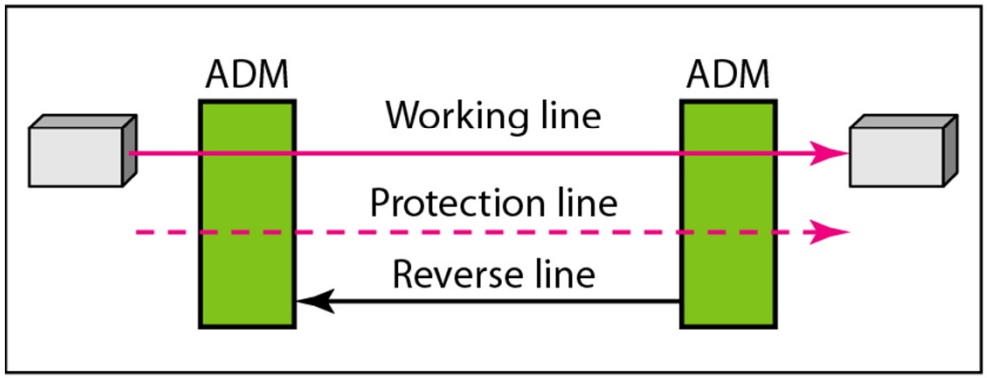


Automatic protection switching

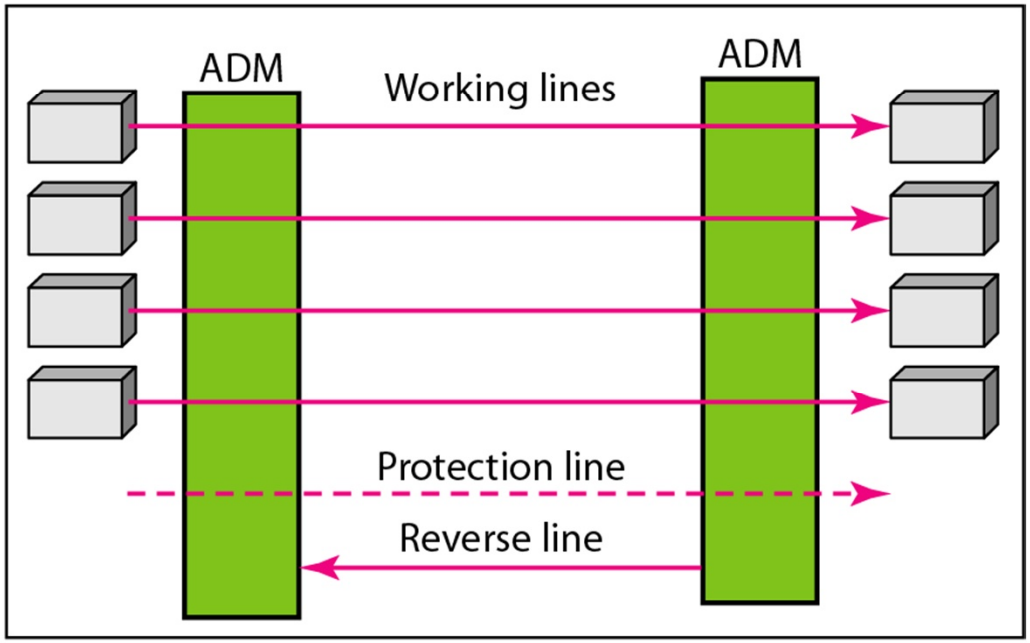
- Failure protection through line redundancy



a. One-plus-one APS

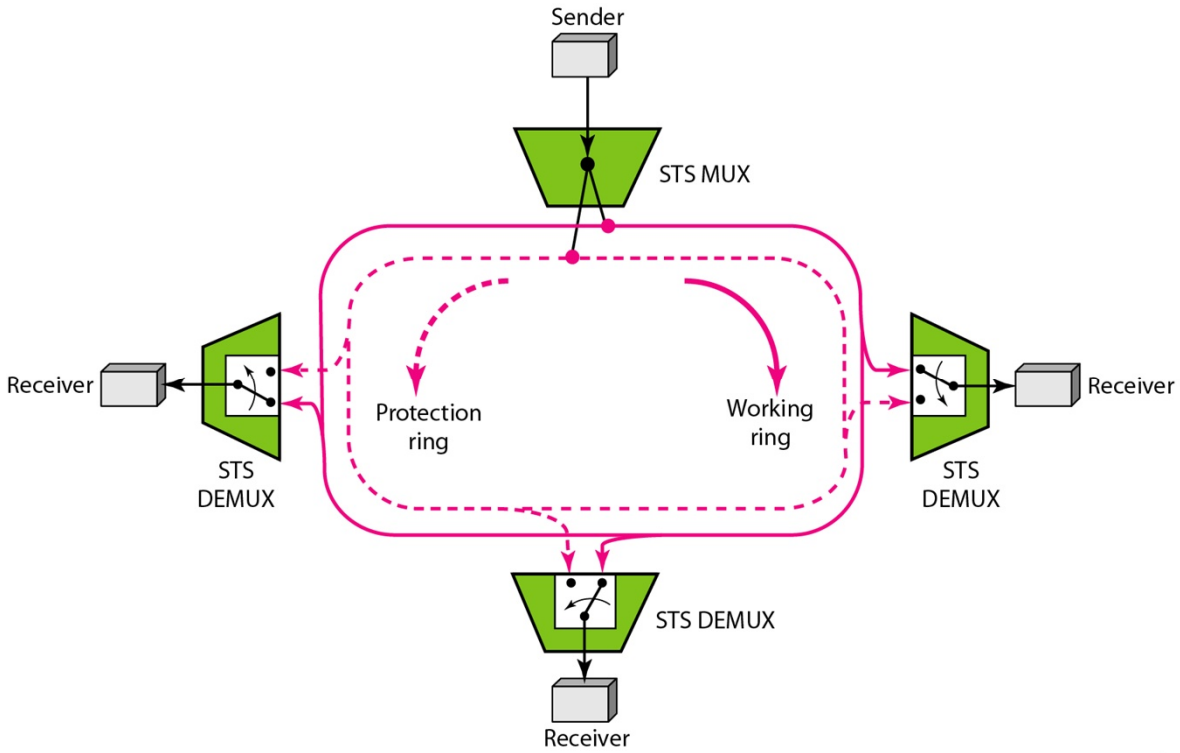


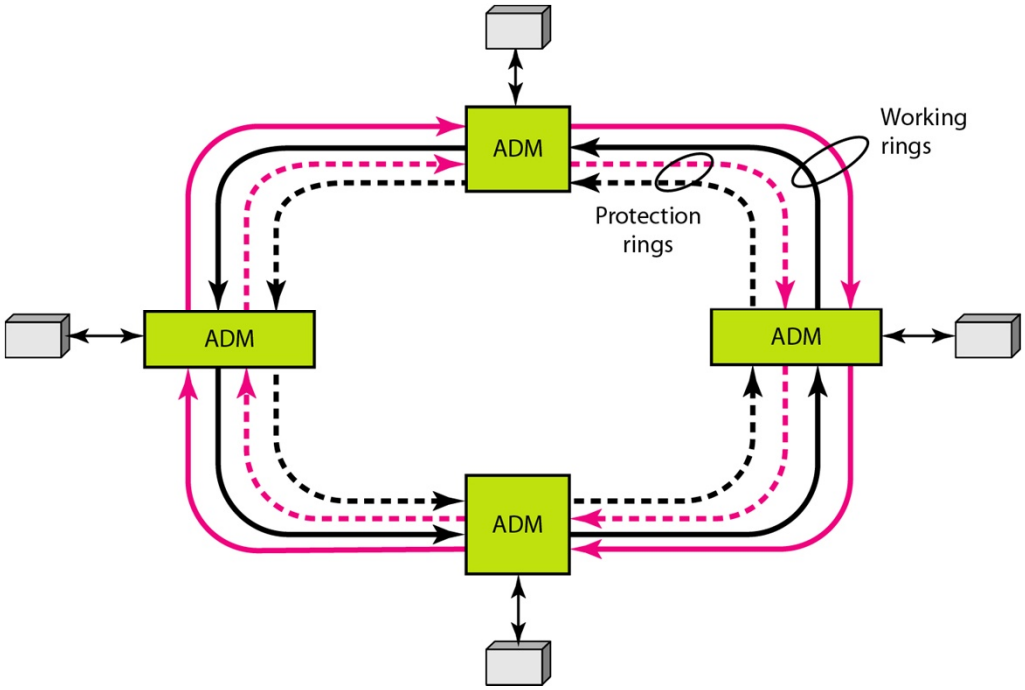
b. One-to-one APS



c. One-to-many APS

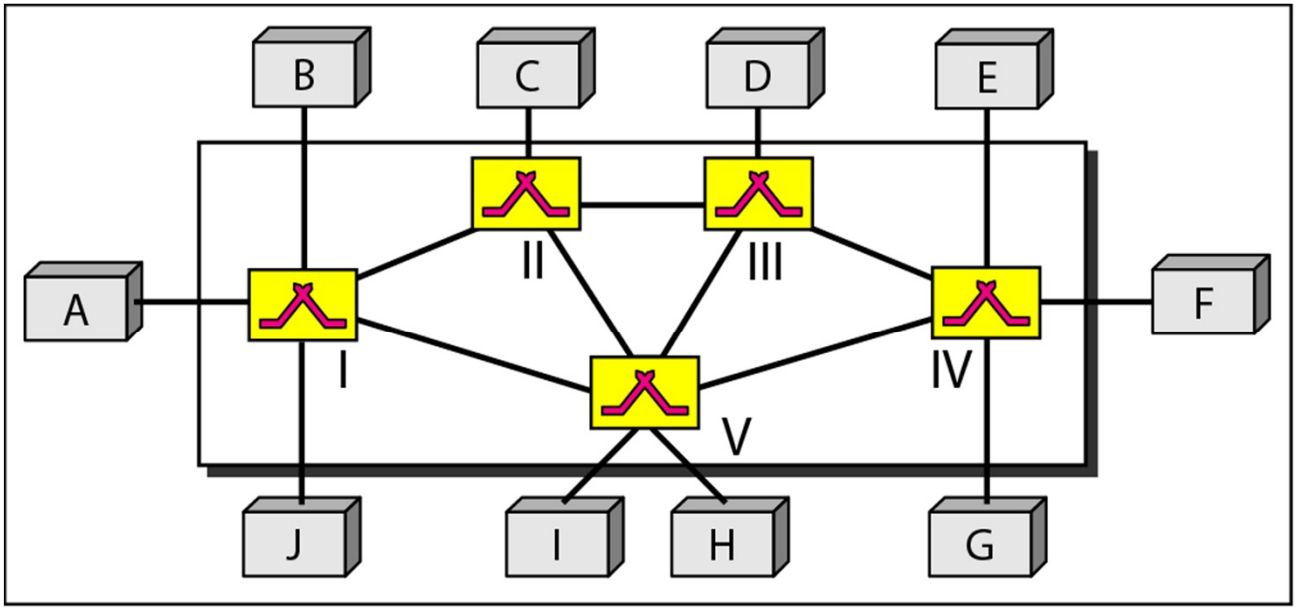
Ring SONET topology



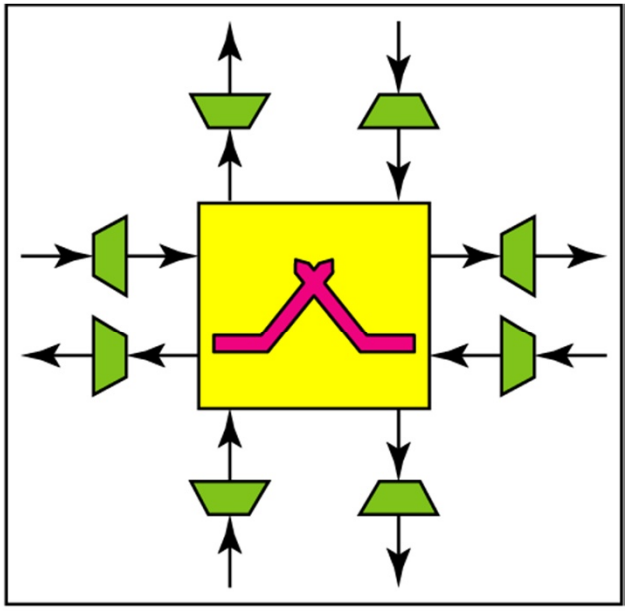


Mesh SONET topology

- Better scalability
  - Multiplexing/demultiplexing at switches



a. SONET mesh network



b. Cross-connect switch

Coming up...

- Short (2 h) exam
  - Wednesday, 24/10, 08:00, E:3308 + E:3336
- Check previous years' questions & answers
  - http://www.eit.lth.se/index.php?ciuid=669&coursepage=3144
- Course part 2 starts in study week 9, HT2
  - Monday, 29/10, 10:00, E:1406!