ATM Introduction

The Grand Unification

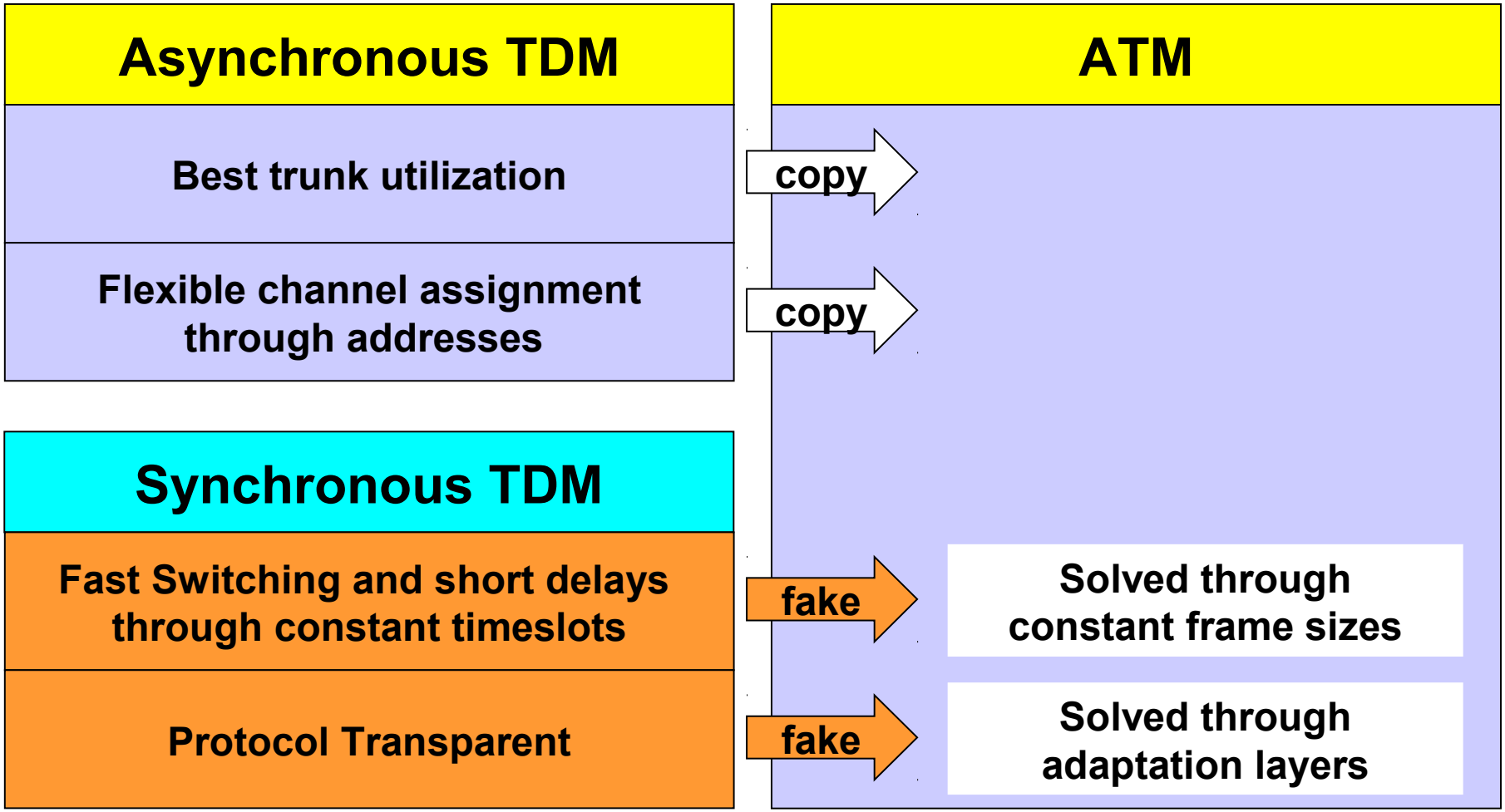
Agenda

- What is it? Who wants it? Who did it?
- Header and Switching
- ATM Layer Hypercube
- Adaptation Layers
- Signaling
- Addresses

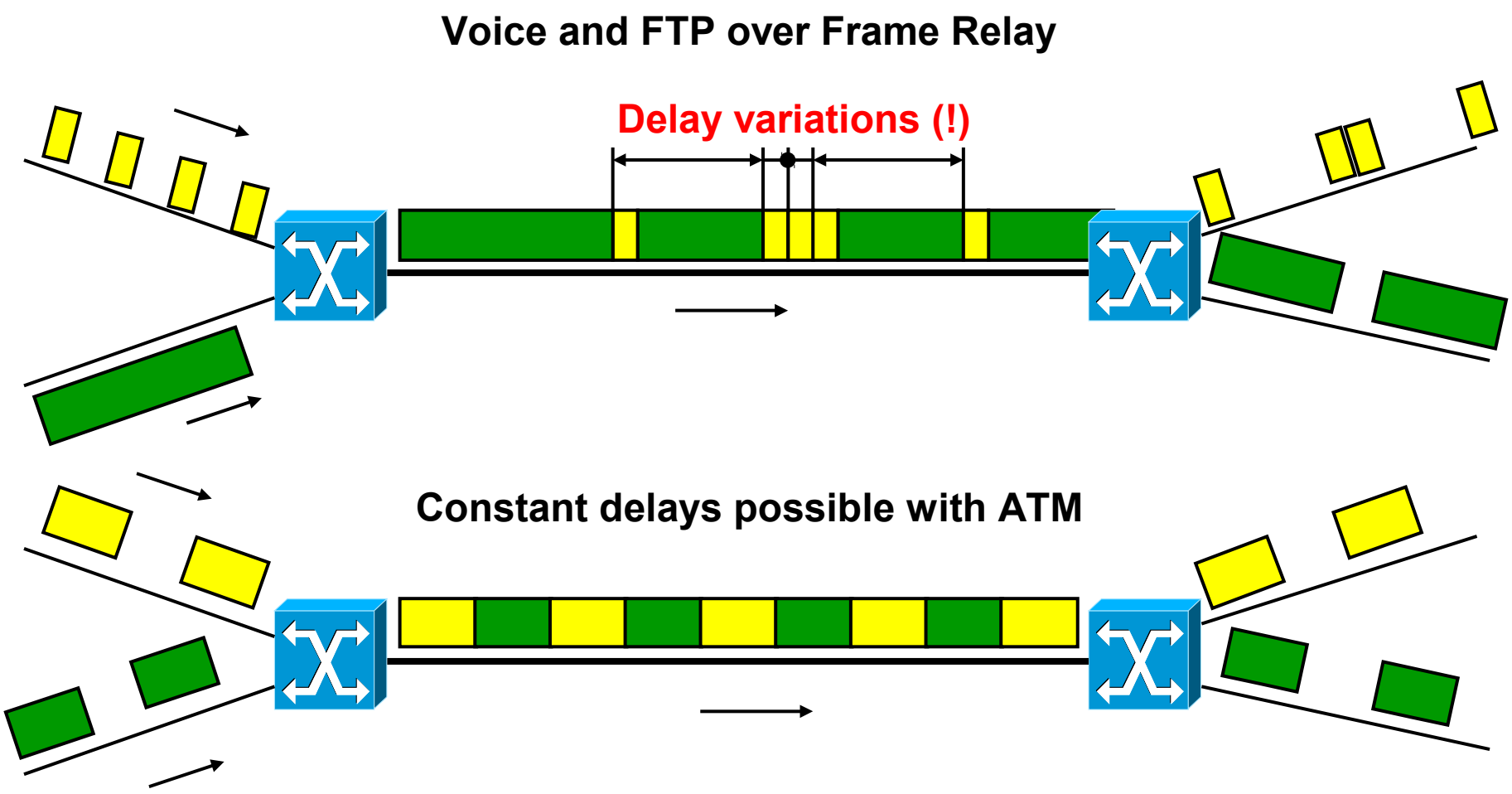
What is ATM ?

- High-Speed Virtual Circuits
  - PVC and SVC
  - No error recovery
- UNI and NNI defined
- Constant frame sizes ➔ Cells
- Based on B-ISDN specifications
  - Voice, Video, Data

Design Ideas



Cell Switching and Jitter



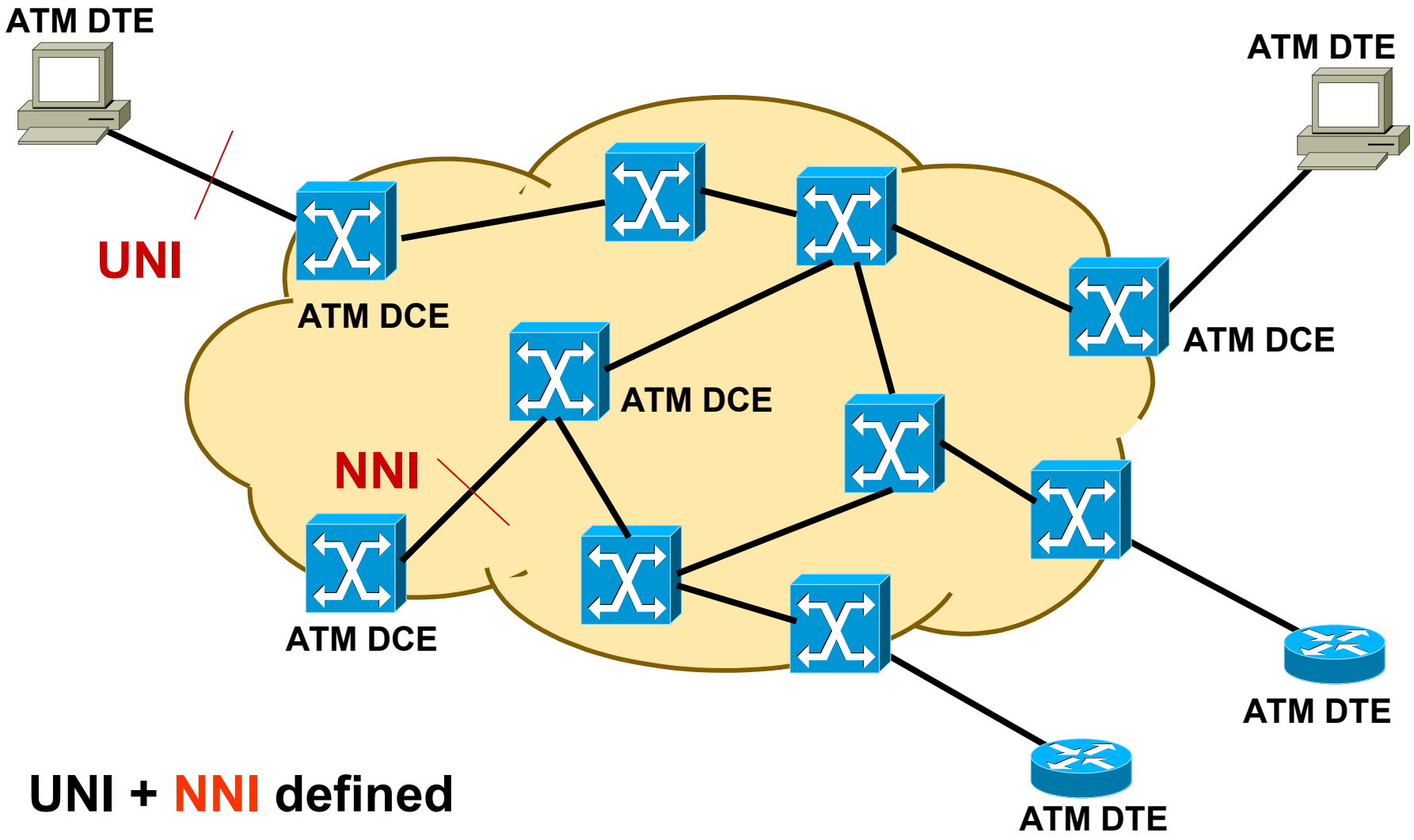
Cell Switching

- Forwarding of cells implemented in HW
  - Very fast
- But still packet switching
  - Store and forwarding
  - Asynchronous multiplexing
- Because of constant cell size the queuing algorithms can guarantee
  - Bounded delay
  - Maximum delay variations

ATM Usage

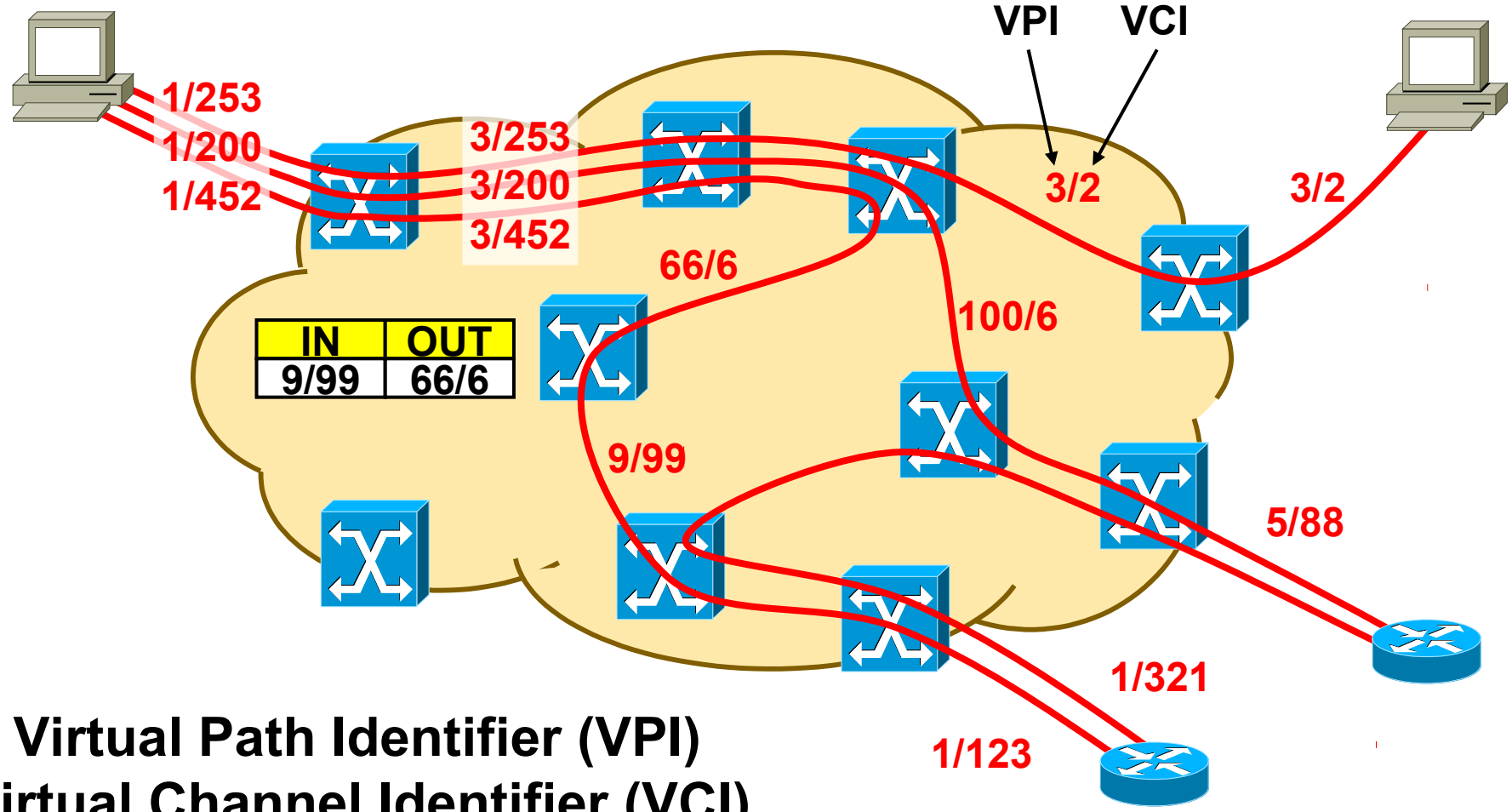
- Public and private networks
  - LAN, MAN, WAN
- Backbone high-speed networks
  - Public (Telcos) or private
- Original goal: World-wide ATM network
  - But Internet technology and state-of-the art Ethernet are more attractive today
- New importance as backbone technology for mobile applications
  - Cellular networks for GSM, GPRS, UMTS, ...

ATM Network



UNI + NNI defined

Virtual Circuits



Virtual Path Identifier (VPI)
Virtual Channel Identifier (VCI)

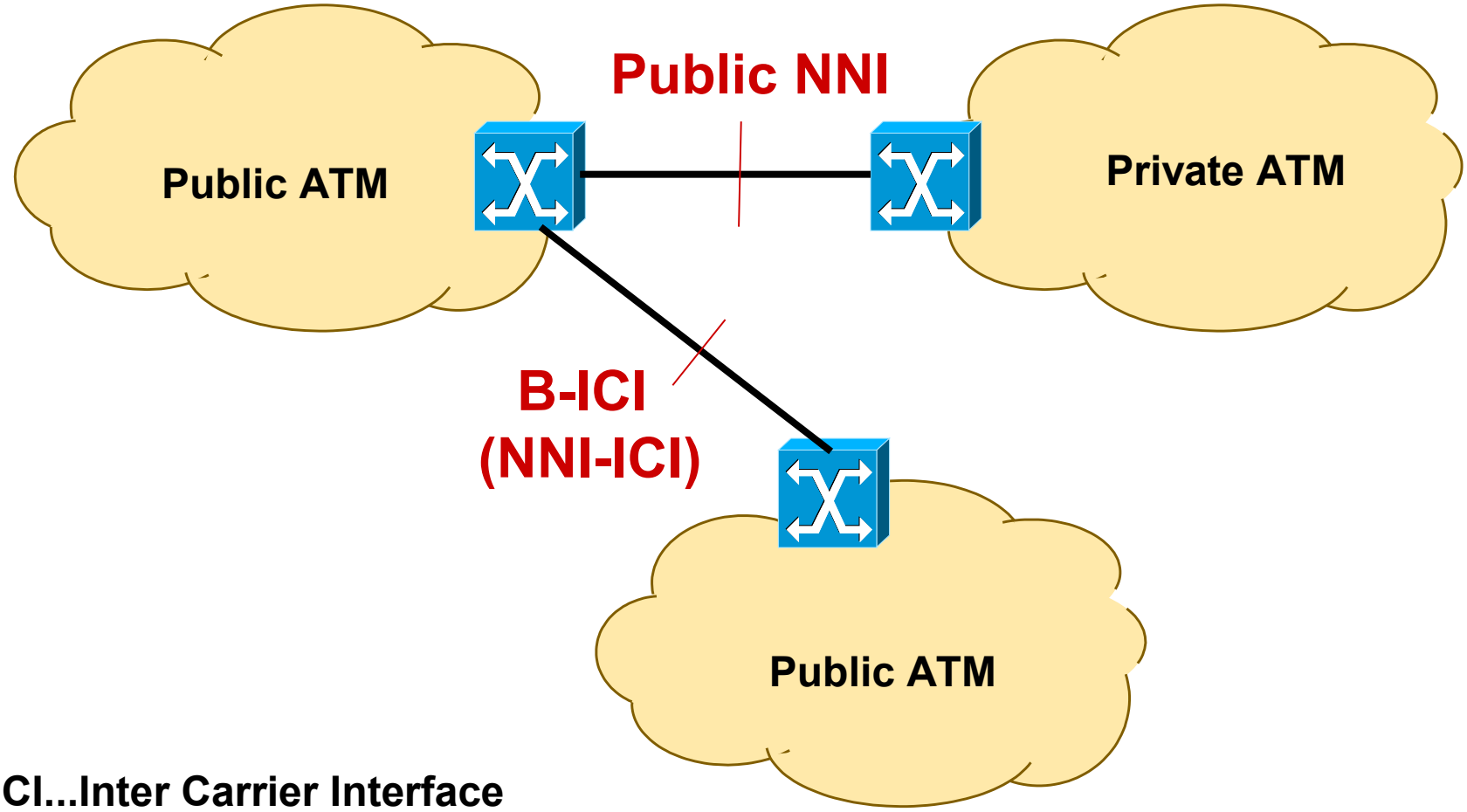
Who Did It?

- CCITT (now ITU-T) issued first recommendations for B-ISDN in 1988
  - Recommendation I.121
  - Aspects and Terms only
- Switch vendors founded ATM-Forum
  - To accelerate development
  - Majority rule instead of consensus
  - Also pushed ITU-T standardization

Public and Private Networks

- ITU-T: Public ATM Networks
  - Public UNI: E.164 addressing
  - Public NNI: Static routing
- ATM-Forum: Private ATM Networks
  - Private UNI: OSI NSAP like addressing
  - Private NNI: Dynamic routing (PNNI)

NNI Types



ICI...Inter Carrier Interface

What is B-ISDN?

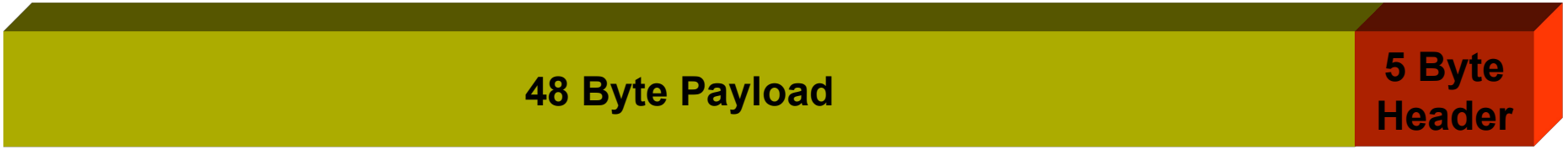
- ITU-T identified several demands
  - Emerging need for broadband services
  - High speed switching
  - Improved data- and image processing capabilites available to the user
  - Support for real-time services
  - Support for interactive services
  - Support for distribution services
  - Circuit and packet mode

ATM and B-ISDN

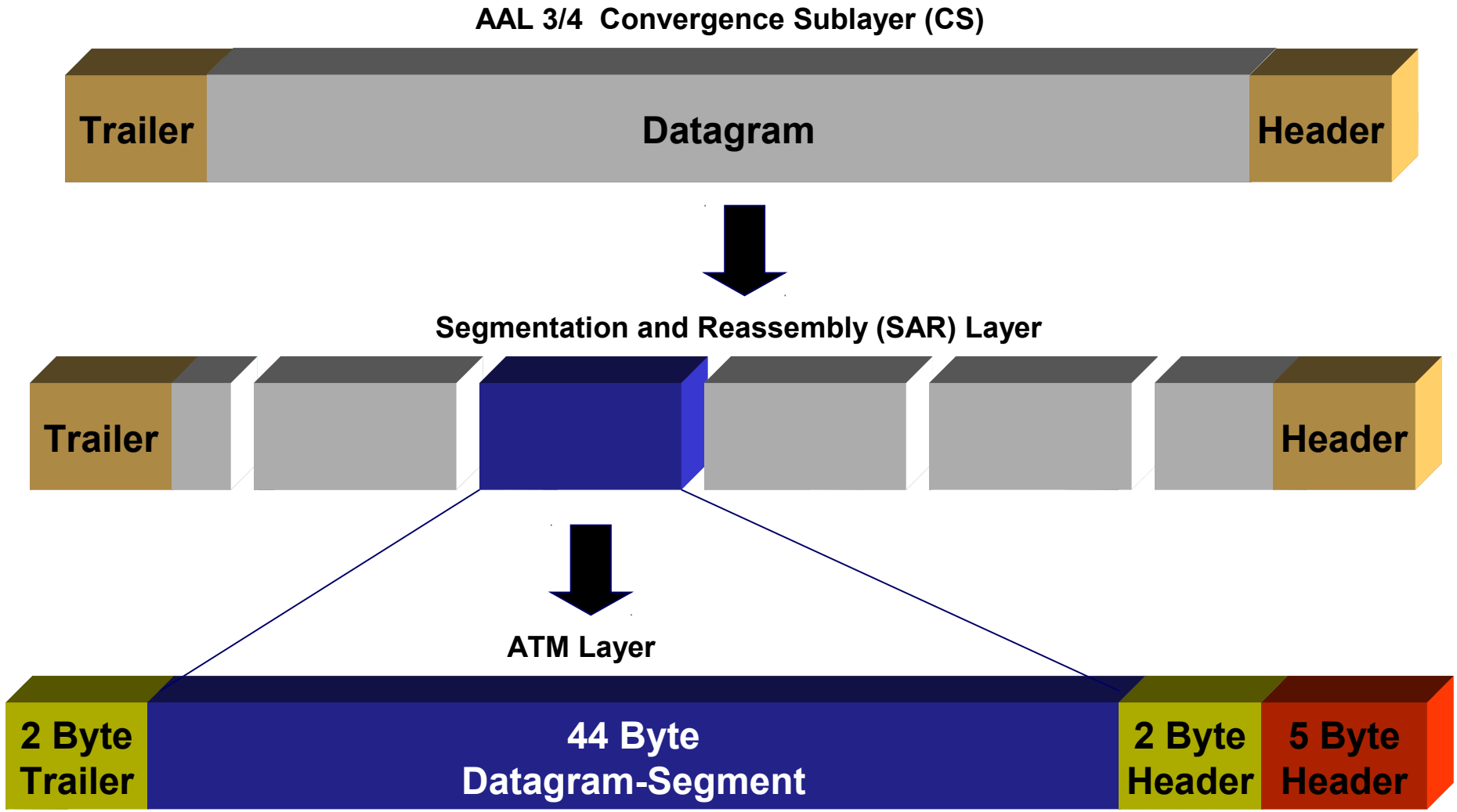
- B-ISDN are broadband (=highspeed) services for the user
- ATM to transport B-ISDN
- Alternatives to B-ISDN
  - IEEE 802.6 (DQDB) pushed by data communication industry (dying out)
  - Gigabit Ethernet (new)

The ATM Cell

- 53 Byte Cells
  - No technical reason
  - Agreement only
- The payload must be encapsulated within predefined AAL frames
  - Framing, Protection, etc

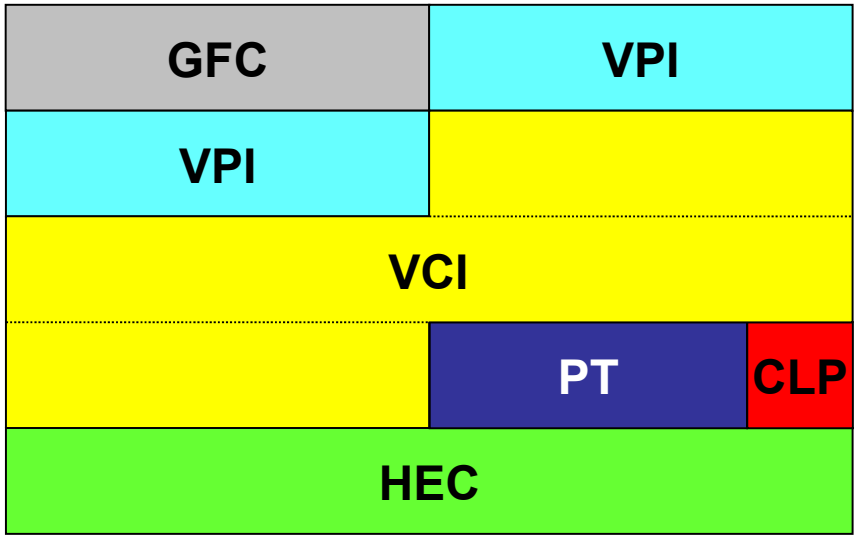


AAL 3/4 Framing Example



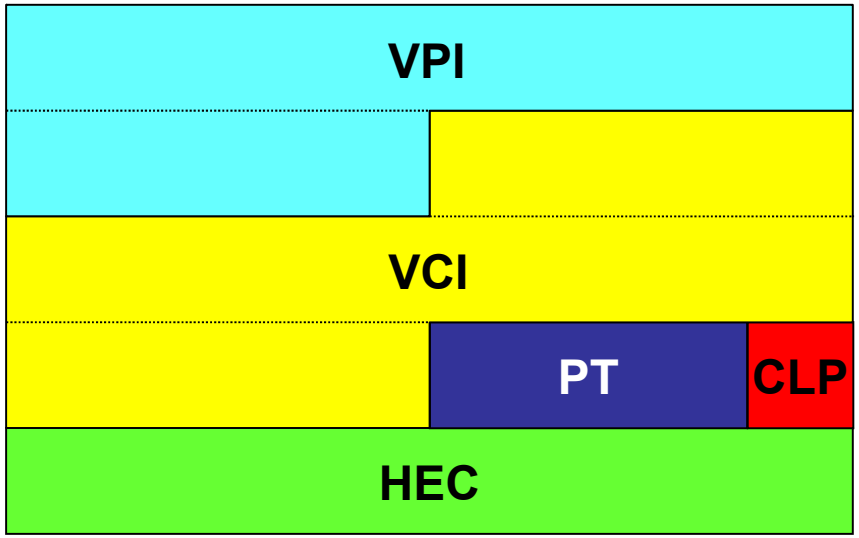
ATM Header

UNI Header



8 bit VPI for users

NNI Header



12 bit VPI inside the network

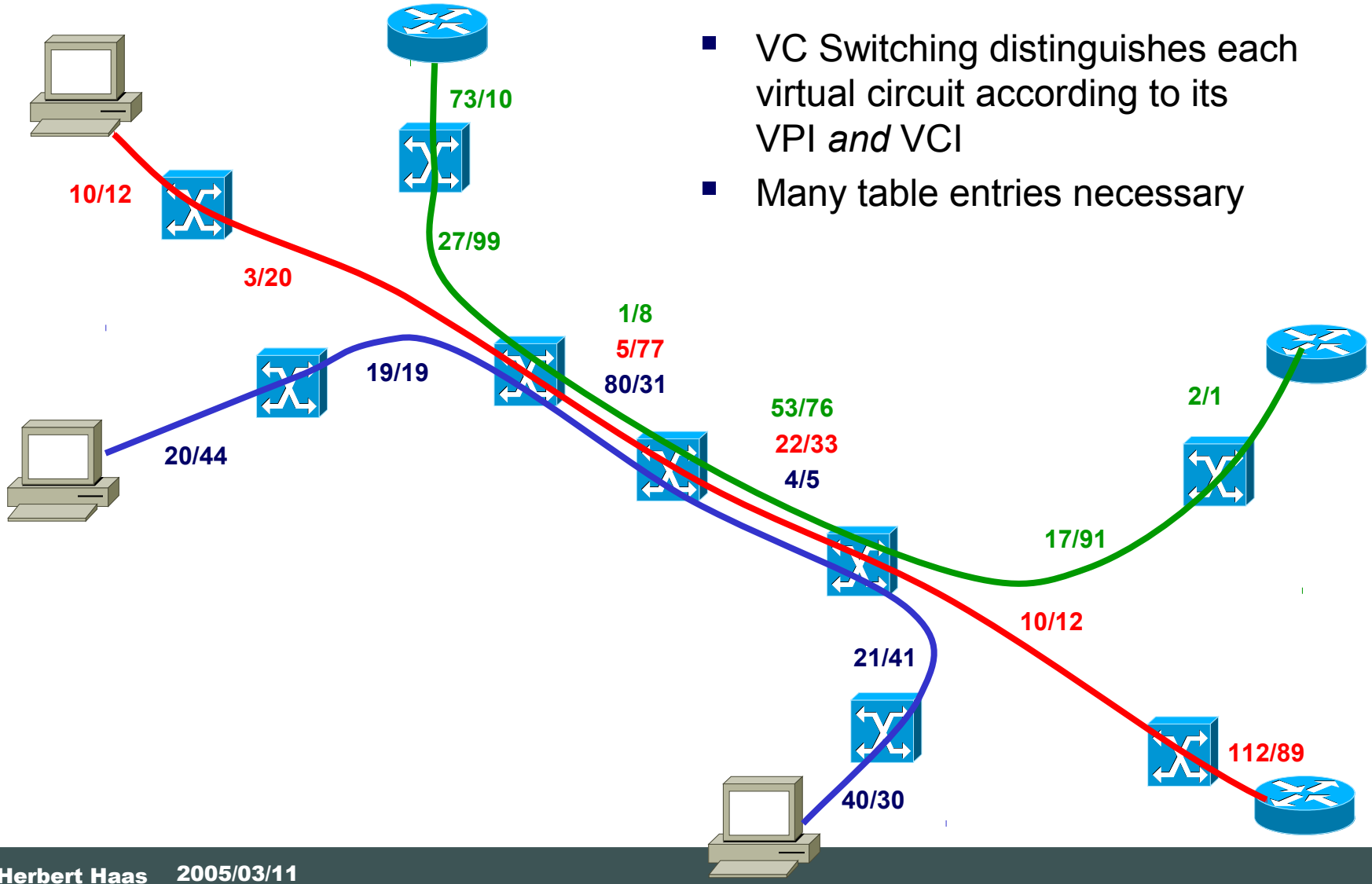
Payload Type

- 100 OAM F5 segment
- 101 OAM F5 end-to-end
- 110 Resource Management (RM)
- Also used by AAL5 to indicate end of block (EOB)
- Other combinations: user data

Header Fields

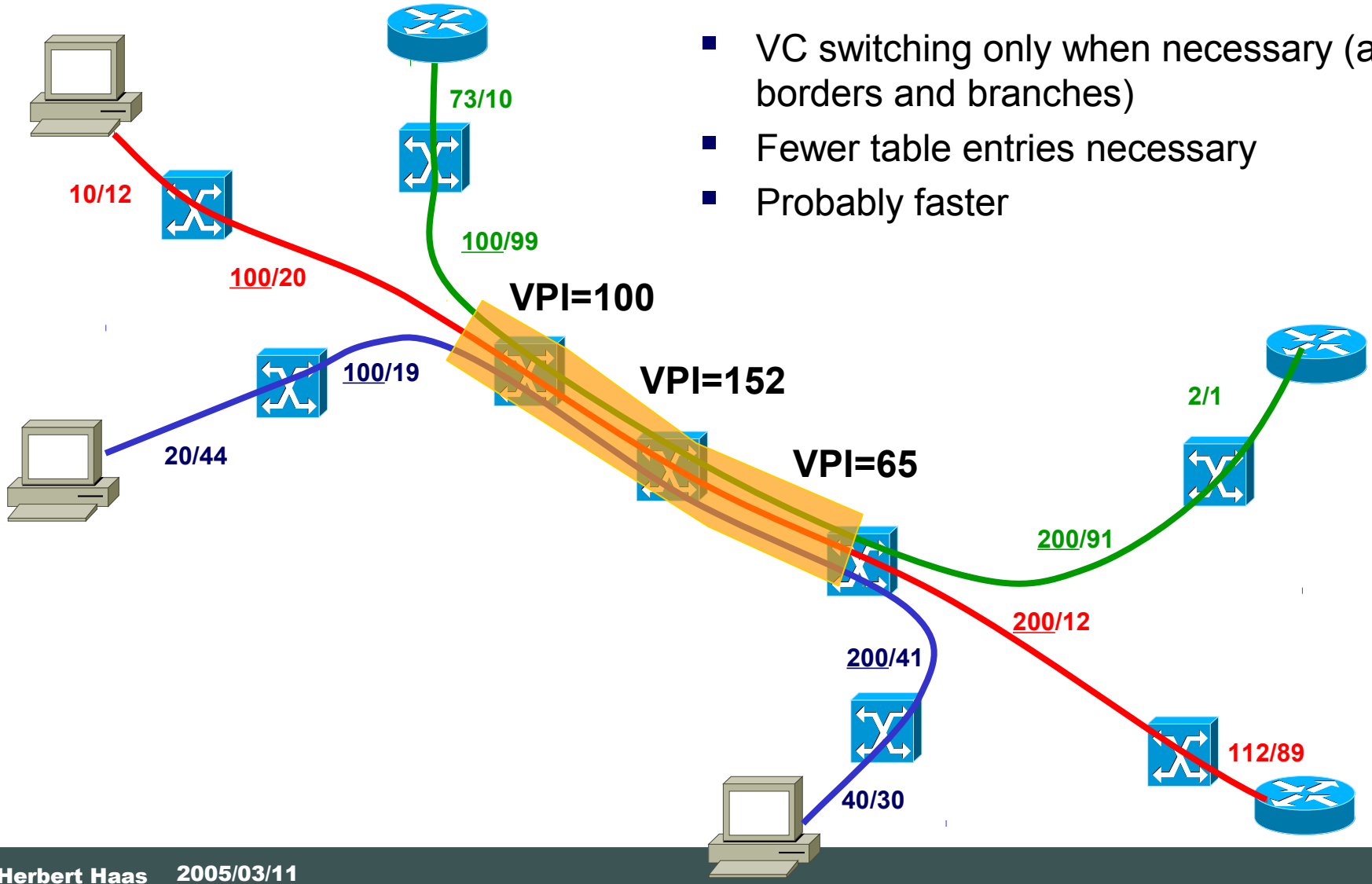
- Cell Loss Priority (CLP)
  - Similar to DE bit in Frame Relay
  - Identifies less important cells
- Header Error Check
  - CRC-8 to protect the header only
  - I 4.321: Used for cell delineation (6 successive hits necessary)

VC Switching



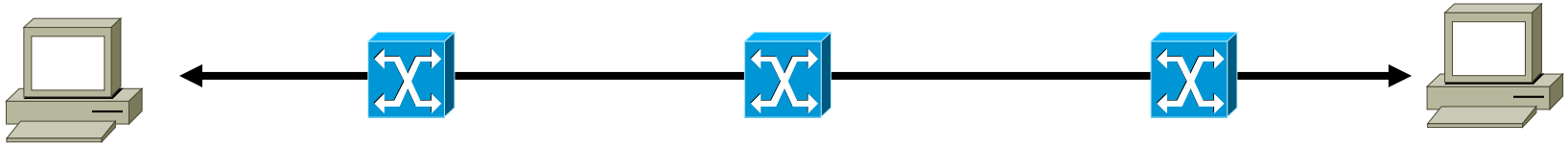
- VC Switching distinguishes each virtual circuit according to its VPI *and* VCI
- Many table entries necessary

VP and VC Switching

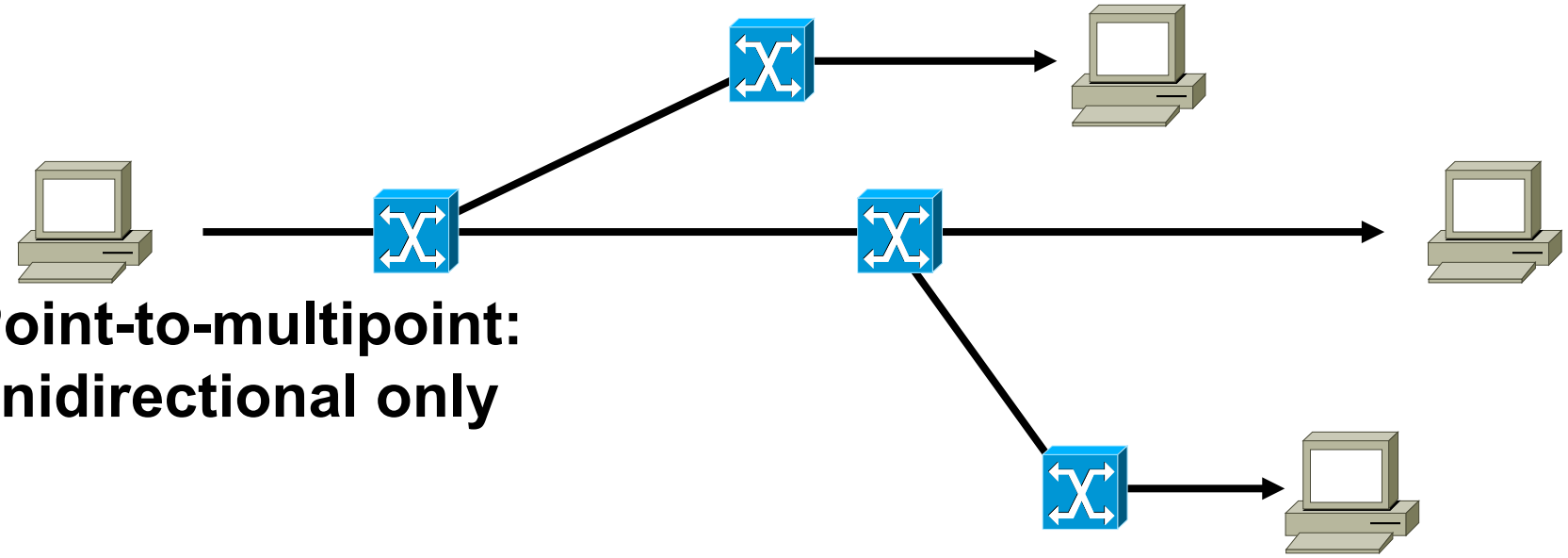


- VC switching only when necessary (at borders and branches)
- Fewer table entries necessary
- Probably faster

Connection Types

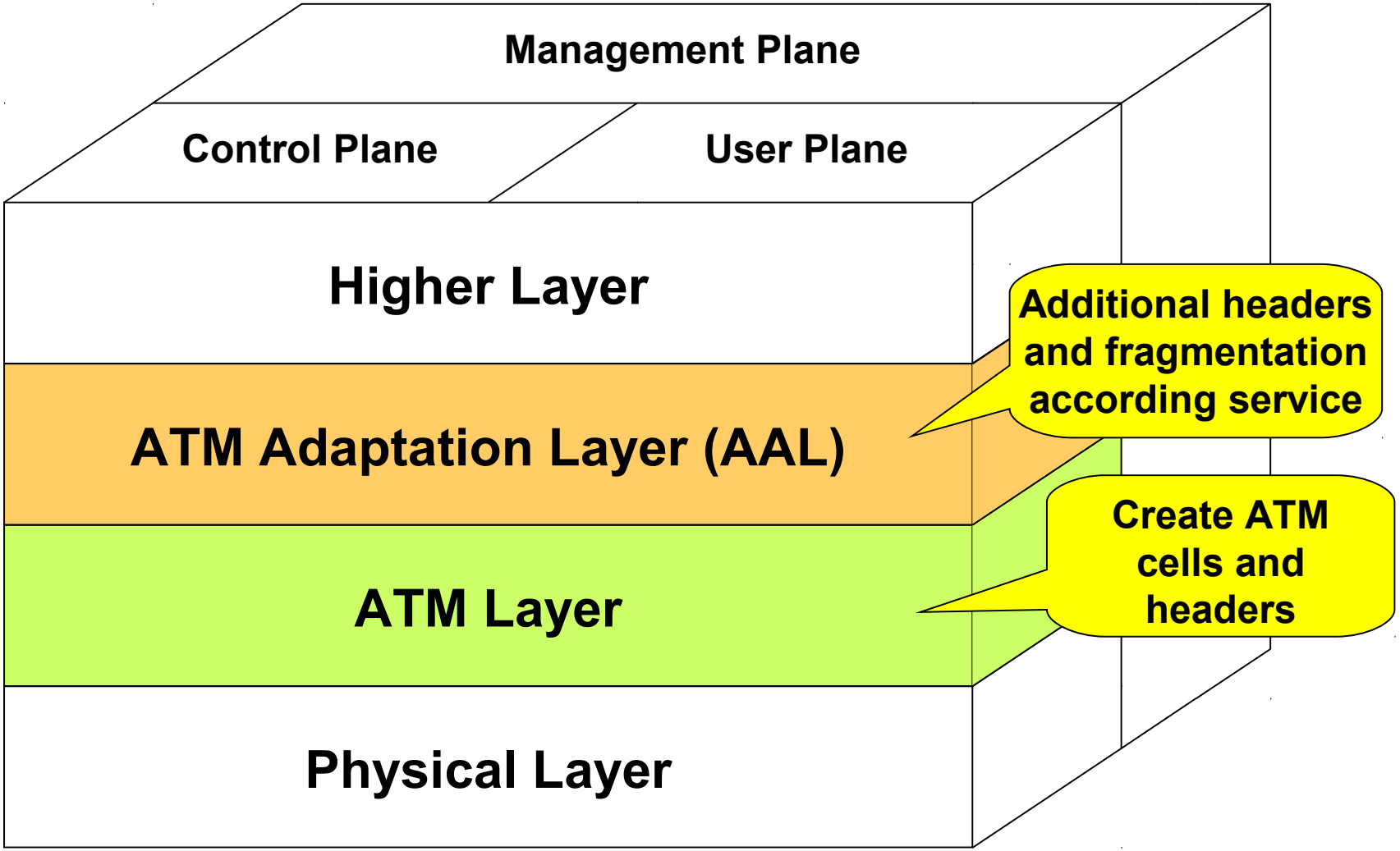


Point-to-point:
unidirectional or bidirectional

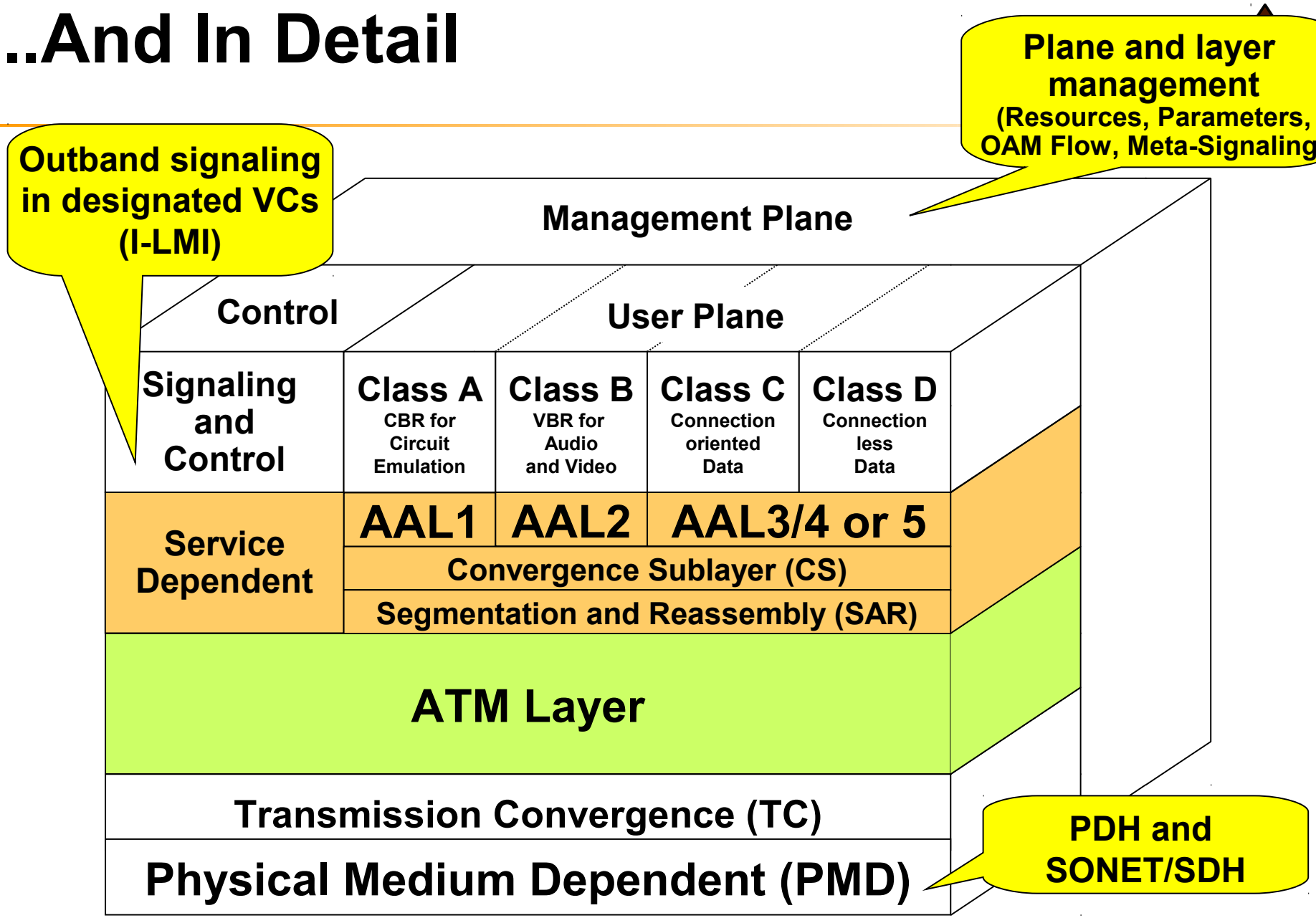


Point-to-multipoint:
unidirectional only

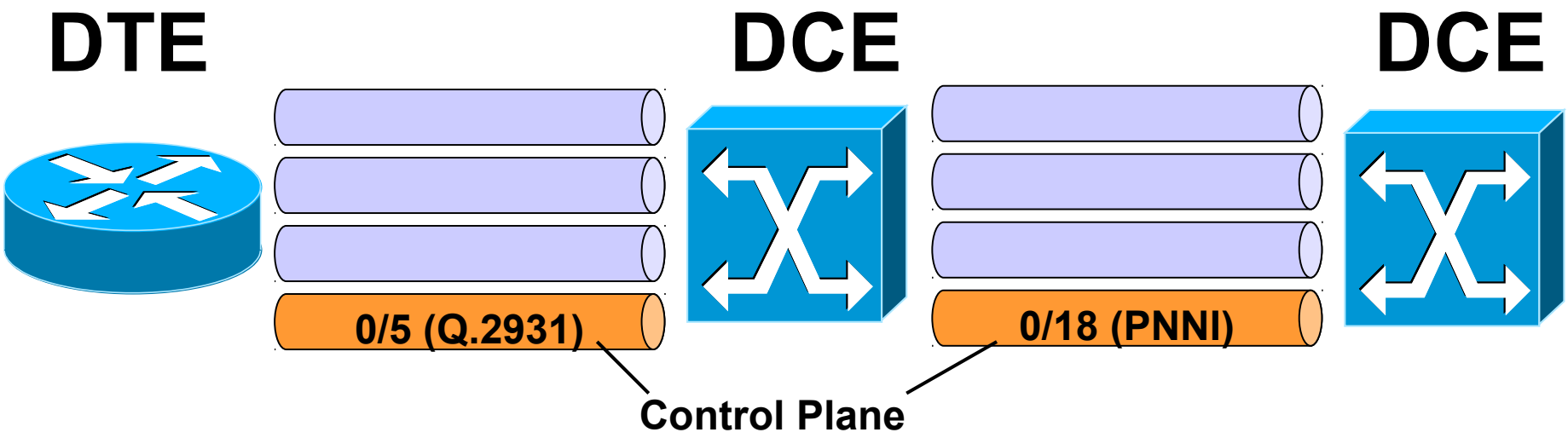
ATM Protocol Architecture



...And In Detail



Control Plane



- Signaling through dedicated virtual ciruit = "Outband Signaling"

Reserved Labels

VPI	VCI	Function
0	0- 15	ITU-T
0	16 - 31	ATM Forum
0	0	Idle Cell
0	3	Segment OAM Cell (F4)
0	4	End-to-End OAM Cell (F4)
0	5	Signaling
0	16	ILMI
0	17	LANE
0	18	PNNI

Physical Layer

- Transmission Convergence (TC) allows simple change of physical media
  - PDH, SDH, SONET
  - HEC and cell delineation
- Physical Medium Dependent (PMD) cares for (e. g.)
  - Line coding
  - Signal conversions

Interface Examples

Standard	Speed	Medium	Comments	Encoding	Connector	Usage
SDH STM-1	155,52	Coax	75 Ohm	CMI	BNC	WAN
PDH E4	139,264	Coax	75 Ohm	CMI	BNC	WAN
PDH DS3	44,736	Coax	75 Ohm	B3ZS	BNC	WAN
PDH E3	34,368	Coax	75 Ohm	HDB3	BNC	WAN
PDH E2	8,448	Coax	75 Ohm	HDB3	BNC	WAN
PDH J2	6,312	TP/Coax	110/75 Ohm	B6ZS/B8ZS	RJ45/BNC	WAN
PDH E1	2,048	TP/Coax	120/75 Ohm	HDB3	9pinD/BNC	WAN
PDH DS1	1,544	TP	100 Ohm	AMI/B8ZS	RJ45/RJ48	WAN
SDH STM-4	622,08	SM fiber		SDH	SC	LAN/WAN
SDH STM-1	155,52	SM fiber		SDH	ST	LAN/WAN
SDH STM-1	155,52	MM fiber	62,5 um	SDH	SC	LAN/WAN
SDH STM-4	622,08	SM fiber		NRZ	SC (ST)	LAN
SDH STM-4	622,08	MM (LED)		NRZ	SC (ST)	LAN
SDH STM-4	622,08	MM (Laser)		NRZ	SC (ST)	LAN
SDH STM-1	155,52	UTP5	100 Ohm	NRZI	RJ45	LAN
SDH STM1	155,52	STP (Type1)	150 Ohm	NRZI	9pinD	LAN
FIber Channel	155,52	MM fiber	62,5 um	8B/10B		LAN
TAXI	100	MM Fiber	62,5 um	4B/5B	MIC	LAN
SONET STS1	51,84	UTP3		NRZI	RJ45	LAN
ATM 25	25,6	UTP3		NRZI	RJ45	LAN

ATM Layer

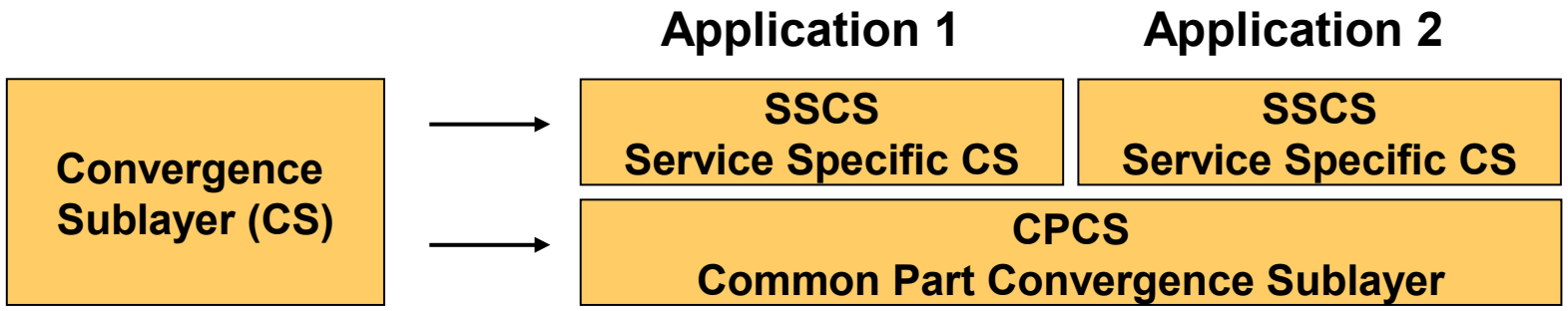
- Multiplexing and demultiplexing of cells according VPI/VCI
- Switching of cells
  - "Label swapping"
  - Note: origin of MPLS
- Error management: OAM cells
- Flow Control
- Qos negotiation and traffic shaping

Adaptation Layers

- ATM only provides bearer service
- ATM cannot be used directly
- Applications must use adaption layers to access the ATM layer
- Consist of SAR and CS
  - Part of DTEs only
  - Transparent for switches (DCEs)

Adaptation Sub-Layers

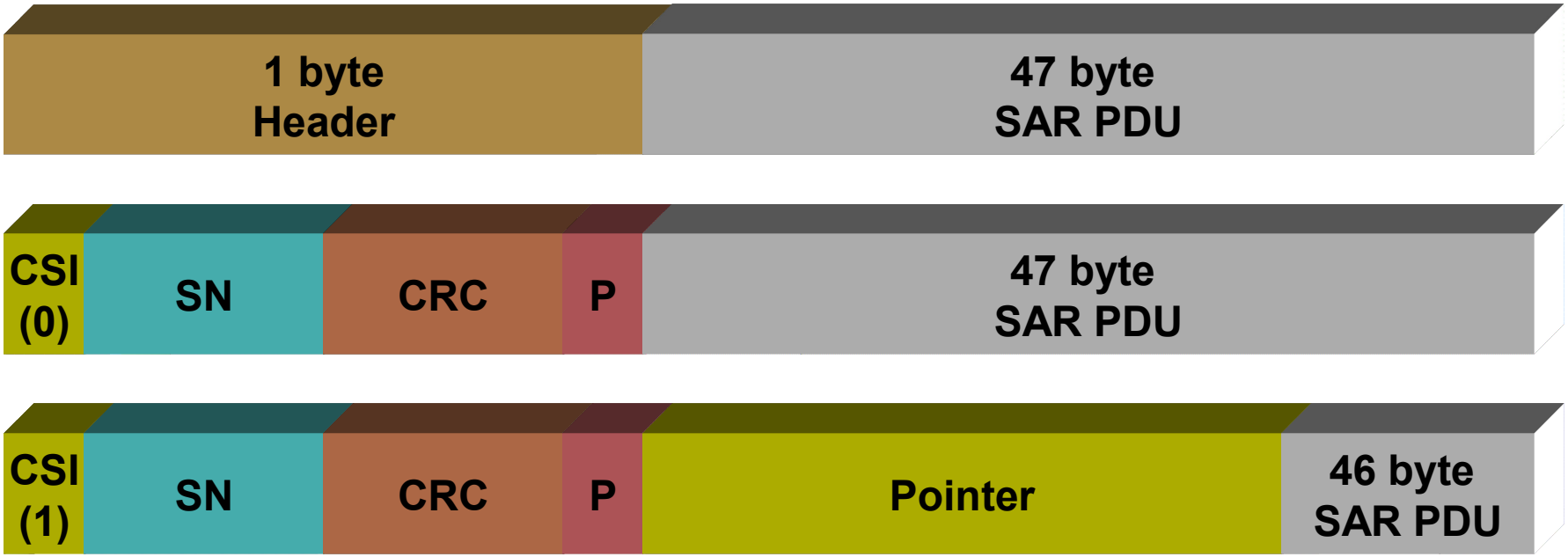
- Convergence Sublayer (CS)
  - Service dependent functions (clock recovery, message identification)
  - Adds special information (e. g. Frame Relay header)
- Segmentation and Reassembly (SAR)
  - You name it...



AAL1

- Constant Bit Rate (CBR)
- Circuit Emulation
- Expensive
  - Overprovisioning like leased line necessary
  - Queuing prefers AAL1 cells over all other traffic (in case of congestion)

AAL1



CSI …. Convergence Sublayer Indication (1 bit) – "1" if pointer exists
SN ….. Sequence Number (3 bits)
CRC ... Cyclic Redundancy Check (3 bits)
P ……. Parity (1 bit)

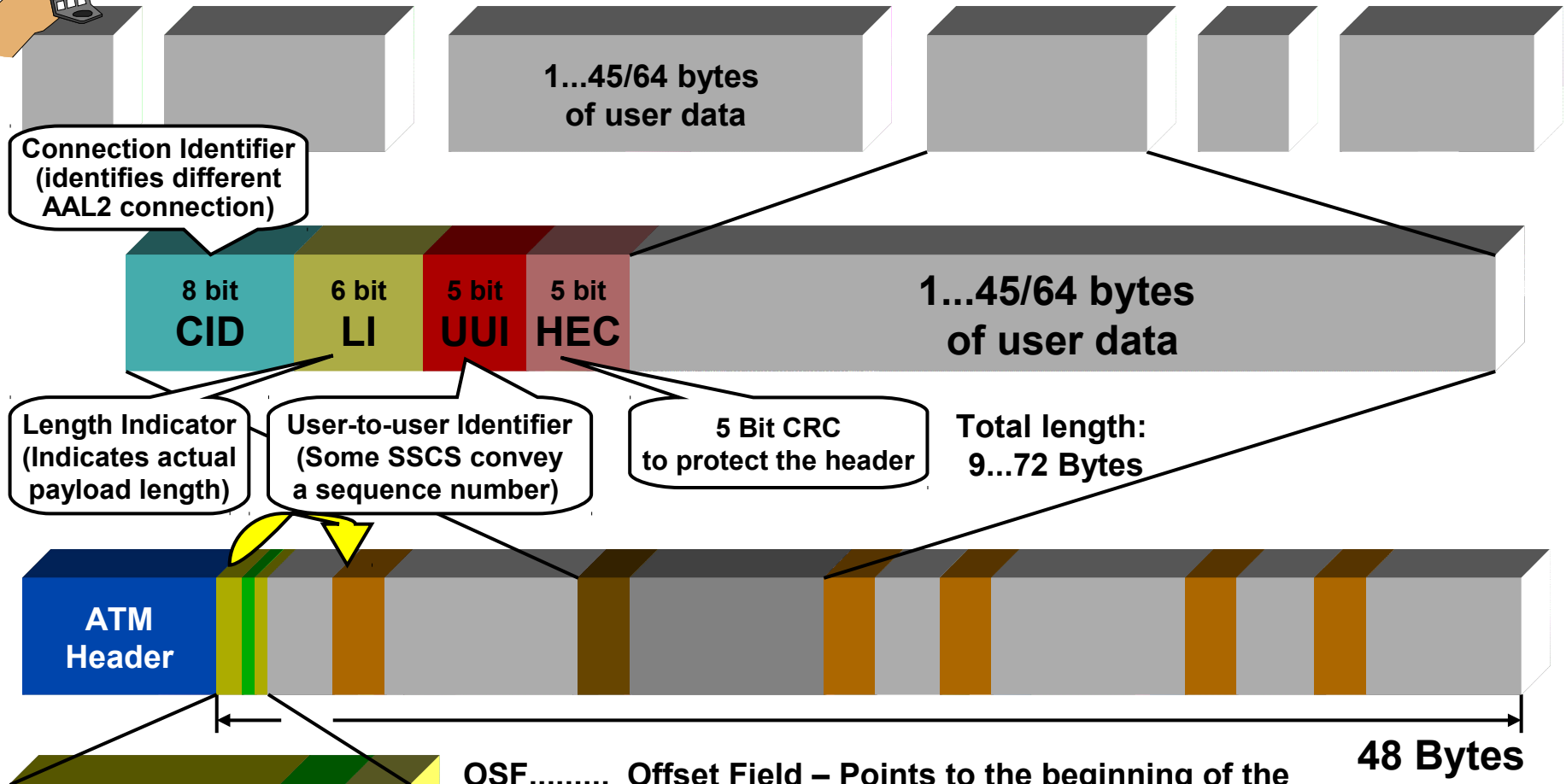
AAL2

- Analog applications that require timing informations but not CBR
  - Variable Bit Rate (VBR)
  - Compressed audio and video
- Relatively new (1997/98)
  - Original standard withdrawn and later reinvented for mobile systems

AAL2 for Mobile Systems

- Cellular communication issues
  - Packetization delay (→ QoS)
  - Bandwidth efficiency (→ Money)
- Before AAL2 low-bit rate real-time applications were used by "partial filling" of ATM cells
  - Using "AAL0" or AAL1
  - Very inefficient (few bytes per cell only)
- AAL2 is designed to be fast and efficient

AAL2 – CS



OSF..... Offset Field – Points to the beginning of the first AAL2 packet starting in this cell

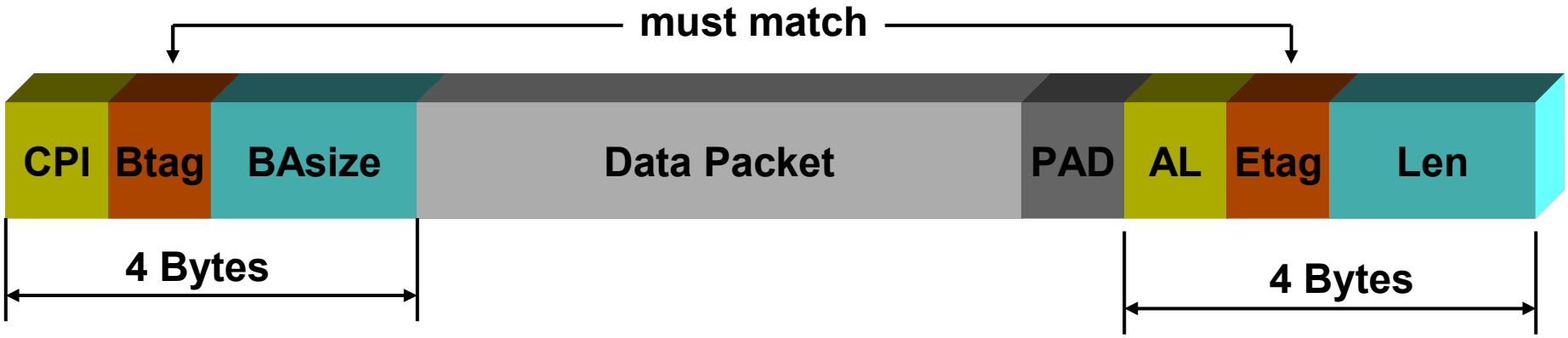
SN ..... Sequence Number

P ..... Parity

AAL3 + AAL4

- AAL3 designed to carry connection-oriented packets
  - Such as X.25 or Frame Relay
- AAL4 designed to carry connection-less datagrams
  - Such as IP or IPX
- Because of similarity both adaptation layers were combined to AAL3/4

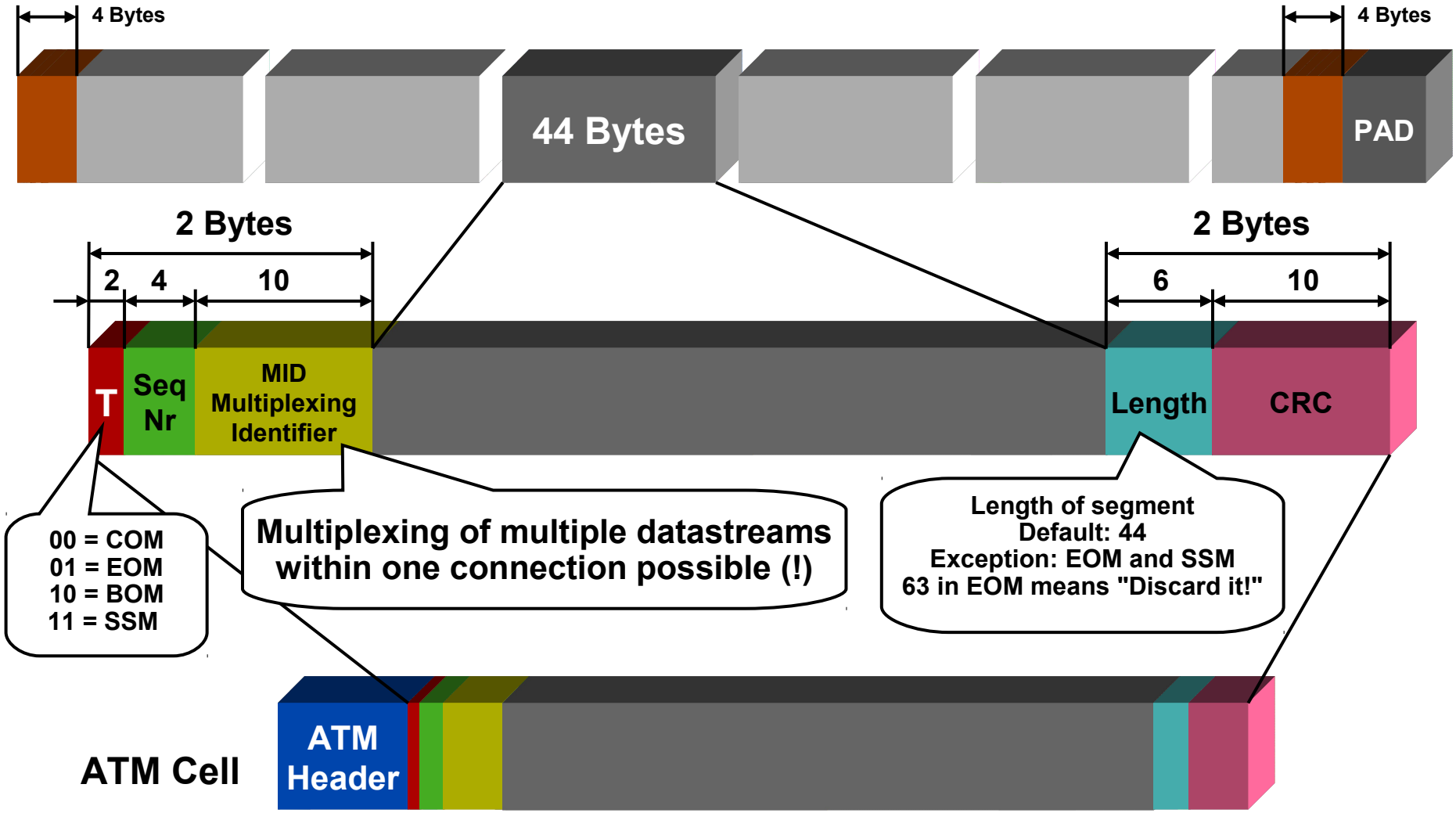
AAL3/4 – Step 1: CS



CPI ..... Common Part Indicator (1Byte)
Btag..... Beginning tag (1 Byte)
BAsize... Buffer allocation size (2 Bytes)

PAD..... for 32 bit alignment
AL..... Alignment (1 Byte)
Etag..... Ending tag (1 Byte) – must match Btag
Len ..... Length of SAR PDU

AAL3/4 – Step 2: SAR



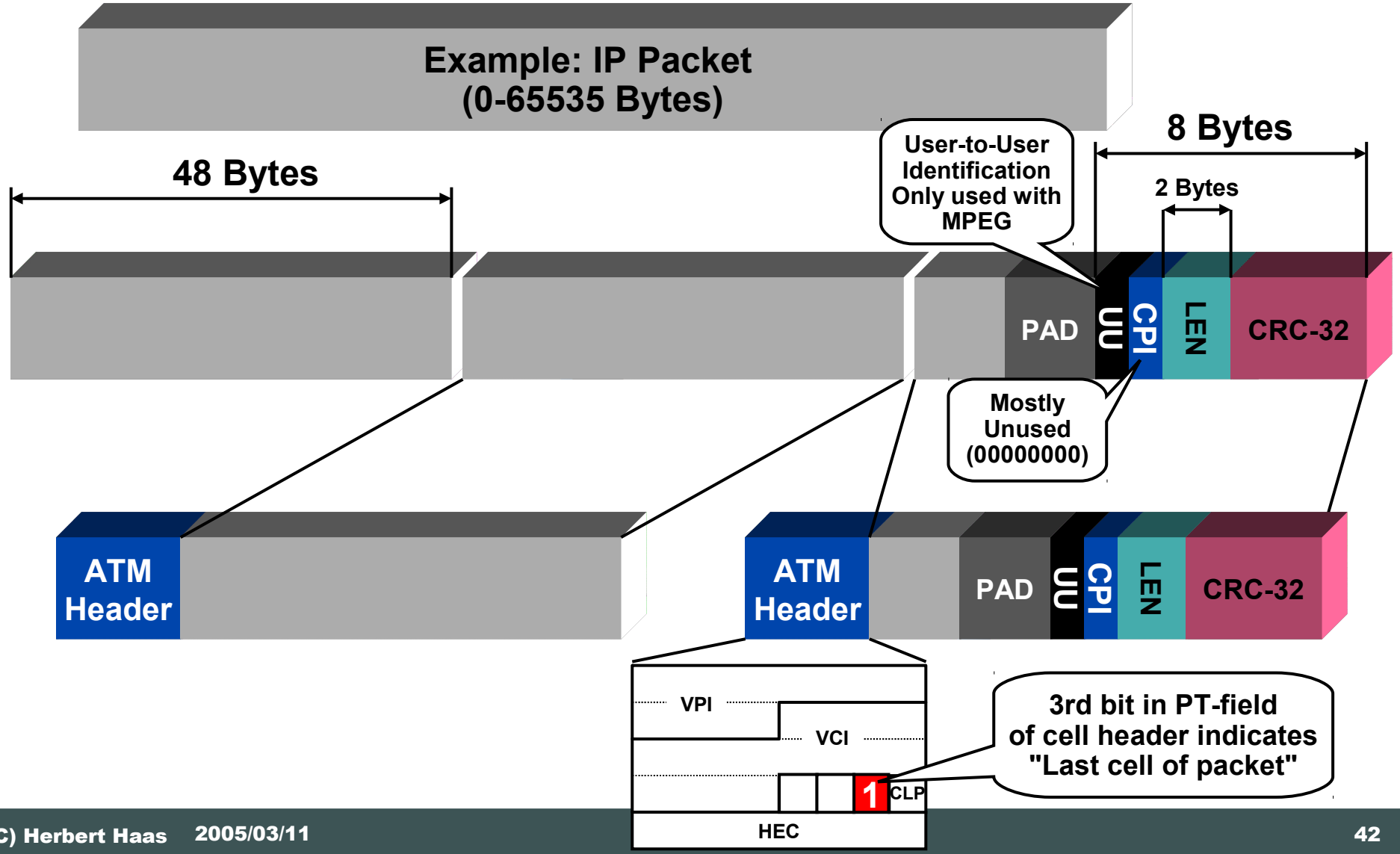
AAL3/4

- Can multiplex different streams of data on the same ATM connection
  - Up to 210 streams using the same VPI/VCI
- But too much overhead
  - Sequence numbers unnecessary when not interleaving
  - One CRC for whole packet would be sufficient
  - Length unnecessary
  - Nearly totally replaced by AAL5

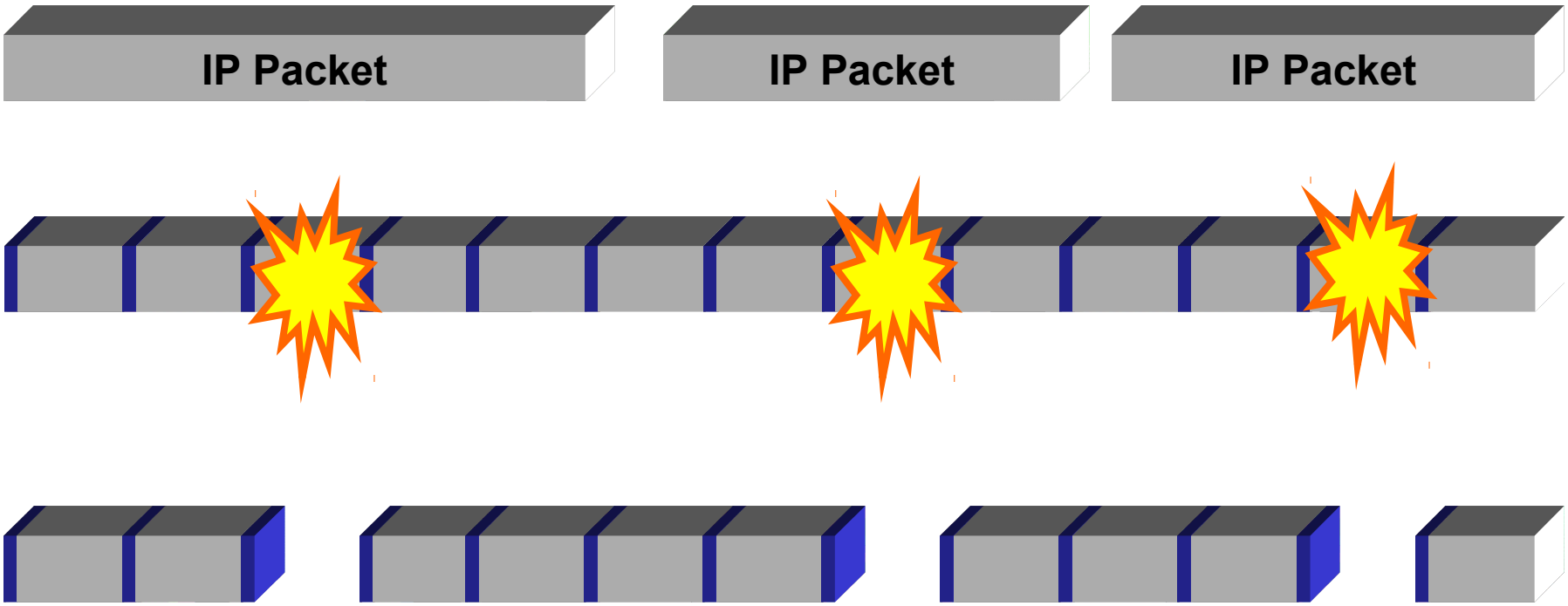
AAL5

- Favorite for data communication
  - AAL 5 simulates connectionless data interface
  - Allows simple migration to ATM
- Smallest overhead
  - Convergence Layer:
    8 byte trailer in last cell
  - SAR Layer:
    just marks EOM in ATM header (PT)

AAL5 Segmentation



Packets and Cell Loss (1)



Receiver can't recognize any IP packets !

Even a small bit error rate (BER) can lead to retransmission and congestion (!)

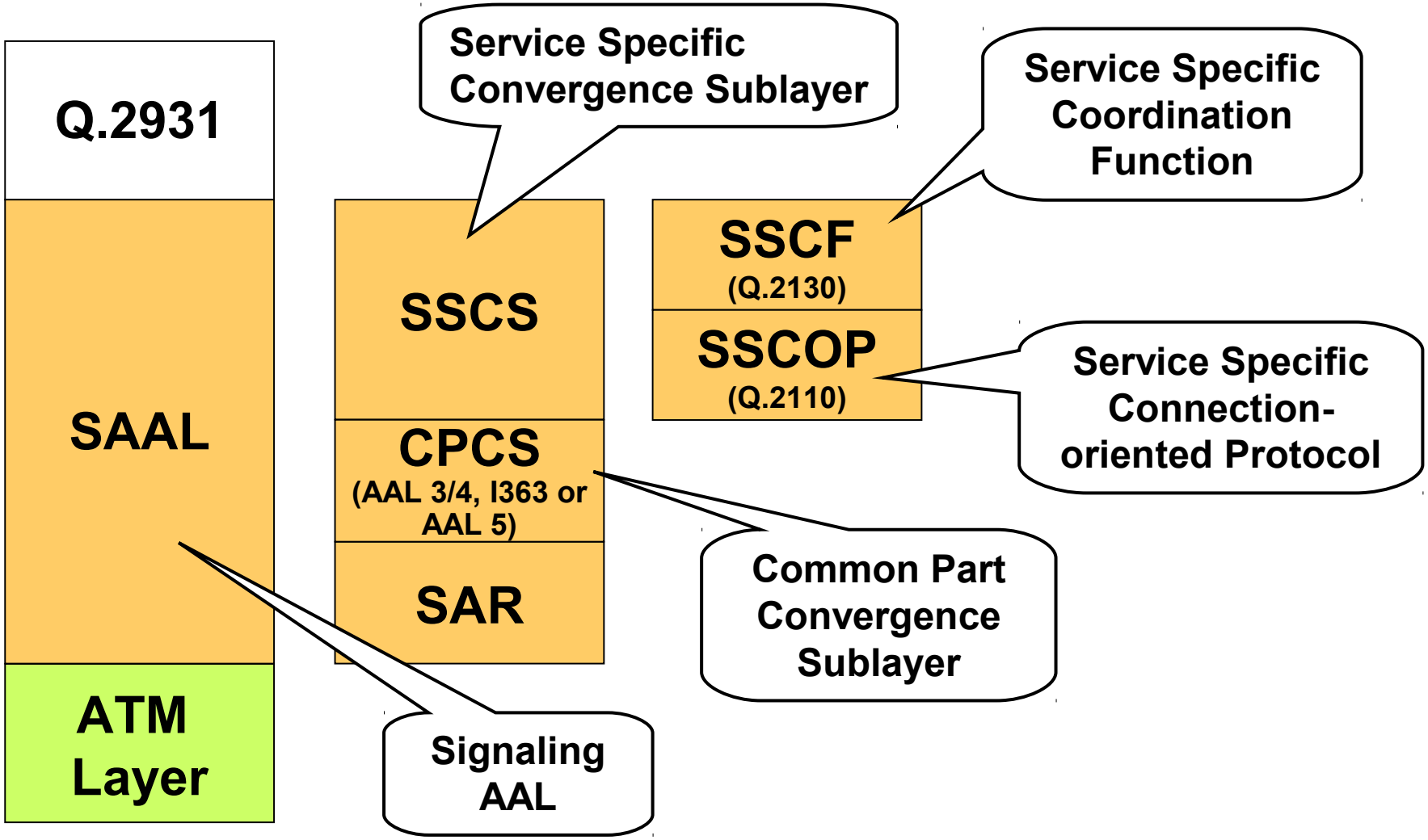
Packets and Cell Loss (2)

- Cells of damaged packets are still forwarded by ATM switches
  - Solution: Intelligent Tail Packet Discard or Early Packet Discard
- IP Routers can immediately drop whole packet
  - And recover queuing resources
  - So BER can be much higher (!)

Signaling

- ATM Forum UNI signaling specification
  - UNI 3.0, 3.1 and 4.0 standardized
    - UNI 2.0 PVC
    - UNI 3.0 PVC+SVC, CBR+VBR+UBR
    - UNI 4.0 +ABR, QoS Negotiation
- Based on ITU-T Q.2931 (B-ISDN)

Signaling Layers

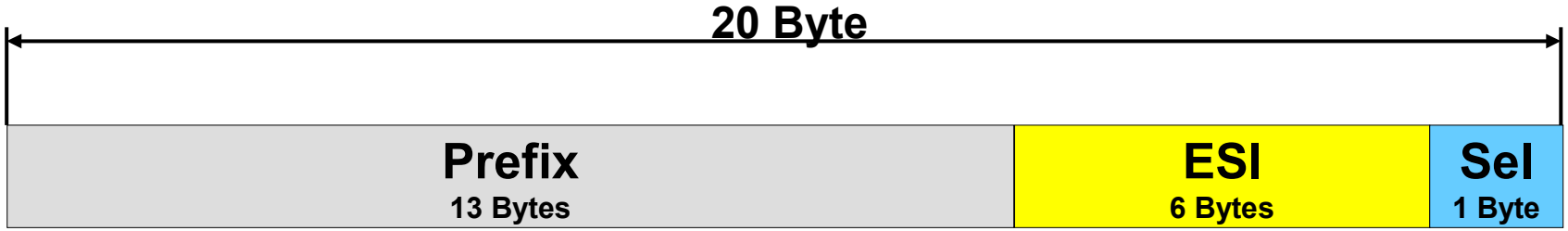


ATM Addresses

- ATM Forum defined three address-formats
  - ISO DCC NSAP format
  - ISO ICD NSAP format
  - E.164 Address format
- Only public networks may use E.164 address format
  - May also choose other formats

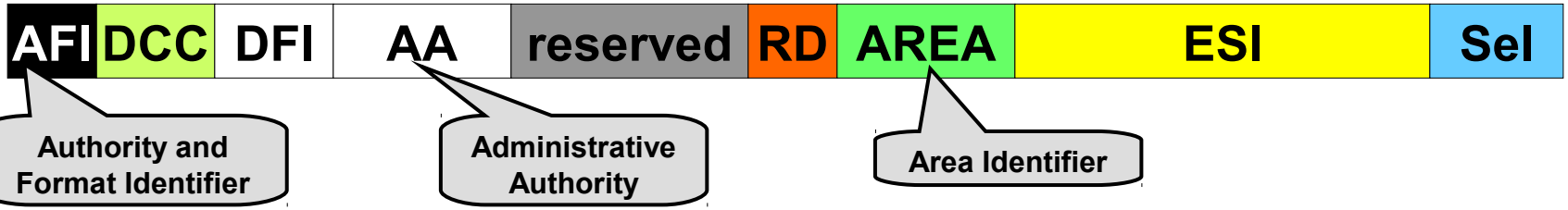
ATM Addresses

- Different types of ATM addresses
- All have 20 byte length
- All consist of three main parts
  - Prefix (Basically topology information)
  - End System Identifier (ESI)
  - NSAP Selector (Selects application)

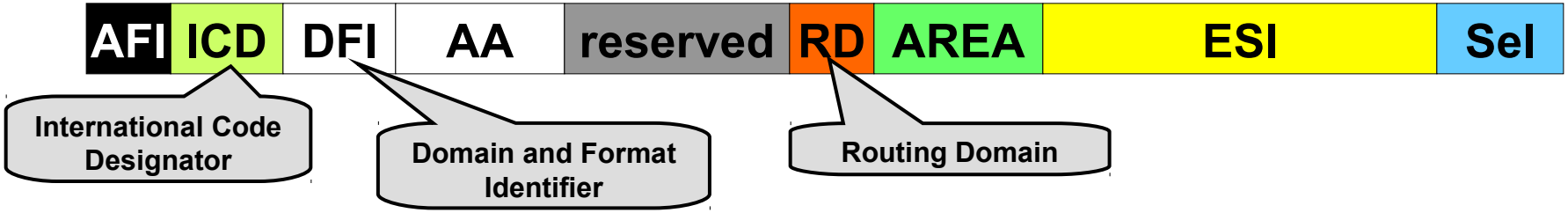


Address Flavours

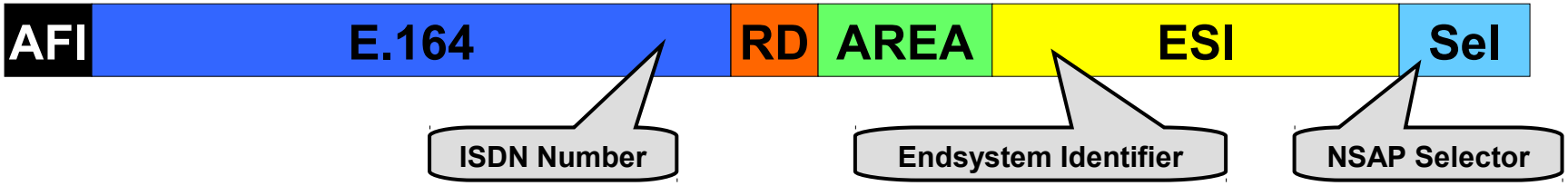
DCC ATM Address Format (AFI=39)



ICD ATM Address Format (AFI=47)



E.164 ATM Address Format (AFI=45)



Summary

- ATM is the solution for B-ISDN
  - Different broadband services upon common cell relay technology
- Remember: 53 bytes, 5 bytes Header
- Services via Adaptation Layers
  - AAL1, AAL2, AAL3/4, AAL5 (IP)
- Quality of Service
  - Details in other module
- VP and VC switching

Quiz

- Which framing is used with XDSL?
- What are the 4 ATM basic service types regarding QoS?
- ATM flow control is similar to...?
- Which concepts of ATM have been copied for IP networks?