

X.25

(packet switched data protocol/service/network)

- X.25 is a connection-oriented / connectionless protocol suitable for a PSPDN (Packet Switched Public Data Network)
- X.25 is "robust" but requires "heavy processing"
- X.25 involves OSI Layers 1 ... 3 in the network
- ITU-T (X-series Recommendations)

X.25 vs. Frame relay vs. ATM

X.25:

- ◆ Store & forward (L3 processing in network node)
- ◆ Low BW (64 kbit/s, 2 Mbit/s)

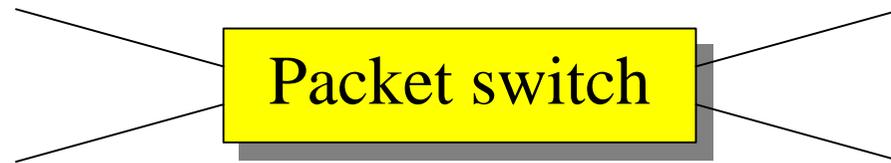
FR:

- ◆ Frame relaying (L2 processing in network node)
- ◆ Low to intermediate BW

ATM:

- ◆ Cell relaying (L2.5 processing in network node)
- ◆ High BW (typically 150 Mbit/s)

Store & forward switching vs. relaying



Layer 3 processing



Layer 2 processing only
(frame "relaying")

Connections in an X.25 network

In an X.25 network, there are the following three options:

- a) **Permanent Virtual Circuits (PVC)**, set up by the operator on a long-term contract basis
- b) **Switched Virtual Circuits (SVC) or virtual calls**, using setup/release type signaling (ITU-T X.25 L3)
- c) **Connectionless service** (using datagrams).

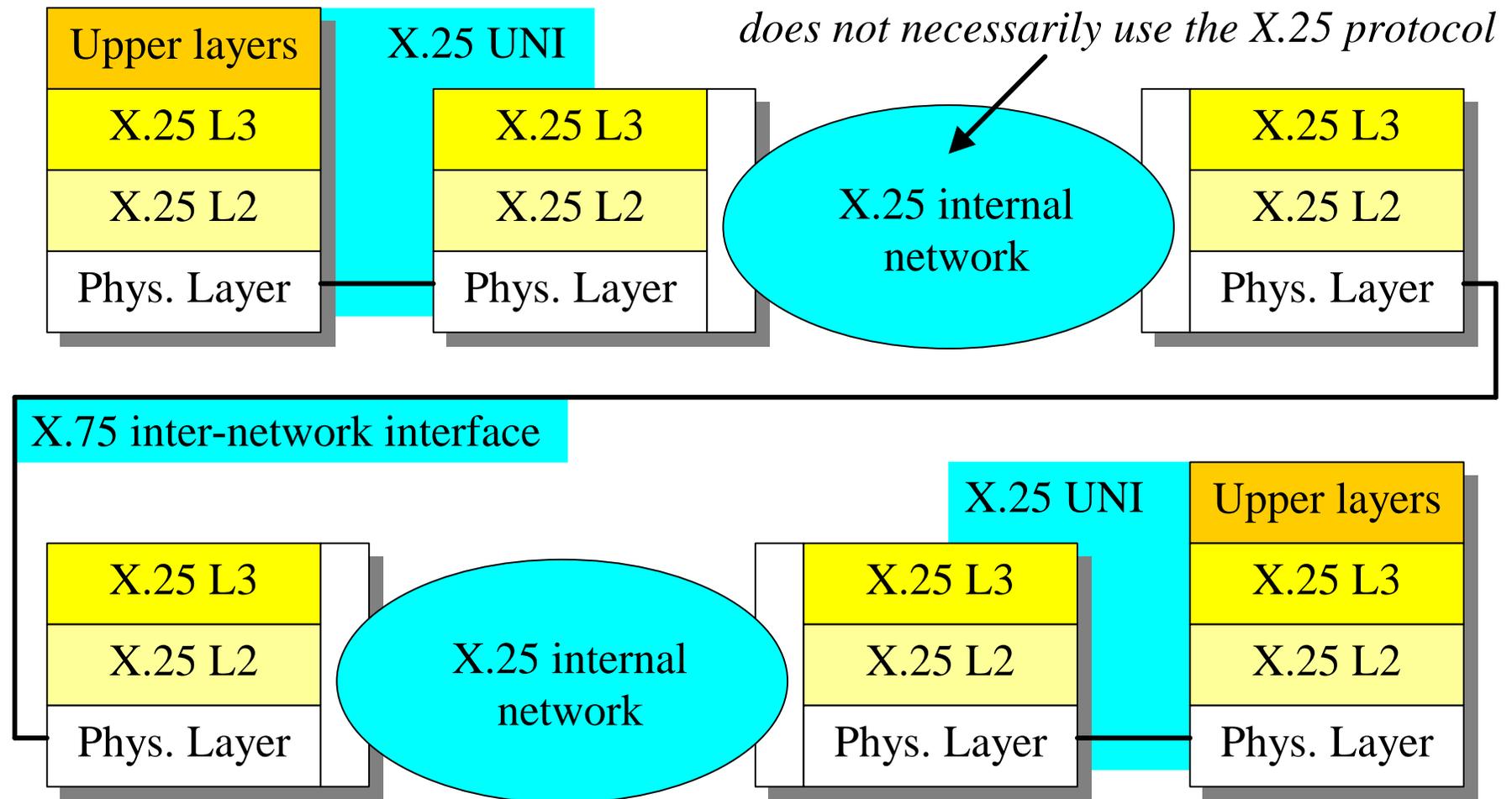
Options (a) and (b) are **connection-oriented**.

In case of option (b) or (c), the network numbering scheme is specified in **X.121**.

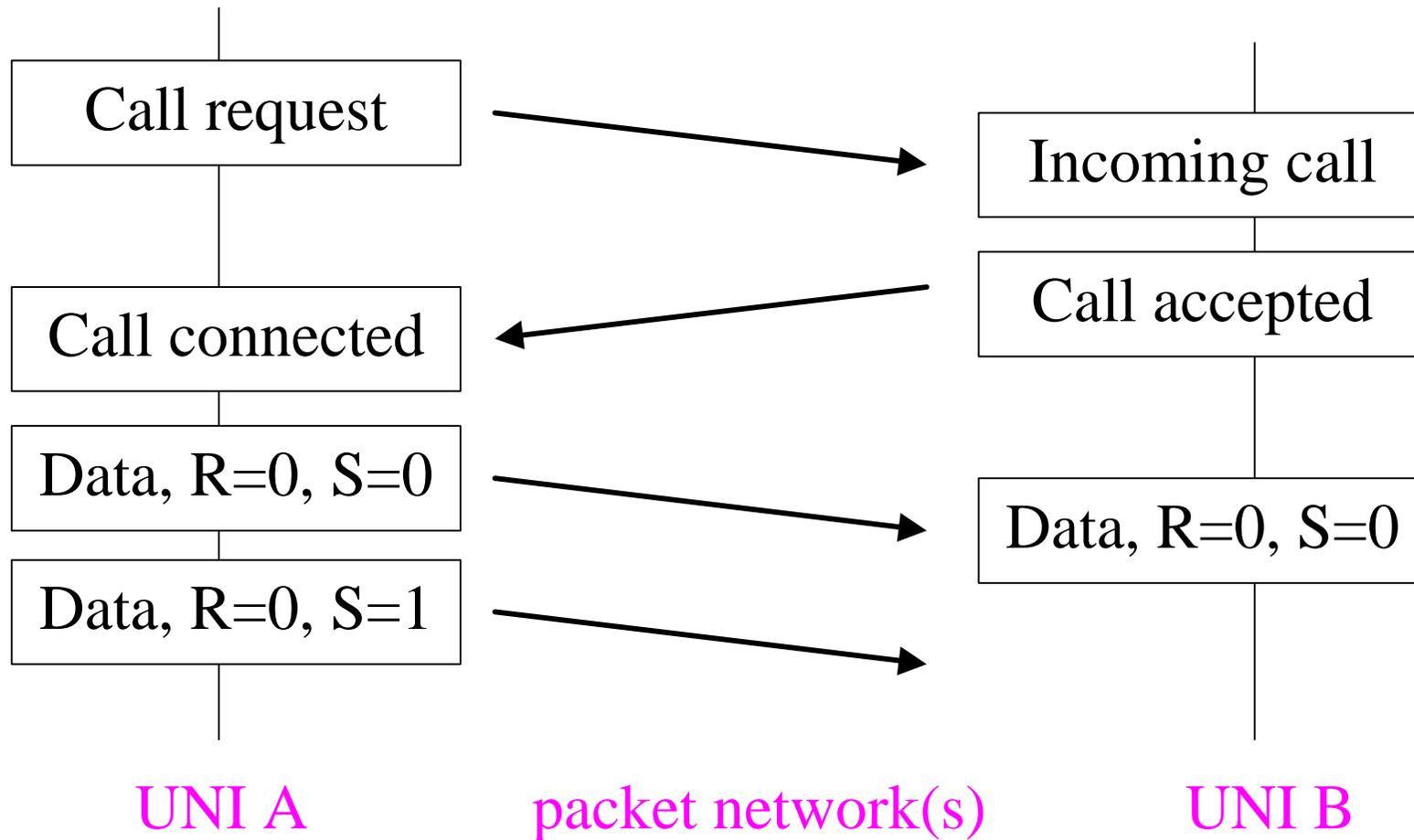
Characteristics of X.25

- Flow control and error control (frame retransmission) at Layer 2 using LAPB
- Flow control and error control (packet retransmission) also "on a link-to-link basis" at Layer 3
- In case of SVC, signaling messages in Layer 3
- Physical layer (Layer 1): X.21 or X.21bis
- X.25 non-compatible asynchronous terminals can be connected to a X.25 network via a PAD facility (packet assembly/disassembly facility) specified in X.3

X.25 protocol layers



X.25 virtual call example



Multiplexing over X.25 interface

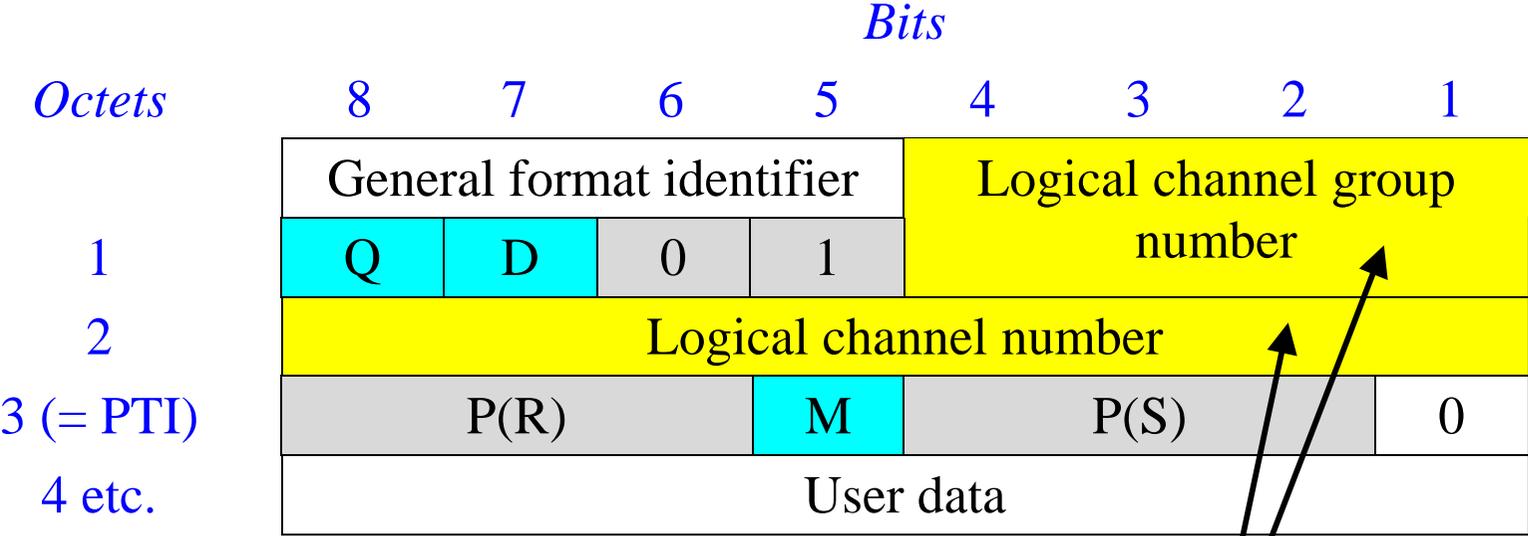
- 4095 virtual circuits can be used simultaneously over a X.25 interface
- 12 bit virtual circuit number (of local significance)
- individual virtual circuits correspond to applications, processes or terminals
- multiple destinations possible (more than one receiver at the same time)

Some examples of X.25 packets

<i>Packet type (a sample of > 20 packet types)</i>		<i>Service</i>	
From DCE to DTE	From DTE to DCE	VC	PVC
<i>Call set-up and clearing</i>			
Incoming call	Call request	X	
Call connected	Call accepted	X	
<i>Data</i>			
DCE data	DTE data	X	X
<i>Flow control and reset</i>			
DCE RR	DTE RR	X	X
Reset indication	Reset request	X	X

VC = virtual call (SVC), PVC = permanent virtual circuit

X.25 data packet format



identifies virtual circuit

- Q = qualifier bit
- D = delivery confirmation bit
- M = more data bit
- P(R) and P(S): modulo 128 or modulo 32768 also available

Some packet type identifiers (PTI)

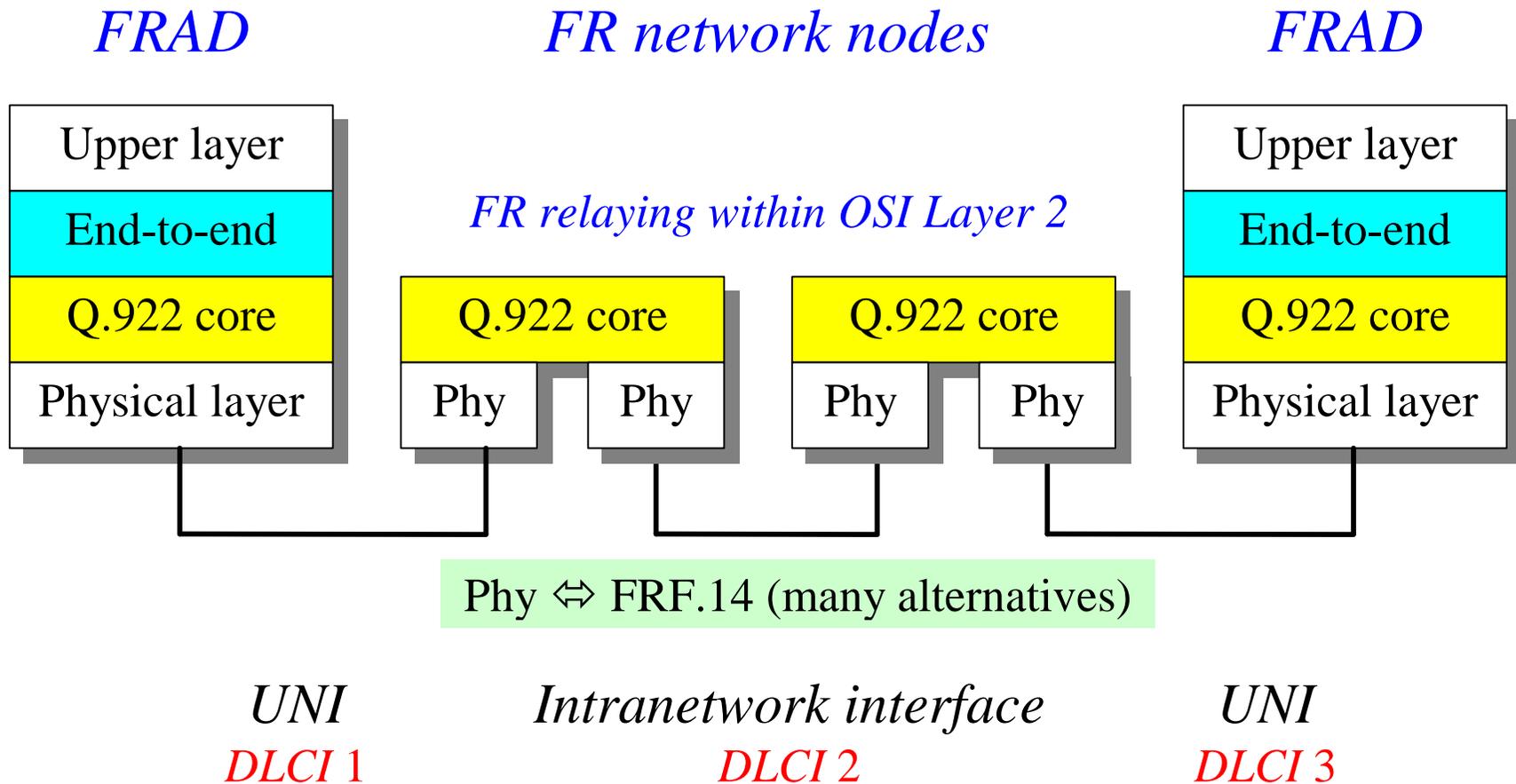
<i>Packet type</i>		<i>Bit position</i>							
From DCE to DTE	From DTE to DCE	8	7	6	5	4	3	2	1
<i>Call set-up and clearing</i>									
Incoming call	Call request	0	0	0	0	1	0	1	1
Call connected	Call accepted	0	0	0	0	1	1	1	1
<i>Data</i>									
DCE data	DTE data	X	X	X	X	X	X	X	0
<i>Flow control and reset</i>									
DCE RR	DTE RR	X	X	X	0	0	0	0	1
Reset indication	Reset request	0	0	0	1	1	0	1	1

Frame Relay (FR)

(frame relay protocol/service/network backbone)

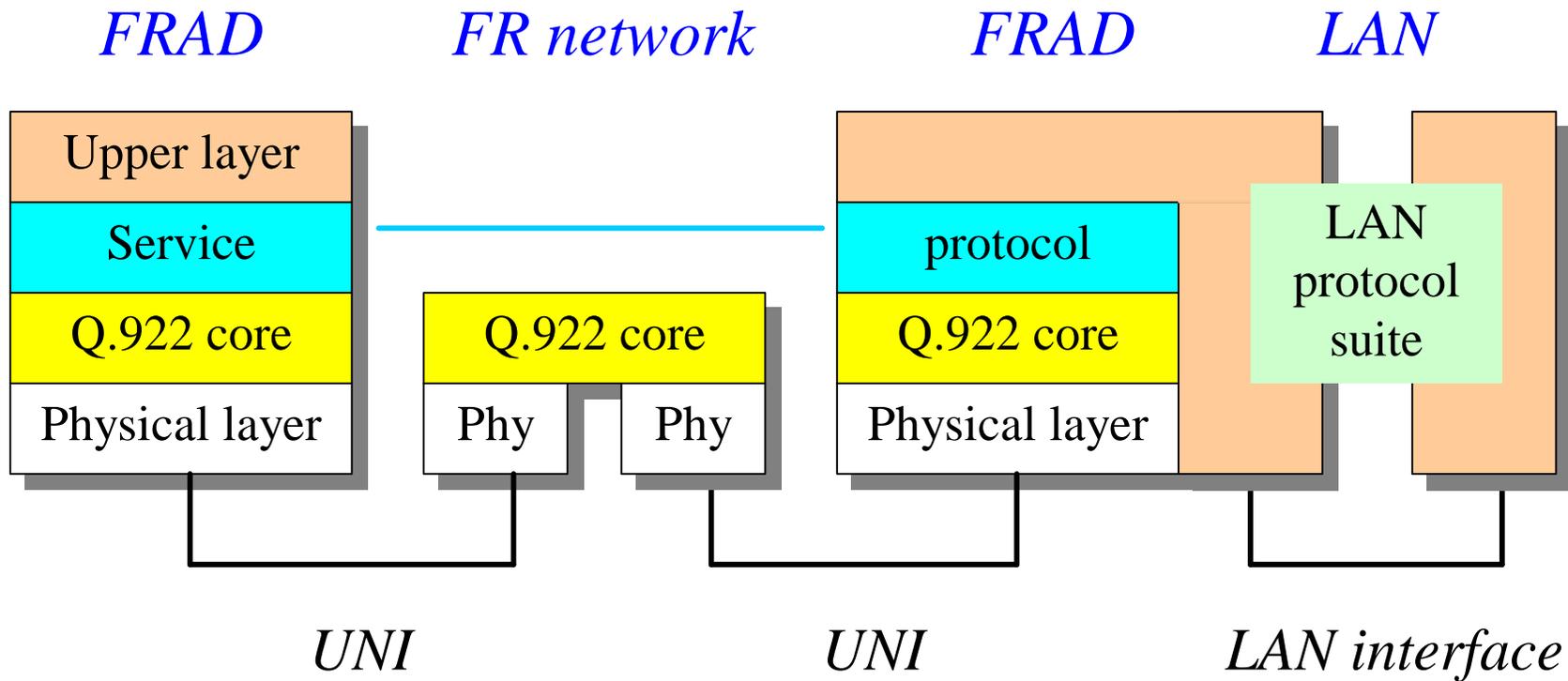
- FR is a connection-oriented protocol/service mainly used for interconnecting LANs
- FR requires "less heavy processing" than X.25 in the transmission network, **in fact**
- **FR only involves OSI Layers 1 ... 2 in the network**
- ITU-T (I and Q-series, e.g., I.233 and Q.922)
- Frame relay forum (www.frforum.com)

FR network connection



FR network interface

frame relay access device » frame relay compatible router



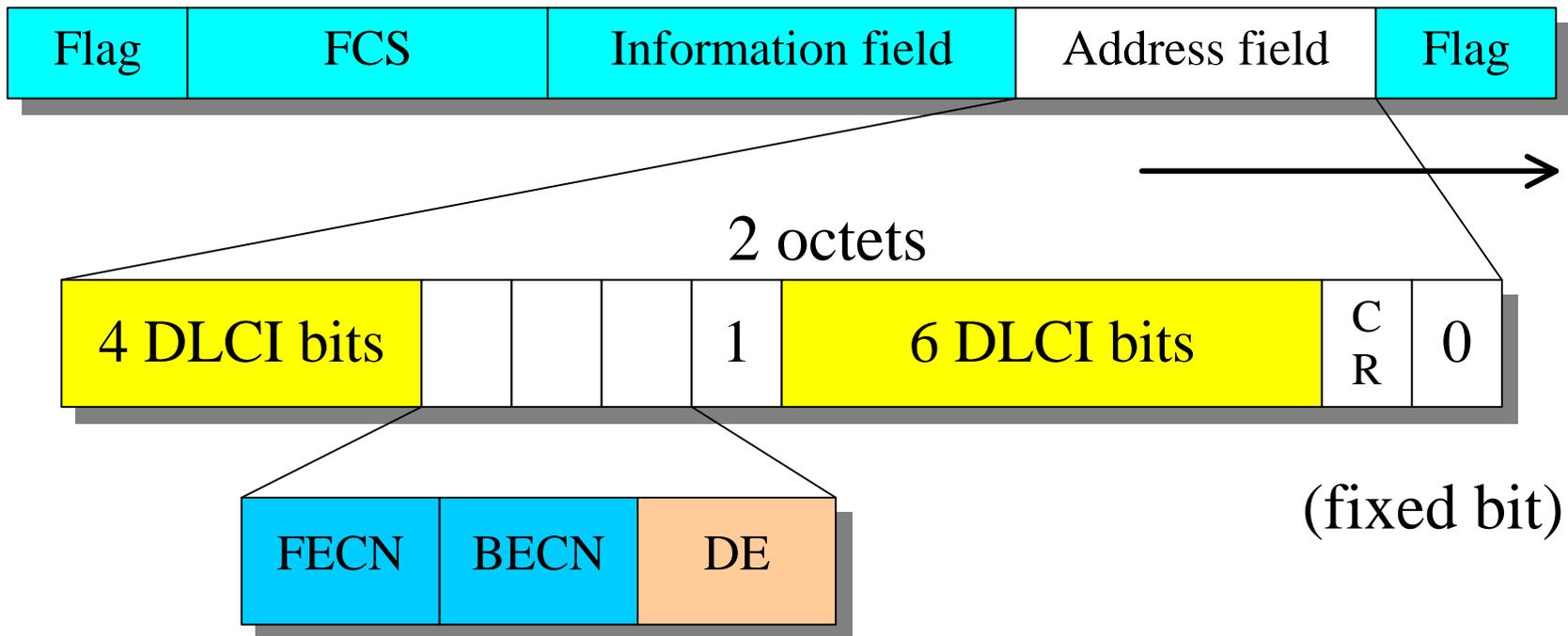
FR Service protocol

- Takes care of end-to-end protocol functions, thus only present in end devices (e.g., FRADs)
- FRAD = Frame Relay Access Device
- Standardized in ITU-T Q.922 ("Q.922 upper")
- LAPB (HDLC) -type flow control & error control (retransmission of error-containing frames)
- Flow control (or rather: congestion control) could make use of FECN/BECN provided by Q.922 core (some FRADs/routers/bridges can utilize this?)

FR Layer2 protocol (Q.922 core)

- Takes care of some Layer2 functions, and is employed in all FR network nodes
- Standardized in ITU-T Q.922 ("Q.922 core")
- No LAPB (HDLC) -type flow control & error control in intermediate network nodes!
- "Core functions" of Q.922 core:
 - frame assembly /disassembly
 - discarding of error-containing frames (FCS)
 - multiplexing and routing at Layer2 (DLCI)
 - elementary traffic management possible

FR frame format

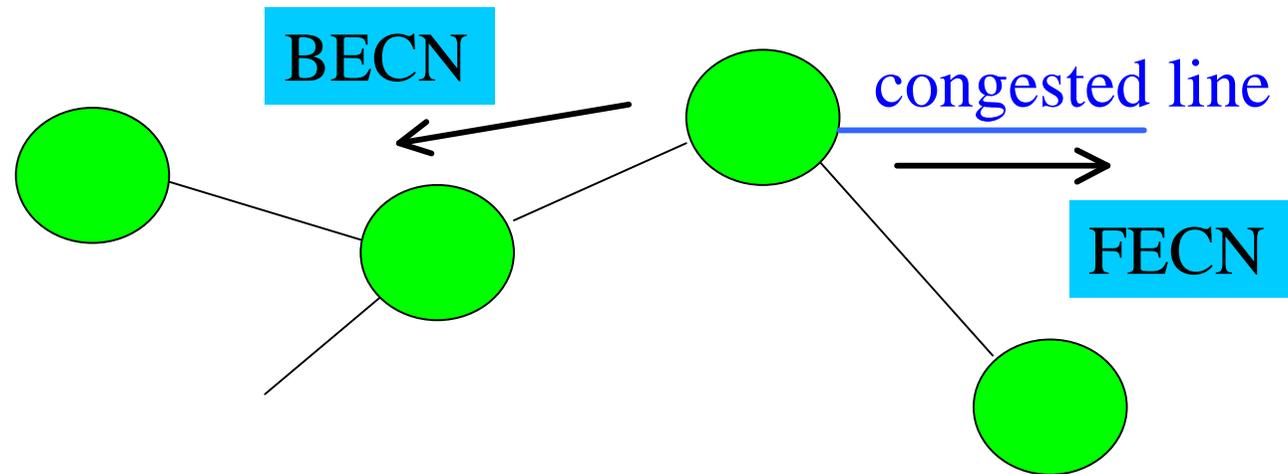


congestion avoidance

congestion recovery

FR traffic control

BECN / FECN:



DE: if set => discard first in case of congestion

CIR *committed information rate* agreed in advance (PVC)

FR traffic control

Committed information rate:

$CIR = B_c / T_c = \text{committed burst size} / \text{time interval } T_c$

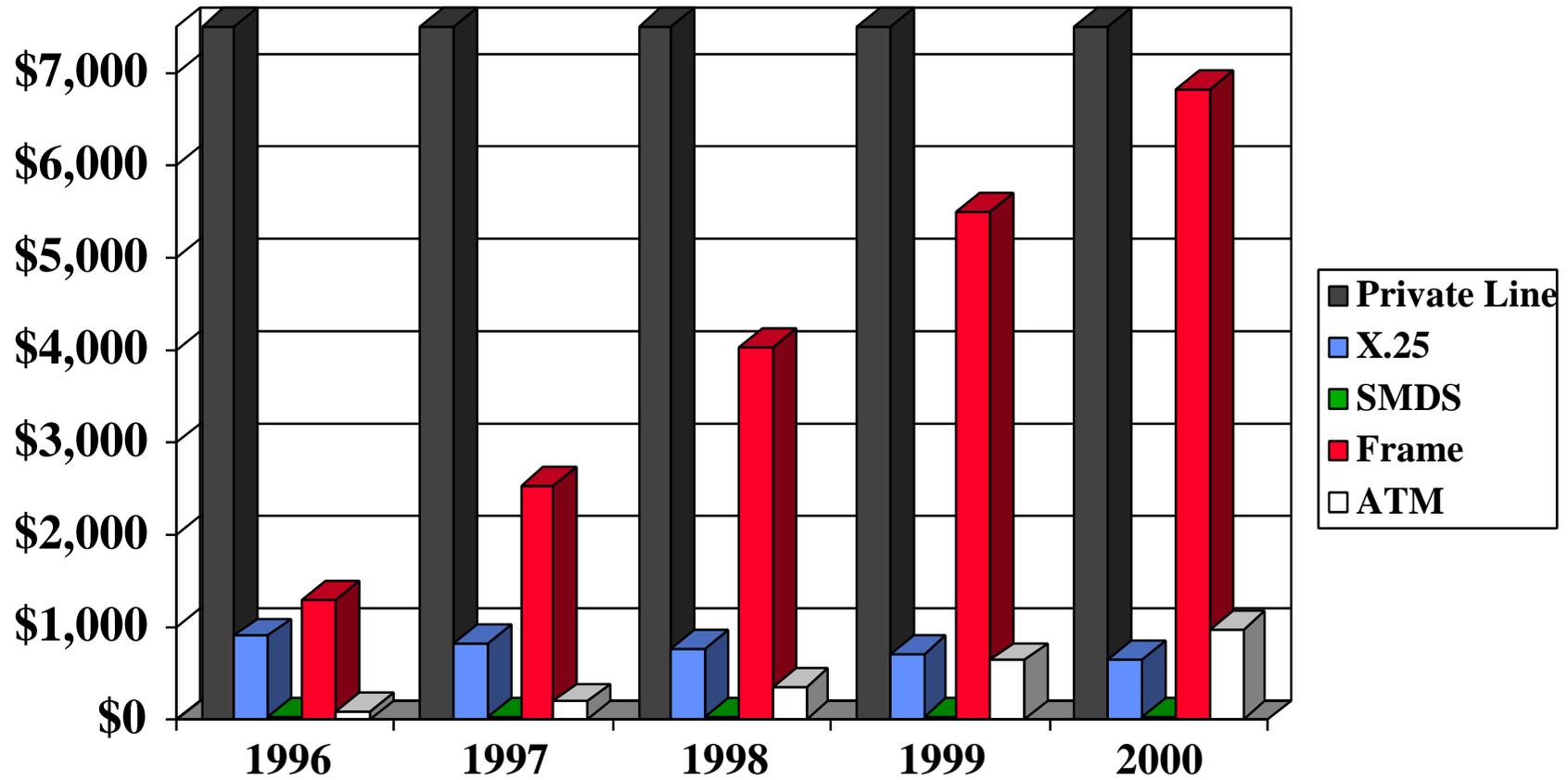
Excess information rate:

$EIR = B_e / T_c = \text{excess burst size} / \text{time interval } T_c$

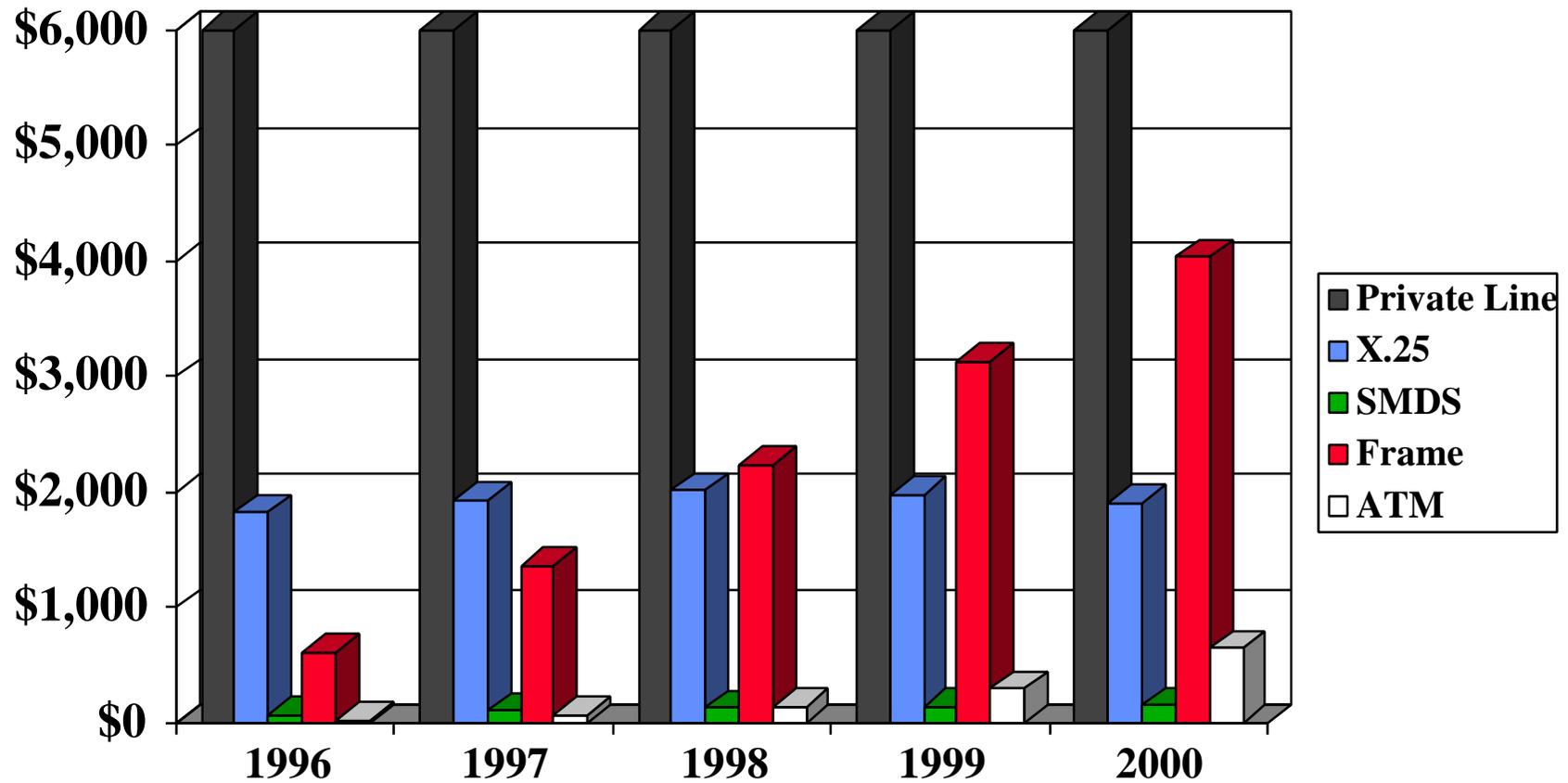


Frame Relay Standards (FRF)

- FRF.1.1 User-to-Network IA (Implementation Agreement)
- FRF.2.1 Network-to-Network IA
- FRF.3.1 Multiprotocol Encapsulation IA
- FRF.4 SVC (Switched Virtual Circuit) IA
- FRF.5 Frame Relay/ATM Network Internetworking IA
- FRF.6 Frame Relay Customer Network Management IA
- FRF.7 Frame Relay PVC Multicast Service and Protocol Description IA
- FRF.8 Frame Relay ATM/PVC Service Interworking IA
- FRF.9 Data Compression over Frame Relay IA
- FRF.10 Frame Relay Network-to-Network Interface SVC IA
- FRF.11 Voice over Frame Relay (VoFR) IA
- FRF.12 Frame Relay Fragmentation IA
- FRF.13 Service Level Definitions IA
- FRF.14 Physical Layer Interface IA



Market success of different technologies - US



Market success of different technologies – non US

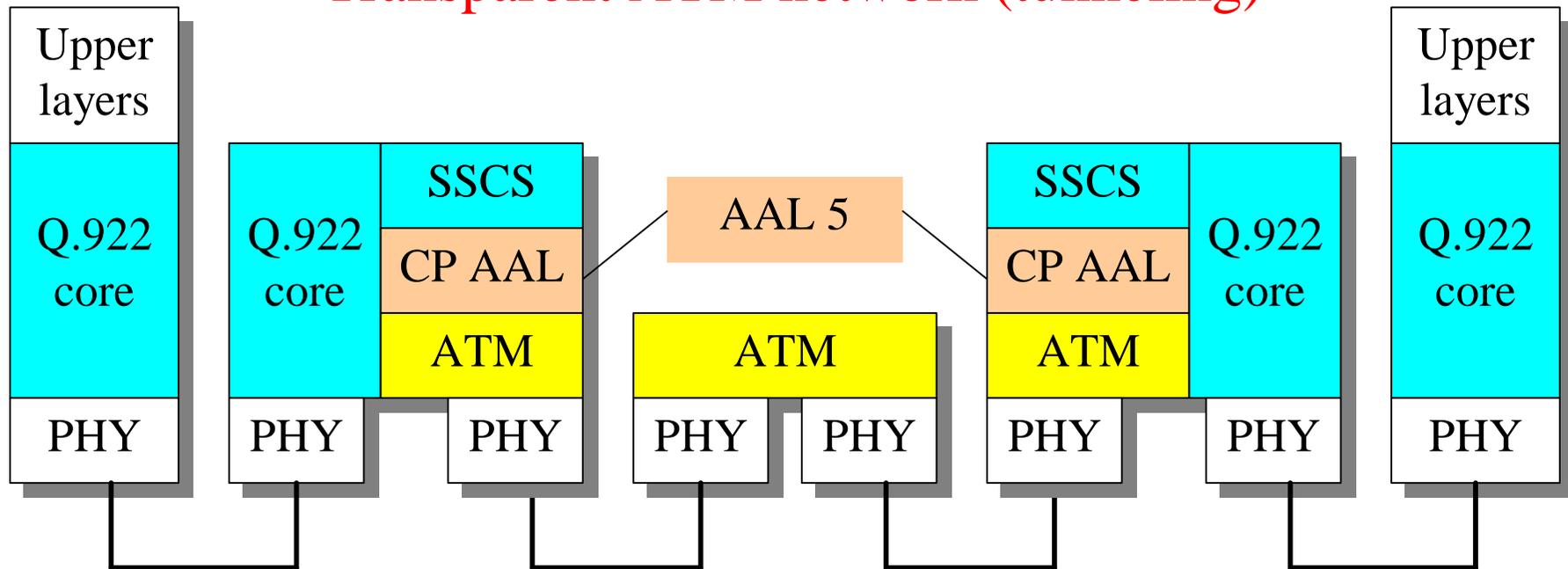
FR / ATM network interworking

(ITU-T: I.555, FR Forum: FRF.5)

PVC only, no Q.933/Q.2931 protocol mapping (SVC)

Protocol interworking in IWF

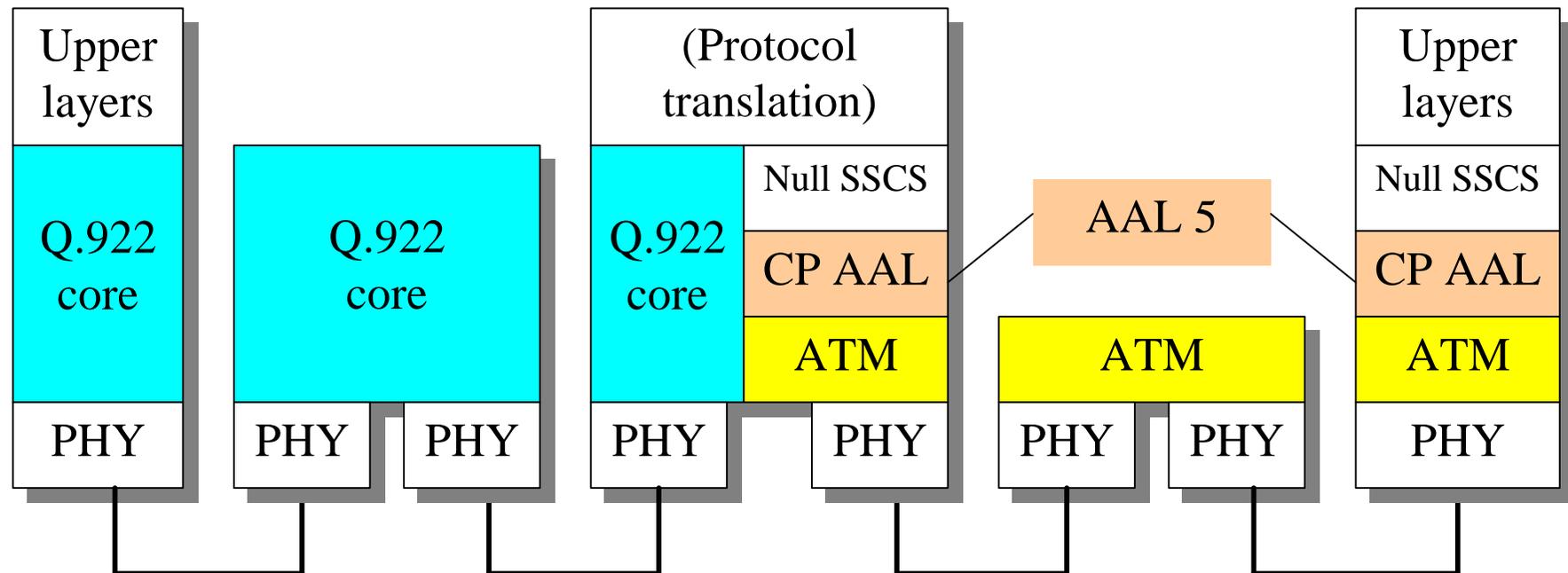
Transparent ATM network (tunneling)



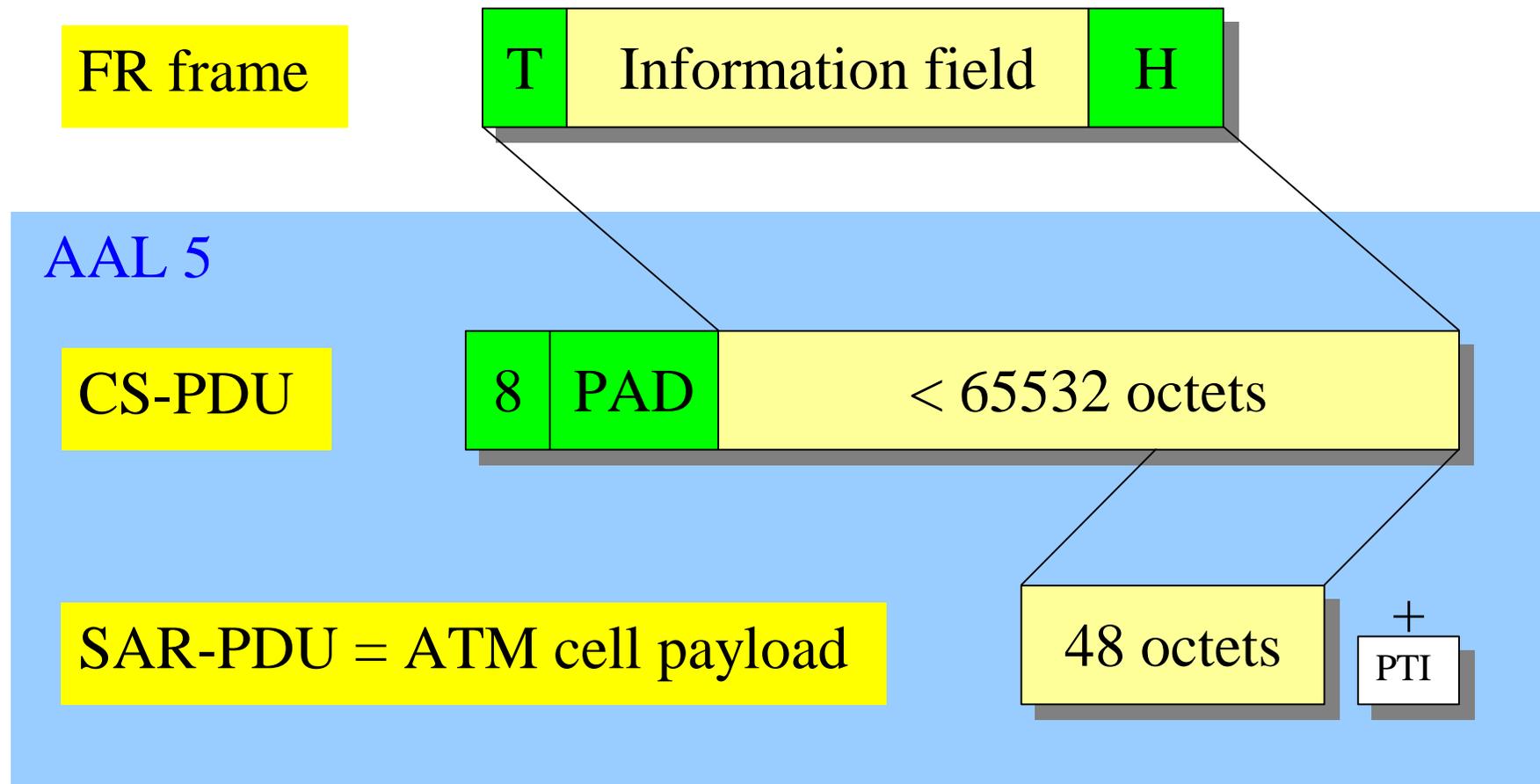
FR / ATM service interworking

(ITU-T: I.555, FR Forum: FRF.8)

PVC only, no Q.933/Q.2931 protocol mapping (SVC)
Protocol translation in IWF at Layer 2 (and higher layers)



FR / ATM network interworking



FR / ATM interworking

Transparent ATM network:

- ◆ Network interworking: **yes**
- ◆ Service interworking: **no**

Virtual connection mapping:

- ◆ Network interworking: **multiplexing possible**
- ◆ Service interworking: **DLCI ⇔ VPI/VCI**

Parameter interworking:

- ◆ **FECN/BECN ⇔ PTI, DE ⇔ CLP**
- ◆ **CIR, EIR ⇔ PCR, SCR, MCR, MBS**