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 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).

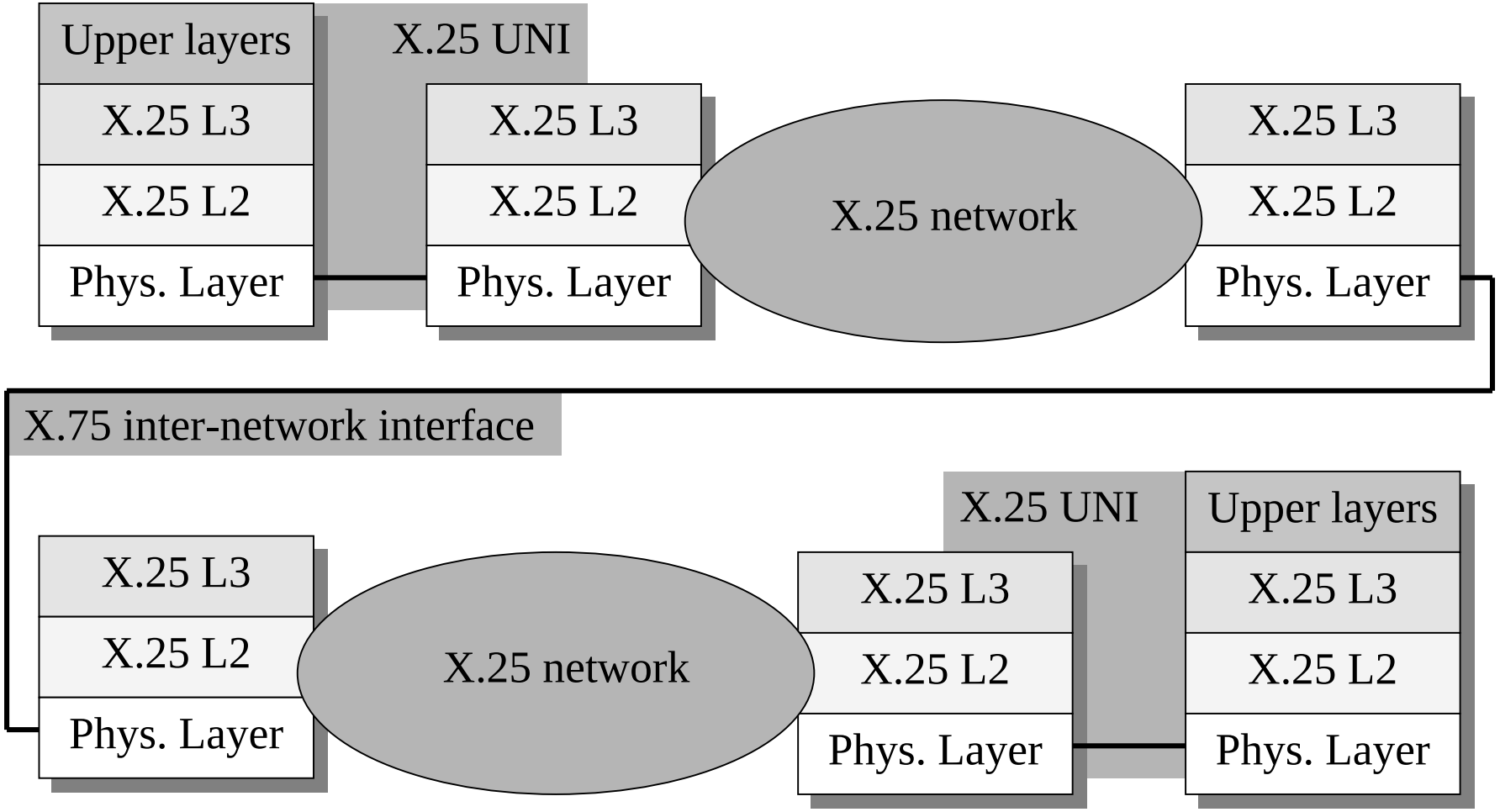
Options (a) and (b) are connection-oriented.

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

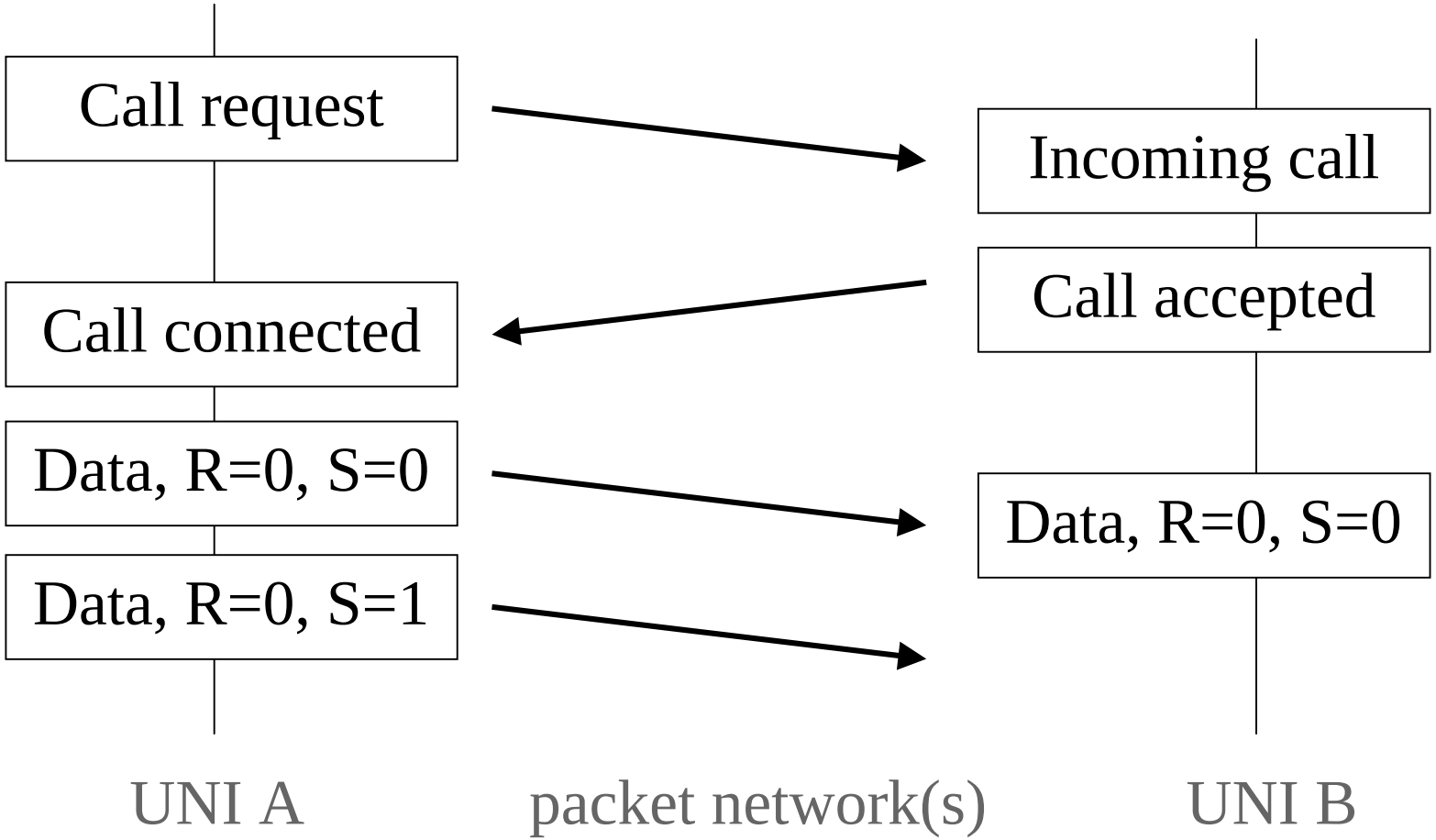
Characteristics of X.25

- Flow control and error control (frame retransmission) on Layer2 using LAPB
- Flow control and error control (packet retransmission) also on Layer3
- In case of SVC, signaling messages in Layer3
- Physical layer (Layer1): 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

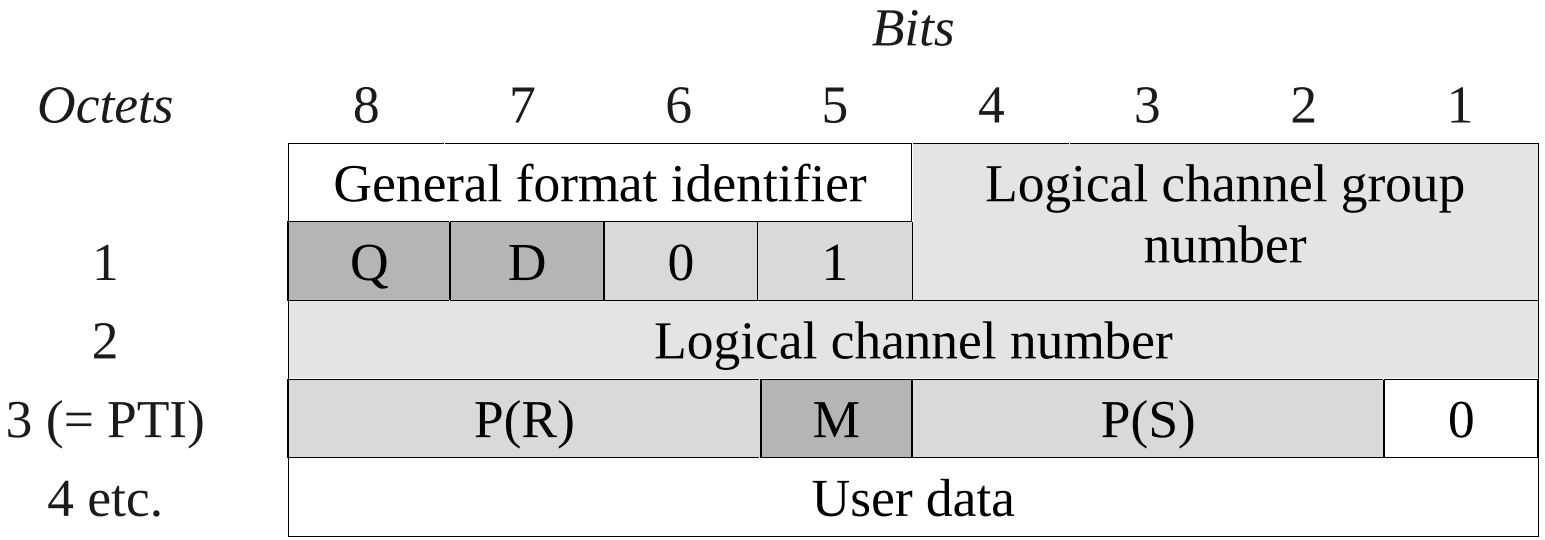
- 4095 virtual circuits can be used simultaneously over a X.25 interface
- 12 bit virtual circuit number (of local significance)
- individual virtual circuits correspond to applications, processes or terminals
- multiple destinations possible (more than one receiver at the same time) ⇔ big advantage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

Some examples of X.25 packets

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



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)

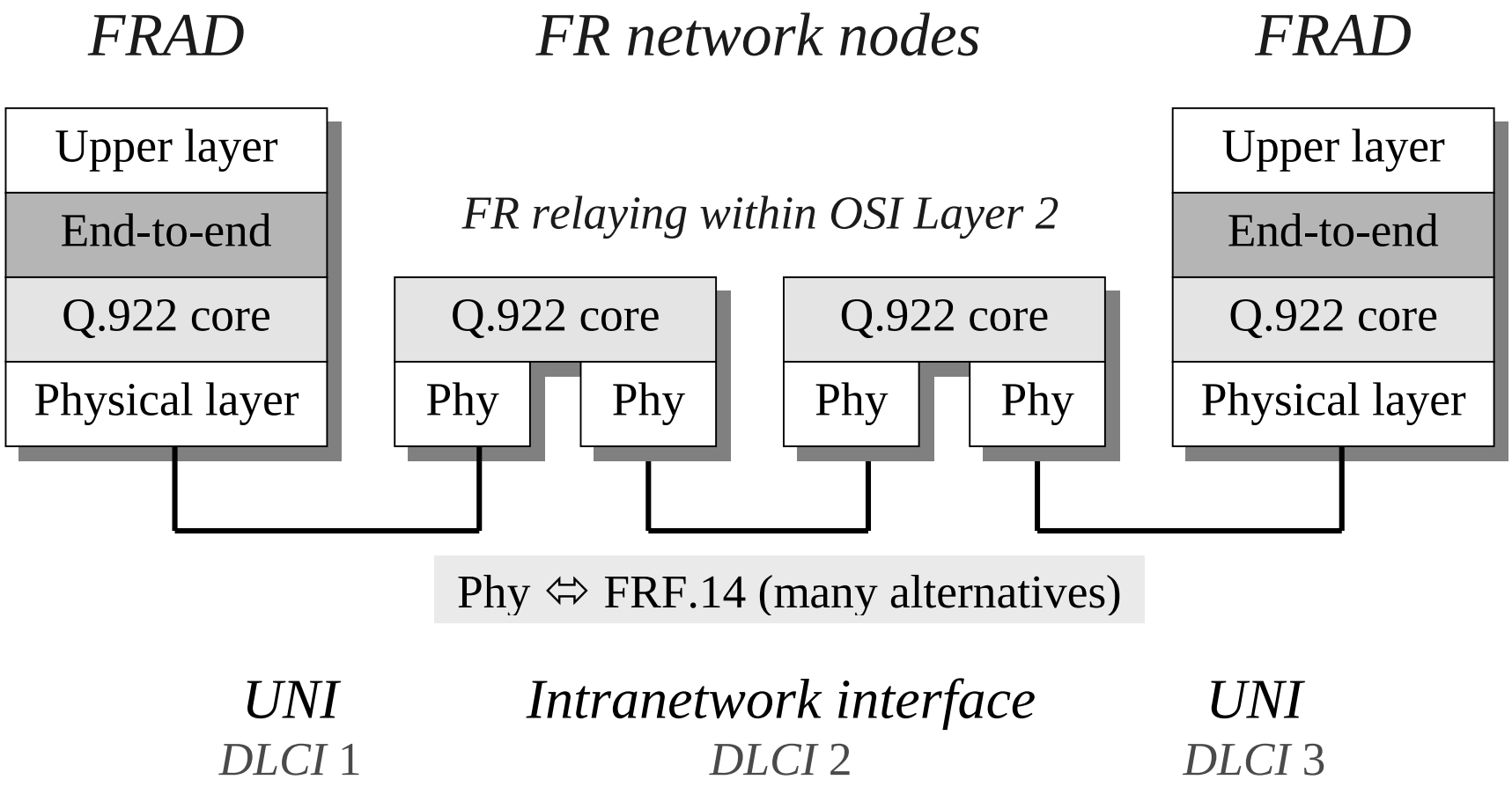
Packet type		*Bit position*							
From DCE to DTE	From DTE to DCE	8	7	6	5	4	3	2	1
Call set-up and clearing									
Incoming call	Call request	0	0	0	0	1	0	1	1
Call connected	Call accepted	0	0	0	0	1	1	1	1
Data									
DCE data	DTE data	X	X	X	X	X	X	X	0
Flow control and reset									
DCE RR	DTE RR	X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

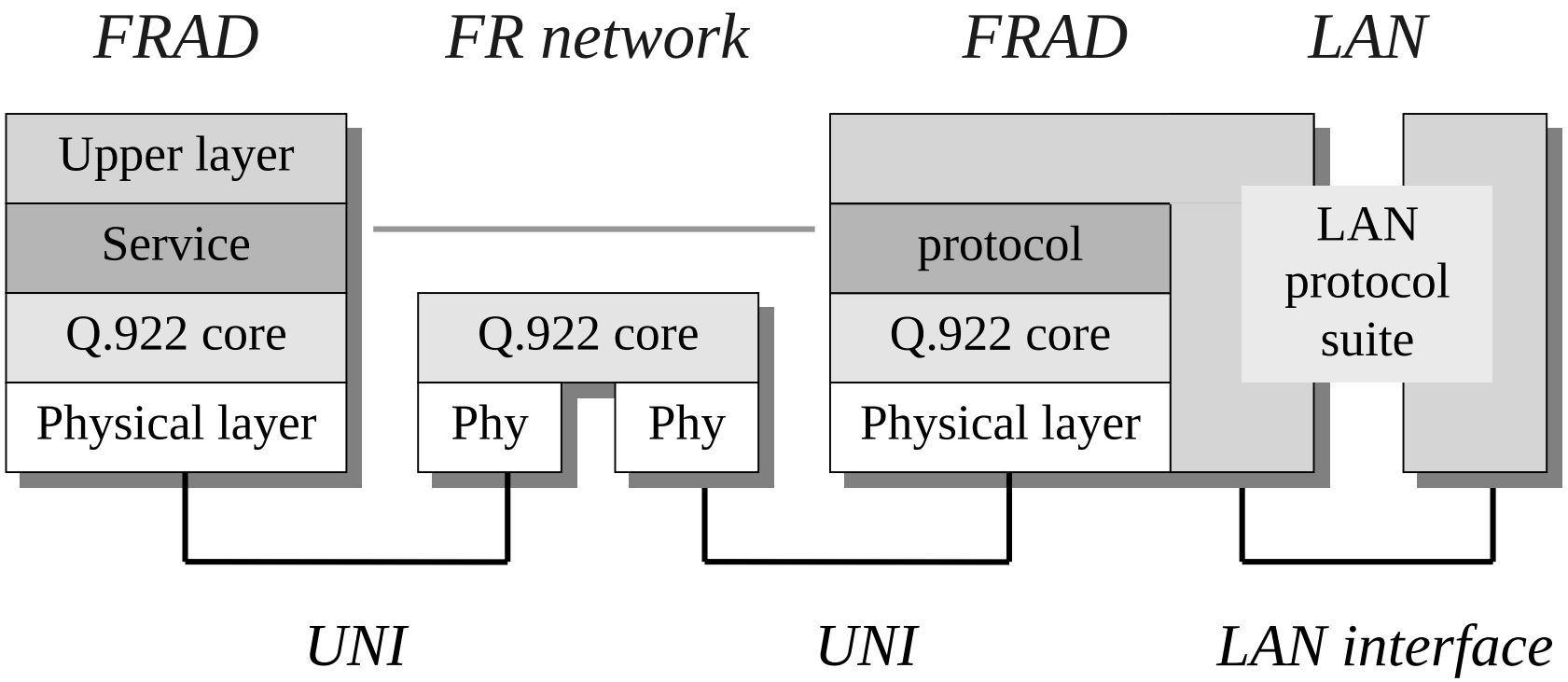
- FR is a connection-oriented protocol/service mainly used for interconnecting LANs
- FR requires ”less heavy processing” than X.25 in the transmission network, in fact
- FR only involves OSI Layers 1 … 2 in the network
- ITU-T (I and Q-series, e.g., I.233 and Q.922)
- Frame relay forum (www.frforum.com)

FR network connection



FR network interface

frame relay access device ≈ frame relay compatible router



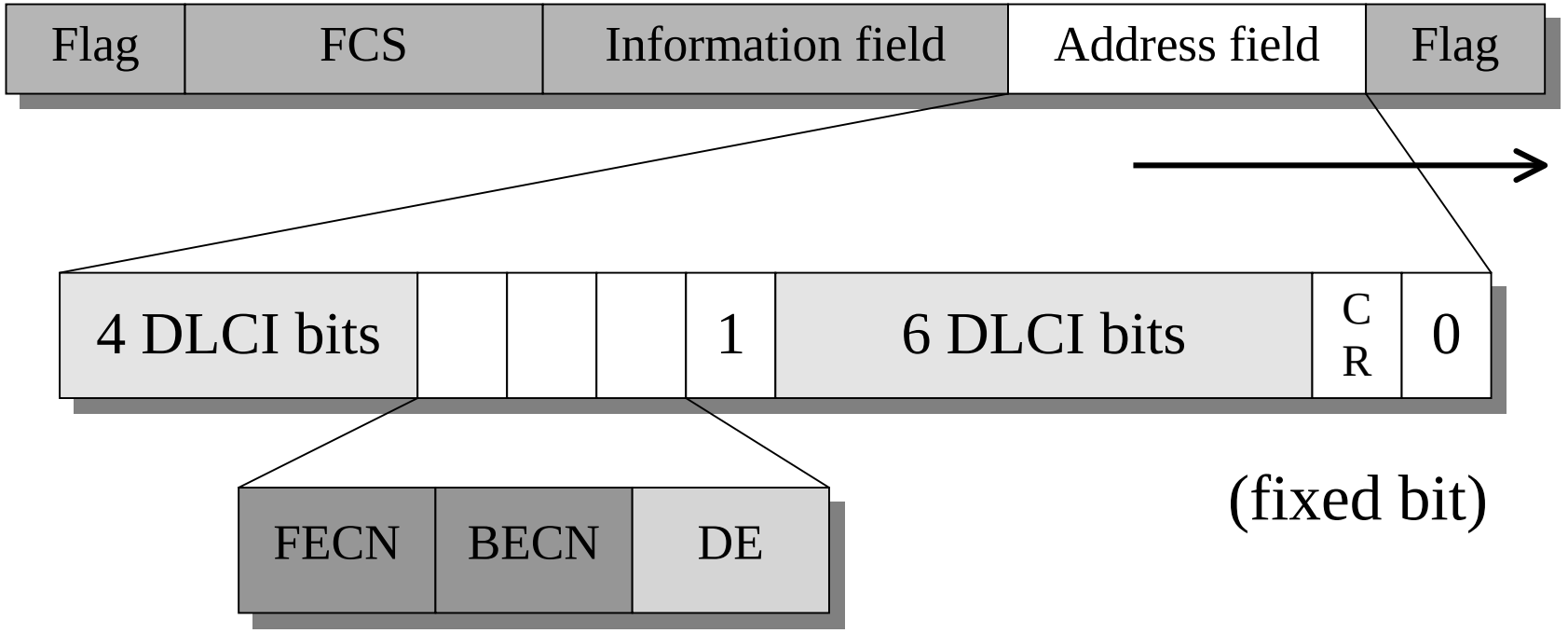
FR Service protocol

- 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

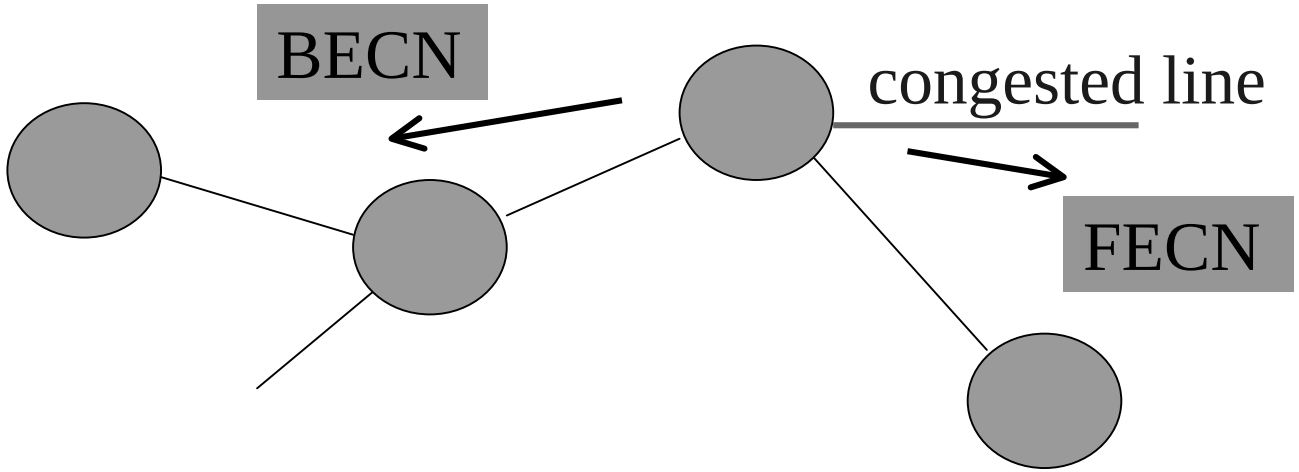
FR frame format



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)

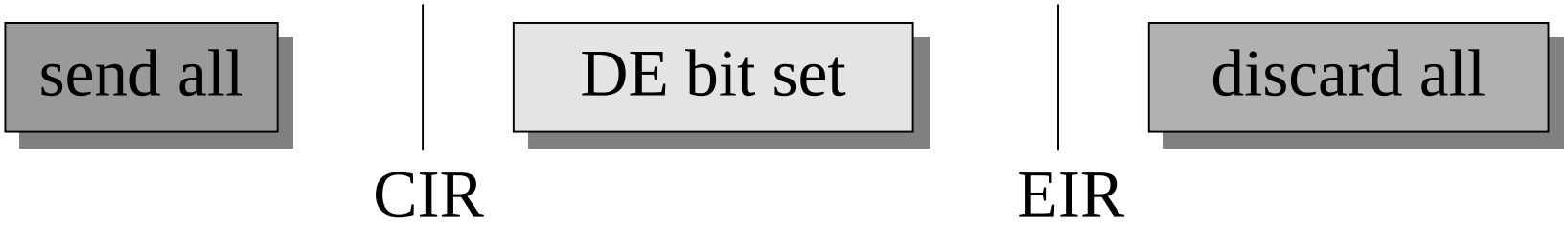
FR traffic control

Committed information rate:

CIR = Bc / Tc = committed burst size / time interval Tc

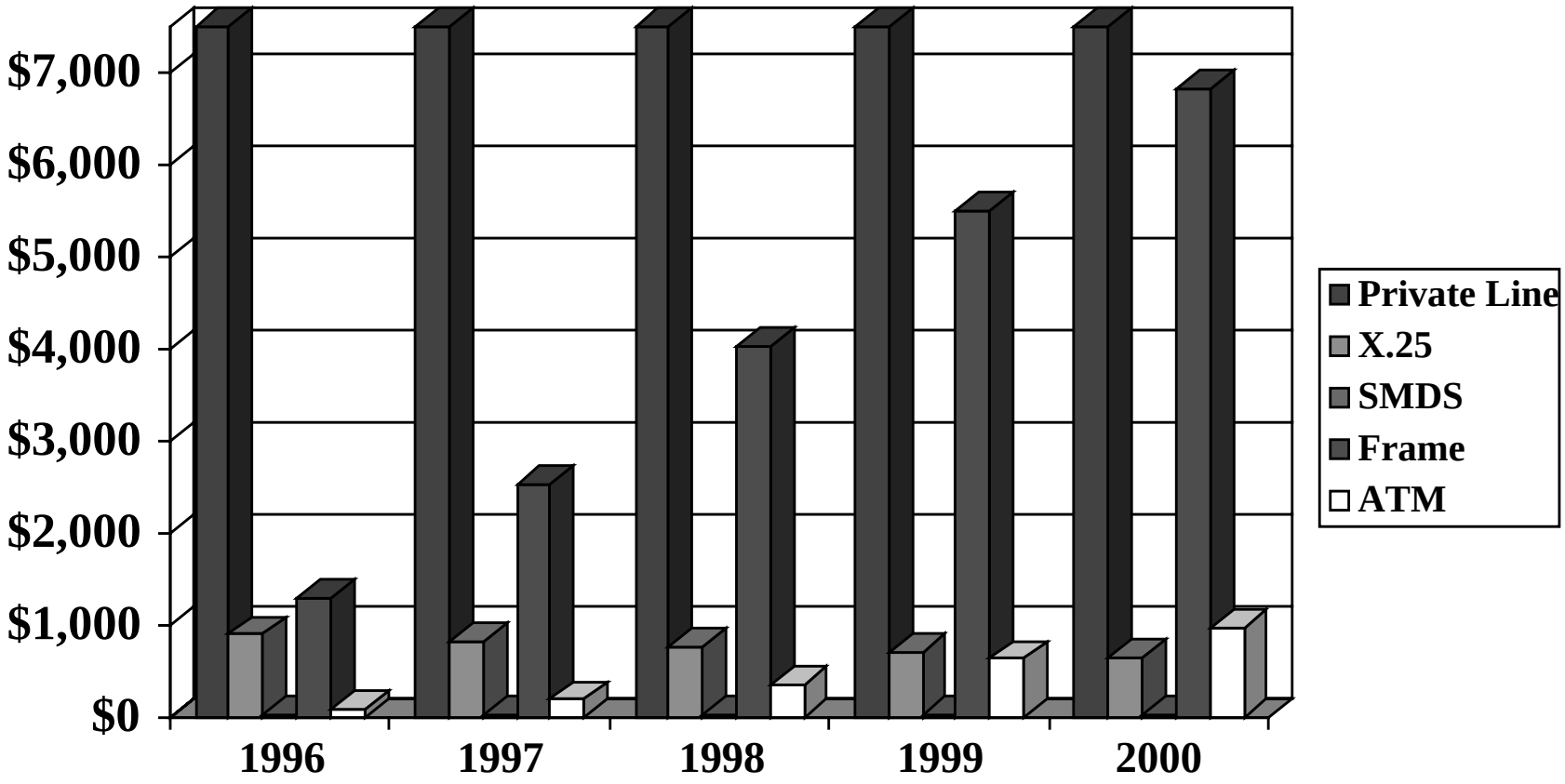
Excess information rate:

EIR = Be / Tc = excess burst size / time interval Tc

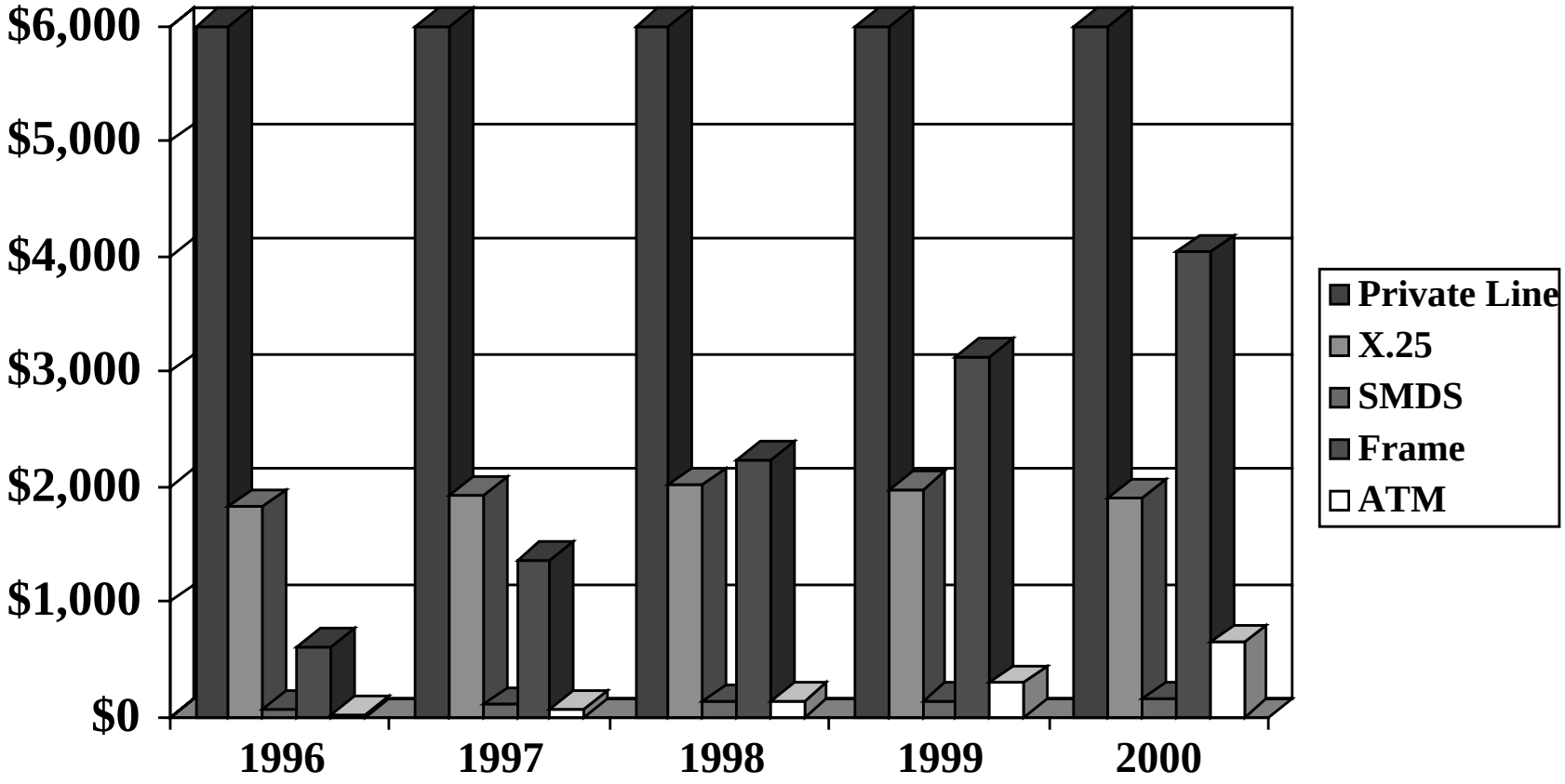


Frame Relay Standards (FRF)

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

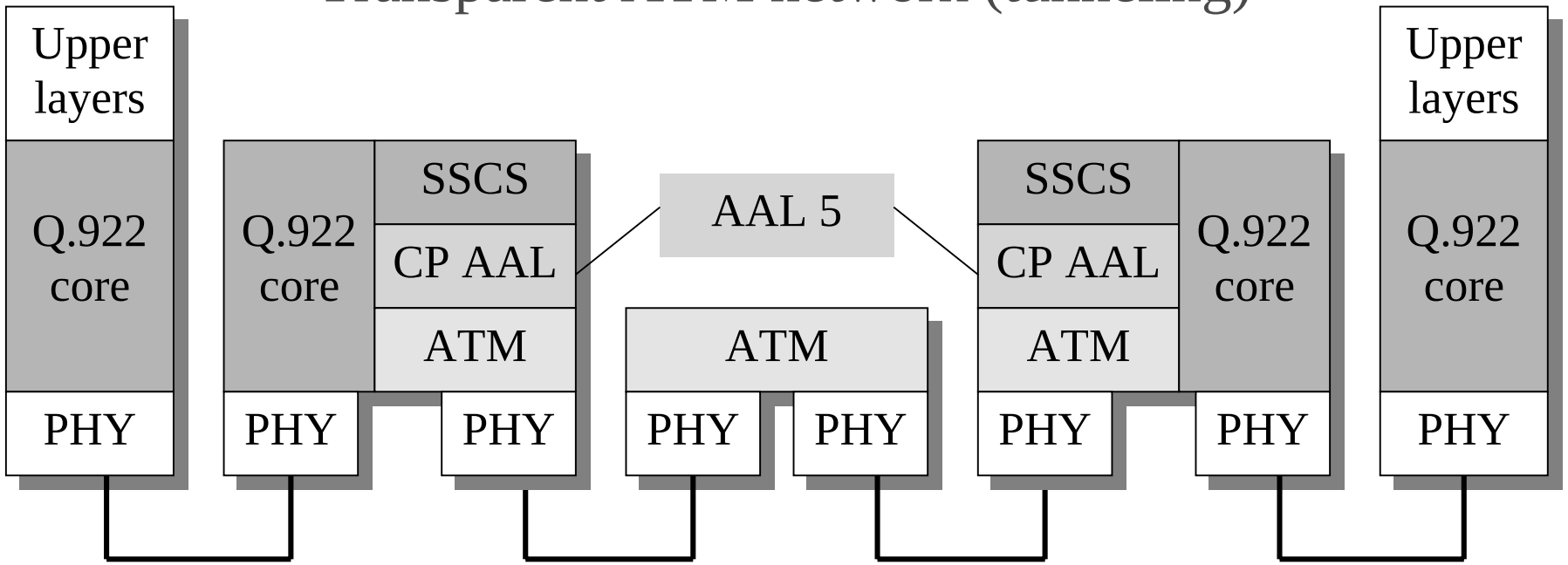


Market success of different technologies – non US

FR / ATM network interworking

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

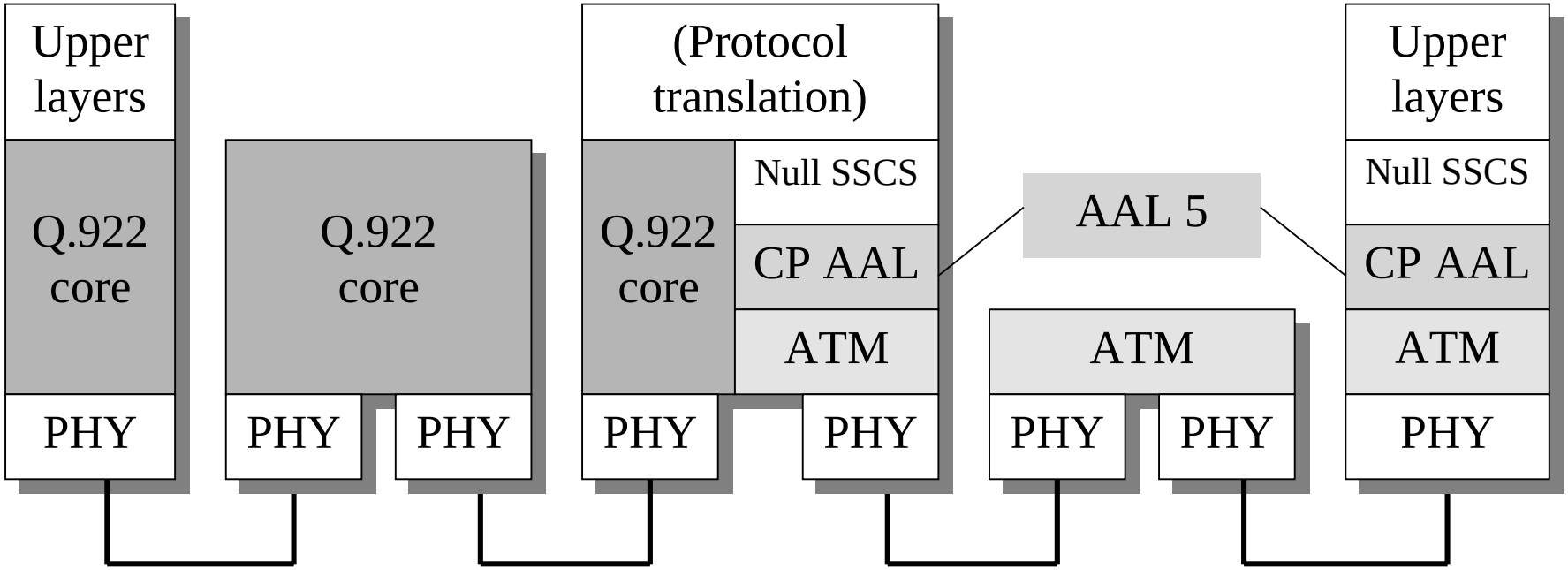
PVC only, no Q.933/Q.2931 protocol mapping (SVC)
Protocol interworking in IWF
Transparent ATM network (tunneling)



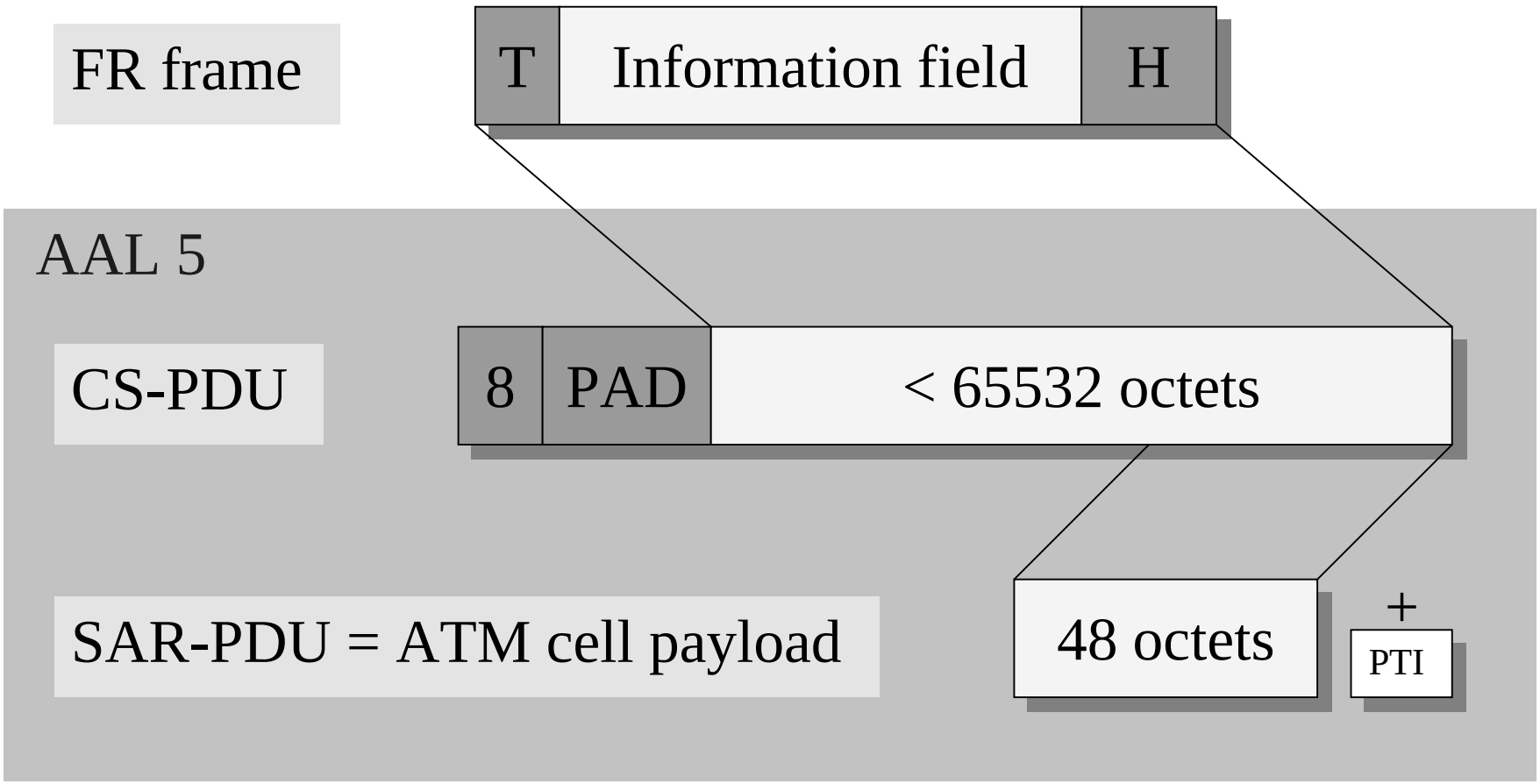
FR / ATM service interworking

(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 FR frame transmission:

- Network interworking: yes
- Service interworking: no

Virtual connection mapping:

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

Parameter interworking:

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