Narrowband ISDN

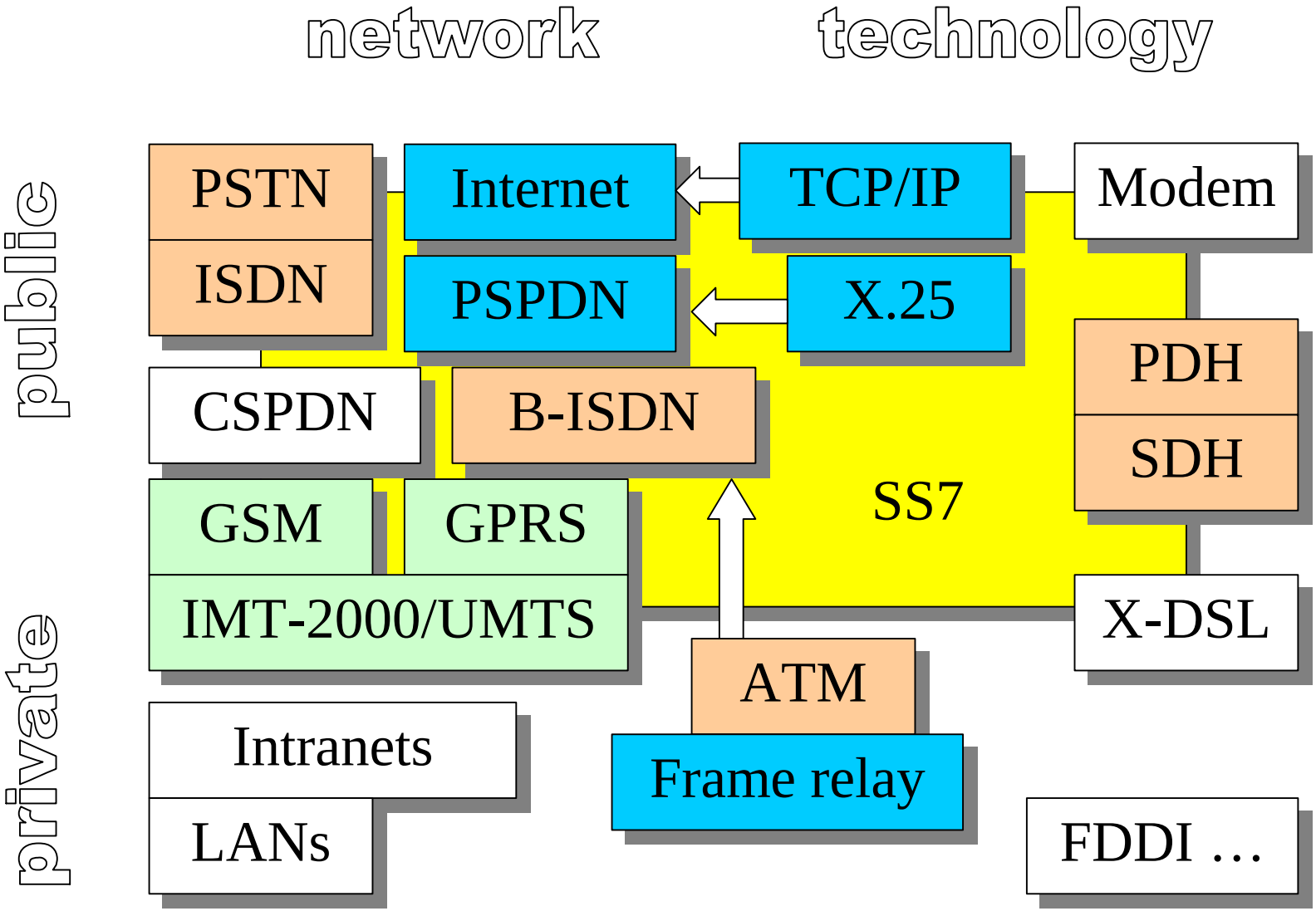
(ISDN = Integrated Services Digital Network)

- critically: ”Invention Subscribers Don’t Need” (technology push instead of demand pull)
- is that really so?
- N-ISDN vs. B-ISDN (based on ATM)
- How is ISDN related to modem technology?
- How is ISDN related to X-DSL technology?
- ITU-T standardization (I-series)

Before going into ISDN details …

… some general network concepts

… and a lot of acronyms !


network
technology
public
private
PSTN
ISDN
Internet
PSPDN
TCP/IP
X.25
Modem
PDH
SDH
CSPDN
B-ISDN
SS7
GSM
GPRS
IMT-2000/UMTS
X-DSL
ATM
Frame relay
Intranets
LANs
FDDI …

Circuit switched

N x 64 kb/s channels

TDM / FDM multiplexing

setup – connected – release

pay for connected time

fixed & short delay services (speech, video)

Packet switched

bit rate is not constant

statistical multiplexing

packet routing

pay for transmitted bits

variable delay and bursty services (data)

PSTN / ISDN

PSPDN (X.25)

GSM / DECT

UMTS / IMT-2000

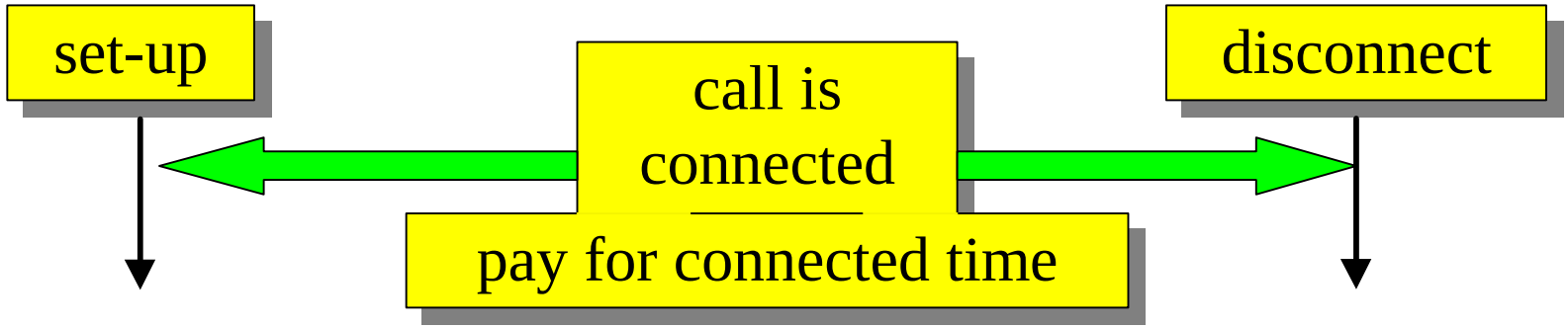
GPRS

B-ISDN (ATM)

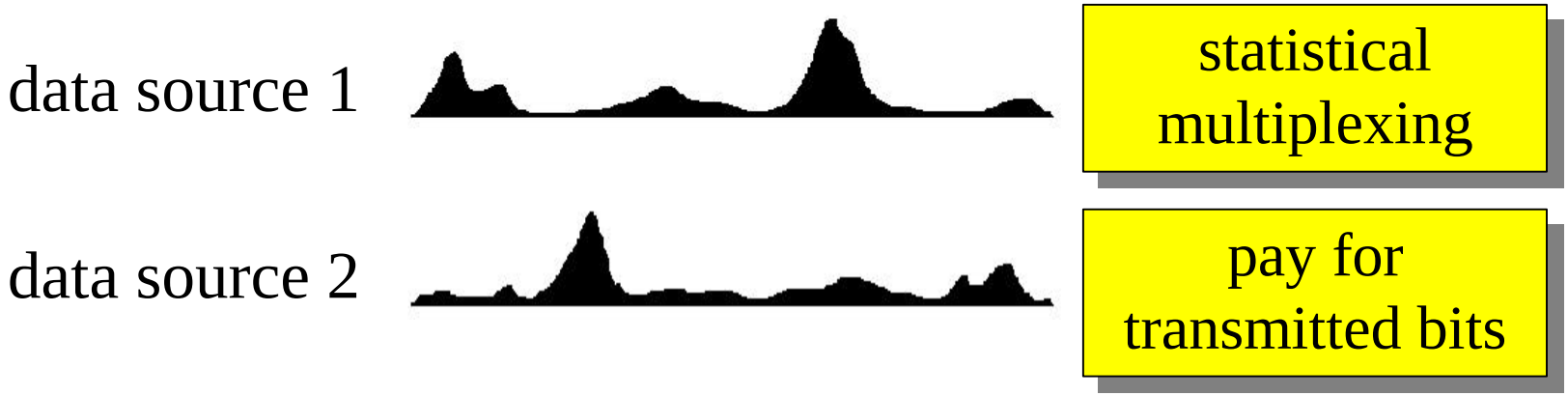
Frame relay

Internet (TCP/IP)

Circuit switched call



Packet switched connection



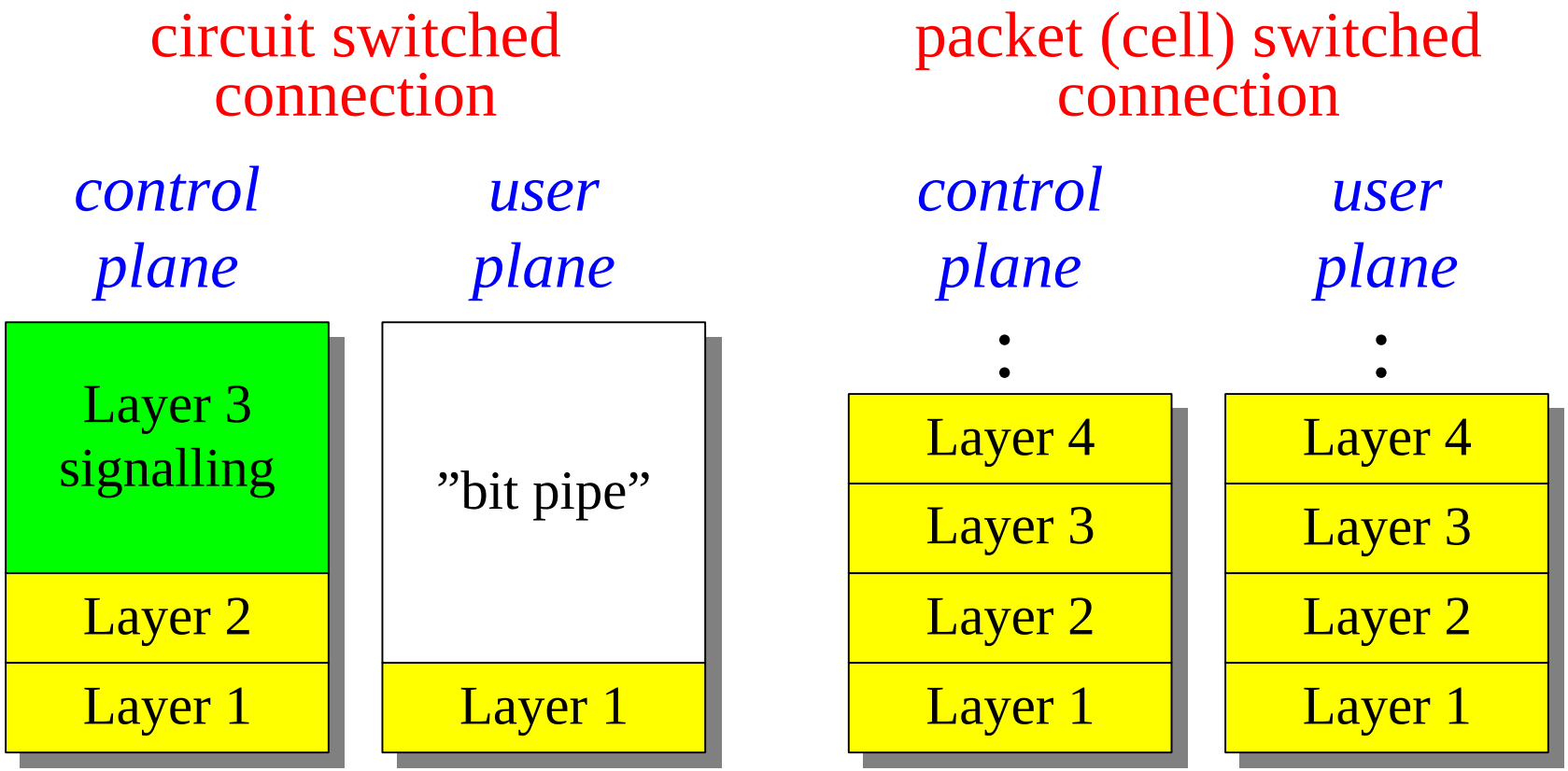
Networks are based on protocols organized in structured layers

Even if the OSI layer model as such is not used everywhere, the structured layer concept is used !

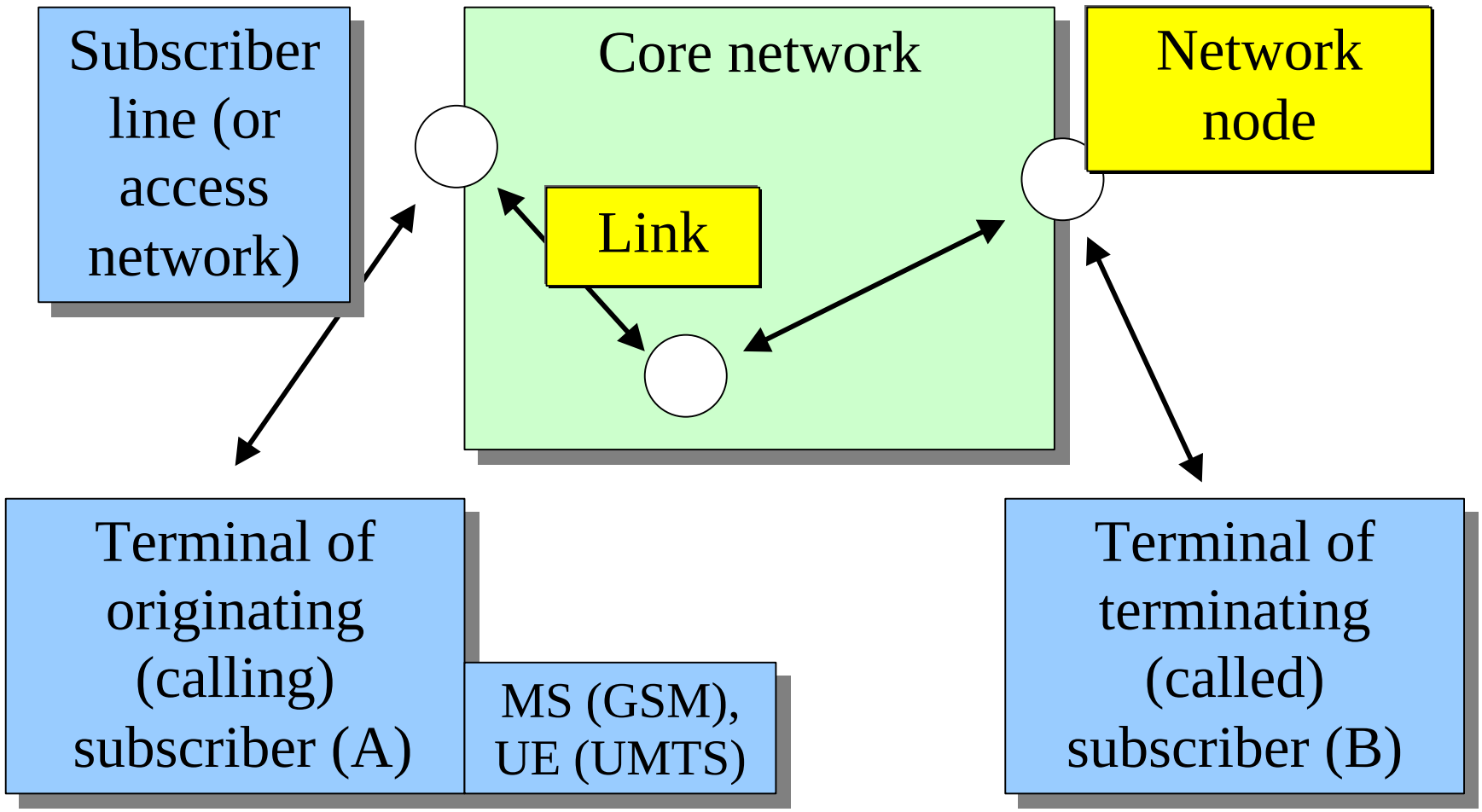
OSI layer model (layers 1 … 4)

4	Transport	end-to-end error & flow control
3	Network	routing through the network
2	Data link	link-level error & flow control, MAC
1	Physical	framing, multiplexing …

Protocol stacks in user / control plane



Network terminology



What is ISDN ?

1. End-to-end digital connectivity between users
2. Enhanced subscriber signaling
3. A wide variety of new services (due to 1 and 2)
4. Standardized subscriber interfaces and terminals

ISDN is not a new network separated from the PSTN.

Rather, ISDN has evolved from the PSTN and is an integral part of the PSTN or interleaved with the PSTN.

Success of ISDN depends on:

1) public network => standardization (different equipment suppliers, different operators …)

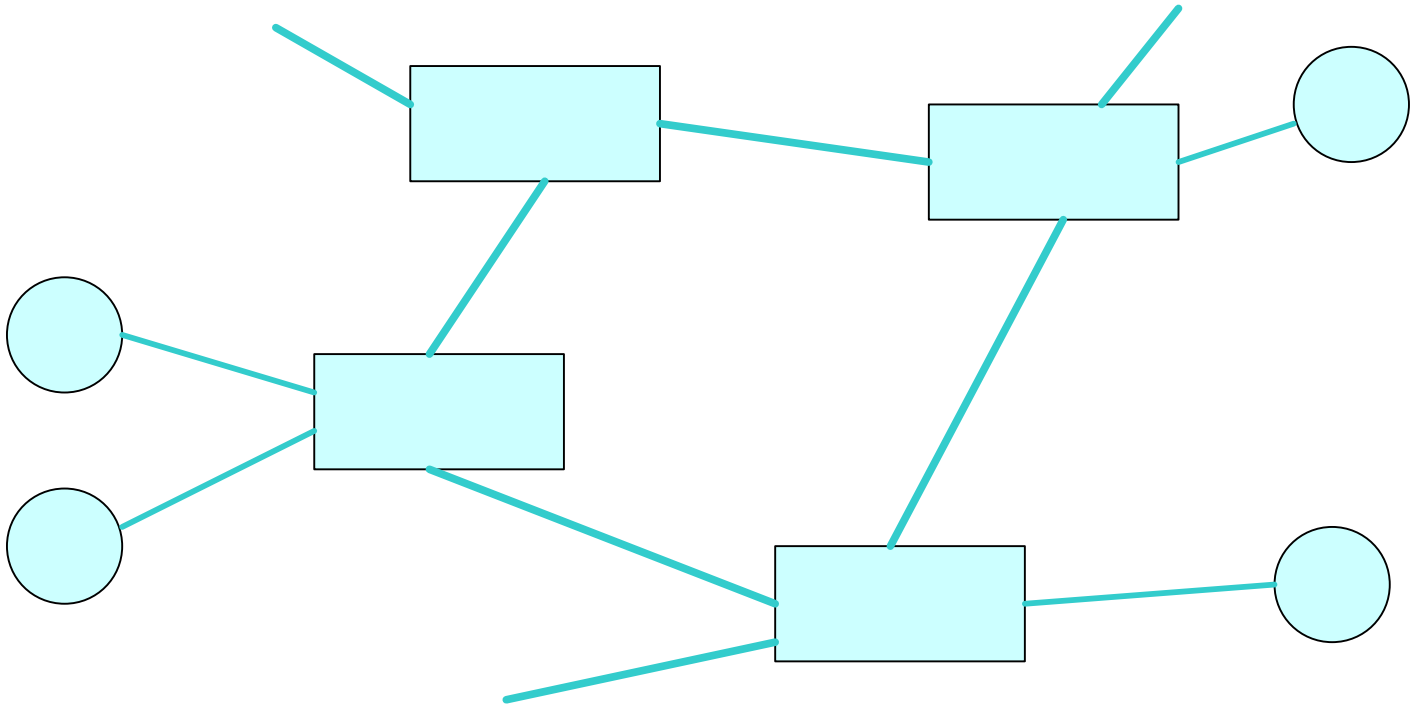
2) critical mass of services, subscribers, and inexpensive terminal equipment, (chicken and egg problem)

3) bearer services: transparency

4) problem-free evolution from PSTN, problem-free integration of new services (Internet access …)

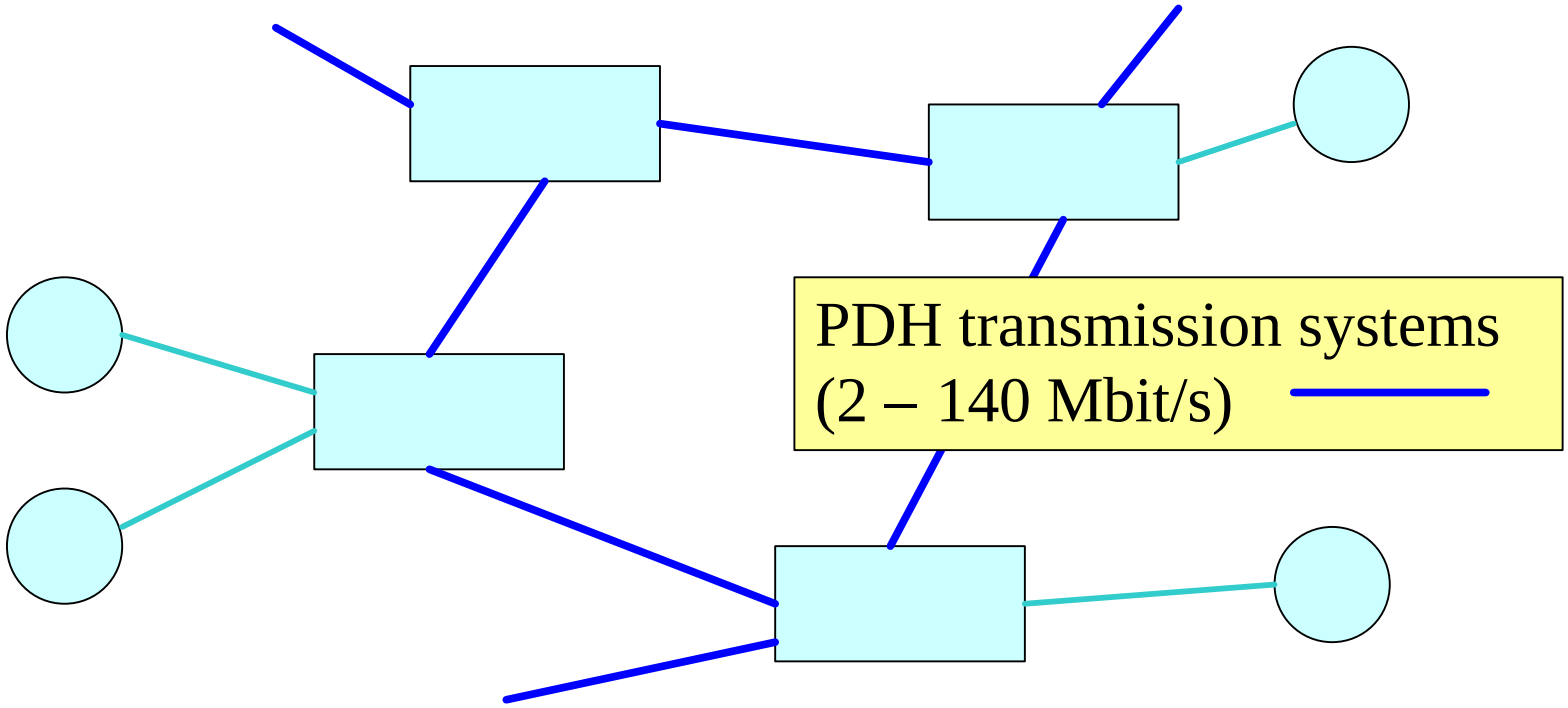
Evolution of the PSTN / ISDN

Step 1: all-analogue network (before 1960)



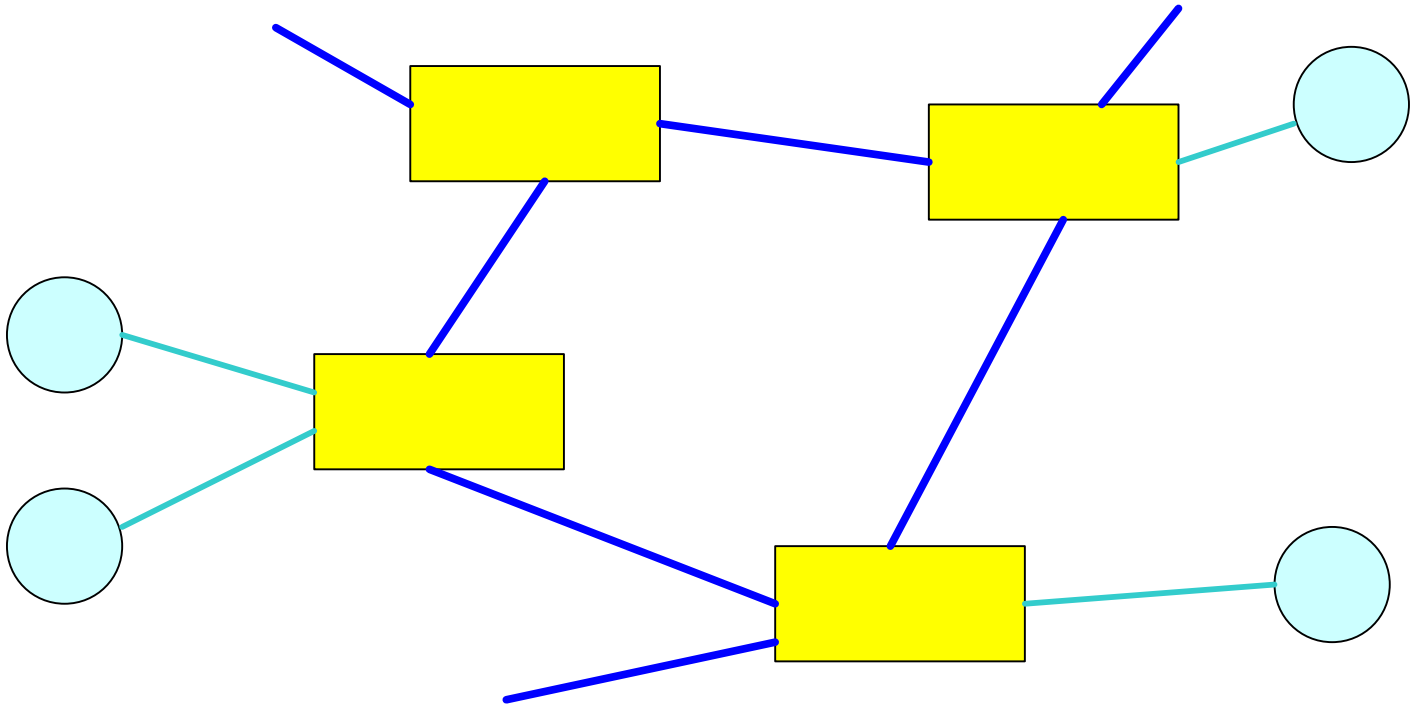
Evolution of the PSTN / ISDN

Step 2: digital transmission in the core network (1960 - 1980)



Evolution of the PSTN / ISDN

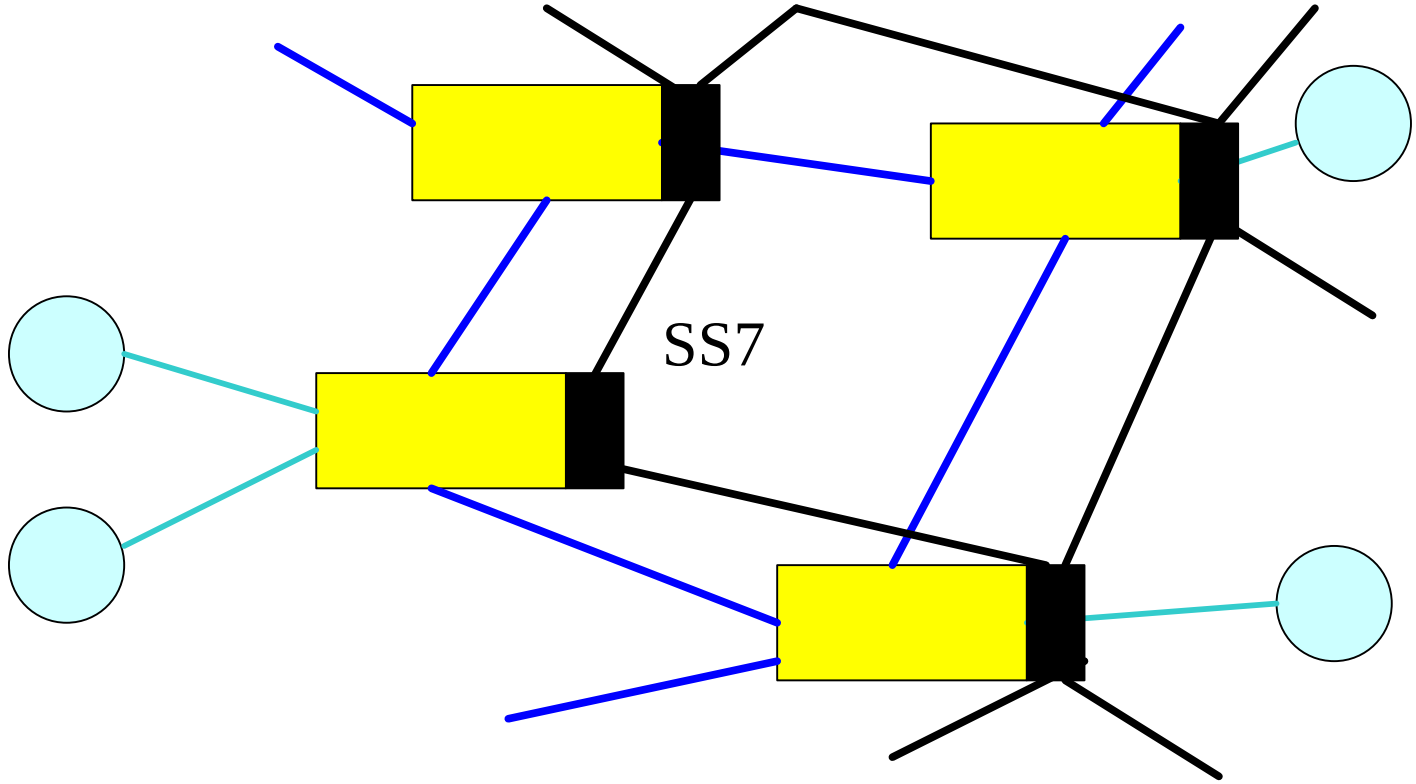
Step 3: digital switching at 64 kbit/s (1970 - 1990)



Evolution of the PSTN / ISDN

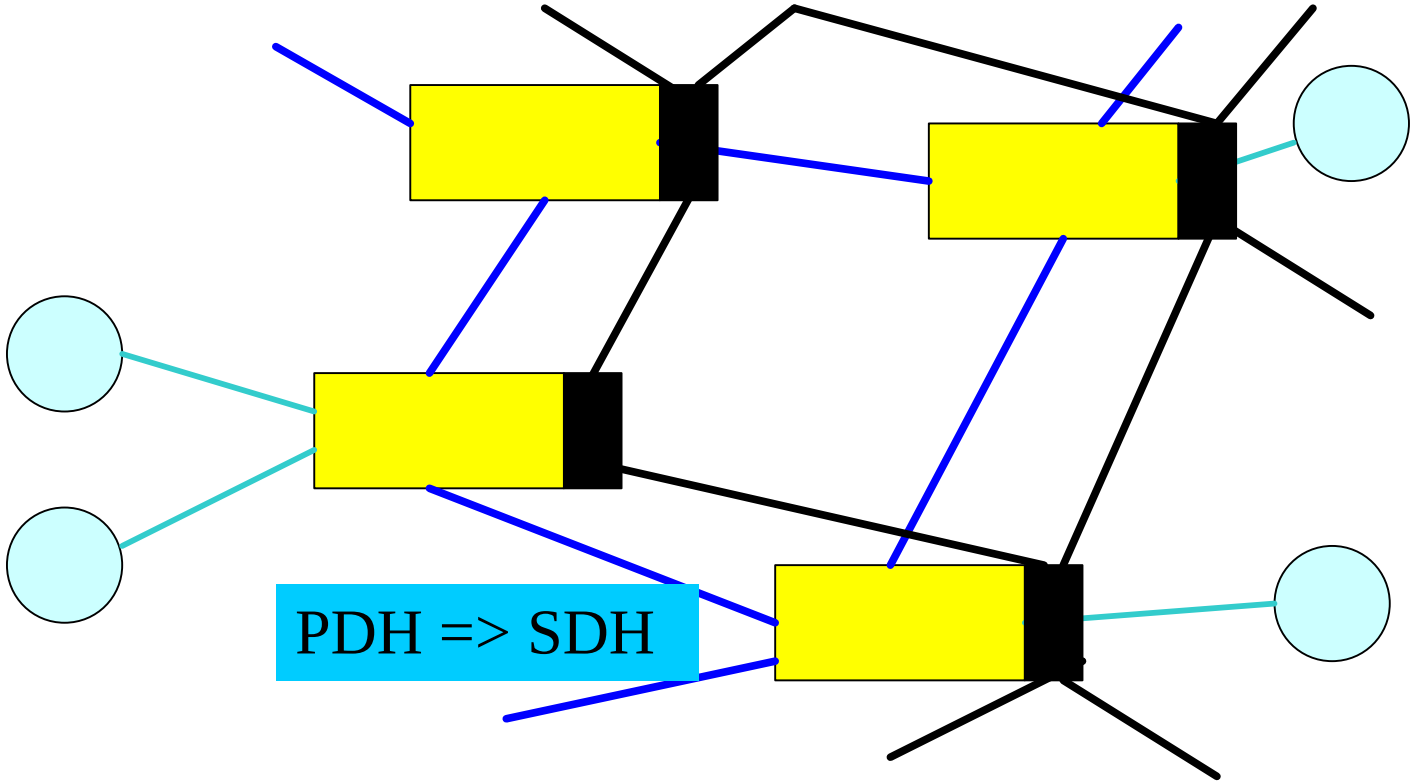
Step 4: common channel signaling in the core network

(1980 ...)



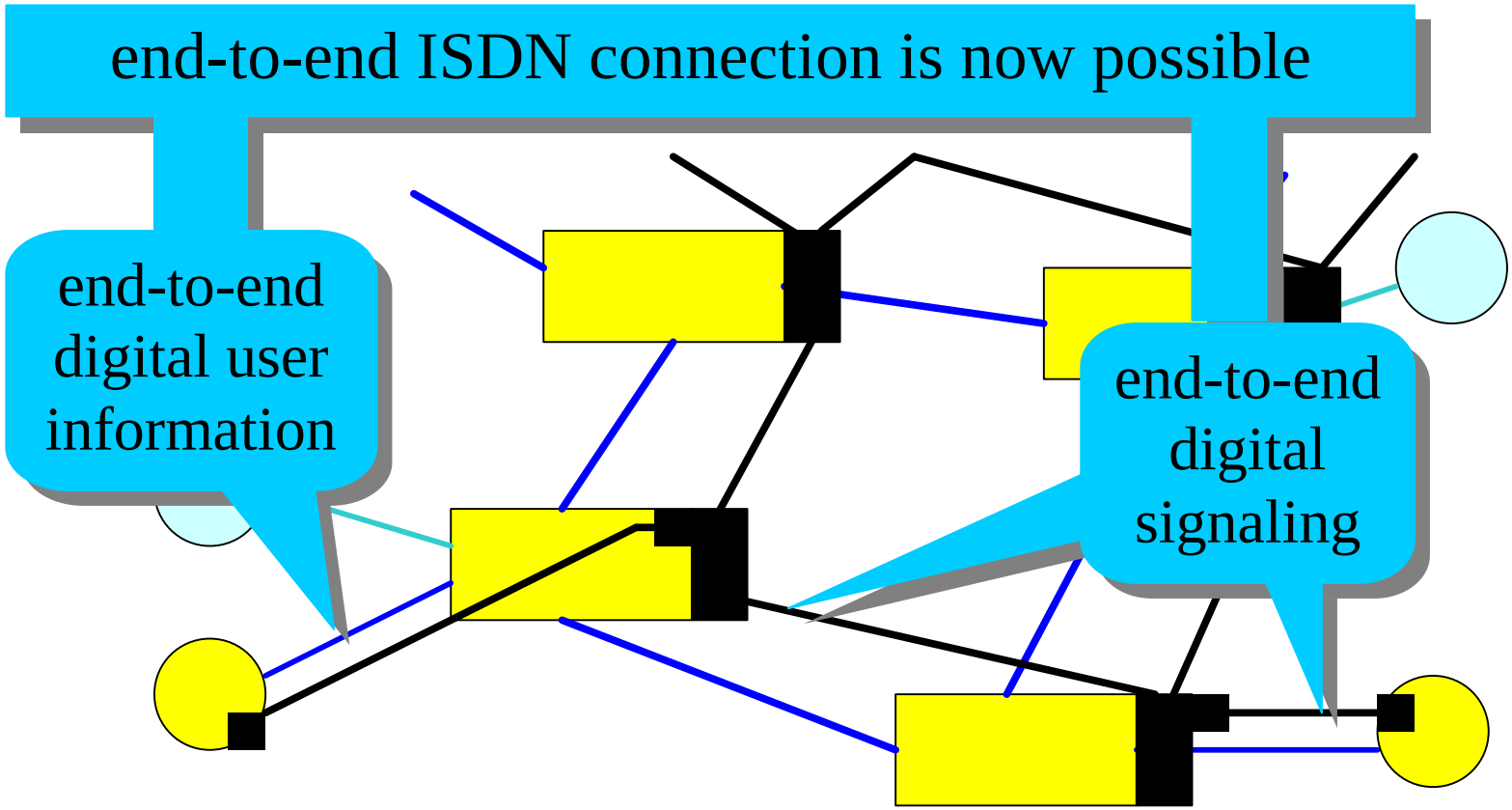
Evolution of the PSTN / ISDN

Step 5: PDH systems are being replaced by SDH (1990 ...)



Evolution of the PSTN / ISDN

Step 6: digital subscriber lines installed (1990 …)



Main difference between PSTN and ISDN:

Subscriber (user) connection to the network

PSTN:

- 300 … 3400 Hz analogue transmission band
- “poor-performance” subscriber signaling

ISDN:

- 2 x 64 kbit/s digital channels (B-channels)
- 16 kbit/s channel for signaling (D-channel)

- 30 x 64 kbit/s digital channels (B-channels)
- 64 kbit/s channel for signaling (D-channel)
- concatenated B-channels -> H-channels

Subscriber signaling in PSTN

1. Off-hook (on-hook) <-> short (open) circuit in the telephone <-> *call request (disconnect)* information for the exchange ("one-bit signaling")

2. Called party numbering information <-> pulse or DTMF dialing

3. Alerting (ringing) <-> exchange sends a sinusoid

4. In-channel information (audio signals / DTMF data)

Subscriber signaling in ISDN

- Packet switched information exchange on the D-channel (16 kbit/s in *BRA = Basic Rate Access* configuration)
  -> virtually unlimited subscriber signaling capacity

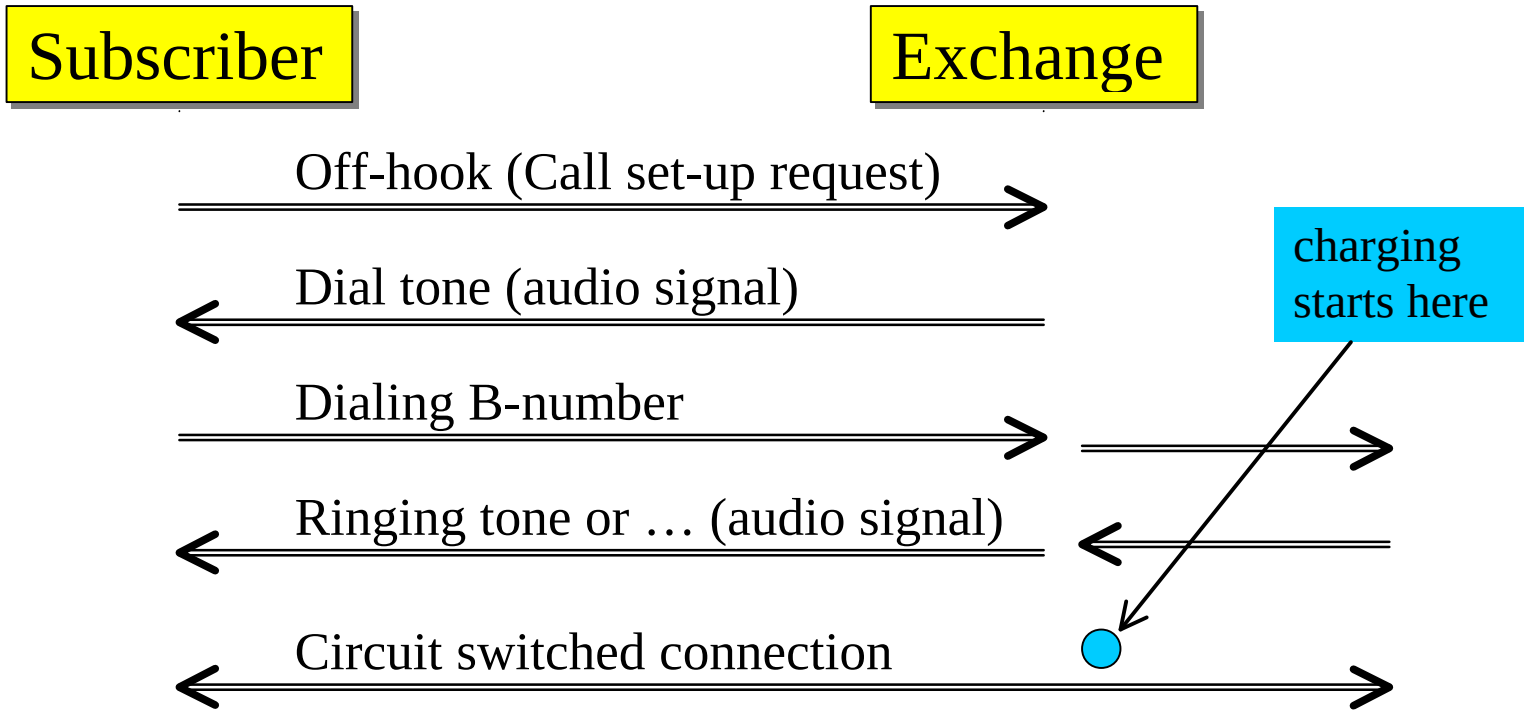
- Signaling on the D-channel is totally independent of the information transmission on the B-channels

- The signaling protocols are widely standardized (Q.931)

- The D-channel can also be used for data transmission in packet switched mode

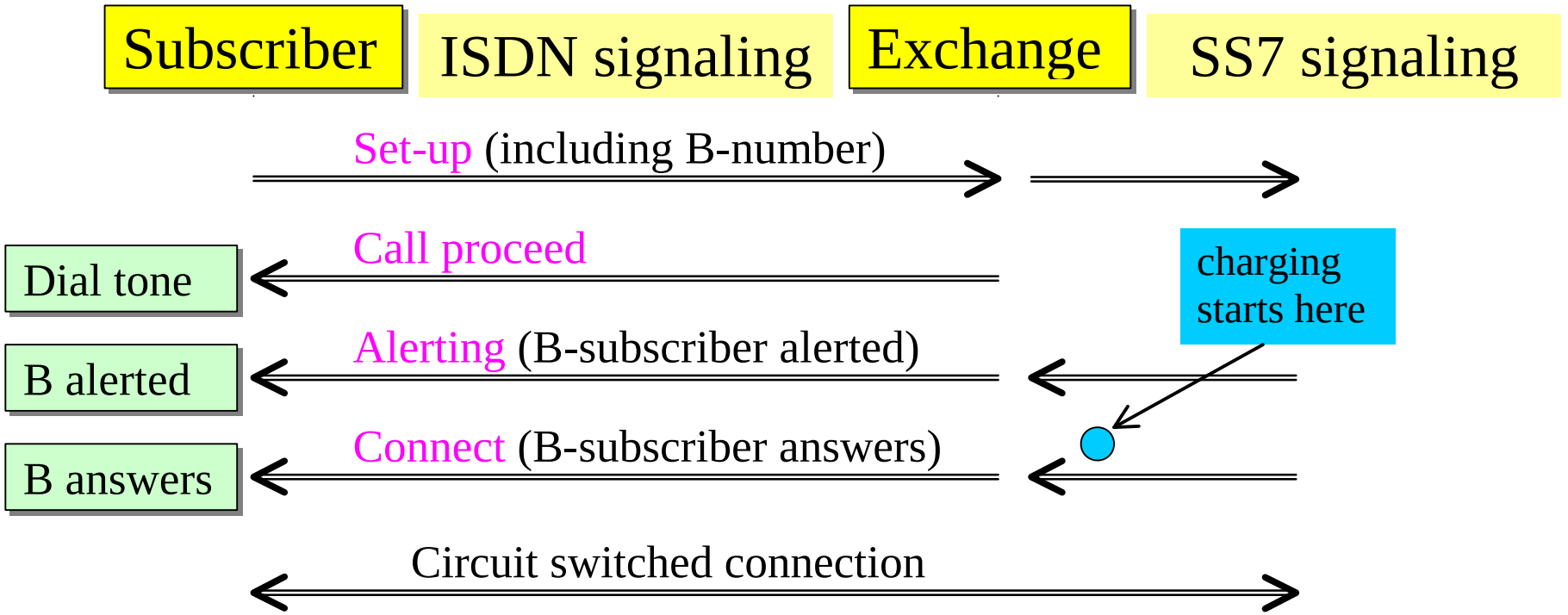
Subscriber signaling sequence in PSTN

(Call set-up)



Subscriber signaling sequence in ISDN

(Call set-up)



Typical content of ISDN Set-up message

- Called party (B-subscriber) number & numbering plan
- Calling party (A-subscriber) number (+ CLIP/CLIR)
- Bearer capability (64 kbit/s unrestricted, speech, 3.1 kHz audio, packet mode B-channel, packet mode D-channel)
- Channel identification (B1, B2, D, or H channel request)
- Low-layer compatibility (type of bit rate adaptation, type of modem …)
- High-layer compatibility (teleservice-related issues)
- Keypad facility

ITU-T Standardization (I-Series Recommendations)

Well defined and exact description of ISDN

very boring to read

I.100-199 General issues
I.200-299 Service issues
I.300-399 Network aspects
I.400-499 User-network interfaces
I.500-599 Internetwork interfaces
I.600-699 Maintenance principles

Q.921 & Q.931 Subscriber signaling issues

Basic telecommunication services

Bearer services provide the capability of transmitting signals between network access points. Higher-level functionality of user terminals is not specified.

Teleservices provide the full communication capability by means of network functions, terminals, dedicated network elements, etc.

Supplementary services

A supplementary service modifies or supplements a basic telecommunication service. It cannot be offered to a customer as a stand-alone service.

Some typical teleservices

- Telephony (normal, high quality)
- Telefax (Group 4)
- Video-telephony

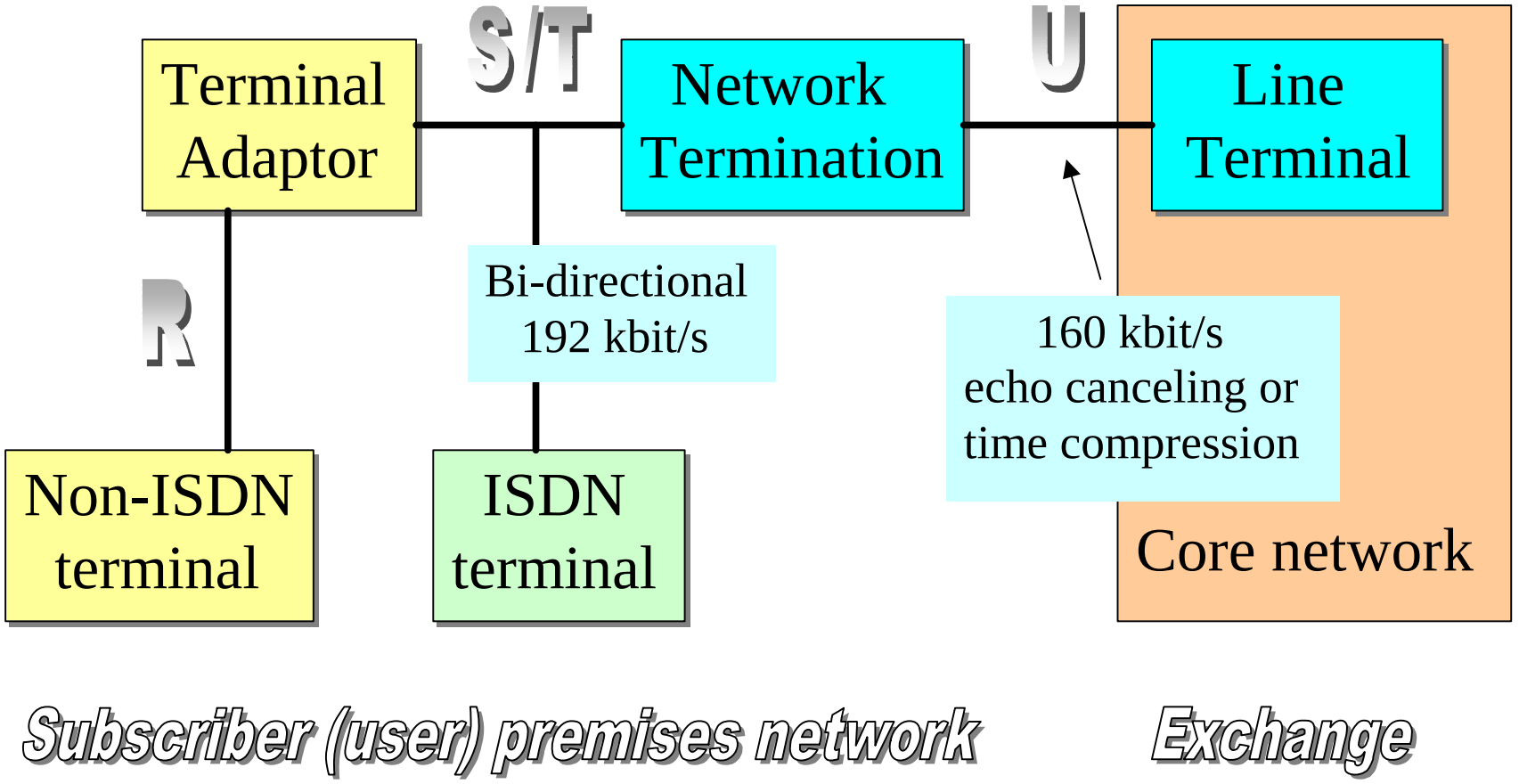
Some typical bearer services

- Speech (transparency not guaranteed)
- 64 kbit/s unrestricted
- 3.1 kHz audio (non-ISDN interworking)

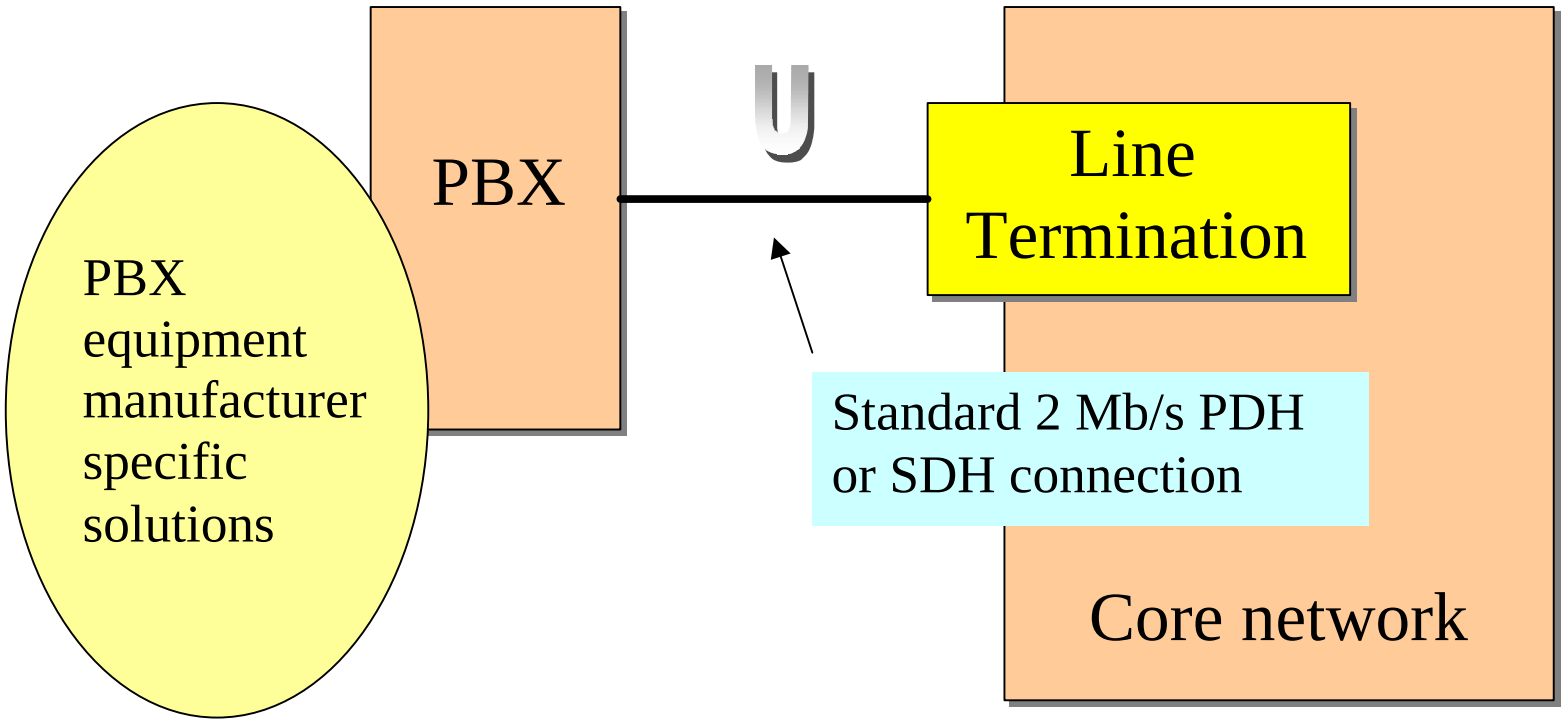
Some typical supplementary services

- CLIP / CLIR
- Call forwarding / waiting / hold
- Charging supplementary services

Basic rate access – user interface



Primary rate access – user interface



Layered DSS1 signaling structure

DSS1 = Digital Subscriber Signaling system no.1

Layer 1: Bit sequence structure, framing & multiplexing

I.430

Layer 2: Link control (HDLC-type protocol called LAPD)

Q.921 (I.441)

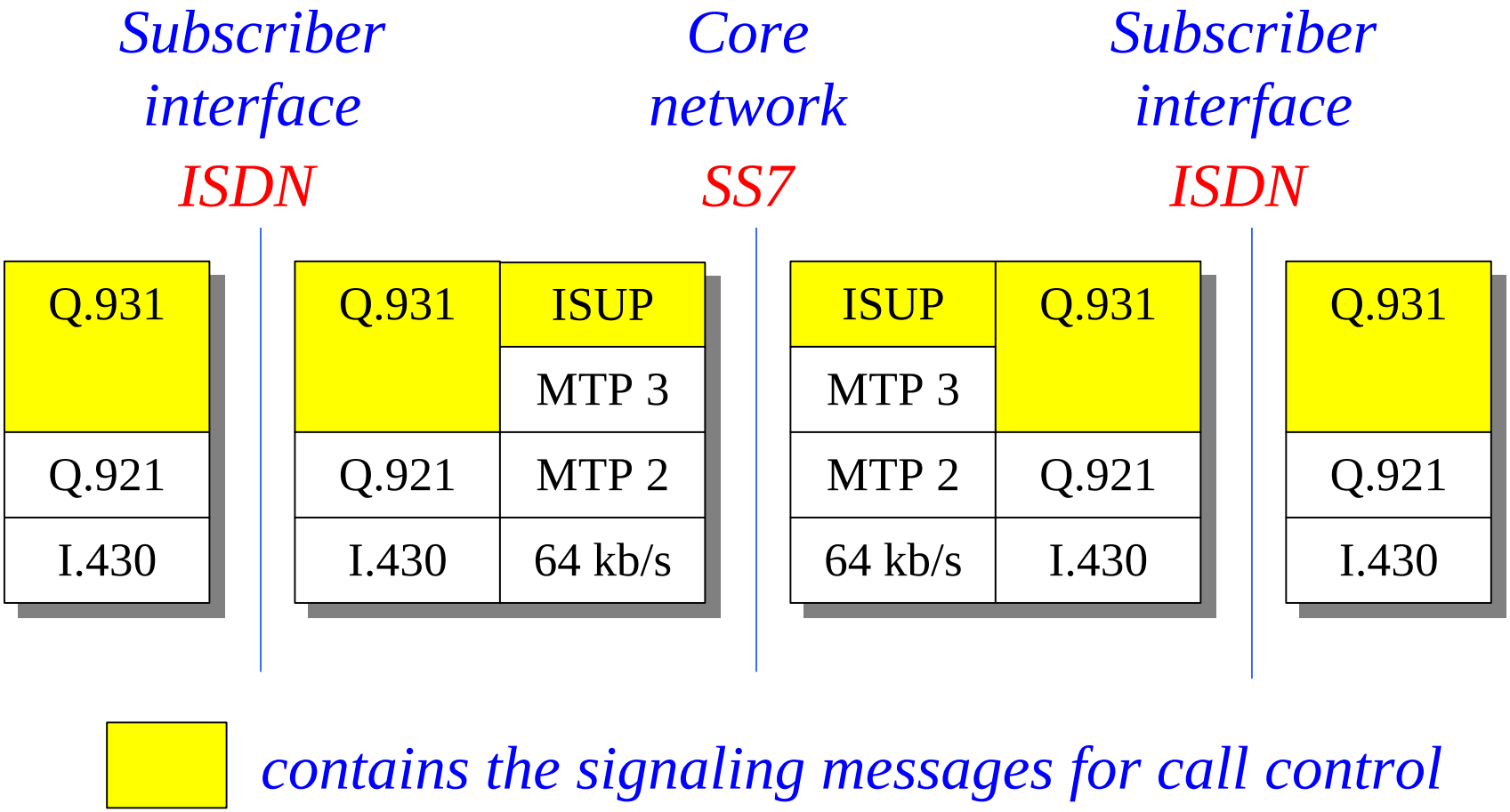
GSM, X.25

Layer 3: Signaling messages

Q.931 (I.451)

B-ISDN, GSM

Protocol Stacks



Layer 2

LAPD is used for:

- Establishing data link connections identified by the Data Link Connection Identifier (DLCI = SAPI + TEI)
- frame delimiting, alignment and transparency, allowing recognition of frames transmitted over a D-channel
- sequence control, to maintain the sequential order of frames across a data link connection
- flow control (temporarily stopping transmission)
- detection of errors on a data link connection
- recovery from errors, and notification to the management entity of unrecoverable errors

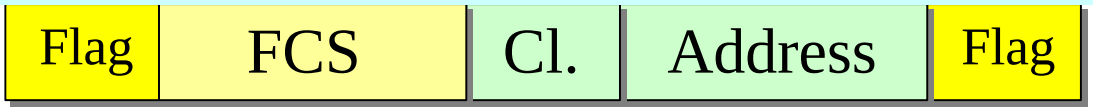
Layer 2

LAPD frame structure

Information (I) frame:

Supervisory (S) frame: RR, RNR, REJ

Unnumbered (U) frame: SABME, UA, DISC, DM, UI, FRMR, XID



Layer 2

LAPD Control field

Control field bits	*8*	*7*	*6*	*5*	*4*	*3*	*2*	*1*
I format	N(S)							0
	N(R)							P
S format	X	X	X	X	S	S	0	1
	N(R)							P/F
U format	M	M	M	P/F	M	M	1	1

N(S)	Transmitter send sequence number
N(R)	Transmitter receive sequence number
S	Supervisory function bit
M	Modifier function bit
P/F	Poll bit when issued as a command, final bit when issued as a response
X	Reserved and set to 0

Layer 2

LAPD Address field

Address field bits	*8*	*7*	*6*	*5*	*4*	*3*	*2*	*1*
octet 1	SAPI						**C/R**	**0**
octet 2	TEI							**1**

TEI = Terminal Endpoint Identifier

SAPI = Service Access Point Identifier

SAPI value	*Related layer 3 or management entity*
0	Q.931 call control procedures
16	X.25 (level 3) packet communication
63	Layer 2 management procedures

Q.931 Call-related messages

Call establishment messages:	*Section*
ALERTING	3.1.1
CALL PROCEEDING	3.1.2
CONNECT	3.1.3
CONNECT ACKNOWLEDGE	3.1.4
PROGRESS	3.1.8
SETUP	3.1.14
SETUP ACKNOWLEDGE	3.1.15
Call clearing messages:	*Section*
DISCONNECT	3.1.5
RELEASE	3.1.9
RELEASE COMPLETE	3.1.10

Other Q.931 messages

Call information phase messages:	*Section*
RESUME	3.1.11
RESUME ACKNOWLEDGE	3.1.12
RESUME REJECT	3.1.13
SUSPEND	3.1.18
SUSPEND ACKNOWLEDGE	3.1.19
SUSPEND REJECT	3.1.20
Miscellaneous messages:	*Section*
INFORMATION	3.1.6
NOTIFY	3.1.7
SEGMENT	Annex H (Note 2)
STATUS	3.1.16
STATUS ENQUIRY	3.1.17

Structure of Q.931 message (Release)

Message type: RELEASE Significance: Local (Note 1) Direction: Both				
Information element (IE)	**Reference (subclause)**	**Direction**	**Type**	**Length**
Protocol discriminator	4.2	Both	M	1
Call reference	4.3	Both	M	2-*
Message type	4.4	Both	M	1
Cause	4.5	Both	O (Note 2)	2-32
Display	4.5	n → u	O (Note 3)	(Note 4)
Signal	4.5	n → u	O (Note 5)	2-3

Large number of causes (for connection release) possible

Protocol discriminator IE

- Discriminates (for instance) between Q.931 (N-ISDN) and Q.2931 (B-ISDN) protocol family messages
- 1 octet

Message type IE

- Describes the type of Q.931 message (Setup, Release, Alerting …) in question
- 1 octet

Call reference IE

The purpose of the call reference is to identify the call at the local user-network interface. The call reference does not have end-to-end significance in an ISDN network.

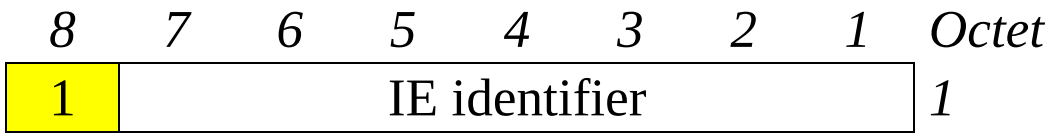
Octet bits	*8*	*7*	*6*	*5*	*4*	*3*	*2*	*1*
octet 1	0	0	0	0	CR length (octets)			
octet 2	F	Call reference value						
octet 3 etc.								

F = 0: message *from* the side setting the call reference

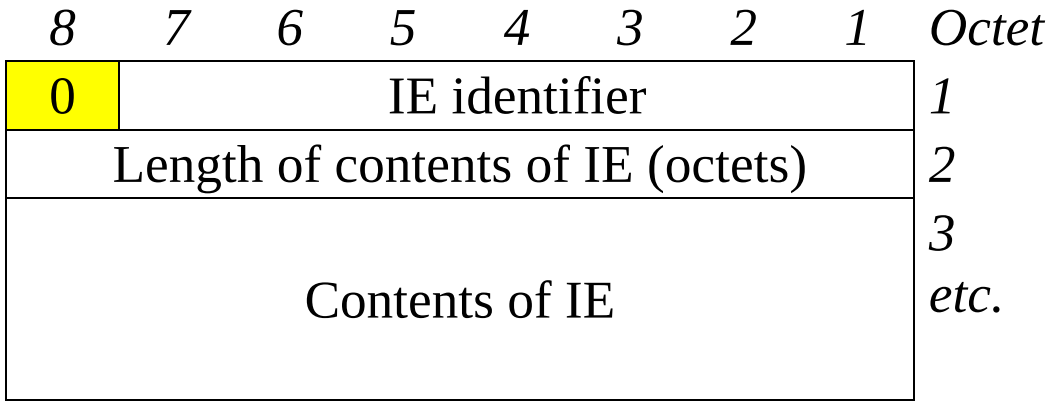
F = 1: message *to* the side setting the call reference

Other Information Elements (IE)

Single octet IE:



Variable length IE:



Example of Information Element

Called party number IE
(usually included in *Setup* message)

8	*7*	*6*	*5*	*4*	*3*	*2*	*1*	*Octet*
	Called party number information element identifier							
0	1	1	1	0	0	0	0	1
Length of called party number contents								2
Ext. 1	Type of number			Numbering plan identification				3
0	Number digits (IA5 characters)							4 etc.

Type of number (TON)

Bits 5 … 7 in octet 3 of the Called party IE:

7 6 5	
0 0 0	Unknown
0 0 1	International number (note 3)
0 1 0	National number (note 3)
0 1 1	Network specific number
1 0 0	Subscriber number (note 3)
1 1 0	Abbreviated number
1 1 1	Reserved for extension
All other values are reserved.	

note 3 – Prefix or escape digits shall not be included

Numbering plan identification (NPI)

Bits 1 … 4 in octet 3 of the Called party IE:

4 3 2 1	
0 0 0 0	Unknown
0 0 0 1	ISDN/telephony numbering plan (Rec. E.164)
0 0 1 1	Data numbering plan (Recommendation X.121)
0 1 0 0	Telex numbering plan (Recommendation F.69)
1 0 0 0	National standard numbering plan
1 0 0 1	Private numbering plan
1 1 1 1	Reserved for extension

All other values are reserved.

- applies for TON = 000, 001, 010 and 100

Another IE example

Bearer capability IE
(mandatory in *Setup* message)

8	*7*	*6*	*5*	*4*	*3*	*2*	*1*	*Octet*
	Bearer capability IE identifier							
0	0	0	0	0	1	0	0	1
Length of the bearer capability contents								2
ext. 1	Coding standard		Information transfer capability					3
ext. 1	Transfer mode		Information transfer rate					4
Further octets …								5 etc.

Information transfer capability

Bits 1 … 5 in octet 3 of the Bearer capability IE:

5	*4*	*3*	*2*	*1*	
0	0	0	0	0	Speech
0	1	0	0	0	Unrestricted digital information
0	1	0	0	1	Restricted digital information
1	0	0	0	0	3.1 kHz audio
1	0	0	0	1	Unrestricted digital information with tones/announcements (previously “7 kHz audio”)
1	1	0	0	0	Video

- Unrestricted digital information – “true” ISDN
- 3.1 kHz audio – PCM encoding (for modems)
- Speech – echo suppression & satellite link allowed
- 3.1 kHz audio & Speech – A / μ -law transcoding ?

Transfer mode

Bits 6 and 7 in octet 4 of the Bearer capability IE:

7	*6*	
0	0	Circuit mode
1	0	Packet mode

Information transfer rate

Bits 1 … 5 in octet 4 of the Bearer capability IE:

5	*4*	*3*	*2*	*1*	*Circuit mode only*
1	0	0	0	0	64 kbit/s
1	0	0	0	1	2 x 64 kbit/s
1	0	0	1	1	384 kbit/s (H0 = 6B)
1	0	1	0	1	1536 kbit/s (US & Japan)
1	0	1	1	1	1920 kbit/s (H12 = 30B)
1	1	0	0	0	Multirate (separate encoding)

- In *Packet mode* all bits are set to zero