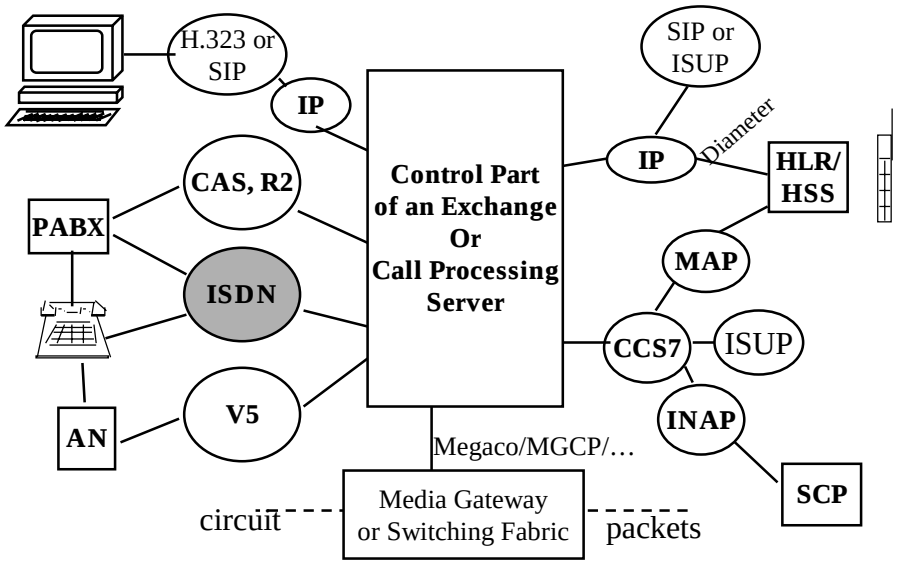
Integrated Services Digital Network

- ✔ **Some repetition**
- ✔ **ISDN access**
  - › **structure**
  - › **interfaces**
  - › **physical layer**
- ✔ **ISDN signaling**
  - › **bearer and telecommunication services**
  - › **layer 1**
  - › **layer 2**
  - › **layer 3**

Summary of course scope (1)

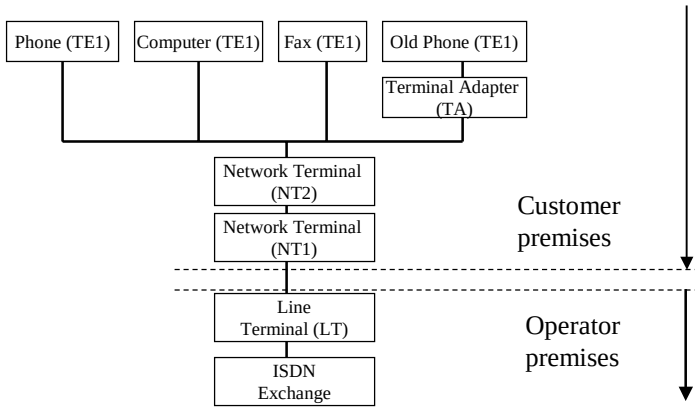


Some repetition

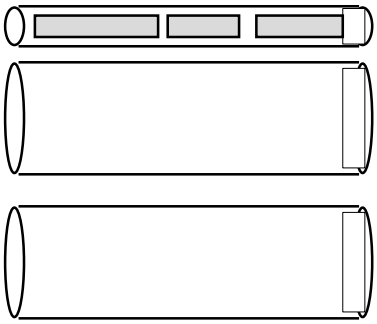
- ✔ **Channel Associated Signaling (CAS) is tightly tied to the voice channel either in space, time or frequency -> no signaling unless voice channel is reserved.**
- ✔ **CAS has many limitations: in a PCM -frame one tsl needs to be dedicated to signaling and a multi-frame of 16 frames needs to be maintained. A set of signals is limited.**
- ✔ **Channel Associated R2-signaling is the first widely adopted, standardized CAS signaling system (but still not used in every country).**
- ✔ **R2 signaling is compelled.**
- ✔ **Call setup or register signaling vs. line signaling.**

ISDN -access has a set of standardized interfaces

- ✔ **ISDN-access provides a bus for connecting user terminals, the max of 8 terminals can be attached.**
- ✔ **Many interfaces are specified between logical entities in the access**



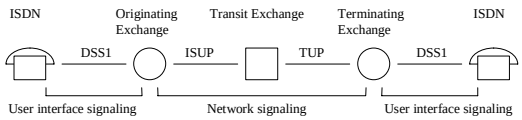
ISDN Basic Interface provides 2 x 64kbit/s to the user



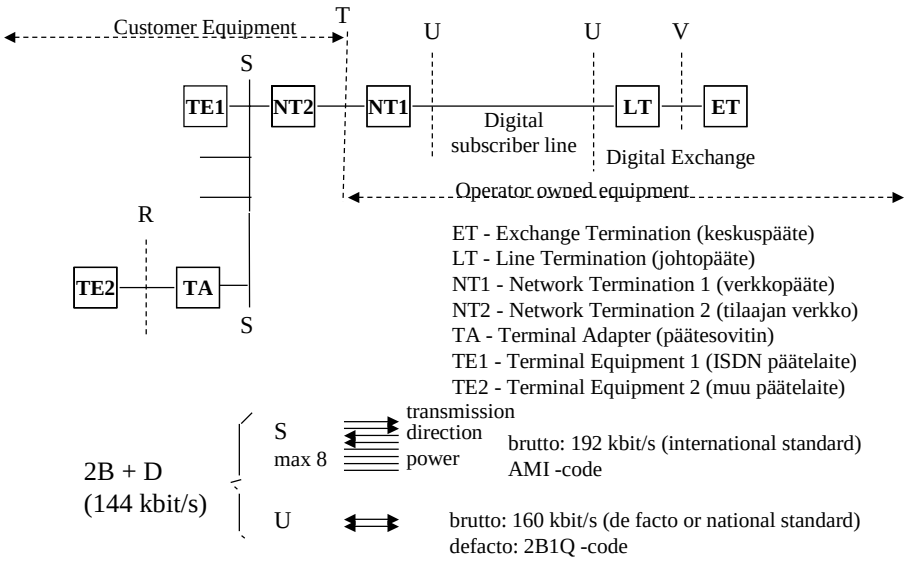
- ✔ **Two types of Interfaces:**
  - › **Basic Rate Interface (BRI) (**$2B+D_{16}$**)**
  - › **Primary Rate Interface (PRI) (**$30B+D_{64}$**)**
- ✔ **BRI provides two B-channels for information transfer and a signaling channel (D-channel) :**
  - › **Two independent terminals can use one B-channel each at a time.**
  - › **The main purpose of the D-channel is transport of signaling between the terminals and the local ISDN exchange. Packet mode transfer is used on the D-channel.**

Message based signaling systems

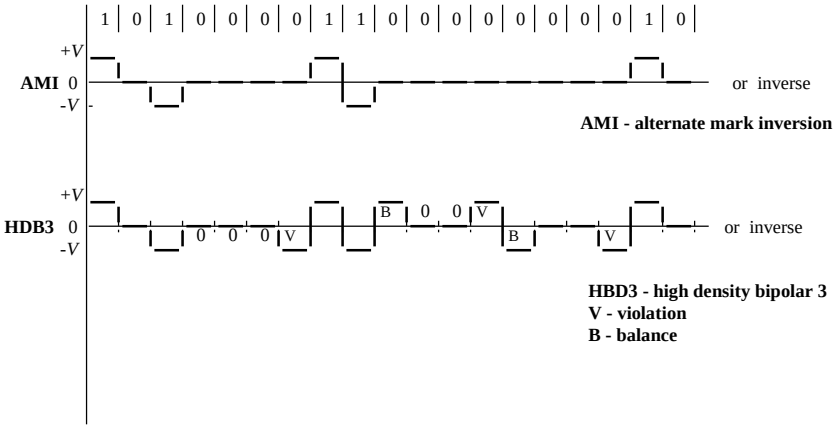
- ✔ **Message based signaling has been developed to improve the control possibilities of the network by terminals.**
- ✔ **Message based signaling can be used only by Computer controlled, fully digital exchanges.**
- ✔ **Message based signaling is natural for computers - the signaling information is largely in the same format in which it is processed and stored.**
- ✔ **Message based signaling is based on ITU-T:n SS6 (now CCS7 and ISDN) recommendations.**



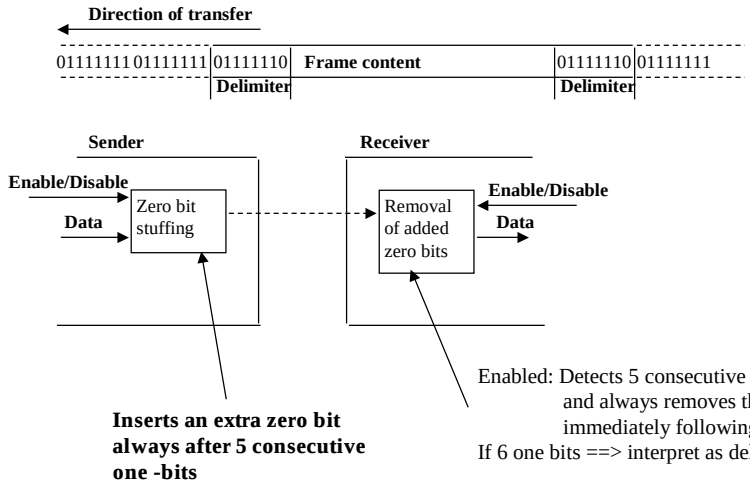
ISDN Access and ISDN Interfaces



Examples of line codes



HDLC - transfers frames, delimited by 0111 1110 delimiters.



ISDN D-channel layer 2 = LAPD -protocol is based on this HDLC principle.
HDLC - High level Data Link Control

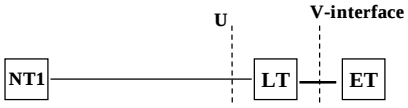
HDLC Sender

```
Do forever
    count=0
    Do While Enable
    if databit=1
        count=count+1
        if count = 5
            send 0
            set count = 0
        fi
    else
        set count = 0
    fi
    send databit
    End do while enable
    If disable
        send 01111110
    fi
End
```

HDLC Receiver

```
Do forever
    When 01111110 received
    count=0
    set Enable
    Do While Enable
    if databit=1
        count=count+1
        if count = 6
            01111110 received !
            set disable
        else
            pass databit (to) onwards
        fi
    else if databit = 0
        if count = 5
            remove 0
        else
            pass databit (to) onwards
        fi
        set count = 0
    fi
End while enable
if disable
    remove tail 011111 from onwards
    pass frame from onwards to the upper
        layer
fi
End do forever
```

(U ja V) -interfaces



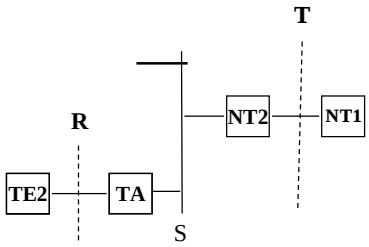
- **Network Termination NT1 is connected to the exchange Line Termination using the U-interface.**
  - **Data transfer takes place on a twisted pair copper cable (BRI), the bit rate is 160 kbit/s bi-directionally (full duplex).**
  - **In Finland (originally in US) multi level code 2B1Q is used (-> baud rate is 80 kbaud).**
  - **Bi-directional full duplex transfer is based on echo cancellation: both parties send at the same time, receiver deducts what it has just sent, gets what the far end has sent!**
- **On the V-interface a number of specifications may be used.**
  - **V1-interface applies for the Basic rate interface.**
  - **V3-interface is meant for PBXs with a capacity of $30B+D_{64}$ channels.**

(S, T) -Interfaces

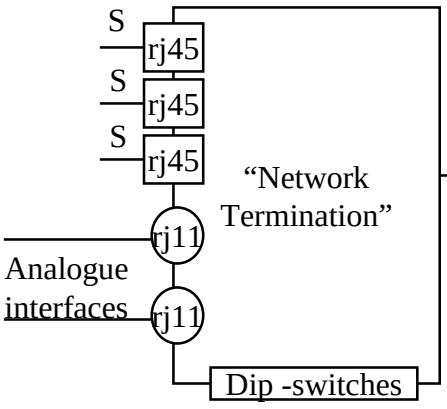
- **S-interface is meant for terminals.**
  - **The interface is a bus by structure**
  - **8 ISDN terminals can be connected.**
  - **Transfer in both directions uses 4 wires.**
- **T-interface is meant for PBXs**
  - **Resides between network termination NT1 and an ISDN-PBX (= NT2).**
  - **T0-interface = S0-interface and is used in PBXs that can serve only BRI connected users.**
- **T2-interface is meant for corporate PBXs**
  - **Transfer rate is 2048 kbit/s.**
  - **T2-interface has 32 channels with 64 kbit/s. Of those 30 are normal B-channels, one is the D-channel and one is used for synchronization. I.e. the structure is like a PCM.**

R -interface

- ✔ **R-interface separates the Terminal Adapter and a non-ISDN device from each other. It follows some existing specification understood by the non-ISDN device (e.g. V.24, V.35 or X.21 - protocol specification).**



In practice logical functions are grouped in the equipment



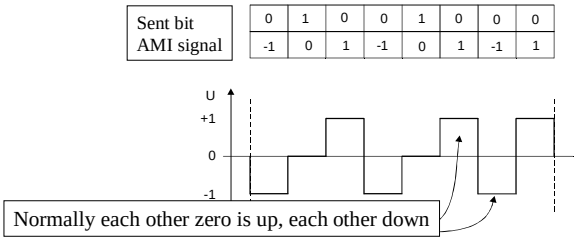
U-interface (twisted pair)

A Home-ISDN "NT" is likely to look like this. DIP switches are used for configuration.

Here physical "NT" = NT1+TA(for analogue phones)

Communication between NT and a Terminal

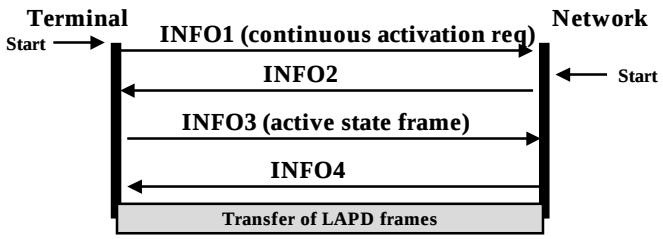
- ✔ **AMI -line code is used between a Terminal and the NT (AMI, Alternate Mark Inversion).**



- ✔ **When there is not traffic over an ISDN interface, terminals are deactivated. A continuous INFO 0 signal is on the the interface.**

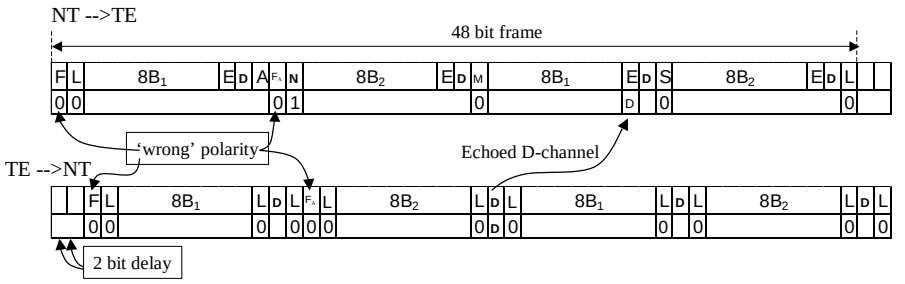
Activation of the basic rate interface

- ✔ **Terminal starts activation by sending a continuous activation request: INFO 1. When the network detects the request, it starts sending synchronization frames INFO 2.**
- ✔ **When the network initiates activation, it starts sending INFO 2 directly.**
- ✔ **When the terminal detects a synchronization frame, it stops sending the activation request signal and starts sending active state frames INFO 3. When the local exchange has received active state frames, it moves to INFO 4 state. The physical layer is now active and ready for information transfer.**



Frame structure on the S-interface

- ✔ **48 bit frames 4000 times per second are used between a terminal and the NT1.**
- ✔ **The resulting bit rate is 192kbit/s**



F	Frame alignment bit	B_1	channel 1 bits	A	Activation bit
F_A	Frame synchronization bit	B_2	channel 2 bits	M	Multi-frame bit (normally 0)
L	DC balance bit	D	D-channel bits	S	Future use (0)
N	Inverted F_A (normally 1)	E	Echo channel bits		

Frame synchronization

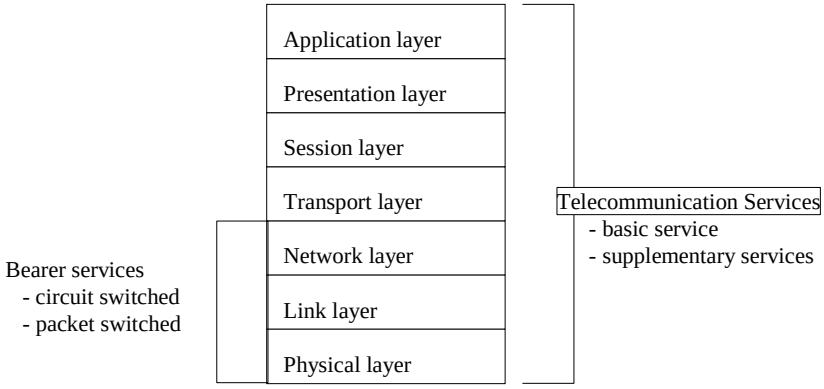
- ✔ **Frame synchronization is achieved by sending violation bits in the AMI code.**
- ✔ **The first (F) and the 14th bit (FA) equal to zero with a wrong polarity I.e. the same as the previous zero. To balance this for the sake of zero average voltage, the wrong zero is followed by DC balance bit (L).**

NB: On S-interface the AMI code is inverted, I.e. logical zero is sent as a pulse with alternating polarity and a logical 1 is sent as zero voltage.

Overhead bit in the frame carry D-ch echo and control power consumption

- ✔ **A Terminal can see that the NT has received its D-channel bits based on E(echo)-bits. NT copies a received D-bit to the next E-bit.**
- ✔ **A-bit is used for power control. With A-bit, the network can command the terminals to deactivate themselves and to transfer to a low power mode in which they are only able to become active again either on network request or user action. The activation procedure uses the A bit.**

Message based signaling can be functionally split following the OSI 7 layer model



Bearer services are transport services that are seen by the "user"

- ✔ **Circuit switched bearer services include:**
  - › **Speech**
  - › **3,1 kHz audio**
  - › **7 kHz audio**
  - › **transparent 64 kbit/s.**
- ✔ **Packet switched bearer services include:**
  - › **virtual call and permanent virtual connection,**
  - › **connectionless packet switched service on the D-channel,**
  - › **user-to-user signaling information.**

Telecommunication Services incorporate all OSI layers

- ✔ **A Telecommunication service is a set of functions offered to a user and it is implemented using the capabilities of all OSI layers.**
- ✔ **Telecommunication services make use of the bearer services.**
- ✔ **Telecommunication services can by further divided into basic and supplementary services.**
- ✔ **Supplementary services can be used only in connection with a basic service.**

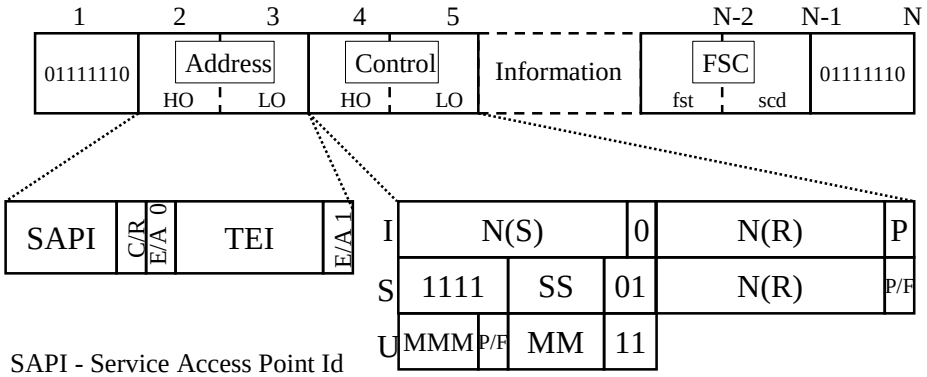
Digital Signaling System Nr 1 (DSS 1)

- ✔ **DSS1 is based on a protocol stack that includes three OSI lower layers.**
- ✔ **DSS1 is fully message based and out-of-band offering the possibility of signaling while the voice channel is open end-to-end.**
- ✔ **DSS1 messages are sent on the D-channel.**
- ✔ **DSS1 layer 2 follows the HDLC principles and is called the LAPD-protocol (Q.920 - Q.921).**
- ✔ **DSS1 signaling overview is given in ITU-T Q.930 and detailed procedures are given in Q.931.**

Q.920/Q.921 - LAPD

- ✔ **Connectivity over the link between a terminal and the Local exchange**
  - › **Inherits HDLC principles.**
  - › **Corresponds to the OSI layer 2 requirements**
- ✔ **Transfers frames from *many terminals to many layer 3 entities*.**
- ✔ **Properties:**
  - › **DLCI - data link connection id identifies the link connections: DLCI = SAPI + TEI. SAPI = Service Access Point Id, TEI = Terminal Endpoint Id - are purely layer 2 concepts. Layer 3 uses CEI - Connection Endpoint Id = (SAPI+CES)**
  - › **Can guarantee frame order due to numbering.**
  - › **Fault management - lighter than MTP in CCS#7.**
  - › **Flow control based on windowing.**

LAPD frame format



SAPI - Service Access Point Id
e.g. 0 = call cntrl procedures
TEI - Terminal Endpoint Id
E/A - Address field extension bit
= 1 = final bit
C/R - Command/Response field bit

N(S) - Transmitter send sequence nr
N(R) - Transmitter receive seq. Nr
S - Supervisory function bit (e.g. ack frames)
M - Modifier function bit
P - poll when issued as a command,
final bit when issued as response

Q.921 - LAPD

- ✔ **Point-to-point link connections, multi-point connections - broadcast**
- ✔ **Initiation state - TEI values not yet chosen.**
- ✔ **Unnumbered Information = UI -frames are not acknowledged**
  - › **also broadcast (e.g. SETUP to B subscriber)**
  - › **faults recovery is left for the upper layers.**
- ✔ **Acknowledged mode - I - numbered frames**
  - › **fault recovery and flow control procedures supported on layer 2**

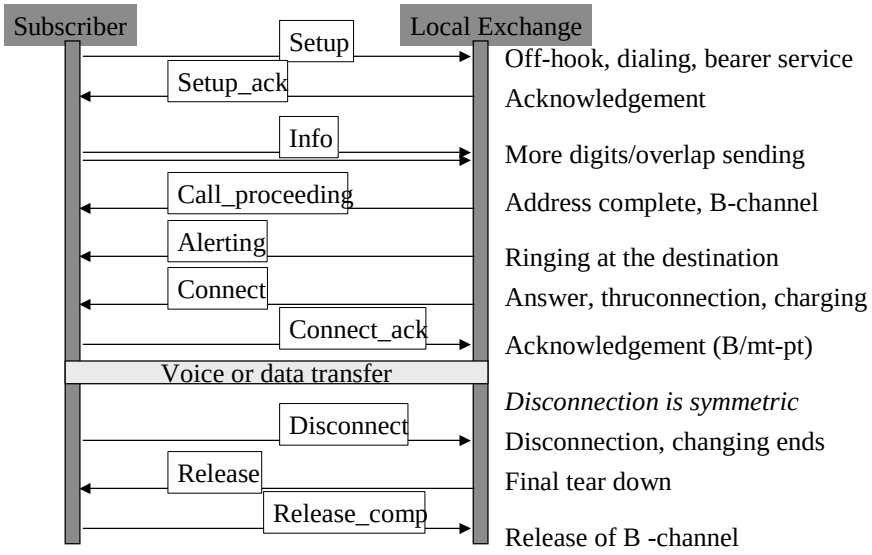
DSS1 - Q.931 - signaling

- ✔ **Corresponds to layer 3 - network layer:**
  - › **understands end-to-end addresses: E.164 telephone numbers**
- ✔ **Can set up, control and release circuit switched calls.**
- ✔ **Supports also packet switched on-demand connections.**
- ✔ **Call identification is based on the *call reference* - and has nothing to do with e.g. the identity of the B-channel in use!**
- ✔ **Supports the functional and the stimulus (keypad) modes of signaling.**
- ✔ **User-to-user information transfer in signaling messages is also supported (charging is an issue).**

Functional and stimulus -modes

- ✔ **Functional**
  - › **Information is encoded in service specific information elements.**
  - › **As a result, signaling becomes *service dependent.* A new service requires new programs both in the CPE and the exchange**
  - › **Can be OK, if CPE = PBX**
  - › **For phones would really require a JAVA -like automatic software download function. There is no such thing in ISDN!**
- ✔ **Stimulus -mode:**
  - › **phone button pushes are carried in signaling as such,**
  - › **Interpretation is the responsibility of the exchange**
  - › **A new service requires new programs only in the network**
  - › **The phone may have programmable soft keys to hide dialing sequences**

Q.931 -signaling call setup procedure



Disconnection is symmetric

NB: gives only one signaling scenario.

ISDN Summary

- ✔ **Signaling and voice channel are both physically and logically separated (out-of-band, common channel + call reference).**
- ✔ **Any signaling info needed for services is supported or can be added.**
- ✔ **Q.931 signaling is service dependent, contains really information that is relevant on OSI-layers 3 - 7! New services require new programs in CPEs in case of functional mode. There is no mechanism for automatic software download to CPEs.**
- ✔ **Multi-point structure complicated the implementation significantly.**
- ✔ **Major consumer value added is in 2 x 64kbit/s bit rate. ISDN adoption is determined by home Internet use.**
- ✔ **ISDN specified a digital PBX access signaling for the first time. This has been widely adopted! ISDN signaling has been reused in many new signaling applications (V5, private PBX networks, IP-Telephony, conferencing, GSM etc.)**