Course 4
Techniques and signaling systems used in classical telephone networks.
Definitions. Characteristics.

- The signaling in telephony refers to control signals, transmission techniques related to these signals and algorithms used for the management of the call; the mentioned signals and processes are used to control the establishment, deployment and interruption of a telephone connection.
- A first classification of the signaling techniques:
    - subscriber signaling – used between the subscriber terminal and the local exchange.
    - trunk signaling – used on trunk lines between exchanges of the public network, between a PBX and a local exchange or between two PBXs.
- According to the transmission mode of the signaling we have:
    - in-band signaling – the signaling is transmitted in the same frequency band as the speech signal.
    - out-band signaling – the signaling is transmitted outside the frequency band of the speech signal.
    - channel associated signaling – each voice (data) channel has assigned a separate signaling channel.
    - common channel signaling – the signaling assigned to all voice (data) channels or to a group of channels is accomplished on a common channel used specially for this operation.
- Another classification of the signaling technique:
    - Call supervision signaling – it is accomplished by using in-band or out-band supervision signals and at his turn has the following elements:
        - call supervision;
        - alert signaling;
        - call progress tones;
    - Address signaling – transmission of the information related to the called number on subscriber lines or on trunks.
    - Network management signaling – characteristic only to trunk signaling – for example management of congestions in switches.
- Call supervision signaling detects the state or changes the condition of a line or trunk (using out-band signaling).
    - There are two possible supervised conditions: ON-HOOK (idle state) and OFF-HOOK (active state). When a line/trunk goes OFF-HOOK, it is interpreted as a seizure by the system and the operating state of the considered equipment goes from idle to active.
    - Brief changes in the on-hook/off-hook status of a line or a trunk (transition called *wink* or *hook flash*) are also part of the supervision signaling.
    - An important part of supervisory signaling is represented by the (subscriber) access signaling and station loop signaling of the exchange. The access signaling refers to detection of the off-hook state of the calling terminal and the station loop signaling refers to the answer of the local exchange (or PBX), signaling related the acceptance or non-acceptance of the access in the network – access accepted: the dial tone is transmitted; unaccepted access: the busy ton is transmitted.

- Another important component of this signaling is the answer and disconnect supervision – important for billing.

- Alert signaling refers usually to sending to the called terminal (telephone or trunk equipment) of a ringing signal, signal applied to a line or a trunk.
- Call progress (indicator) signals refer to audible tones that indicate to the calling side the progress of the telephone call. These tones are characterized by frequency (or groups of frequencies) and timing (cadence). These tones are the following:
  - Dial tone – the CO is ready to accept the digits from the subscriber.
  - Busy tone – the called terminal is busy.
  - Reorder tone – the same as the busy tone, but the non-establishment of the call is due to congestion of local/transit exchanges or to unavailability of trunk circuits.
  - Special information tones – faulty line or non existent number, a.s.o.
  - Ring-back tone – indicates to the calling terminal the establishment of the connection and the alerting of the called terminal.
- Address signaling – the subscriber or the switching equipment sends to the network the information related to the called terminal; can be accomplished by sending impulses or DTMF tones; this information have to be sent in a public network across different links up to the final completion of the connection.
  - the address signaling on trunks is accomplished usually using a MF (Multi-frequency) type technique, different to the DTMF technique used by the subscriber (code 2 of 6); this signaling has the format: KP + number +ST, where KP (Key Pulse) represents the beginning of the number transmission and ST (Start) represents the end of this transmission and the beginning of the call processing.

Digit	Frequency #1 (Hz)	Frequency #2 (Hz)
KP	1100	1700
KP2	1300	1700
1	700	900
2	700	1100
3	900	1100
4	700	1300
5	900	1300
6	1100	1300
7	700	1500
8	900	1500
9	1100	1500
10	1300	1500
ST	1500	1700

Tab. 1 MF coding of the characters (digits) used in trunk address signaling

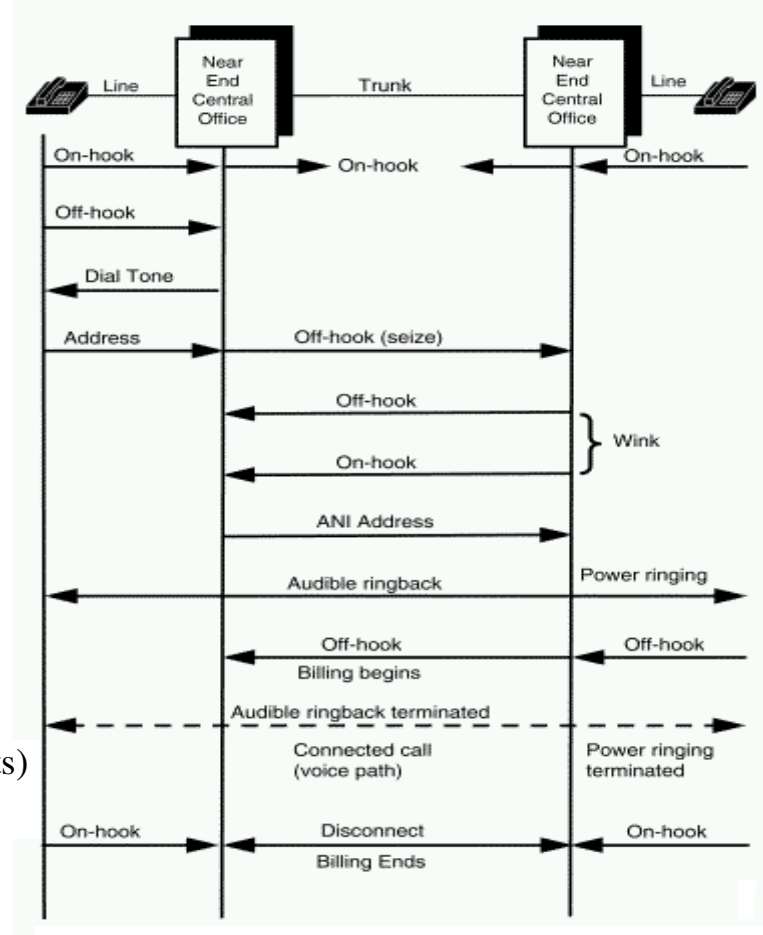

Fig. 1 Signaling sequence associated to a normal telephone call

- Access signaling – determines when a line is off-hook or on-hook; there are two basic variants of this signaling, namely:
  - *loop start* type signaling
  - *ground start* type signaling
    - *loop start* is characteristic to PSTN (Public Switched Telephone Network) – when the phone is active a current loop is closed, loop composed of the phone, wires and the central battery located in the exchange; the current is detected by a current sensing circuit and the exchange responds with the dial tone; the incoming call to the phone is signaled by a ringing signal repeated according to a given on/off pattern.
      - Problems related to this type of signaling: automatic answer machines could be blocked in off-hook state and the exchange is not capable to interrupt the connection.
      - The line/trunk can be seized in the same time from both directions; the ringing signal is an intermittent signal and in the no-signal period (it is about especially the first non-signal period) it is possible to have a call attempt from the terminal – it is special problem in the case of trunks or automatic call/answer equipments.
    - *ground start* signaling – used especially on analog trunk connections; when an equipment tries to access the network (to initiate a call) it connects the RING lead to the ground – the exchange detects the current through this lead and if it can accept the call connects the TIP lead to the ground; the call initiating equipment senses the current through TIP lead and begins the call; the interruption of the connection can be made by both of the parts; a dial tone can be provided to the calling part, but it is optional.

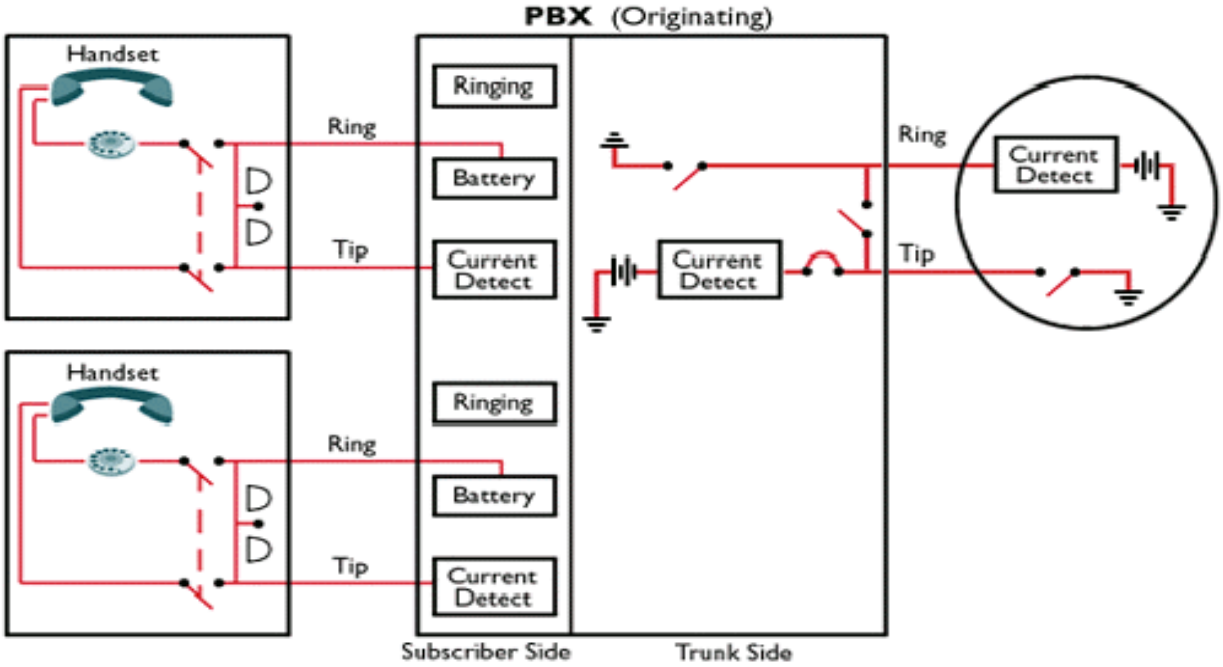

Fig. 2 „loop start" and „ground start" type signaling

- **F**oreign e**X**change (FX) signaling – called also FXS/FXO signaling – Foreign eXchange Station (FXS) / Foreign eXchange Office (FXO) – it was developed for the connection of PBX exchanges to local exchanges (Central Office); these exchanges are considered foreign not because they are located in a different country, but because they do not belong to the network which includes the CO; an FXS type interface is also used for the connection of a telephone device to CO or to the connection of a multiplexer to the exchange.

- the FXS interface located in CO ensures the supply voltage, ringing signal generation, off-hook detection, call progress indicator signals.
- the FXO interface located in PBX (or phone) ensures the detection of dial tone, ring signal detection, call progress signal detection.
- The operations characteristic to this signaling are presented in figure 3, corresponding to the direct respectively indirect connection of a phone device to a CO; the ring signal is not generated usually in the case of a PBX or PCM equipment connection to CO; CO – MUX PCM signaling is associated to each channel apart.

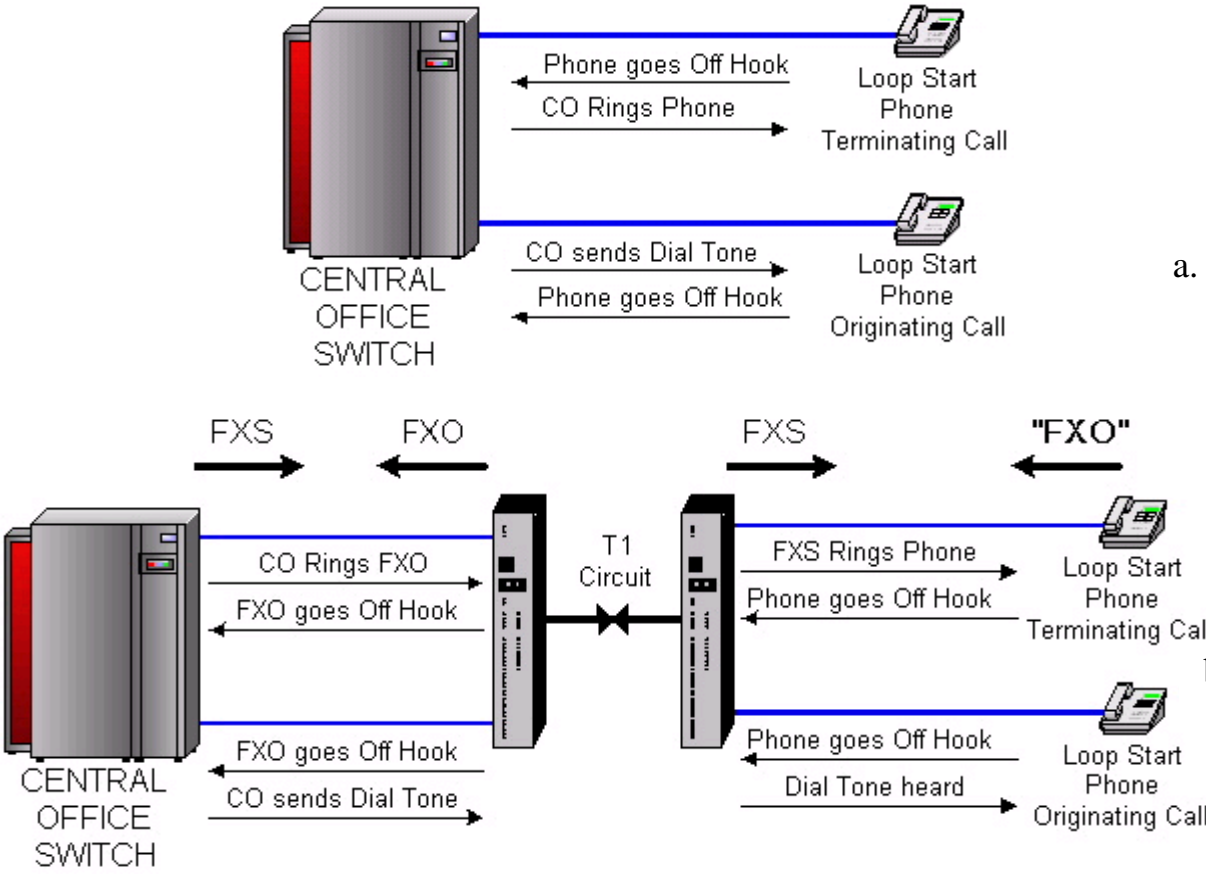

Fig. 3 The principles of FXS/FXO signaling. a. telephone - CO connection; b. PCM equipment – CO connection

- Allocation of (AB)CD bits to signals associated to FXS/FXO signaling is presented in table 2.

SIGNAL DIRECTION	FORWARD (to FXO)	BACKWARD (to FXS)
IDLE / ON HOOK	AB = 01	AB = 01
OFF HOOK		AB = 11
RINGING	AB = 00	
RING GROUND		AB = 00 (GS Only!)
TIP CLOSED	AB = 01 (GS Only!)	
FORWARD DISCONNECT	AB = 11 (GS Only!)	

GS - ground start

Tab. 2 Allocation of AB(CD) bits to physical signals characteristic to FXS/FXO signaling

- E&M signaling (**E**ar and **M**outh or rec**E**ive and trans**M**it) – signaling technique developed for trunk signaling between PBX and PSTN exchanges; there were developed different signaling variants (types I - V), variants which utilize two wire or four wire implementations;

- This signaling technique is based on two signals, called M and E. The M signal is generated by the trunk call initiating exchange, and the E signal is a response sent by the exchange located at the opposite end of the trunk; the E&M signaling channel is separated to the audio channel of the trunk, as it is depicted in fig. 4.
- Using these two signals are coded the states of the equipments located at the two ends of the trunk connection, equipments which can be in the IDLE / ON HOOK state or in the BUSY (SEIZED) / OFF HOOK state; using some impulses (activation – deactivation : „wink") other information can be transmitted on these lines.
- Sending of the called number on the trunk connection is realized using a MF type (coding) transmission on the audio path.

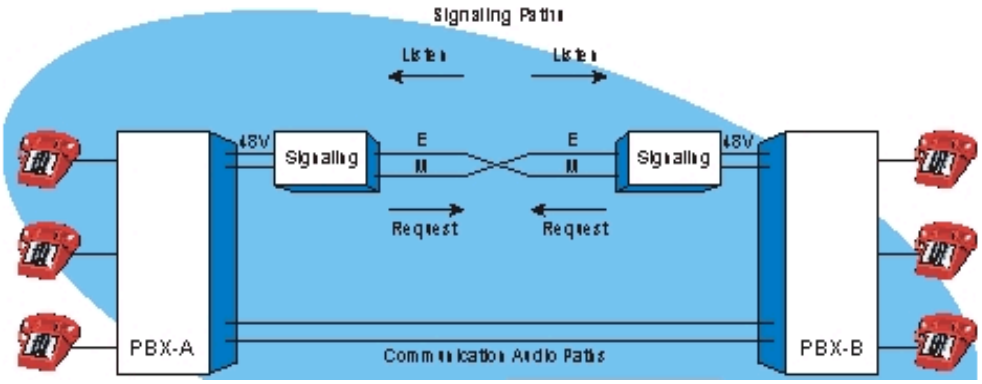

Fig. 4 E&M signaling. General view

- There are three types of E&M signaling, namely:
  - **E&M immediate** – the call initiating equipment goes OFF HOOK and transmits immediately the called number;
  - after the reception of the number the trunk equipment on the opposite end goes OFF-HOOK during the entire call;
  - both equipments can terminate the call by going in the ON-HOOK state;
  - there is the possibility that the called trunk equipment is not ready to receive the number;
  - **E&M wink**
  - the terminal equipment responds to an OFF-HOOK state of the calling equipment with a short OFF-HOOK impulse – meaning „wink" in the moment when is ready to receive the called number;
  - the opening of the audio path and the starting of the billing process is achieved after the E signal (lead) goes OFF-HOOK.
  - the E&M signal sequence is presented in fig. 5

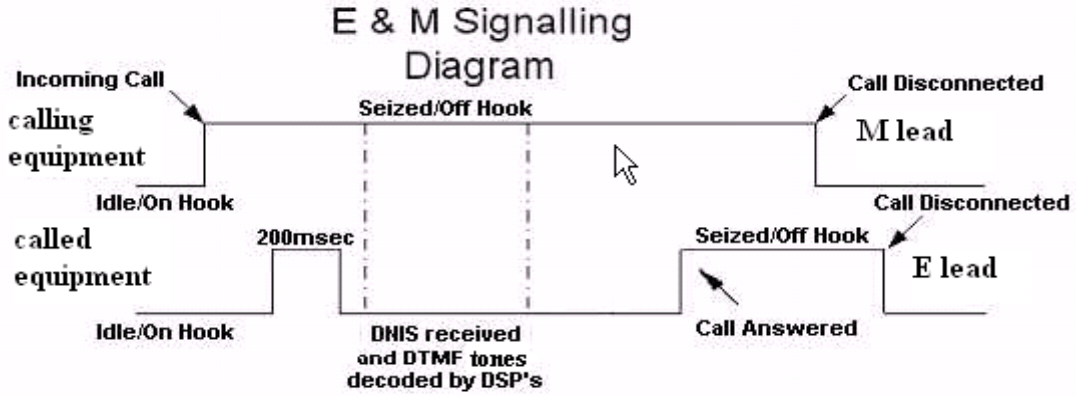

Fig. 5 Signal sequence corresponding to E&M wink type signaling
(DNIS – Dialed Number Identification Service)

- **E&M wink-wink**
- the terminal equipment responds to an OFF-HOOK state of the calling equipment with a short impulse on (lead) signal E;
- the call originating equipment sends the number in MF code on audio the path and the receiving equipment sends another short impulse, signaling that it received all the digits;

- Allocation of (AB)CD bits to signals associated to E&M signaling is presented in table 3.

Direction	State	A	B	C	D
Transmit	Idle/On-Hook	0	0	0	0
Transmit	Seized/Off-Hook	1	1	1	1
Receive	Idle/On-Hook	0	0	0	0
Receive	Seized/Off-Hook	1	1	1	1

Tab. 3 Allocation of AB(CD) bits to physical signals characteristic to E&M signaling

- MFC-R2 signaling – „Multifrequency Compelled R2 Signaling System", called also R2 signaling.
  - the R2 term refers to the region 2, considered to be Europe (USA was considered region 1); it is called also inter-register signaling (register – signaling equipment used to control the switching process – is the part dedicated to address signaling, switching control and (partially) control of the connection – for ex. billing control);
  - it is dedicated especially to E1 type connections;
  - it is characterized by the fact that each command has an appropriate acknowledge signal;
  - it is somewhat similar (as principle) with E&M signaling in the sense that the call supervisory signaling is realized based on digital signals transmitted with A B C D bits, and the address signaling is accomplished also by MF technique; some of the control signals are also transmitted by MF technique;
    - Two distinct parts can be identified in the case of this signaling technique, namely: line signaling, used to seize or to release the trunk at both ends – it is accomplished based on A B C D digital signals and inter-register signaling accomplished by the use of MF signals;
    - The signaling sequence corresponding to R2 technique for different possible situations characteristic to a telephone connection are presented in fig. 7.a – 7.d.
    - The allocation of (AB)CD bits to different signals associated to R2 signaling is presented in table 4; C and D bits are not used for basic operations – these bits can be used for signaling associated to some special supplementary services like call forwarding.

State of the Circuit	Signaling Code	
	Forward	Backward
	A B	A B
Idle/Released	1 0	1 0
Seized	0 0	1 0
Seizure Acknowledged/Meter	0 0	1 1
Answered/Meter	0 0	0 1
Clear-forward	1 0	0 0
Clear-forward	1 0	0 1
Clear-forward	1 0	1 1
Forced Release	0 0	0 0
Blocked	1 0	1 1

Tab. 4 Allocation of AB(CD) bits to physical signals characteristic to R2 signaling

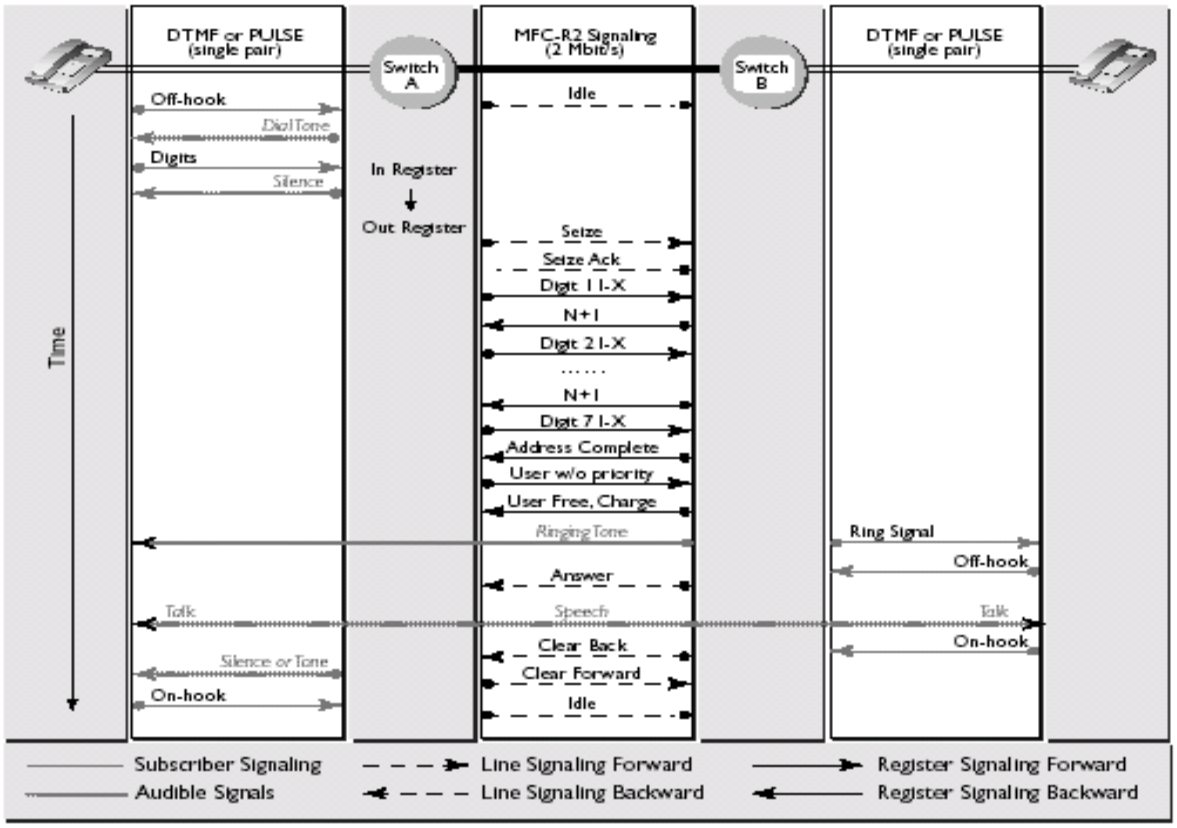

Fig. 6.a *Called party answers and releases the call*

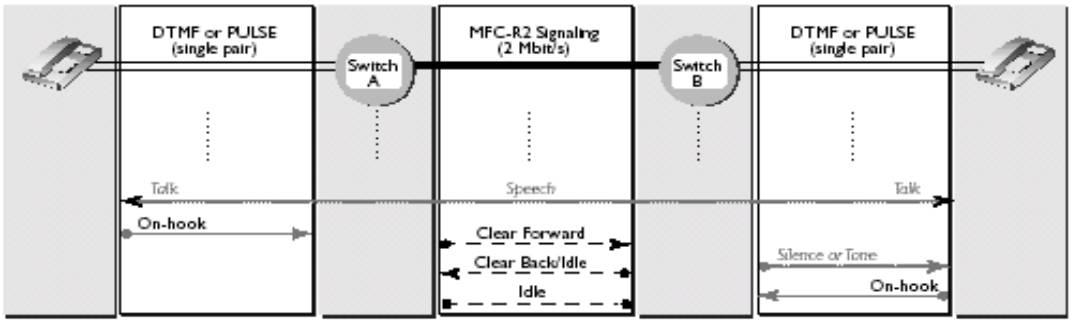

Fig. 6.b *Caller party releases the call*

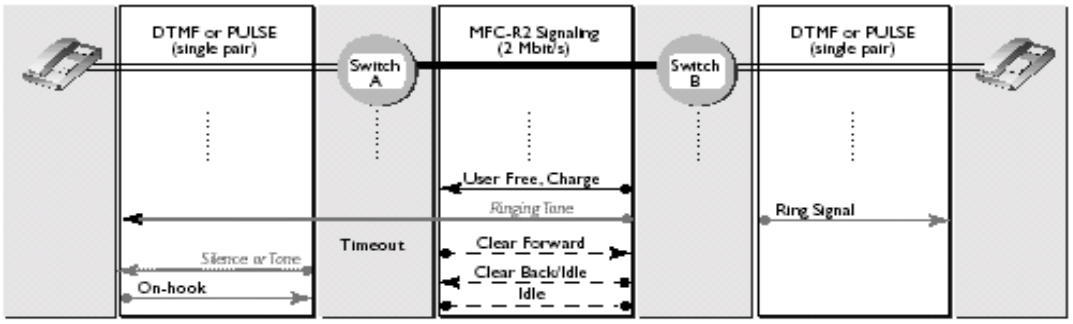

Fig. 6.c *Called party available, but no answer*

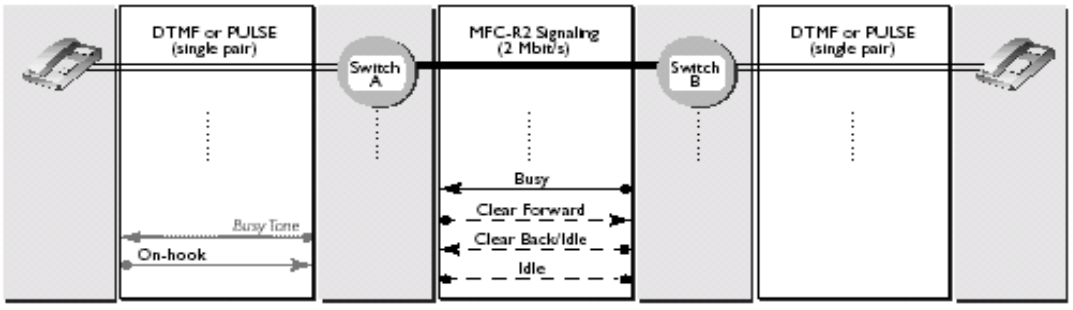

Fig. 6.d *Called party busy or congested*

Fig. 6 Signal sequences associated to R2 signaling. Different situations corresponding to a telephone connection are considered.