Wireless Communications

(Unit-6)

Wireless Networking

What Is A Network

A network is a system of interconnected elements. It can be represented by a group of nodes interconnected by links.

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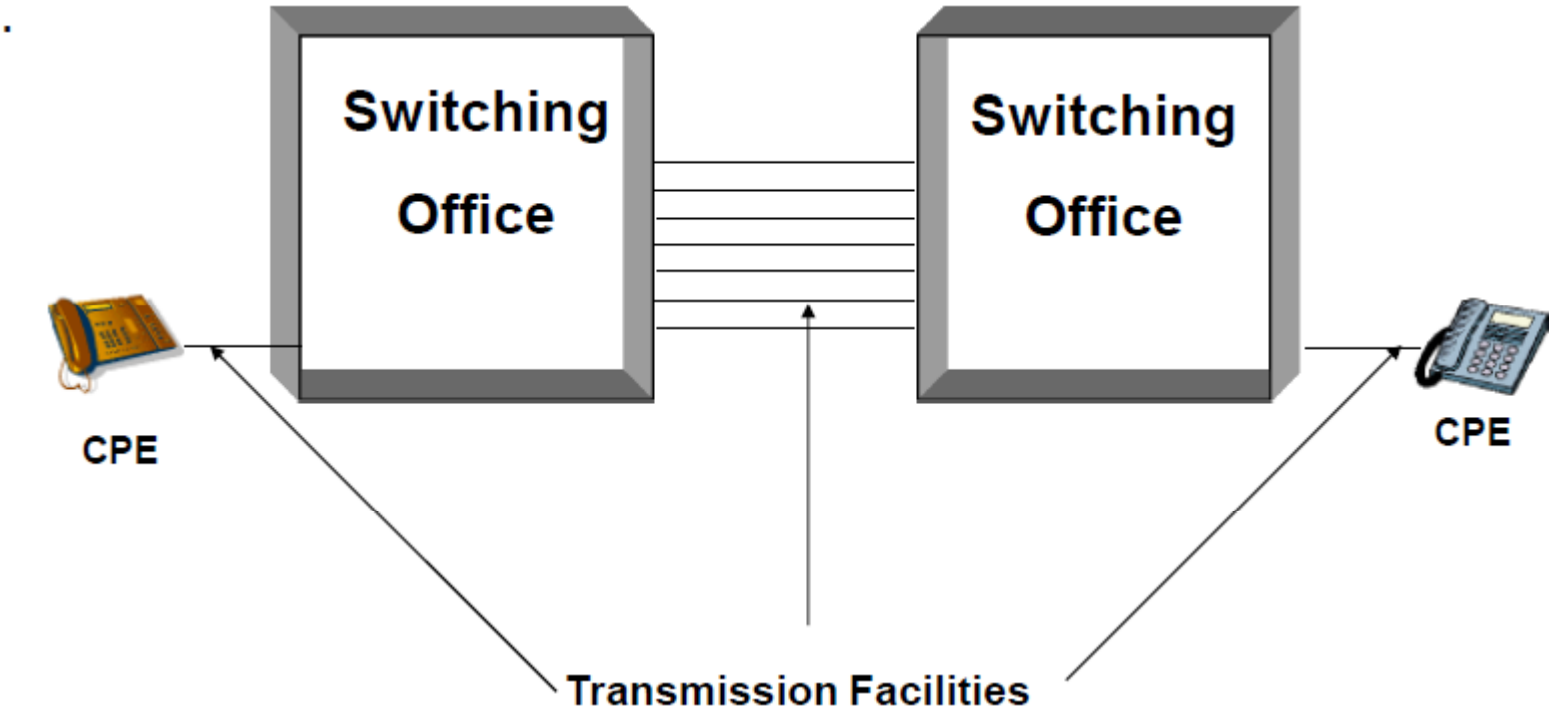


A Telecommunication Network

A telecommunications network is a network of interconnected elements designed to carry telecommunications services. The nodes of a telecommunications network are switching offices and user station equipment called customer premise equipment (CPE). The links represent the transmission facilities.

The flow of messages and information between the nodes over the links is called traffic. Traffic can be generated by simple telephone conversations or complex data, audio, and video services.

A telecommunications network must be able to carry traffic between customers over large geographic areas, generated between any customers at any time, with relatively short delay.

Wireless networks in comparison to fixed networks

NETWORK CONFIGURATIONS

- Network Configurations in PSTN are static since n/w connections can only be changed when subscriber changes residence & requires reprogramming at local central office of the subscriber
- Wireless networks are highly dynamic with the network configuration being rearranged every time a subscriber moves into the coverage region of a different base station.

Wireless networks in comparison to fixed networks

RECONFIGURATIONS

- Fixed Networks are difficult to change while wireless networks must reconfigure themselves for users within small intervals of time to provide roaming and imperceptible handoffs between calls as a mobile moves about.

Wireless networks in comparison to fixed networks

INCREASING AVAILABLE CHANNEL BANDWIDTH:

- In case of fixed networks it can be increased by installing high capacity cables whereas wireless networks are constrained by meager RF cellular bandwidth provided for each user.

Wireless networks in comparison to fixed networks

- **Higher loss-rates due to interference**
  - emissions of, e.g., engines, lightning
- **Restrictive regulations of frequencies**
  - frequencies have to be coordinated, useful frequencies are almost all occupied
- **Low transmission rates**
  - local some Mbit/s, regional currently, e.g., 9.6kbit/s with GSM
- **Higher delays, higher jitter**
  - connection setup time with GSM in the second range, several hundred milliseconds for other wireless systems
- **Lower security, simpler active attacking**
  - radio interface accessible for everyone, base station can be simulated, thus attracting calls from mobile phones
- **Always shared medium**
  - secure access mechanisms important

Effects of device portability

- **Power consumption**
  - limited computing power, low quality displays, small disks due to limited battery capacity
  - CPU: power consumption ~ CV^2f
    - C: internal capacity, reduced by integration
    - V: supply voltage, can be reduced to a certain limit
    - f: clock frequency, can be reduced temporally
- **Loss of data**
  - higher probability, has to be included in advance into the design (e.g., defects, theft)
- **Limited user interfaces**
  - compromise between size of fingers and portability
  - integration of character/voice recognition, abstract symbols
- **Limited memory**
  - limited value of mass memories with moving parts
  - flash-memory or ? as alternative

Limitations and Difficulties of Wireless

- Mobility brings unique challenges of its own.
- Limitations from political and technical difficulties may inhibit wireless technologies (but doubtful today).
- Lack of an industry-wide standard, which should be a concern to the global community (but the global economy will mandate a solution).
- Device limitations
  - e.g., small LCD on a mobile telephone can only display a few lines of text
  - e.g., browsers of most mobile wireless devices use wireless markup language (WML) instead of HTML
- Security – Achilles heel of the technology.
- RF Effects – long term effects on humans? Environment?

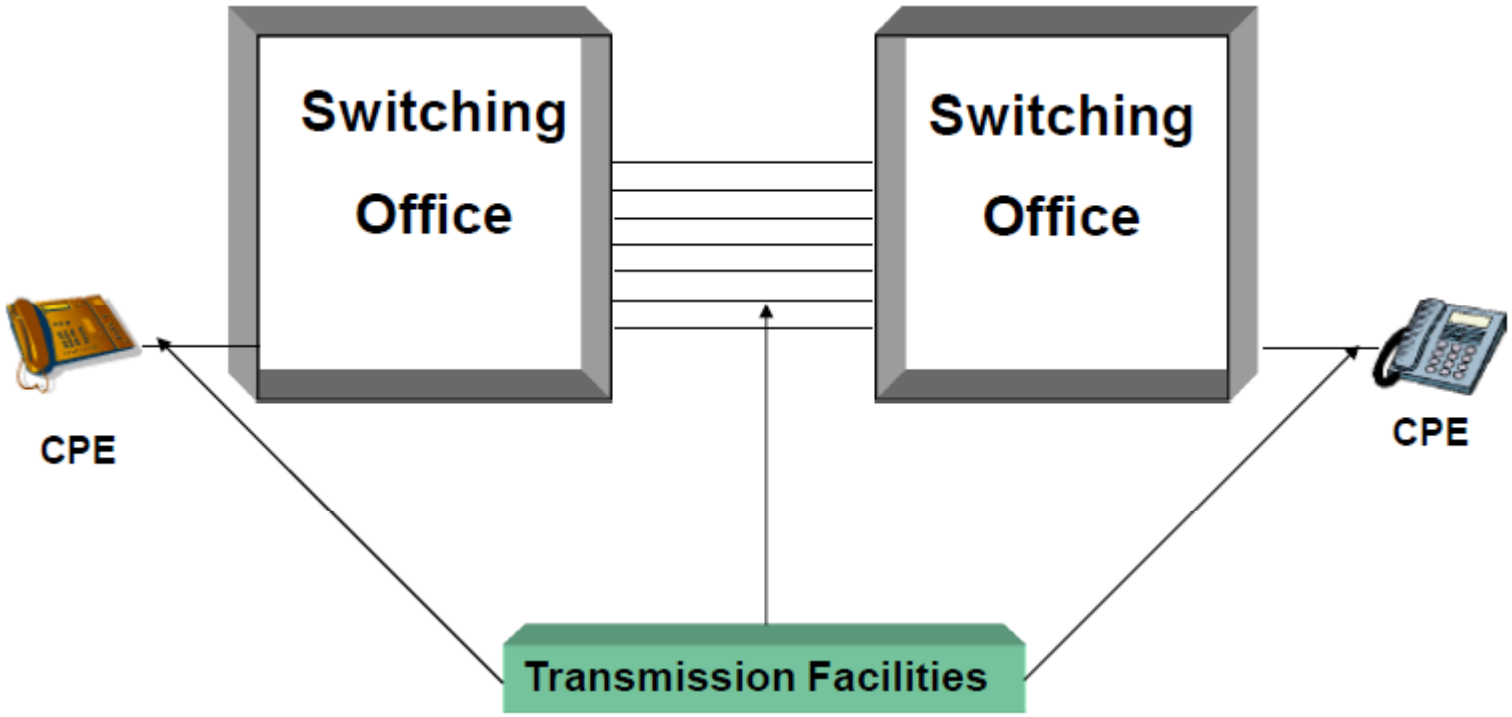
LIMITATIONS IN WIRELESS NETWORKING

- **Requirement of Air Interface** B/W base stations and subscribers to provide telephone grade communications under a wide range of propagation conditions and for any possible user condition.

- **MSC must provide connections for each of the mobile** users to PSTN .This requires simultaneous connection to the LEC,one or more IXCs and to other MSCs.

- **Random Nature of Radio Channel** since users may request service from any physical location while travelling over a wide range of velocities.MSC is forced to switch calls **imperceptibly** between base stations throughout the system and the available radio spectrum is limited.

Public Switched Telephone Network (PSTN)

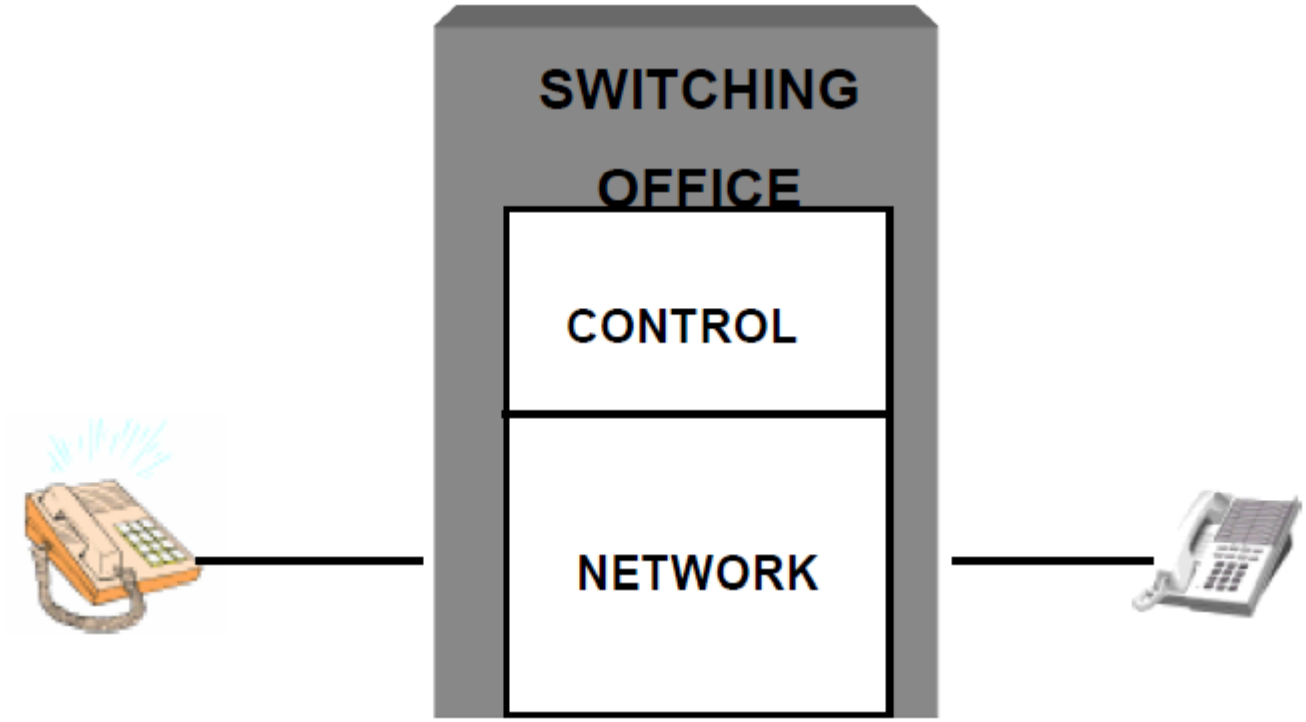


Public Switched Telephone Network (PSTN)

Major Components of the Public Switched Telephone Network (PSTN):

- **Switching Offices**
- **Transmission facilities**
- **Customer Premise Equipment (CPE)**

Switching Offices



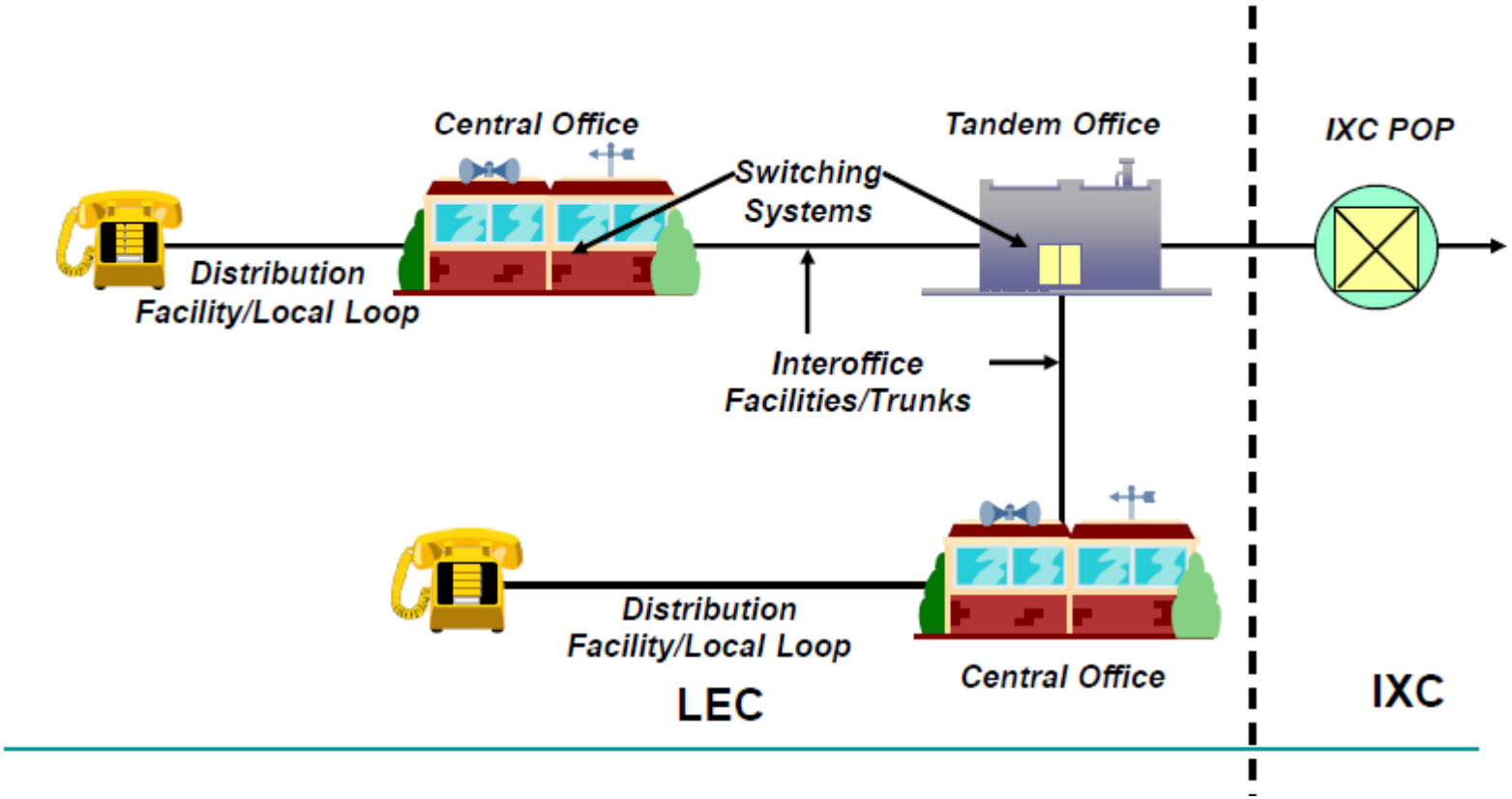
Public Switched Telephone Network (PSTN)

- Each local exchange consists of a central office (CO) which provides PSTN connection to the Customer Premises Equipment (CPE) which may be an individual phone at a residence or a private branch at a place of business.
- The CO may handle as many as million telephone connections.
- The CO is connected to a tandem switch which in turn connects the local exchange to the PSTN.
- The tandem switch physically connects the local telephone network to the point of presence of trunked radio lines provided by one or more IXCs.

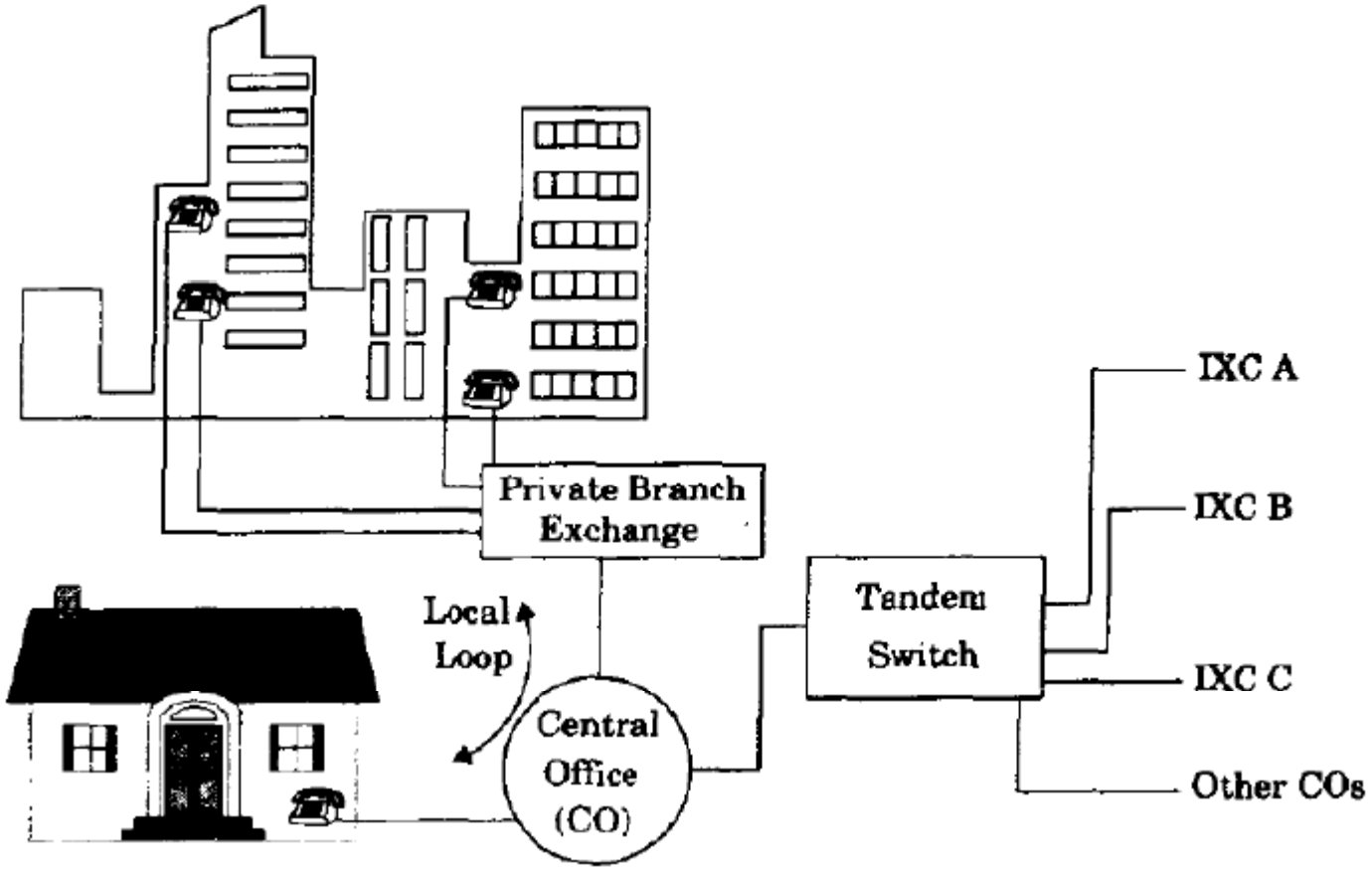
PSTN (Public Switched Telephone Network)

- In PSTN, each city or geographic grouping of towns is called a Local Access and Transport Area (LATA) .
- Surrounding LATAs are connected by a company called a Local Exchange Carrier (LEC).
- A long distance telephone company collects toll fees to provide connections between different LATAs over its long distance network. These companies are referred as interexchange carriers.(IXCs)
- IXCs own and operate large fiber optic and microwave radio networks which are connected to LECs throughout a country.

Typical LEC Network

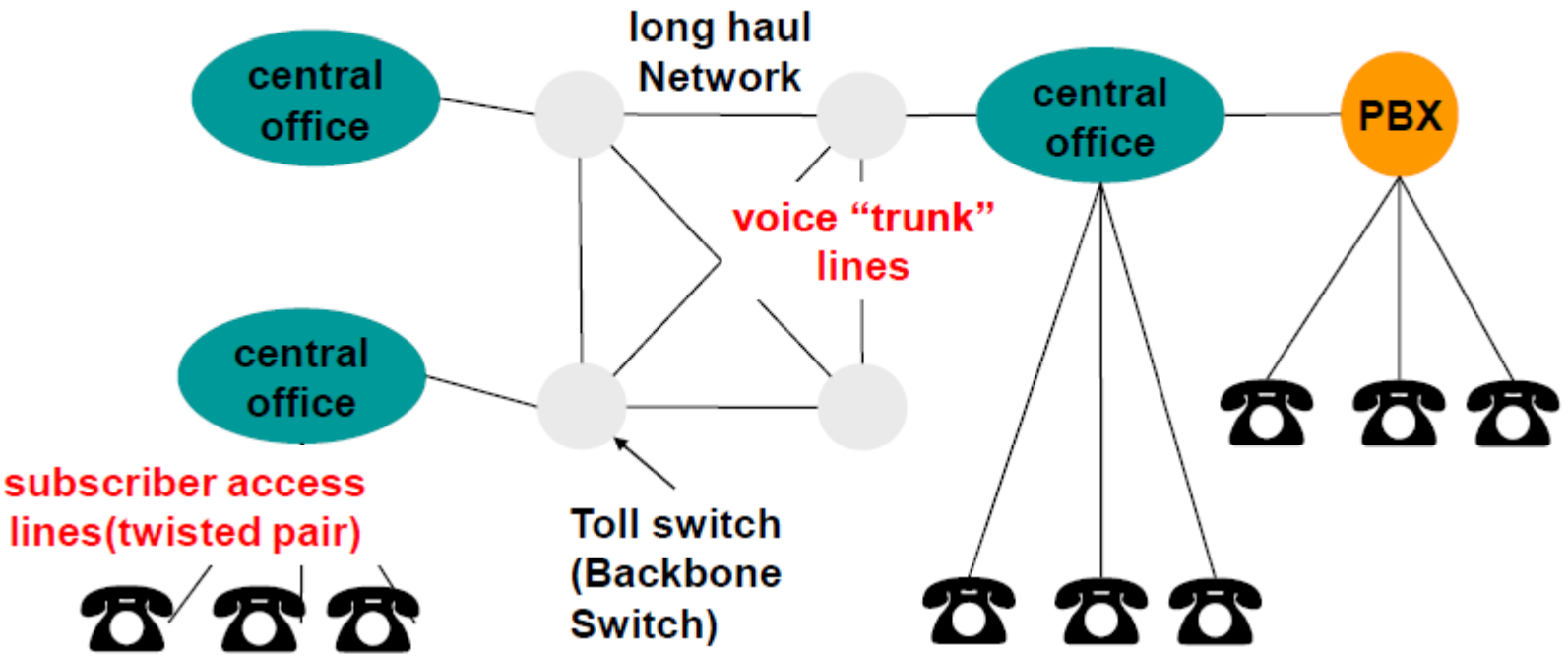


Local Landline Telephone Network

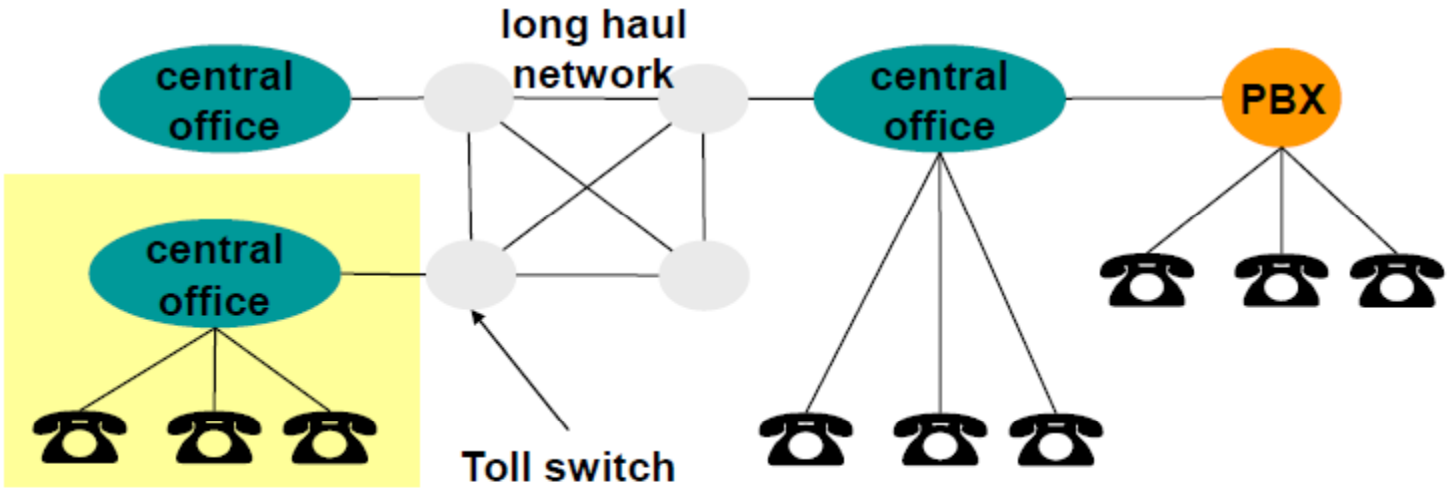


Telephone Network

- created 1876
- currently a global Infrastructure



Central Office and Local Loop



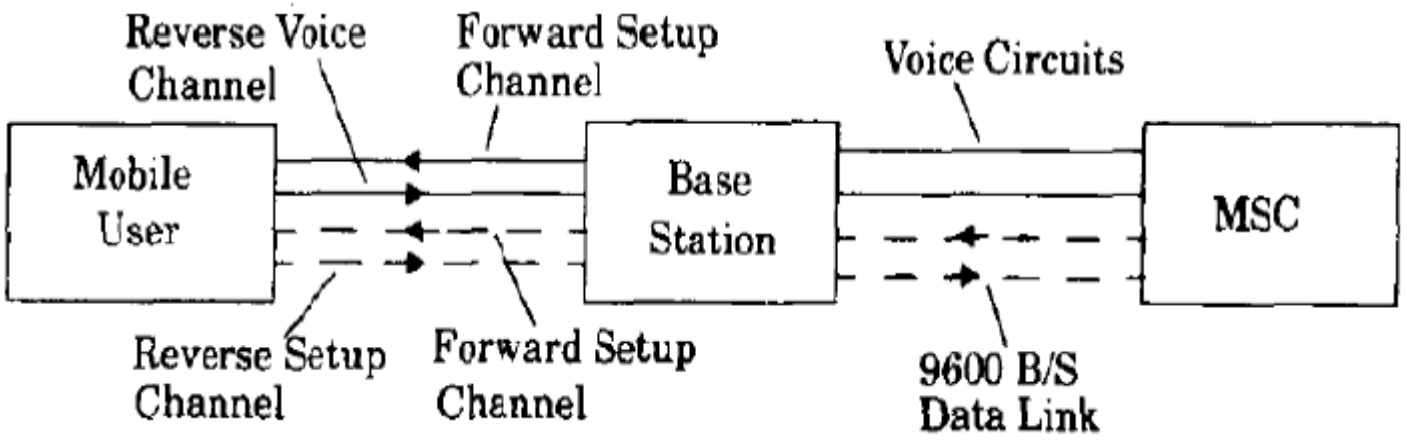
- Each phone user (**subscriber**) has direct connection to switch in central office (**local loop)**
- local loop has length 1 - 10 km
- switches in central office called **(local) exchanges**
- company providing local telephone service called **local exchange carrier** or **LEC.**

Development of Wireless Networks

FIRST GENERATION NETWORKS

- An example is AMPS (Analog Mobile Phone Service)
- Used Frequency Modulation.
- MSC has complete system control like
- ✓ Maintaining Mobile Related Information.
- ✓ Performing all network management functions like call handling ,processing, billing, fraud detection within the market

COMMUNICATION SIGNALLING BETWEEN MOBILE ,BS AND MSC IN 1st GENERATION



2nd GENERATION

- 2 G uses digital modulation ,advanced call processing capabilities and new network architectures reducing computational burden on MSC.
- Examples are-GSM,TDMA&CDMA US Digital Standards.
- GSM introduced the concept of BSC (Base station Controller) thereby standardizing data interface between BSC and MSC

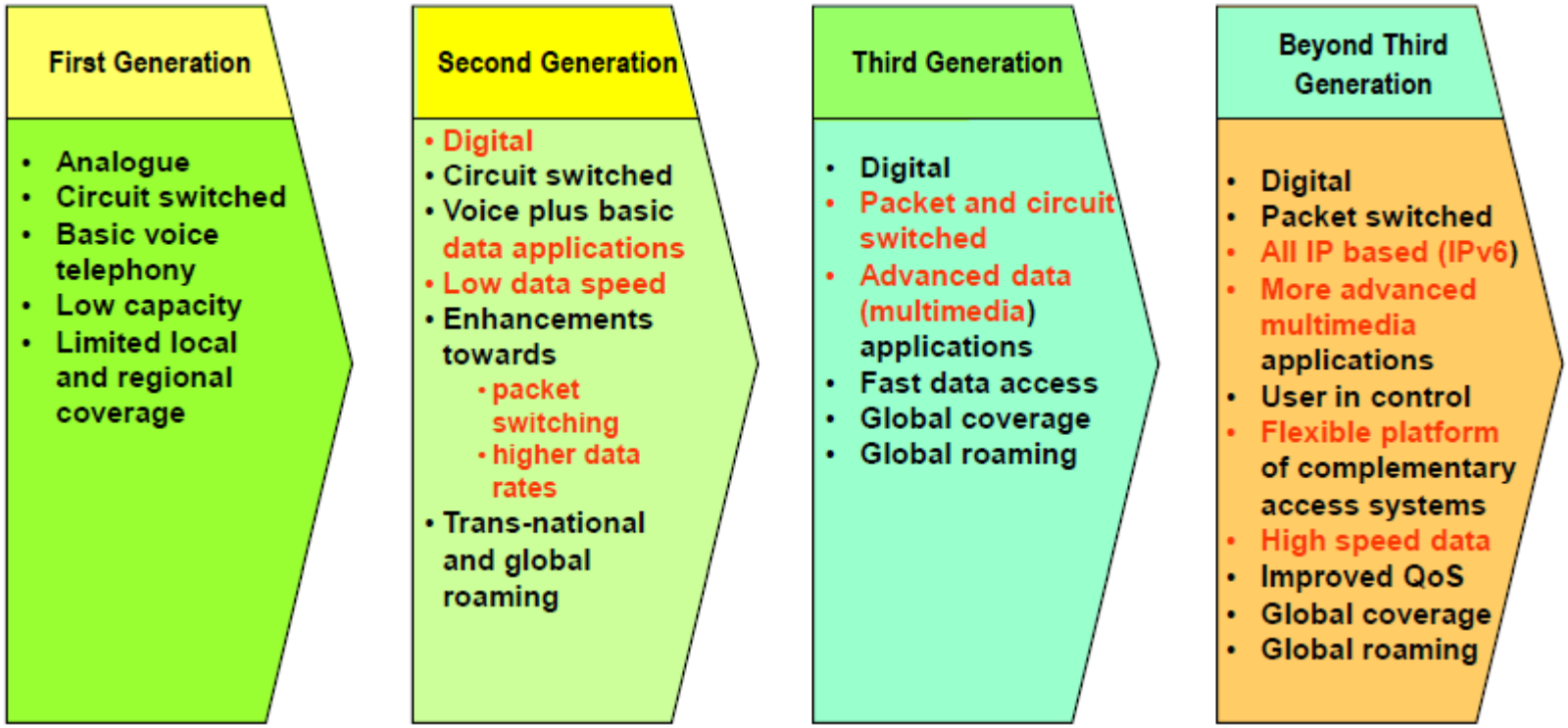
2nd GENERATION

- 2 G systems use digital voice coding &digital modulation techniques.
- Mobile Station assumed greater control functions like
- ✓ MAHO (Mobile Assisted Hand off)
- ✓ Received Power Reporting
- ✓ Adjacent Base Station Scanning
- ✓ Data Encoding
- ✓ Encryption

3rd GENERATION

- Aim of 3 G is to provide a single set of standards that can meet a wide range of wireless applications and provide universal access throughout the world.
- 3 G uses Broadband Integrated Services Digital Network (B-ISDN)
- 3 G networks carry many types of information (voice, data &video) operating in varied regions

Paradigm From 1G to Beyond 3G



Signaling

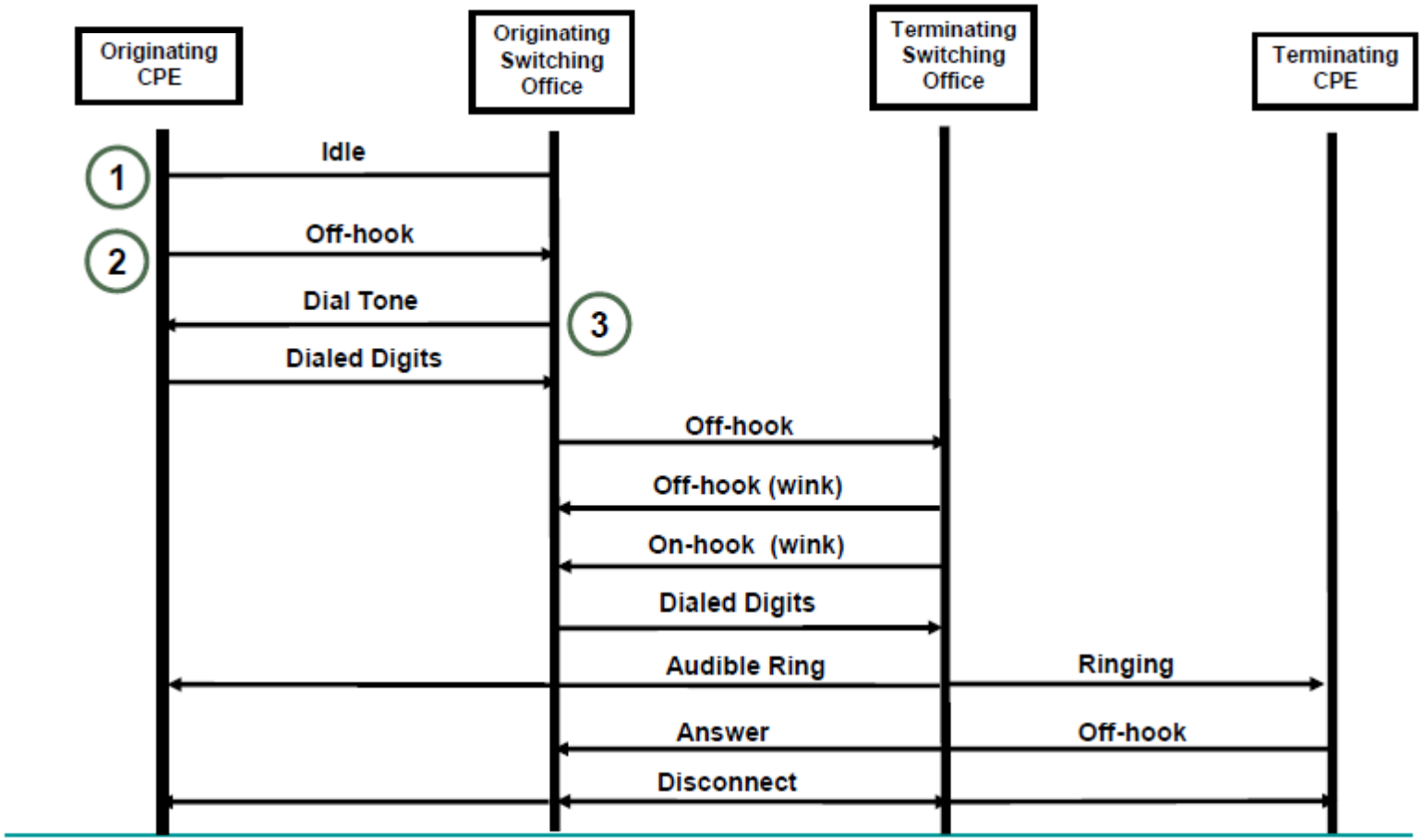
Signaling: **Exchange of messages among network entities to enable (provide service) to connection/call**

- before, during, after connection/call
  - call setup and teardown (state)
  - call maintenance (state)
  - measurement, billing (state)
- between:
  - end-user <-> network
  - end-user <-> end-user
  - network element <-> network element

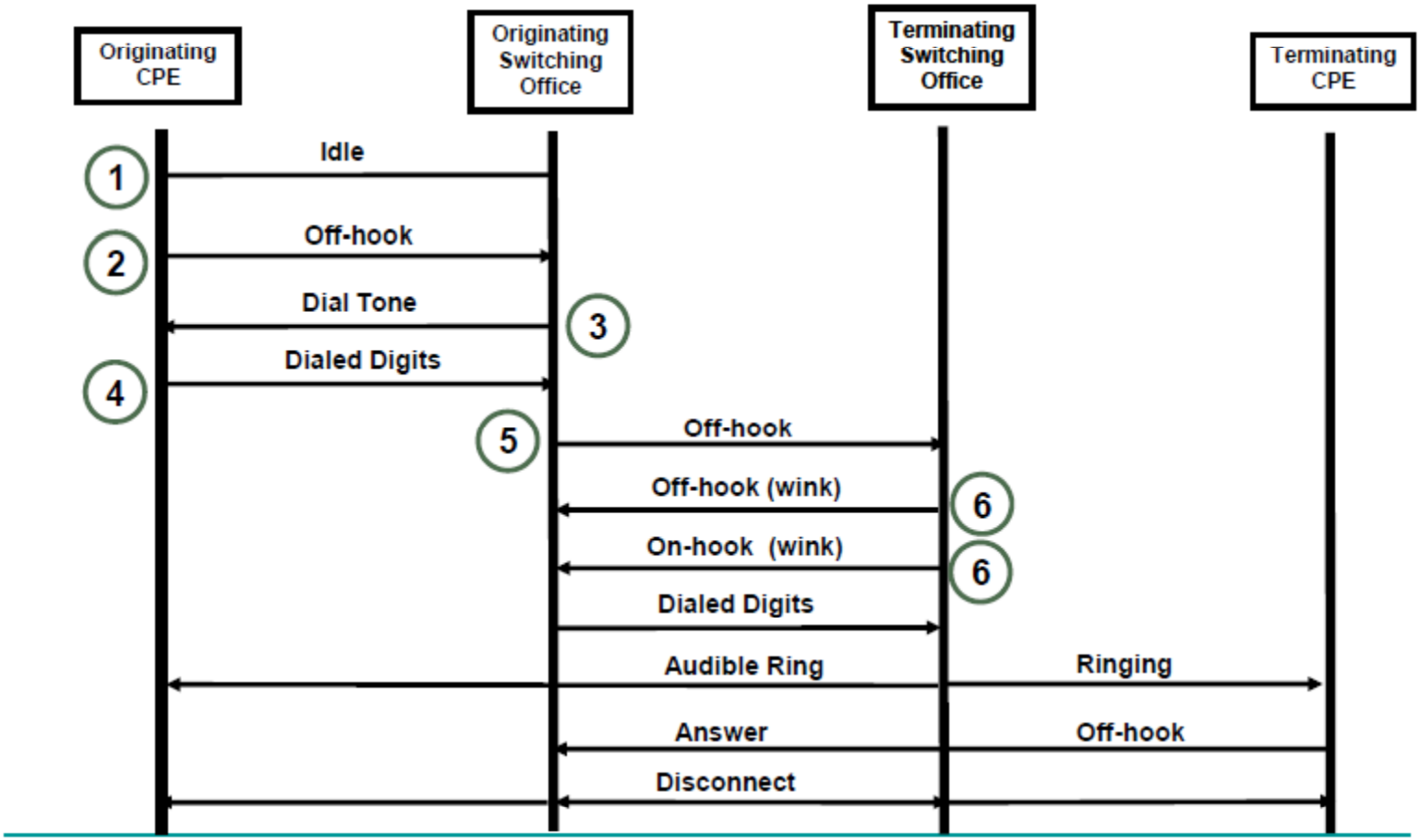
Signaling

Signaling is the generation, transmission, and reception of information needed to direct and control the setup and disconnect of a call.

Signaling


Originating CPE
Originating Switching Office
Terminating Switching Office
Terminating CPE
1
Idle
2
Off-hook
Dial Tone
3
Dialed Digits
Off-hook
Off-hook (wink)
On-hook (wink)
Dialed Digits
Audible Ring
Ringing
Answer
Off-hook
Disconnect

Signaling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6
On-hook (wink)
6
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Audible Ring
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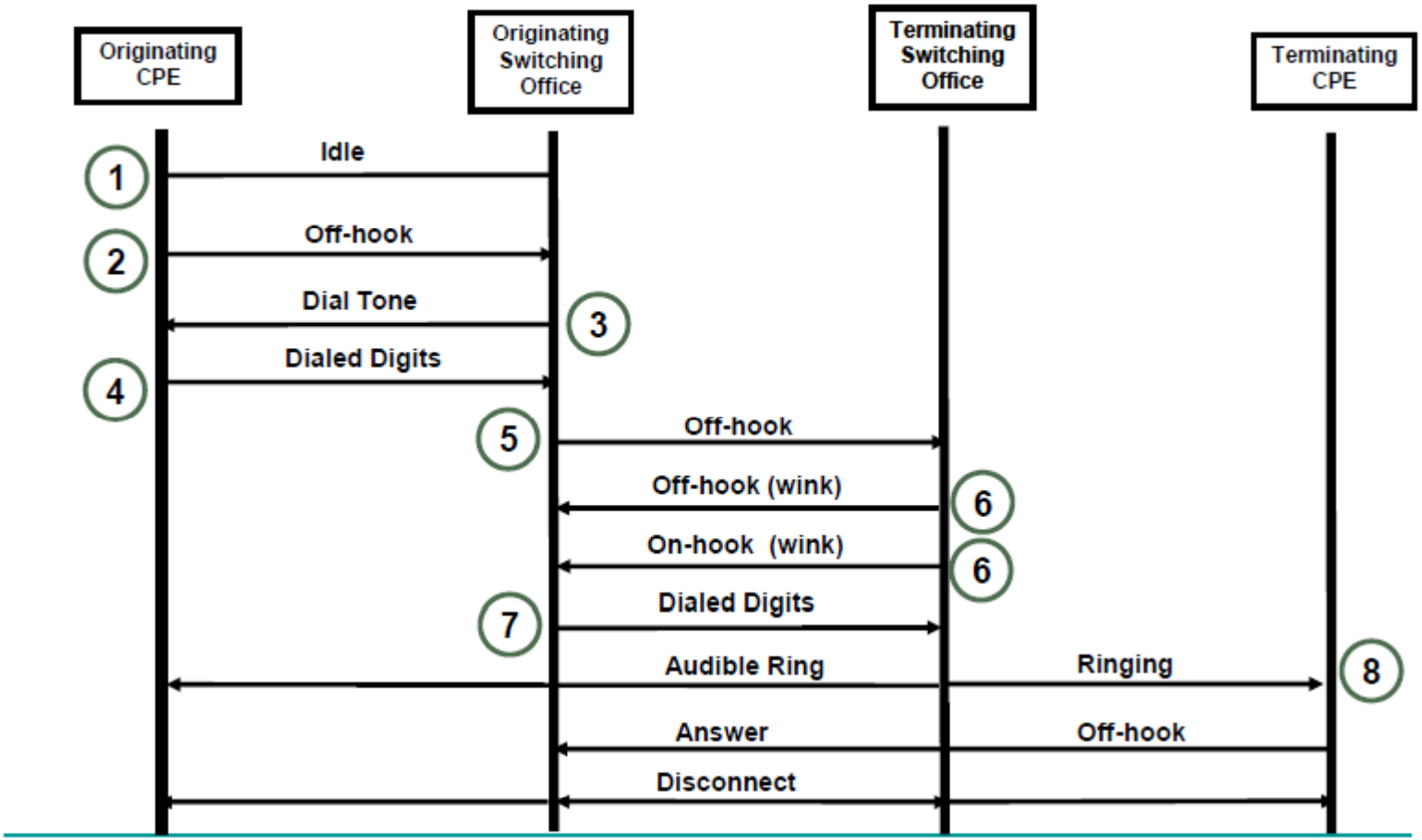
Signaling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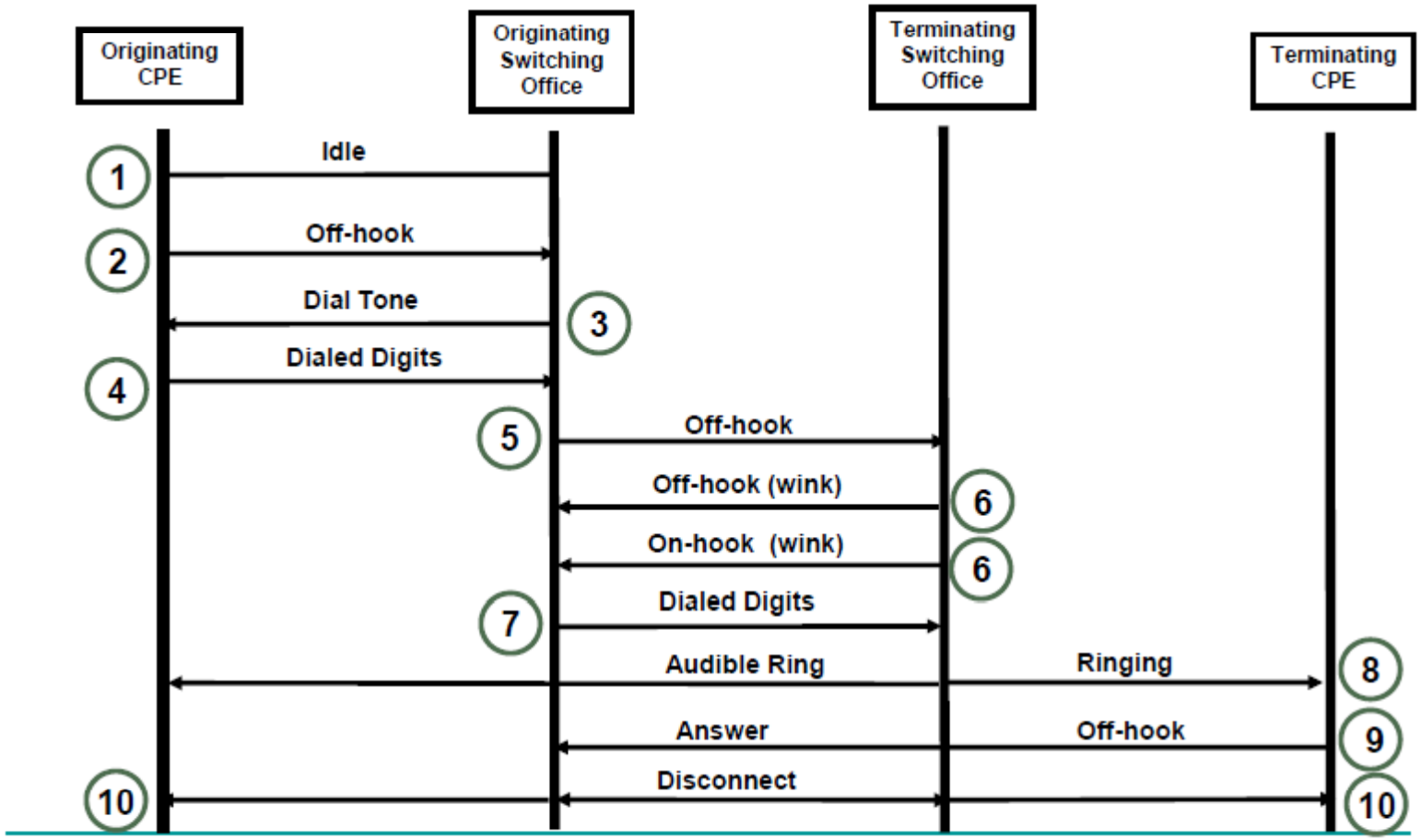
Signaling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Audible Ring
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Answer
Off-hook
9
Disconnect
10
10

Examples

- SS7 (Signaling System no. 7): telephone network
- Q.2931: ATM
- RSVP (Resource Reservation Protocol): Internet

Fixed Network Transmission Hierarchy

- Wireless networks rely heavily on landline connections such as MSC connects to PSTN & SS7 networks using fiber optic or copper cable or microwave links.
- These connections require high data rate for serial transmission schemes to reduce no. of physical circuits between two points of connection.
- Several Digital Signaling (DS) formats form a transmission hierarchy allowing high data rate digital networks to be interconnected throughout the World.

Digital Multiplexing

- DS formats use TDM. The basic DS format is **DS-0** which represents one duplex voice channel which is digitized into a 64 kbps binary PCM format.
- **DS-1** which represents 24 full duplex DS-0 voice channels that are time division multiplexed into a 1.544 Mbps data stream.
- T(N) is the designation used to denote transmission line compatibility for a particular DS format.DS-1 signaling is used for a T-1 trunk

Digital Multiplexing

- Digital Signaling (DS) transmission hierarchy used in US for multiplexing digital voice channels

	Number of voice circuits	Bandwidth
DS0	1	64 kbps
DS1	24	1.544 Mbps
DS2	96	6.312 Mbps
DS3	672	44.736

Digital Multiplexing

- In Europe CEPT (European Conference of Postal & Telecommunications standards) has defined a similar digital hierarchy.
- Level 0 represents a duplex 64 kbps voice channel while Level-1 concentrates 30 channels into a 2.048 Mbps TDM data stream.

Digital Multiplexing

Signal Level	Digital Bit Rate	Equivalent Voice Circuits	Carrier System
North America and Japan			
DS-0	64.0 kbps	1	
DS-1	1.544 Mbps	24	T-1
DS-1C	3.152 Mbps	48	T-1C
DS-2	6.312 Mbps	96	T-2
DS-3	44.736 Mbps	672	T-3
DS-4	274.176 Mbps	4032	T-4
CEPT (Europe and most other PTTs)			
0	64.0 kbps	1	
1	2.048 Mbps	30	E-1
2	8.448 Mbps	120	E-1C
3	34.368 Mbps	480	E-2
4	139.264 Mbps	1920	E-3
5	565.148 Mbps	7680	E-4

Traffic Routing In Wireless Networks

- The amount of traffic capacity required in a wireless network is highly dependent upon the type of traffic carried.
- Some traffic may have an urgent delivery schedule while some may have no need to be sent in real time. The type of traffic carried by a network determines the routing services, protocols and call handling techniques to be employed