

## Three Network Technologies

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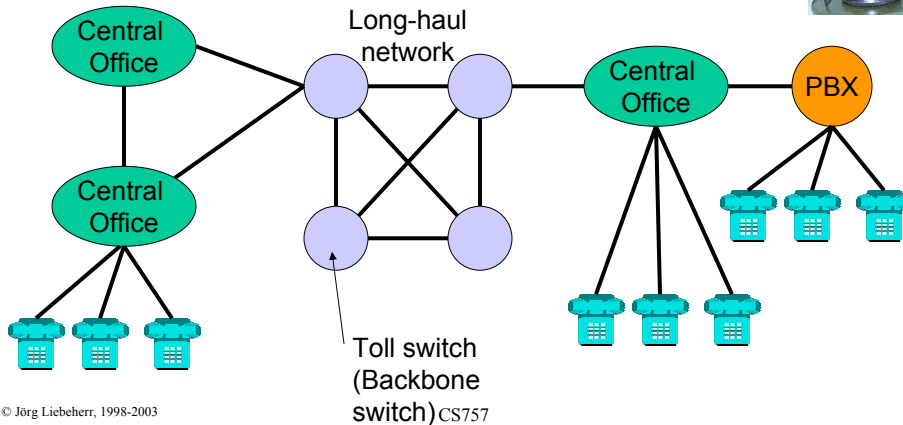
- **Telephone Network**
  - The largest worldwide computer network, specialized for voice
  - Switching technique: [Circuit-switching](#)
- **Internet**
  - The global public information infrastructure for data
  - Switching technique: [Datagram packet switching](#)
- **ATM**
  - Was intended to replace telephone networks and data networks, but lost momentum due the success of the Internet
  - Switching technique: [VC packet switching](#)

## Telephone Network

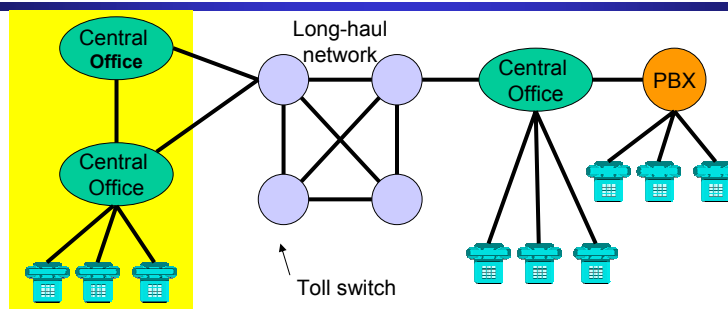
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# Telephone Networks

- Starting in 1876, the public switched telephone network (PSTN) has become a global infrastructure for voice communications

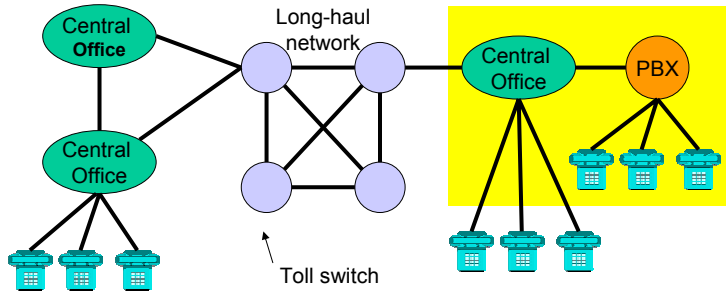


# Central Office and Local Loop



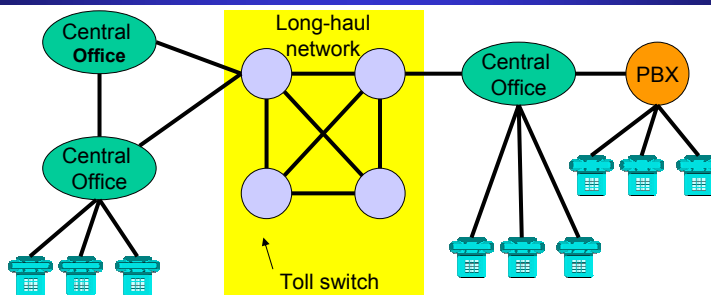
- Each phone user (**subscriber**) has a direct connection to a switch in the central office. This is called the **local loop**
- The local loop has a length of 1 - 10 km
- The switches in the central office are called **(local) exchange**
- A company which provides local telephone service is called a **local exchange carrier** or **LEC** (e.g., Bell Atlantic)

# PBX



- A **PBX (Private Branch Exchange)** is a telephone system within an enterprise that switches calls within the enterprise on local lines, while allowing all users to share a certain number of external lines to the central office
- The main purpose of a PBX is to save the cost of requiring a line for each user to the telephone company's central office.

# The long-haul network



- Toll or backbone switches provide long-distance connectivity over long-distance trunks
- There are only about 500 toll switches in the United States. Each toll switch can run more than 100,000 simultaneous phone calls

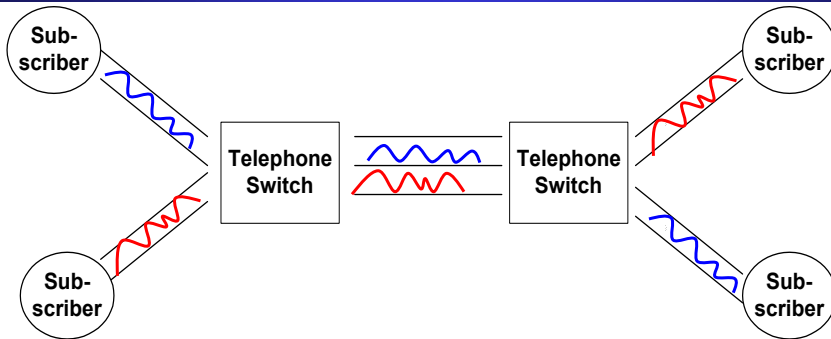
## How is voice transmitted ?

- Voice can be transmitted in two ways:
  - **Analog voice transmission:** Each voice channel is allocated a bandwidth of 3.5 kHz
  - **Digital voice transmission:** Analog voice stream is converted in a digital stream:
    - Standard scheme for a voice call: Obtain 8000 samples per second, each with length 8 bit

## How is voice transmitted ?

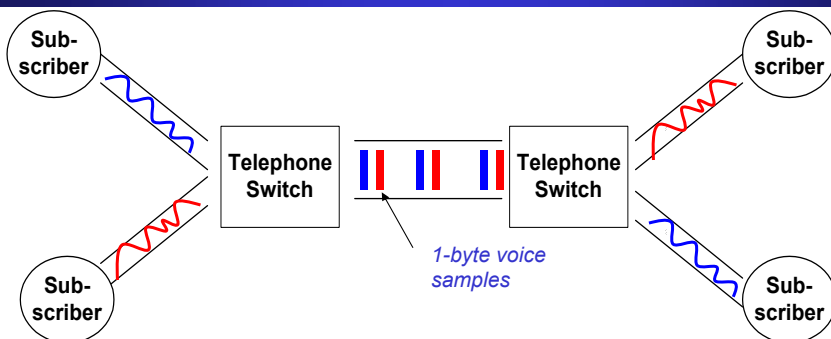
- **Until 1960s:**
  - Entire telephone network is analog
  - Frequency-division multiplexing
- **Today:**
  - The local loop is analog.
  - The rest of the network is digital (based on TDM)
- **All digital: When do we get an all digital network?**
  - ISDN (Integrated services Digital Network) is an all digital circuit-switching technology. ISDN is available since the early-1990s (in Europe) or mid-1990s (US). No wide deployment in US
  - Another all digital –but **not** circuit-switched – telephony solution is IP telephony.

## All analog telephone network



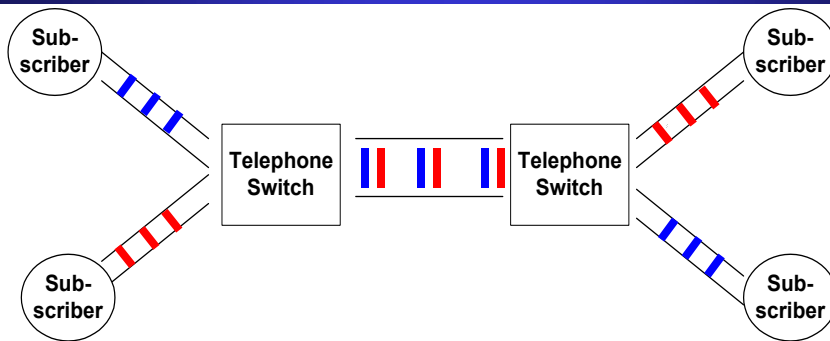
- The telephone switch bundles (multiplexes) multiple voice calls on a high-bandwidth link
- The multiplexing method is FDM.

## Analog local loop / digital network



- The first telephone switch digitizes a voice call (8000 8-bit samples per second)
- Switching method is TDM.
  - Switch bundles multiple calls, by interleaving samples in time. Each call receives one 8-bit slot every 125  $\mu$ s

## All digital telephone network



- The telephone at the subscriber digitizes voice and sends one 8-bit samples every 125  $\mu$ s

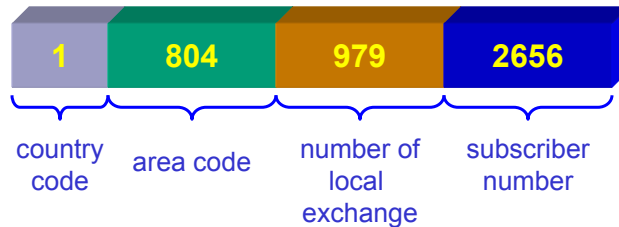
## Digital Multiplexing

- Digital Signaling (DS) transmission hierarchy used in the 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

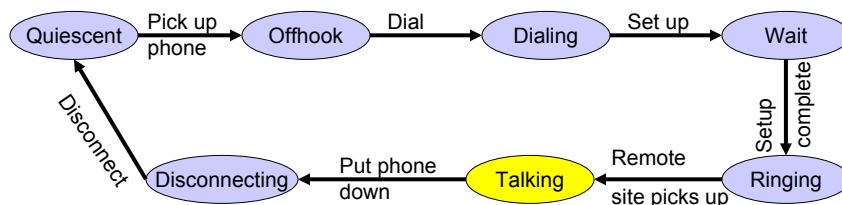
# Addressing and Routing

- Each subscriber has an address (telephone number)
- Addresses are hierarchical
- **Example:** Domino's Pizza in downtown Charlottesville



- The information contained in a telephone address is exploited when establishing a route from caller to callee

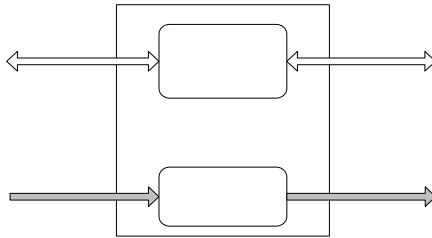
# Signaling



- **Signaling** refers to the control functions performed to setup a phone call
- Signaling between users and the local exchange in the central office is quite simple: dial-tone, punch numbers, put phone down, etc.
- Signaling between exchanges/switches is more complicated and is done via a separate network, which uses packet

## Switching in the Telephone Network

- Telephone switch has two parts:
  - Switch controller responsible for signaling (**control plane**)
  - Switching hardware responsible for handling voice data (**data plane**)

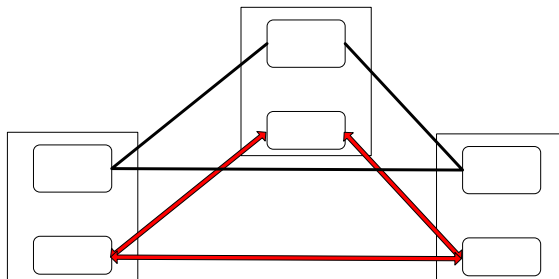


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## Signaling Network

- Signaling between switch controllers is done over a (packet switching) network that is separate from the data plane
- This is called out-of-band signaling.
- Packet network is called **Signaling System 7 (SS7)**. SS7 has a complete protocol stack.



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## **Other Topics on Telephone networks**

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- **Toll-Free numbers**
- **Cellular telephone networks**
- **ISDN (Integrated Services Digital Networks)**
- **Billing**
- **VoIP (Voice over IP networks)**