

Telephone Systems

COMP476

Home Telephones

- Plain Old Telephone Service (**POTS**) provides a twisted pair connection from your phone to the central office.
- You own your home wiring and the telephone company owns the wires outside your home.



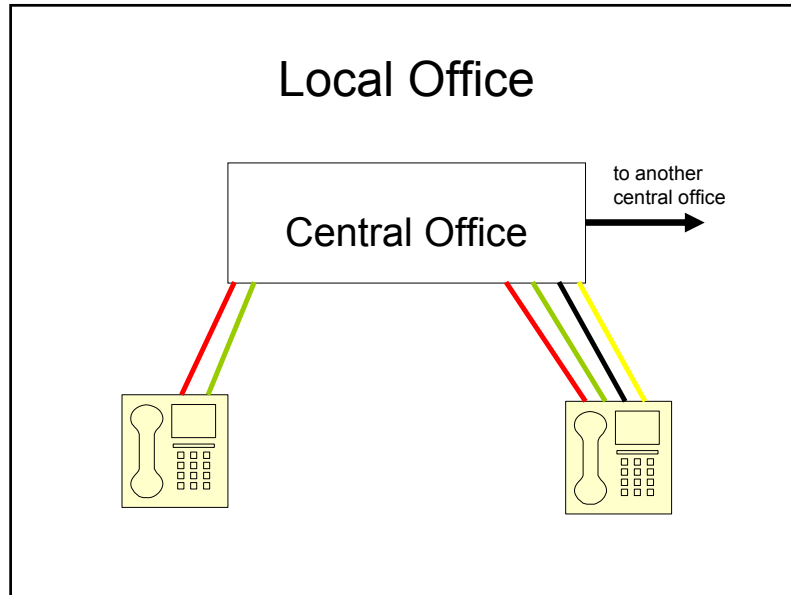
Central Office

- There is a central office for each local three number prefix (or subset).
- The central office has a computer controlled switch.
- Local calls are connected within the switch
- Calls to other switches are digitized using a coder-decoder (codec)
- The U.S. has over 22,000 central offices.

Local Loop

- The wiring from your home phone to the central office is sometimes called a local loop.
- For calls within the same central office, the equipment connects one phone to another.



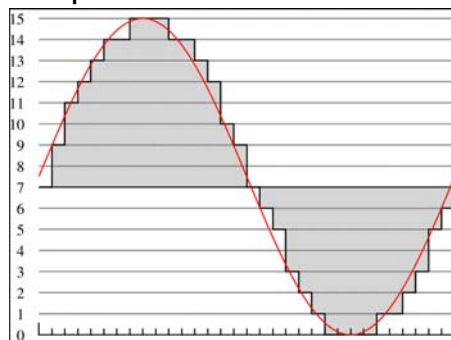


Analog and Digital

- The twisted pair line between your home phone and the central office runs an analog signal.
- Communications between central offices is done using digital lines.
- Long distance calls are over digital lines.

A/D conversion

- The analog voice signal is converted to a digital stream of bytes.
- 8000 times a second (every 125 μ sec) an 8 bit sample is taken.

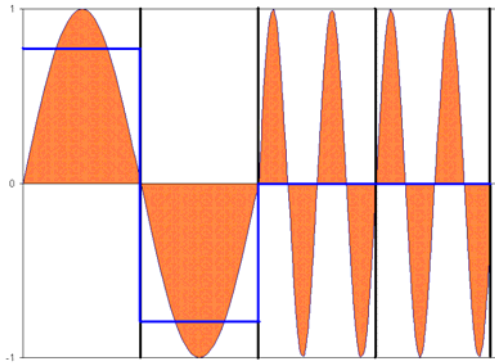


Codec

- Sending 8000 eight bit values every second requires 64K bits/sec for a voice channel.
- Some system take 7 bit samples to transmit data at 56K.

Frequency Limits

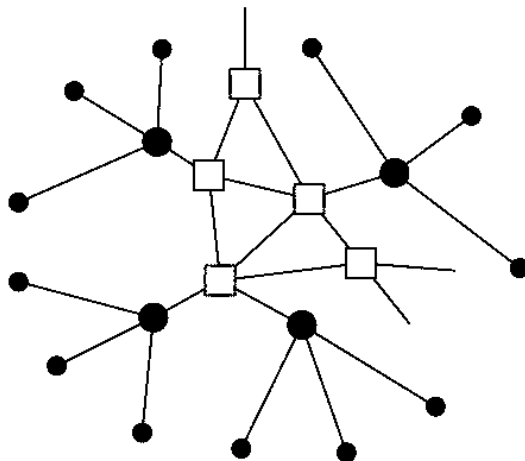
- If the analog signals frequency is too high, it cannot be converted properly to digital.



Interoffice Traffic

- Calls between central offices are transmitted digitally over time division multiplexed lines.
- Long distance calls may travel through many switches and several company's equipment.

Routing Hierarchy



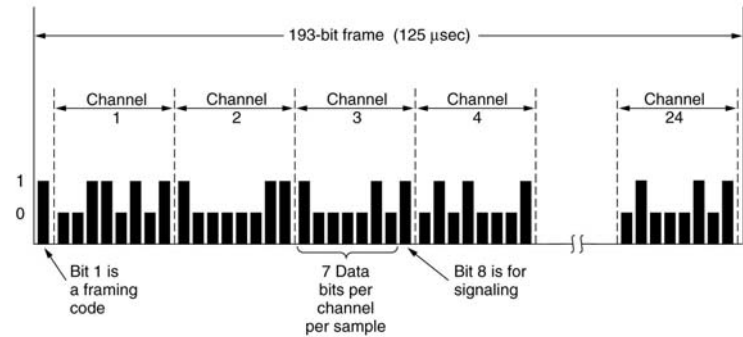
PBX

- A Private Business Exchange is like a local office but owned by the organization that owns the phones.
- Companies can install a PBX, purchase a multiplexed line from the phone company and not have to pay for each telephone.

Multiplexed Phone Lines

- Digitized voice channels can be combined on one line.
- A T1 line provides 24 voice channels over a single line 1.544 Mbits/sec
- 4 T1 lines make a T2 line, 6.3 Mbits/sec
- 7 T2 lines make a T3 line, 44.7 Mbits/sec
- 6 T3 lines make a T4 line, 274 M bits/sec
- Different systems are used in other countries.

T1 line



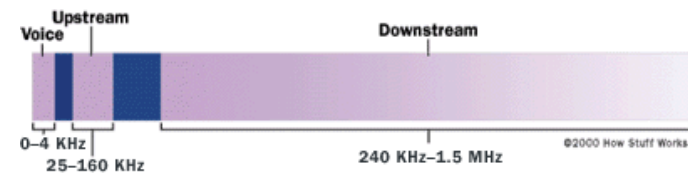
$$193 \text{ bits} / 125 \times 10^{-6} \text{ sec} = 1.544 \text{ Mbits/sec}$$

ADSL

- Asymmetric Digital Subscriber Line (or just DSL) provides a means of transmitting high speed data to homes.
- The system is asymmetric because the transmission rate is different for upload and download.
- Not every phone line can support ADSL. You must be within 18,000 feet of the central office with good wires.

ADSL Multiplexing

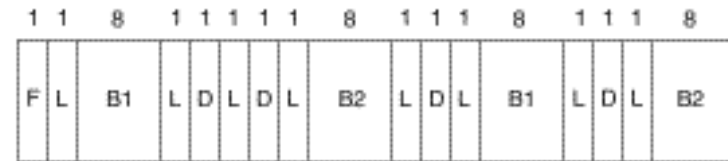
- The phone line is frequency division multiplexed to provide a channel for analog POTS, digital up link and down link.
- The central office modulates the data signals to the proper frequencies.



ISDN

- Integrated Services Digital Networks is a means of providing both phone and data services.
- ISDN using time division multiplexing to send data and voice over the same line.
- Basic ISDN provides two 64K “B” channels and one 16K “D” channel.
- Users must have ISDN digital phones.

ISDN frame



One frame of 48 bits is sent every 250 μ sec or 4000 / sec giving 192K bits/sec

Each frame sends two bytes for each B channel

Each frame sends four bits of the D channel;

Cordless vs. Cell Phones

- Cordless phones use a radio signal to connect to a base station owned by the user.
- Cordless range is about 100 to 300 m.
- It is advantageous if different cordless phones are incompatible.

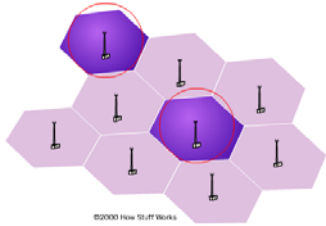
Cell Phones

- There are many different cell phone technologies.
- The world is moving from analog phones to digital cell phones.



Cells

- The world is divided into cells, each of which has an antenna.
- As you move to a different cell, the next antenna handles your call.



Central Office

- A **Mobile Telephone Switching Office** (MTSO) receives the radio signals from a cell phone and transmits the messages on a land line.
- The MTSO keeps track of where you are.
- Every so often a cell phone announces its location.

Transmission Encoding

- Older cell phones used FDMA.
- Most newer phones use CDMA.
- Between eight and 10 separate calls can be carried in the same frequency channel.

Code Numbers

- **Electronic Serial Number** (ESN) - a unique 32-bit number programmed into the phone when it is manufactured
- **Mobile Identification Number** (MIN) - a 10-digit number derived from your phone's number
- **System Identification Code** (SID) - a unique 5-digit number that is assigned to each carrier by the FCC

Cell Phone Startup

- When you first power up the phone, it listens for an **SID** on the **control channel** from the MTSO.
- When it receives the SID, the phone **compares it** to the SID programmed into the phone. If the SIDs match, the phone knows that the cell it is communicating with is part of its **home** system.

Handoff

- When you move to a different cell, another MTSO must handle your call.
- When the signal from another MTSO is stronger than the MTSO you are currently using, the system will do a handoff.
- The new MTSO will handle the communications and the previous MTSO will stop communicating.
- The new MTSO needs to establish a connection over the land lines.

Politics of Telephones

- Prior to 1984 the Bell System provided local and long distance service for most of the United States.
- The "Modified Final Agreement" split the system into AT&T Long Lines and 23 Bell Operating Companies.
- Local Exchange Carriers provided traditional phone service in an area.
- Long distance was from a separate company

Continuing Change

- In 1996 Congress passed a law allowing the various telephone companies to enter each others business.