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 μsec) 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 bits / 125 x 10^{-6} sec = 1.544 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 µsec 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.