



School of Computer Science

Winter Term 2000

CS 308-435

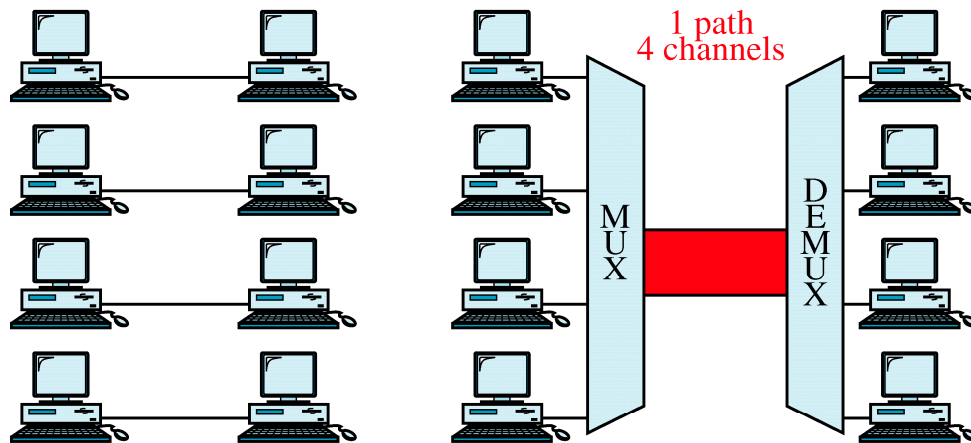
Basics of Computer Networks

Hans Vangheluwe

Multiplexing

- high bandwidth
- many to one: multiplexer (MUX)
- one to many: demultiplexer (DEMUX)

Multiplexing: path vs. channels



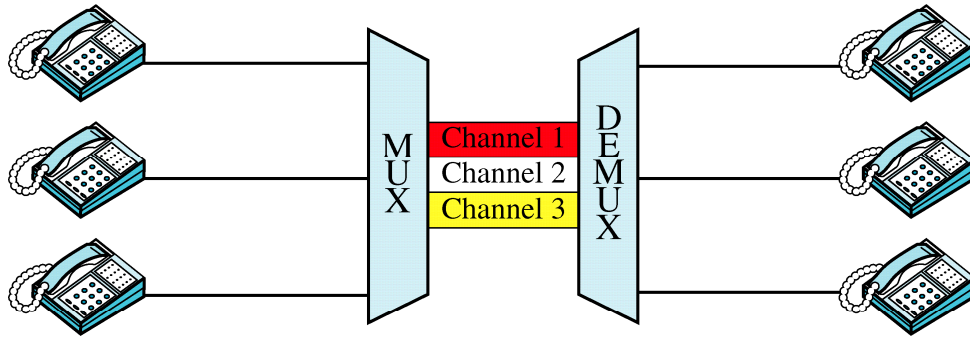
a. No multiplexing

b. Multiplexing

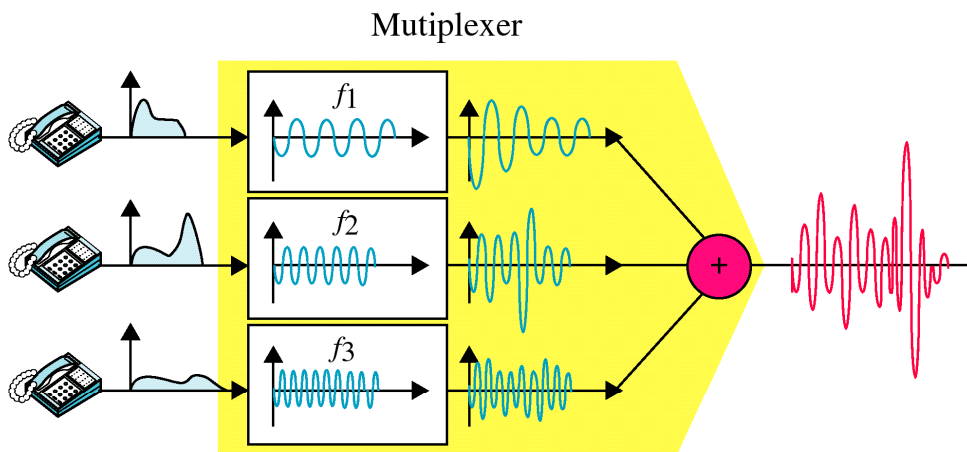
Categories of multiplexing

- Frequency-division multiplexing (FDM)
- Time-division multiplexing (TDM)
 - Synchronous
 - Asynchronous
- Wave-division multiplexing (WDM)

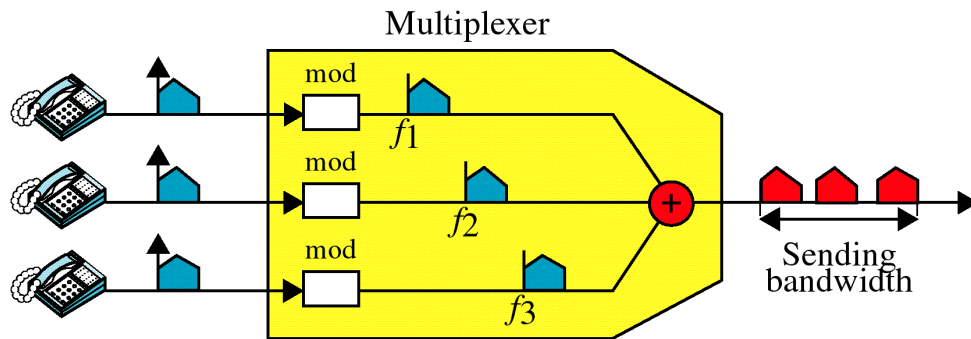
FDM



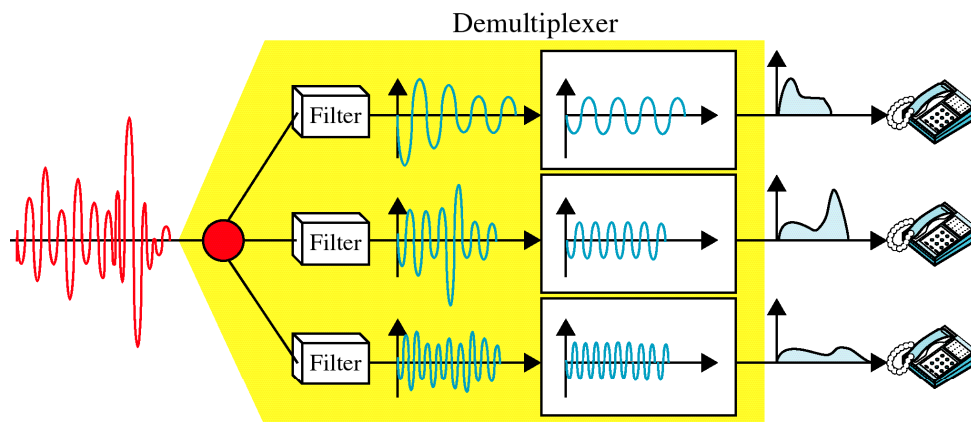
FDM multiplexing in time domain



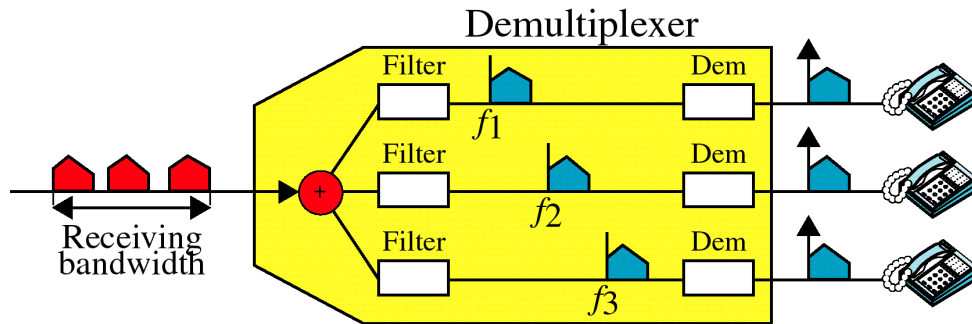
FDM multiplexing in frequency domain



FDM demultiplexing in time domain

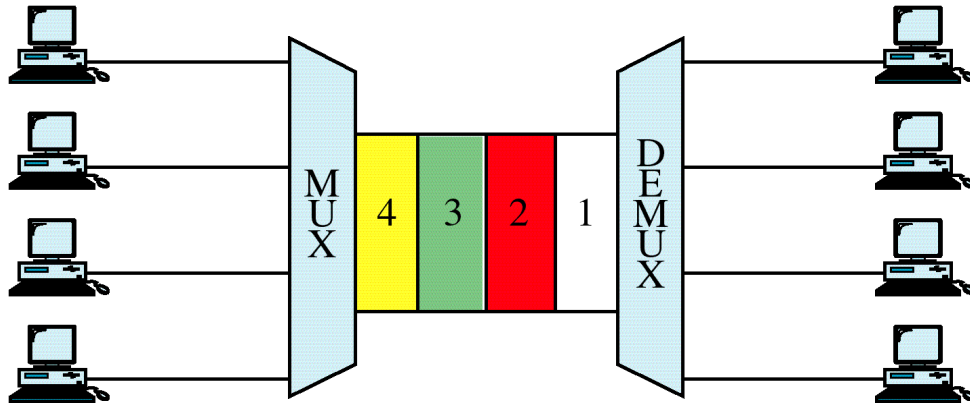


FDM demultiplexing in frequency domain

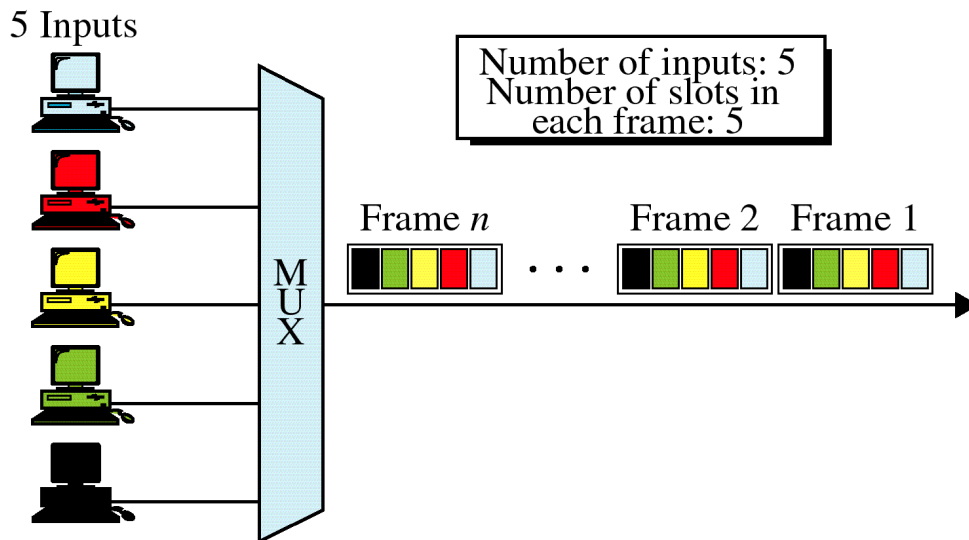


Wave Division Multiplexing (WDM)

TDM

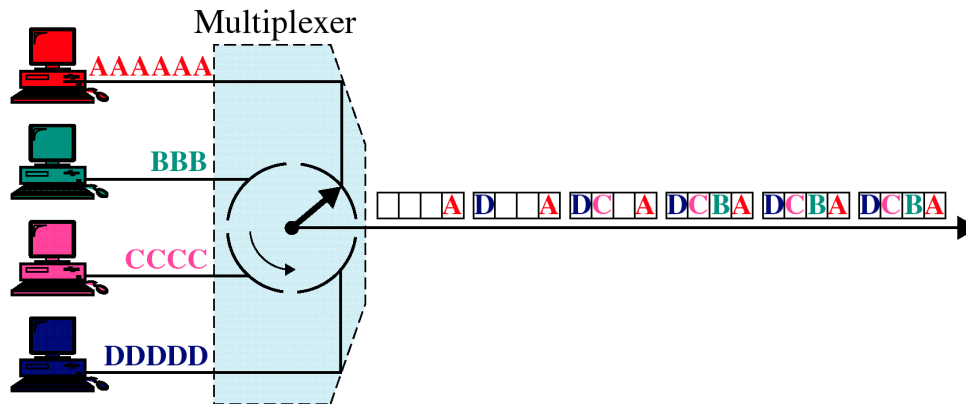


Synchronous TDM

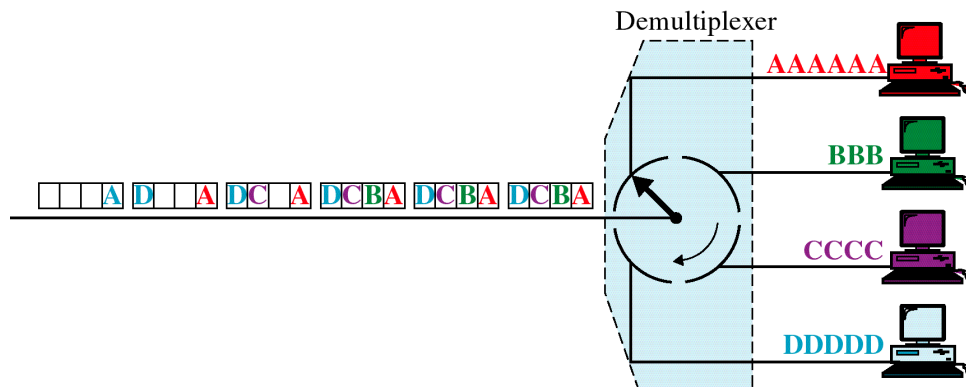


Synchronous TDM, multiplexing

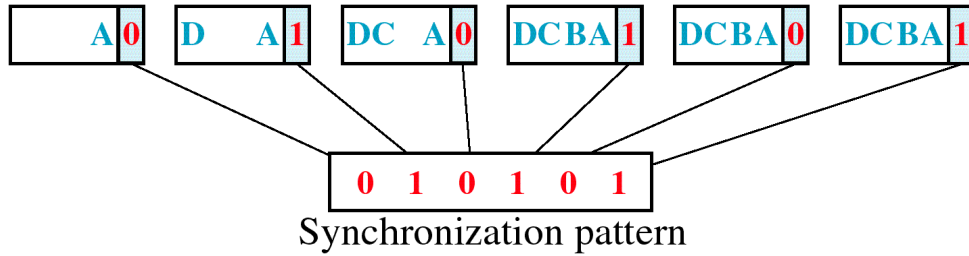
constant rate, fixed order
interleaving, any number of bits



Synchronous TDM demultiplexing



Framing bits

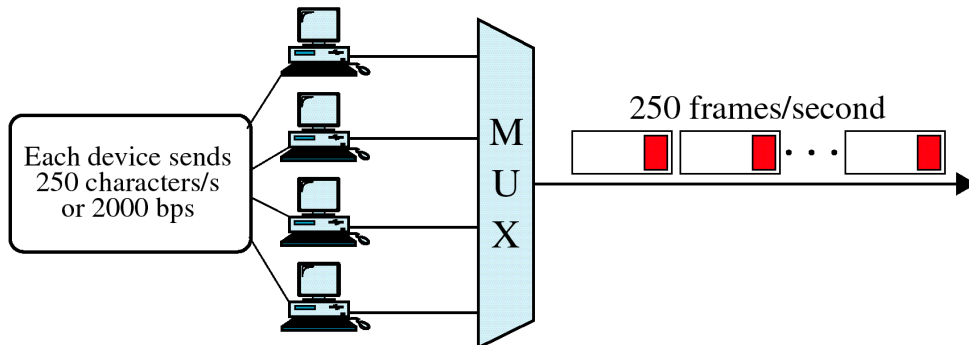


Data rate for frames

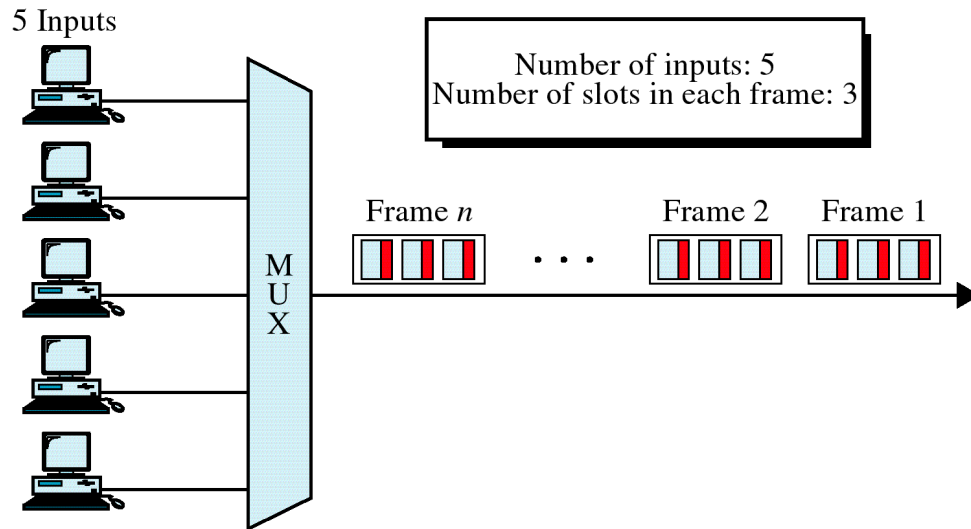
$$8250 \text{ bps} = 250 \text{ frames/second} \times 33 \text{ bits/frame}$$

or

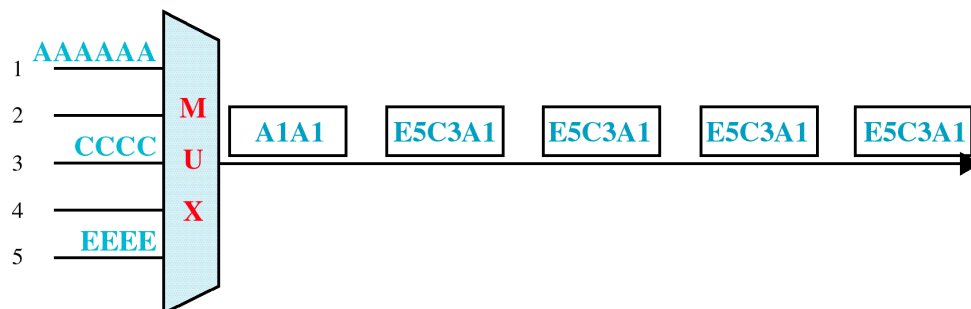
$$8250 \text{ bps} = 4 \times 2000 \text{ bps} + 250 \text{ synchronization bps}$$



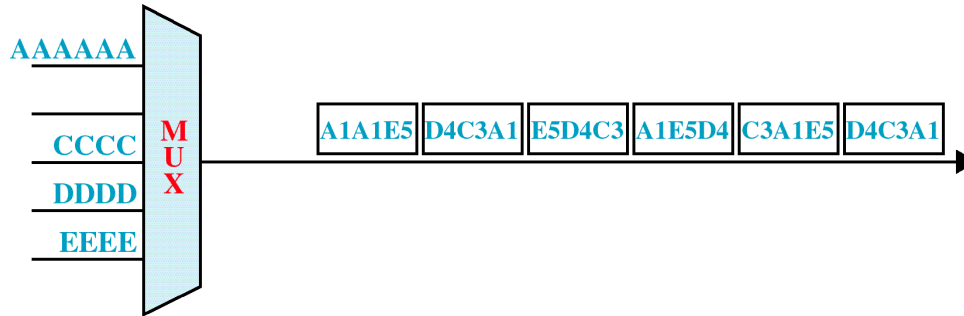
Asynchronous TDM: statistical analysis



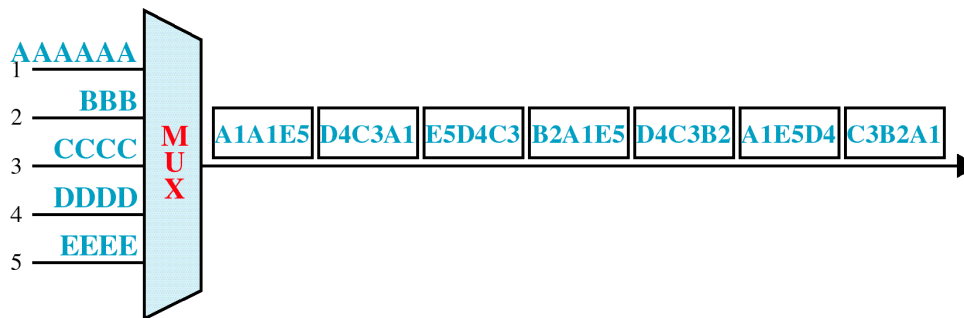
Asynchronous TDM example: addressing



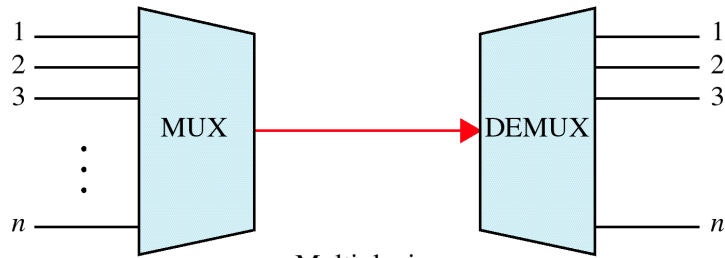
Asynchronous TDM example: not symmetric



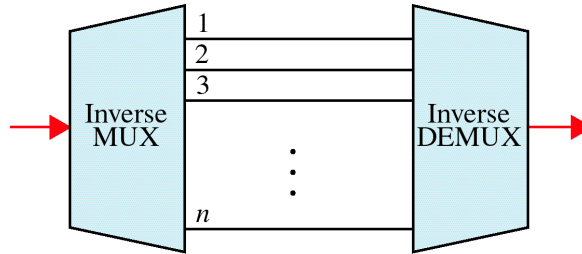
Asynchronous TDM example: buffer needed



Multiplexing and inverse multiplexing



a. Multiplexing

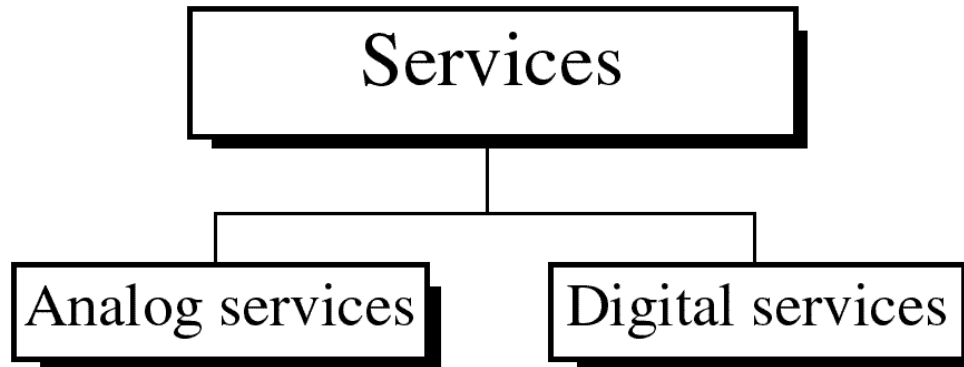


b. Inverse multiplexing

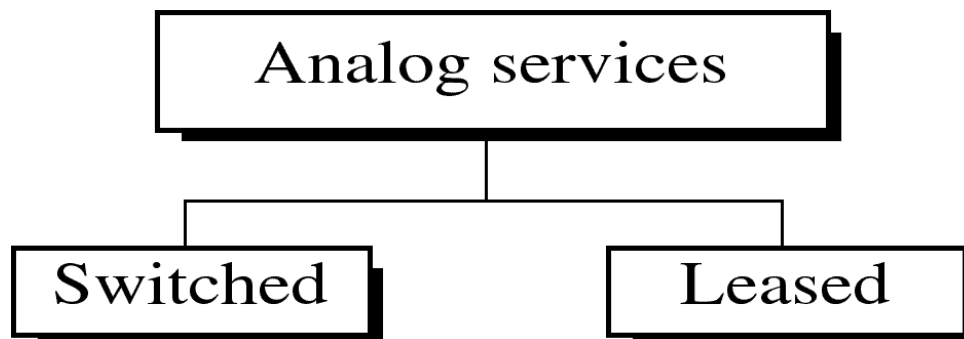
Multiplexing applications: telephone network



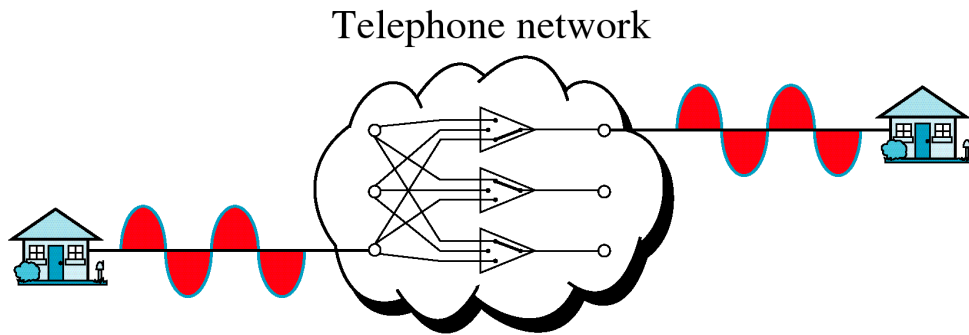
Telephone services



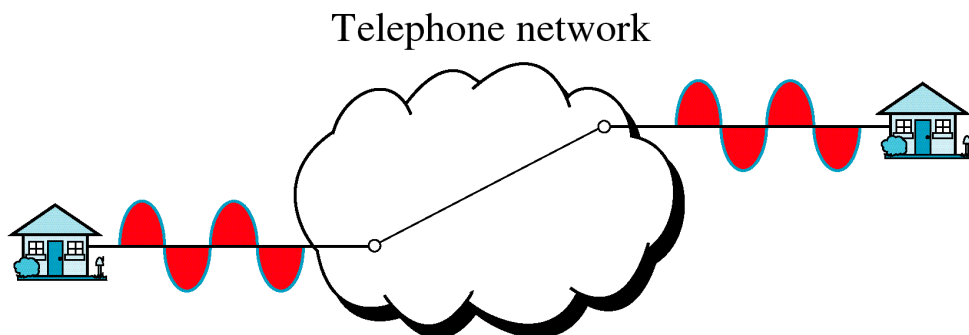
Analog services



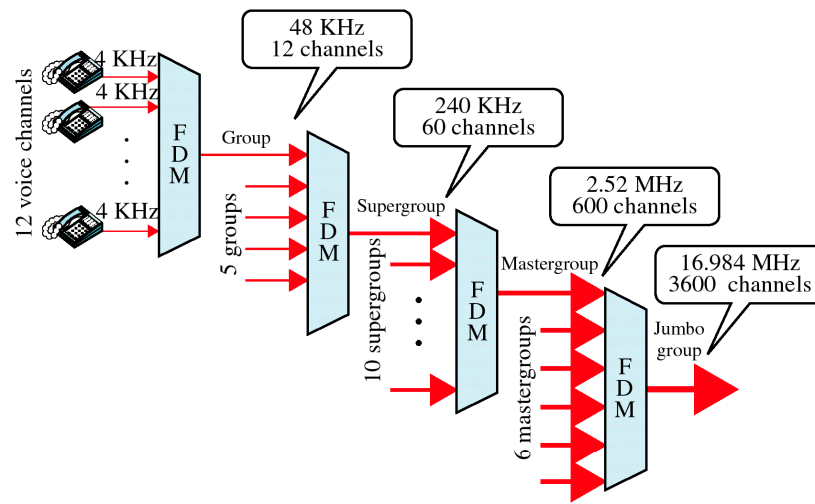
Analog switched service



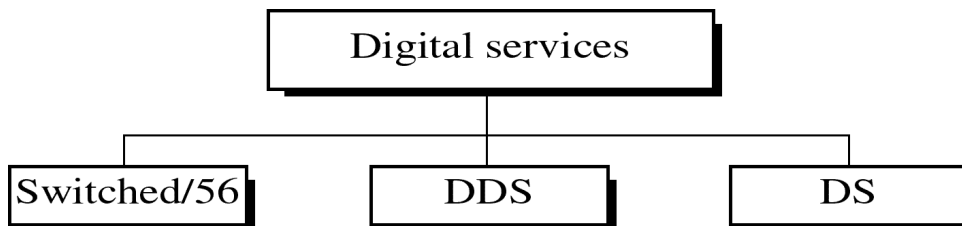
Analog leased service



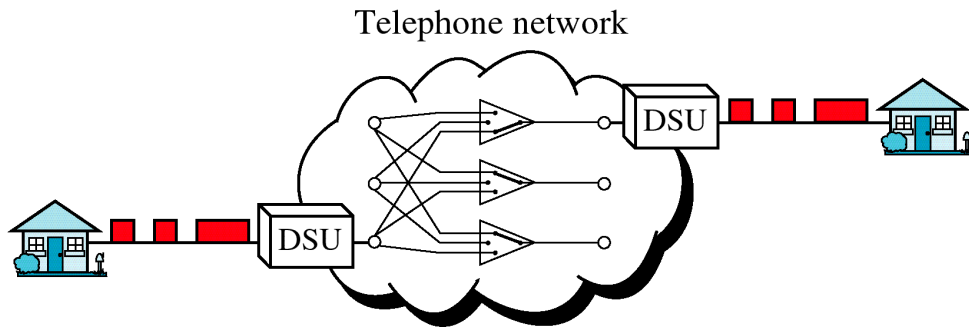
Analog hierarchy



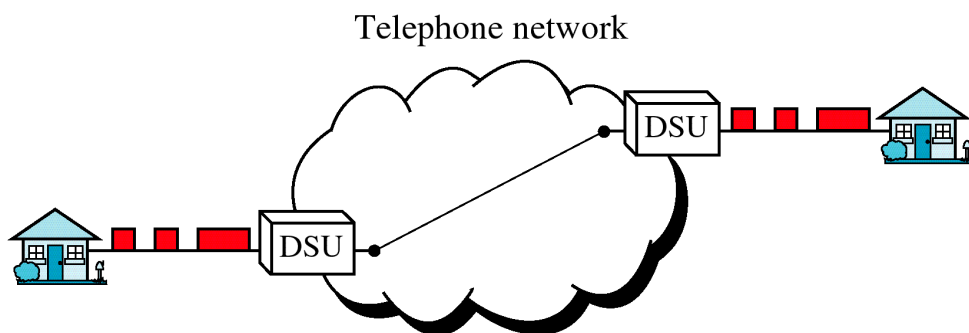
Digital services



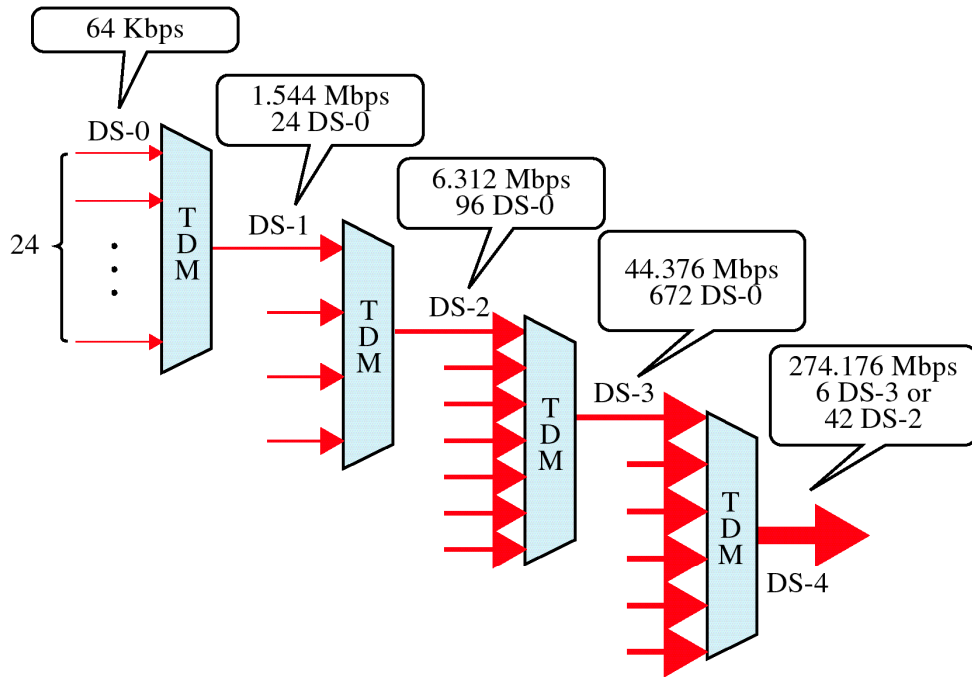
Switched/56 service, Digital Service Unit



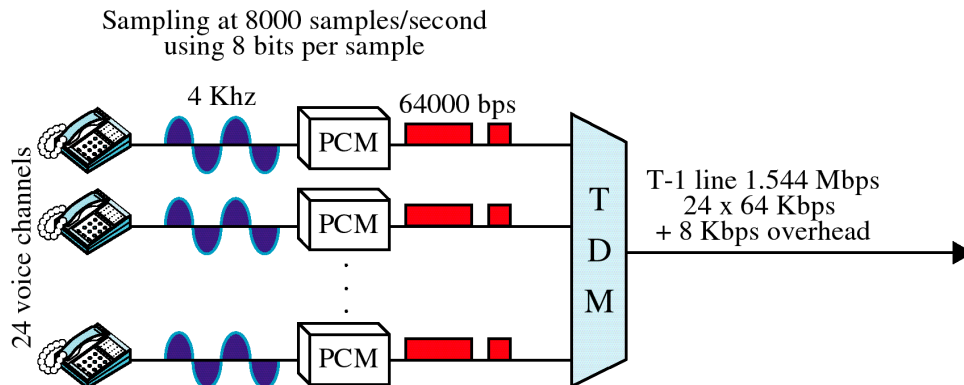
Digital Data Service



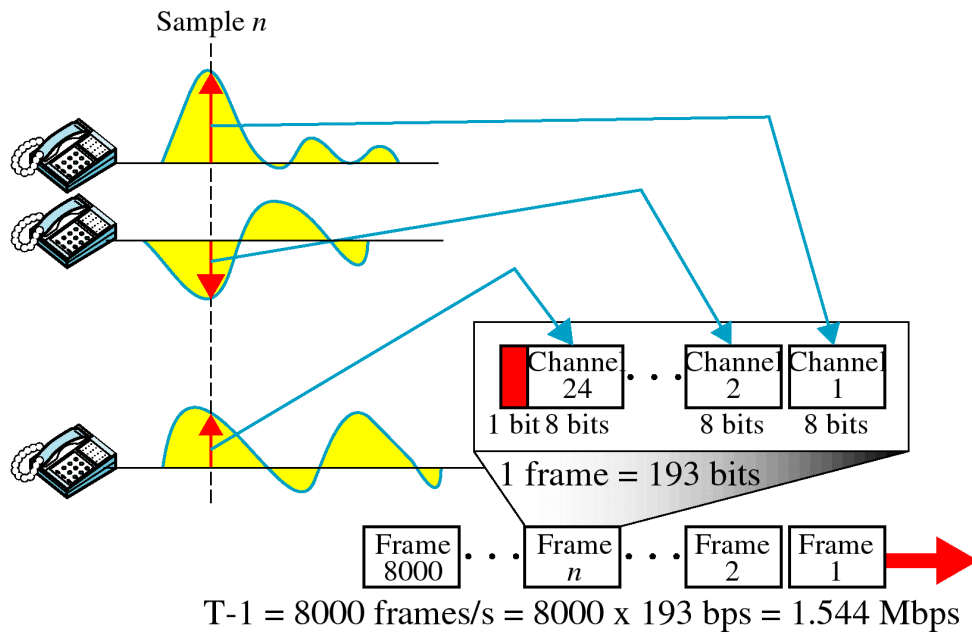
Digital Signal Service hierarchy



T-1 line for multiplexing telephone lines

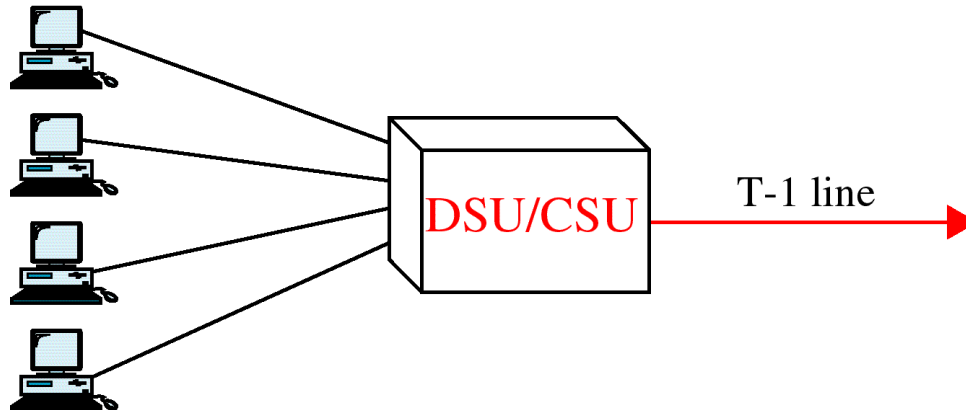


T-1 frame structure



Fractional T Line

Digital Service Unit/ Channel Service Unit



Asymmetric Digital Subscriber Line (ADSL)