Analog Signaling

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Important Terms

- Resolution - the number of bits used to represent a piece of (digital) information
- Sampling rate - sampling frequency
- Sampling time - the time it takes to get one sample ($t_{sampling} = 1 / f_{sampling}$)

Important Terms

- In-band signaling - control information is part of the data or control and data go through the same channel
- Out-of-band signaling - control information is not part of the data, bandwidth is reserved for it
- bit robbing - the process of using a bit of another channel for control signaling

DS0

- Digitized voice transmission
- 8-bit resolution
- 8-kHz sampling rate (125 uSec)
- 64-kbps transmission rate (bandwidth)
- basic multiplexing unit of T1, DS1, E1

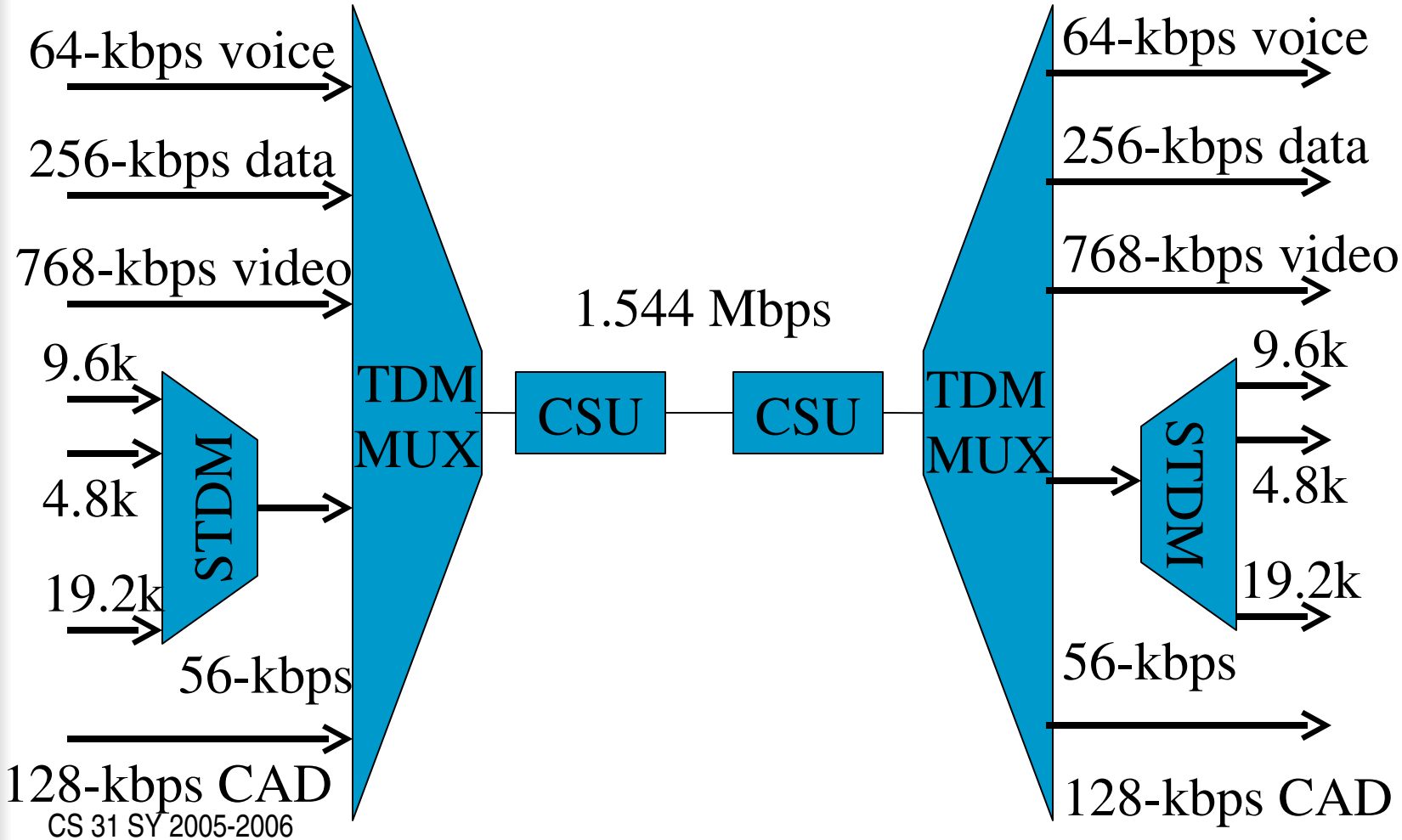
DS1 or T1

- High capacity digital transmission
- 1.544 Mbps using PCM or ADPCM
- 24 multiplexed digitized voice channels into one TDM circuit + 1 bit for timing
- Used in North America
- DS1 is the (digital) signaling system
- T1 is the name of the carrier equipment

E1

- ITU standard similar T1 to but came after T1 used primarily in Europe
- 2.048 Mbps using PCM or ADPCM
- 32 multiplexed digitized voice channels into one TDM circuit including two channels reserved for timing (out-of-band signaling)

Typical T1 Layout



Carrier Systems Mux Hierarchy

- North America
  - DS1 = 24 DS0 = 1.544 Mbps
  - DS2 = 96 DS0 = 4 DS1 = 6.312 Mbps
  - DS3 = 672 DS0 = 28 DS1 = 44.736 Mbps
- Europe
  - E1 = 30 DS0 = 2.048 Mbps
  - E2 = 120 DS0 = 4 E1 = 8.448 Mbps
  - E3 = 480 DS0 = 16 E1 = 34.368 Mbps

T1/E1

- Based on DS0 mux, designed for voice
- electrically based
- physical layer protocol or technology
- fast for its time (1960's)
- asynchronous timing which leads to awkward multiplexing
- T1 uses bit-robbing

T1/E1

- Limited management operations capability, limited network management functionalities
- little support for end-user control for the provisioning of services
- born in an age where bandwidth is a premium commodity and end processors are slow