Multiplexing

ITS323: Introduction to Data Communications
CSS331: Fundamentals of Data Communications

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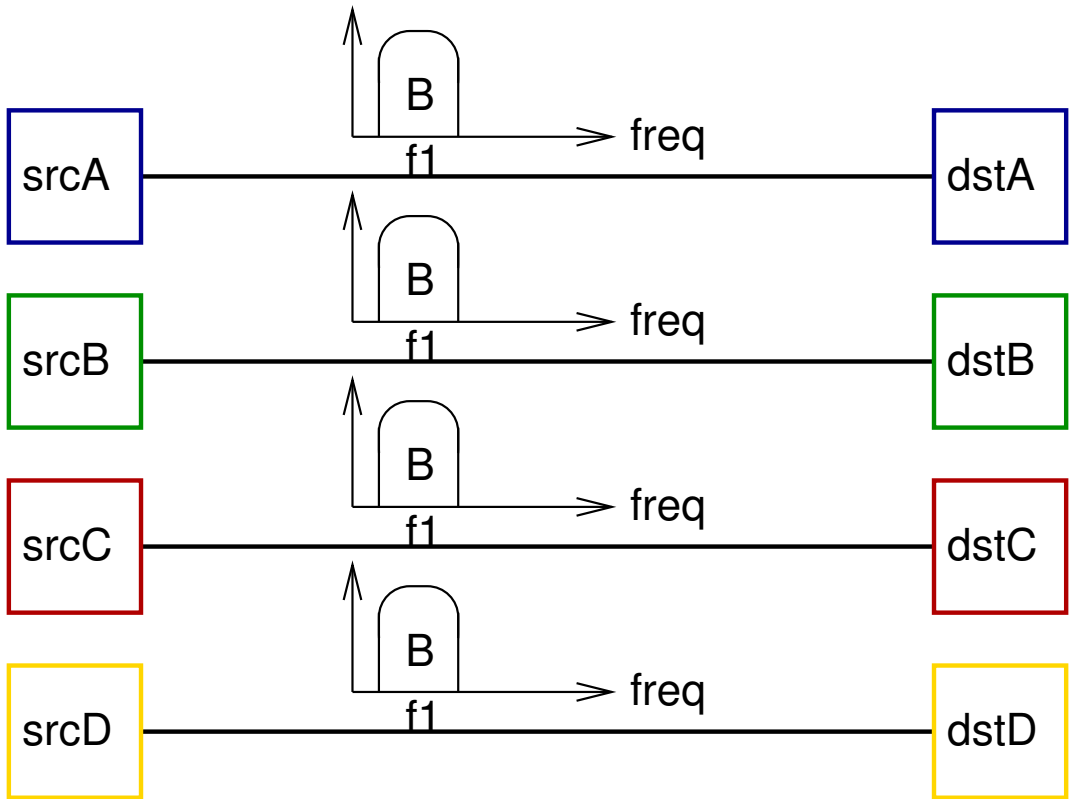
Contents

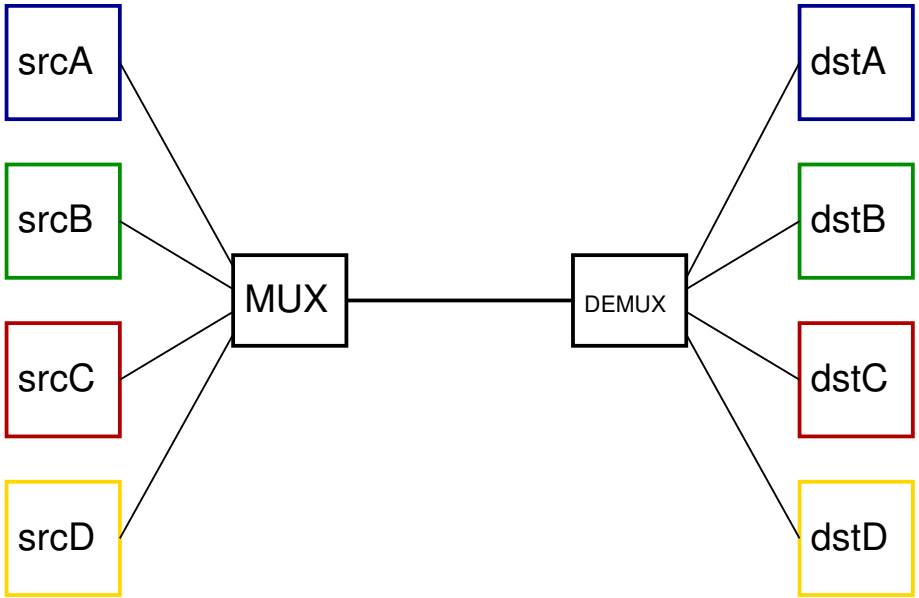
Supporting Multiple Users

- Multiple users in one location want to communicate with multiple users in another location
- Option 1: one link (line) per pair of users
- Each user has dedicated link, no interference
- Wasteful of resources; hard to expand



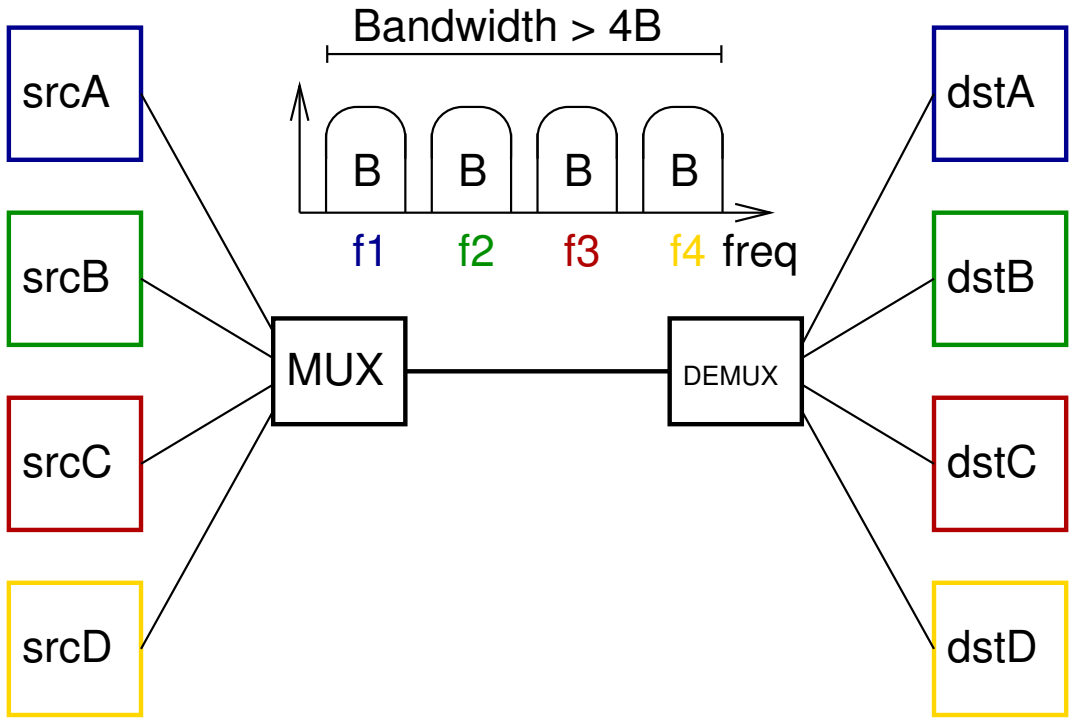
Multiplexing

- A single line connects two locations via special devices
- Multiplexer (MUX) combines signals from each source user, and transmits one signal
- Demultiplexer (DEMUX) splits received signal into separate signals and sends to destination users
- How to combine signals from multiple users?



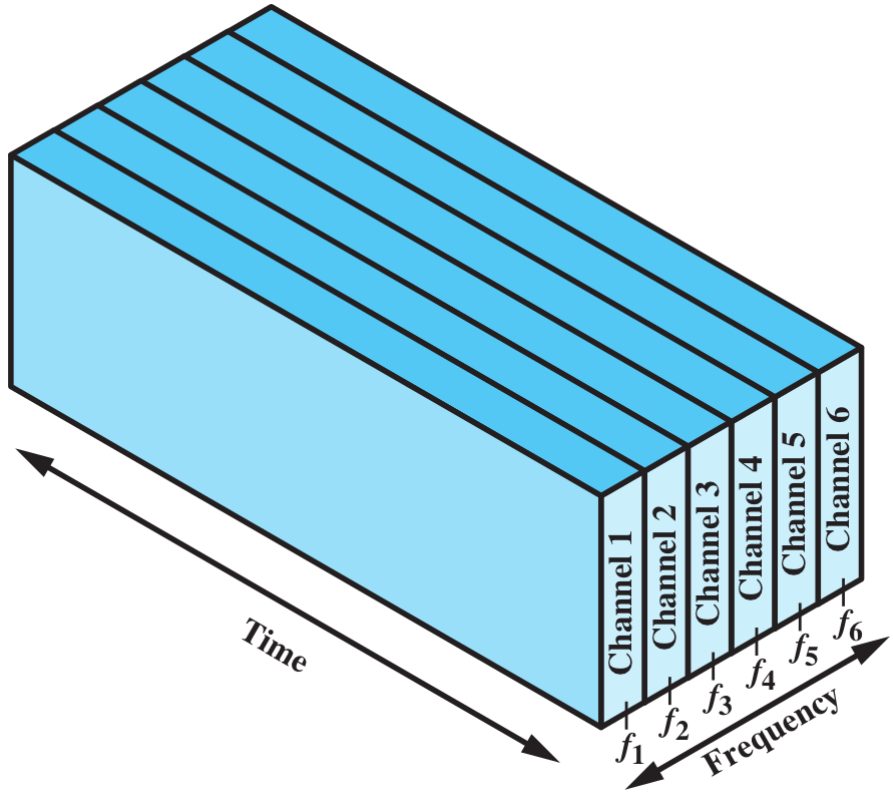
Frequency Division Multiplexing

- Signals from each user are transmitted at same time, but different frequencies



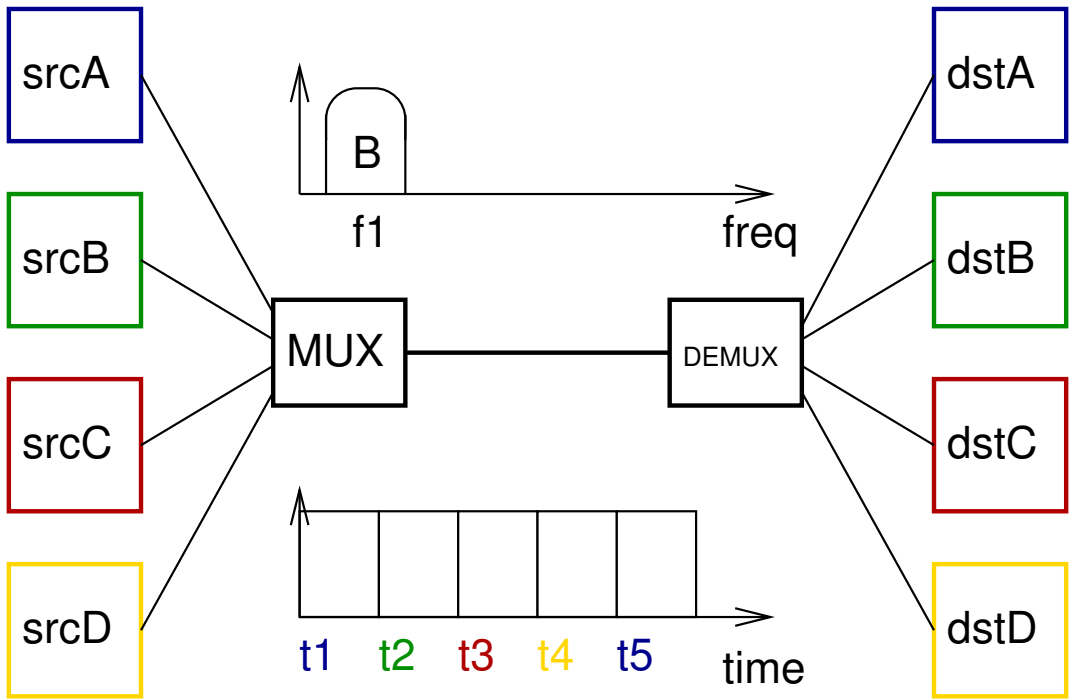
Frequency Division Multiplexing

- FDM possible when useful bandwidth of medium exceeds required bandwidth of signals
- Each signal modulated onto different carrier frequency, sufficiently separated so signals do not overlap



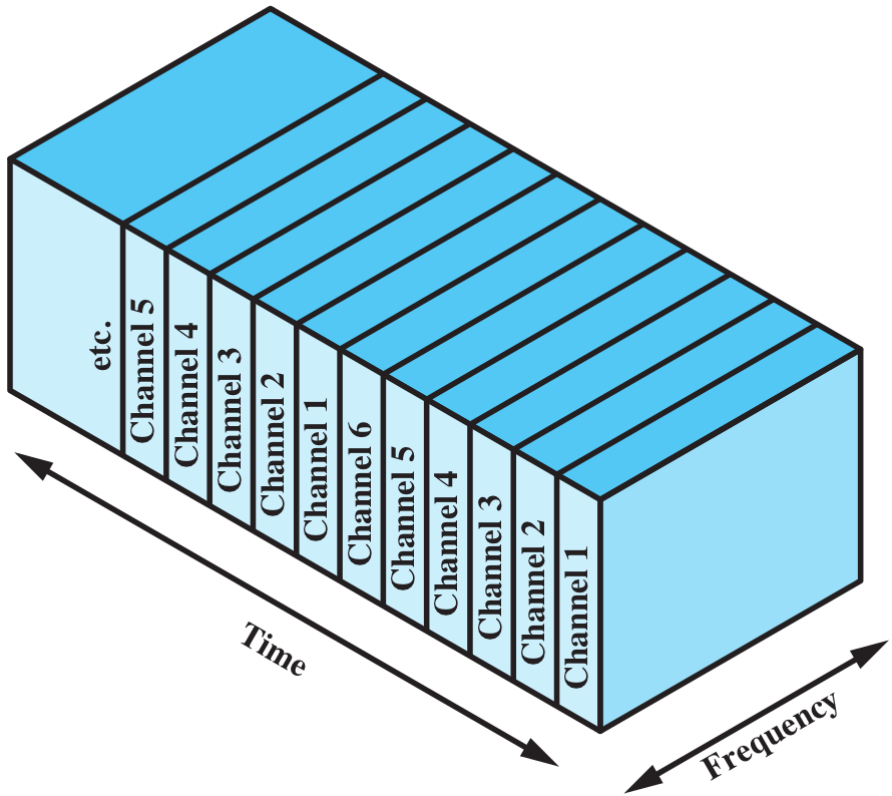
Time Division Multiplexing

- Signals from each user are transmitted on same frequency, but at different times



Time Division Multiplexing

- Multiple digital signals carried on single transmission path by transmitting portions of each signal one at a time
  - Synchronous TDM
  - Statistical TDM



Example Multiplexing Technologies

FDM

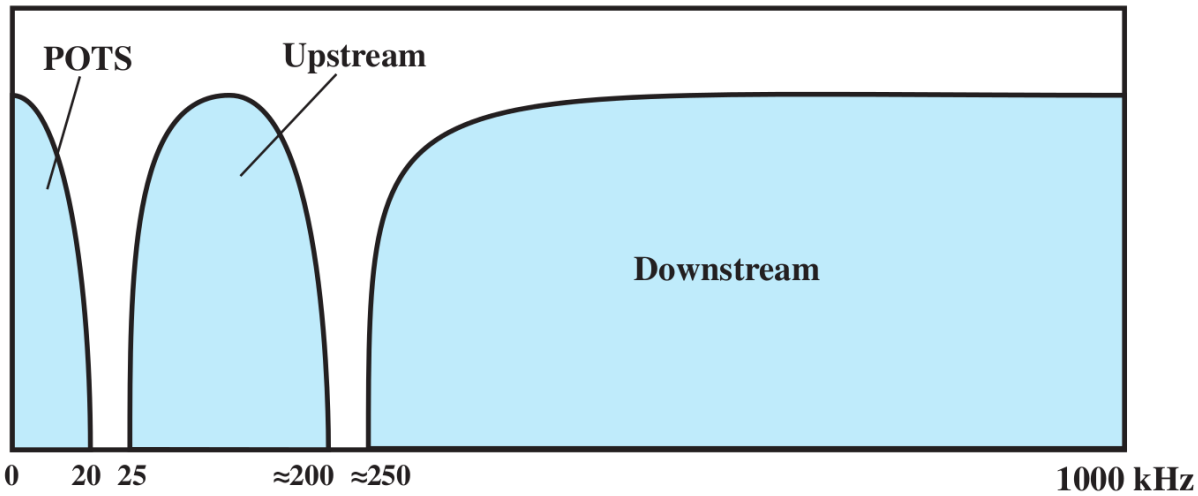
- Broadcast and cable TV, radio
- Long-distance carrier system deployed by telecom operators
- Optical fibre: Wavelength Division Multiplexing
- ADSL

TDM

- Digital carrier systems to replace FDM carrier systems (T-hierarchy, PDH)
- SONET/SDH

FDM Example: ADSL

- Plain Old Telephone Service (POTS), voice calls: 0—20 kHz
- Uplink data to ISP: 25—200 kHz
- Downlink data from ISP: 250—1000 kHz



TDM Example: SONET/SDH Signal Hierarchy

- PDH (T1, T2, E1, . . .) used electrical digital signals for connections between buildings, cities, countries: upto about 500 Mb/s
- Gradually replaced with SONET (US) and SDH (rest of world), which uses optical carrier (OC) signals

SONET Designation	ITU-T Designation	Data Rate	Payload Rate (Mbps)
STS-1/OC-1		51.84 Mbps	50.112 Mbps
STS-3/OC-3	STM-1	155.52 Mbps	150.336 Mbps
STS-12/OC-12	STM-4	622.08 Mbps	601.344 Mbps
STS-48/OC-48	STM-16	2.48832 Gbps	2.405376 Gbps
STS-192/OC-192	STM-64	9.95328 Gbps	9.621504 Gbps
STS-768	STM-256	39.81312 Gbps	38.486016 Gbps
STS-3072		159.25248 Gbps	153.944064 Gbps

Contents

Supporting Multiple Users in Point-to-Multipoint Links

- Multiple users share a point-to-multipoint link
- Typical for wireless systems (WiFi, mobile phone) and some wired LANs
- Use multiple access schemes to determine who transmits and when

Multiple Access: Fixed Assignment

A fixed assignment of transmission opportunities to users based on:

- Frequency Division Multiple Access (FDMA): users are assigned frequencies; transmit at same time
- Time Division Multiple Access (TDMA): users are assigned time slots; transmit on same frequency
- Code Division Multiple Access (CDMA): users are assigned codes, that allow receive to "separate" signals; transmit on same frequency, at same time
- Space Division Multiple Access (SDMA): transmissions in different physical areas, e.g. using directional antennas

Multiple Access: Demand Assignment

Transmission opportunities are assigned to users on-demand:

- Reservation-based: users are assigned schedule of transmissions based on earlier reservations; use FDMA, TDMA, CDMA, SDMA
- Polling-based: users are asked if they want to transmit

Multiple Access: Random Access

- Users transmit when desired, but after some random waiting time and as long as no-one else is transmitting
- The user that selects the smallest random waiting time will get to transmit first (and others will wait until they finish)
- Simple, can operate in distributed manner
- Used in wireless LANs (WiFi)