Multiplexing

ITS323: Introduction to Data Communications

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Contents

Multiplexing

Multiplexing

- Data link includes mechanisms for efficiently utilizing a communications link
- Source device has multiple frames on link at same time
- Opposite problem: what if two stations do not have enough data to fully utilize the link?
- Solution: allow data from multiple stations to share the link, i.e. multiplexing
- Multiplexing is commonly used in long-distance communications
  - (When more than 2 users sharing medium, referred to as *multiple access*; common in wireless technologies)
- Allow link with large capacity to carry information from many users at same time

Multiplexing

n inputs — **MUX** ———— **1 link, n channels** ———— **DEMUX** — n outputs
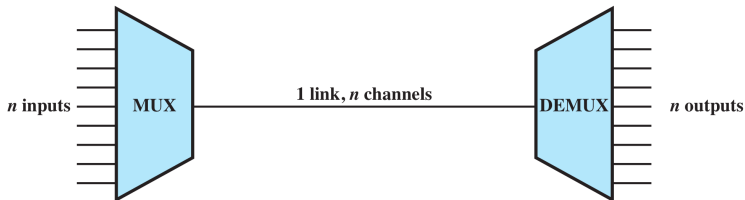
Why Multiplex?

▶ Higher the data rate, more cost effective the transmission facility

    ▶ Cost of link and transmission equipment per kb/s decreases with increases data rate

▶ Data rate required by most end-user devices is relatively small

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
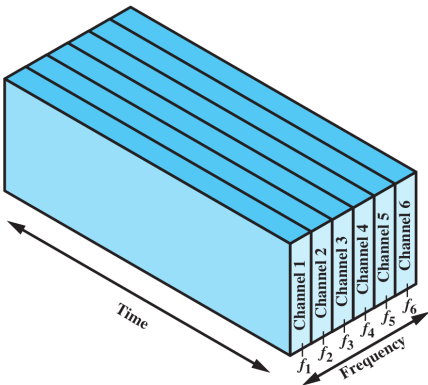
Time Division Multiplexing

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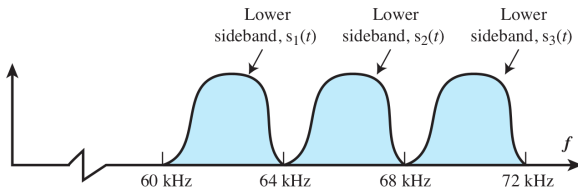 - Statistical TDM
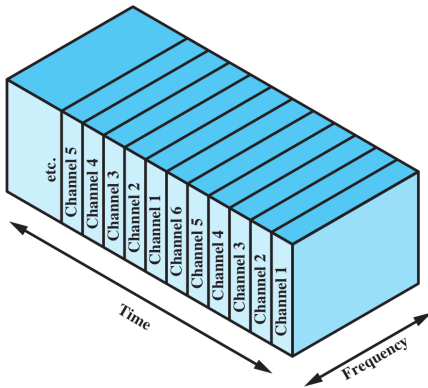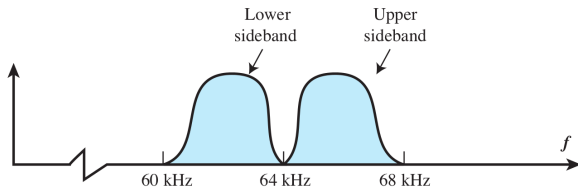
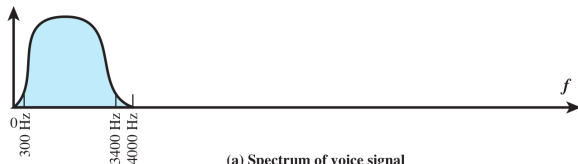# Example Multiplexing Technologies

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 of Three Voiceband Signals

(a) Spectrum of voice signal

North American and International FDM Carrier Standards

Number of Voice Channels	Bandwidth	Spectrum	AT&T	ITU-T
12	48 kHz	60–108 kHz	Group	Group
60	240 kHz	312–552 kHz	Supergroup	Supergroup
300	1.232 MHz	812–2044 kHz		Mastergroup
600	2.52 MHz	564–3084 kHz	Mastergroup	
900	3.872 MHz	8.516–12.388 MHz		Supermaster group
$N \times 600$			Mastergroup multiplex	
3,600	16.984 MHz	0.564–17.548 MHz	Jumbogroup	
10,800	57.442 MHz	3.124–60.566 MHz	Jumbogroup multiplex	

North American and International TDM Carrier Standards

North American			International (ITU-T)		
Designation	Number of Voice Channels	Data Rate (Mbps)	Level	Number of Voice Channels	Data Rate (Mbps)
DS-1	24	1.544	1	30	2.048
DS-1C	48	3.152	2	120	8.448
DS-2	96	6.312	3	480	34.368
DS-3	672	44.736	4	1920	139.264
DS-4	4032	274.176	5	7680	565.148

- ▶ North American system also referred to as T-hierarchy, e.g. T1 leased line
- ▶ International system also referred to as E-hierarchy and PDH

SONET/SDH Signal Hierarchy

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