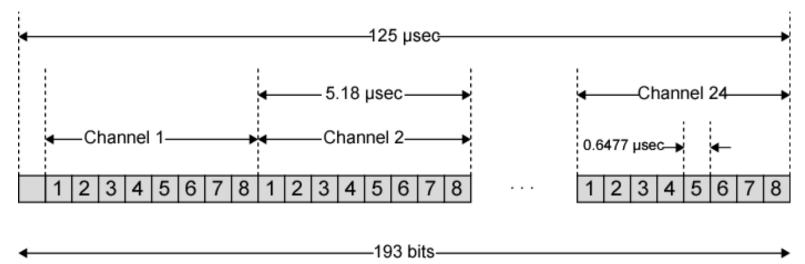
Mixed Data

- DS-1 can carry mixed voice and data signals
- 24 channels used
- No sync byte
- Can also interleave DS-1 channels
 —Ds-2 is four DS-1 giving 6.312Mbps

DS-1 Transmission Format



Notes:

- 1. The first bit is a framing bit, used for synchronization.
- 2. Voice channels:

8-bit PCM used on five of six frames.

7-bit PCM used on every sixth frame; bit 8 of each channel is a signaling bit.

3. Data channels:

Channel 24 is used for signaling only in some schemes.

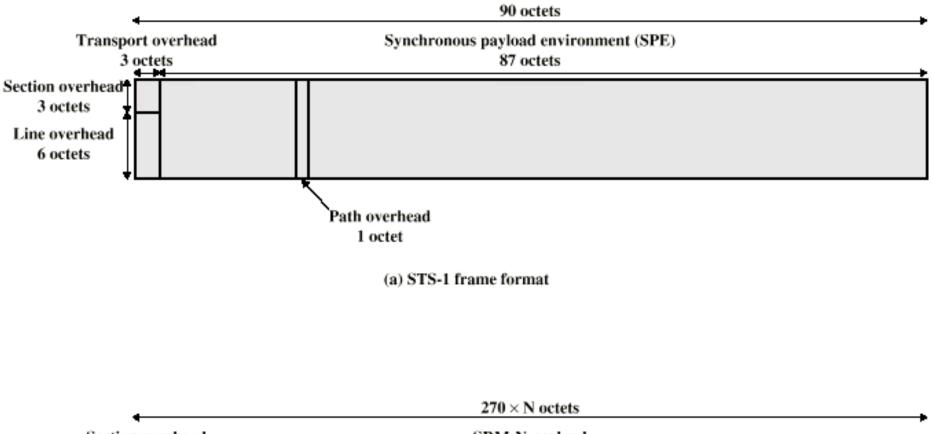
Bits 1-7 used for 56 kbps service

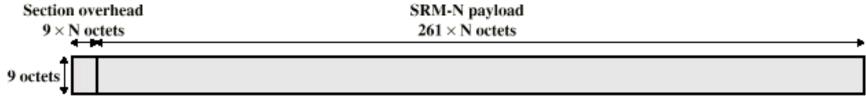
Bits 2-7 used for 9.6, 4.8, and 2.4 kbps service.

SONET/SDH

- Synchronous Optical Network (ANSI)
- Synchronous Digital Hierarchy (ITU-T)
- Compatible
- Signal Hierarchy
 - —Synchronous Transport Signal level 1 (STS-1) or Optical Carrier level 1 (OC-1)
 - -51.84Mbps
 - —Carry DS-3 or group of lower rate signals (DS1 DS1C DS2) plus ITU-T rates (e.g. 2.048Mbps)
 - -Multiple STS-1 combined into STS-N signal
 - —ITU-T lowest rate is 155.52Mbps (STM-1)

SONET Frame Format





(b) STM-N frame format

SONET STS-1 Overhead Octets

(Framing A1	Framing A2	STS-ID C1
Section	BIP-8	Orderwire	User
Overhead	B1	E1	F1
	DataCom	DataCom	DataCom
L C	D1	D2	D3
ſ	Pointer	Pointer	Pointer
	H1	H2	Action H3
1	BIP-8	APS	APS
ł	B2	K1	K2
]	DataCom	DataCom	DataCom
Line	D4	D5	D6
Overhead	DataCom	DataCom	DataCom
1	D7	D8	D9
	DataCom	DataCom	DataCom
1	D10	D11	D12
ł	Growth	Growth	Orderwire
L	Z1	Z2	E2

(a) Transport Overhead

Trace
J1
BIP-8
B3
Signal
Label C2
Path
Status G1
User
F2
Multiframe
H4
Growth
Z3
Growth
Z4
Growth
Z5

(b) Path Overhead

Statistical TDM

- In Synchronous TDM many slots are wasted
- Statistical TDM allocates time slots dynamically based on demand
- Multiplexer scans input lines and collects data until frame full
- Data rate on line lower than aggregate rates of input lines

Statistical TDM Frame Formats

	Flag	Address	Control	Statistical TDM subframe	FCS	Flag
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(a) Overall frame

Address Data	
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(b) Subframe with one source per frame

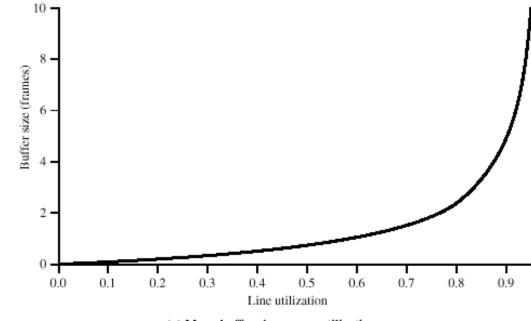


(c) Subframe with multiple sources per frame

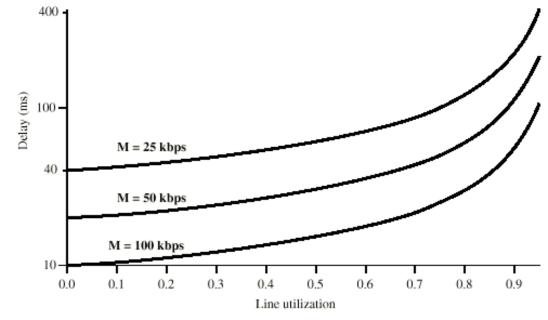
Performance

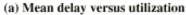
- Output data rate less than aggregate input rates
- May cause problems during peak periods —Buffer inputs
 - -Keep buffer size to minimum to reduce delay

Buffer Size and Delay



(a) Mean buffer size versus utilization





Cable Modem Outline

- Two channels from cable TV provider dedicated to data transfer
 - One in each direction
- Each channel shared by number of subscribers
 - Scheme needed to allocate capacity
 - Statistical TDM

Cable Modem Operation

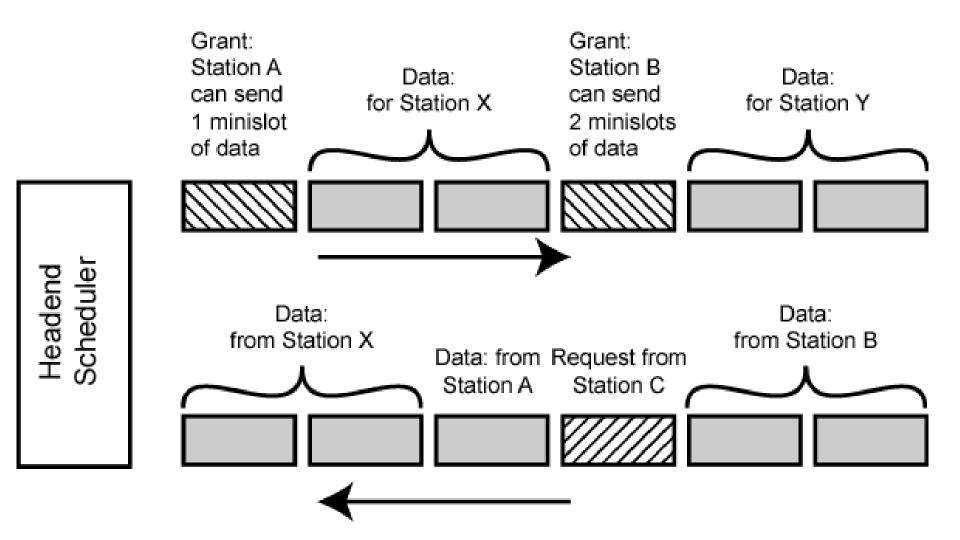
• Downstream

- Cable scheduler delivers data in small packets
- If more than one subscriber active, each gets fraction of downstream capacity
 - May get 500kbps to 1.5Mbps
- Also used to allocate upstream time slots to subscribers

Upstream

- User requests timeslots on shared upstream channel
 - Dedicated slots for this
- Headend scheduler sends back assignment of future tme slots to subscriber

Cable Modem Scheme



Asymmetrical Digital Subscriber Line

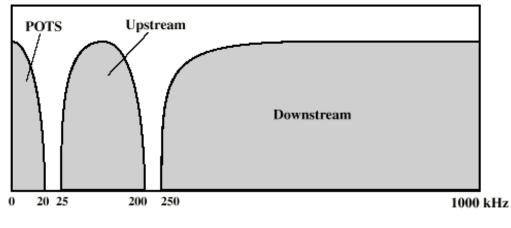
- ADSL
- Link between subscriber and network

 Local loop
- Uses currently installed twisted pair cable
 —Can carry broader spectrum
 —1 MHz or more

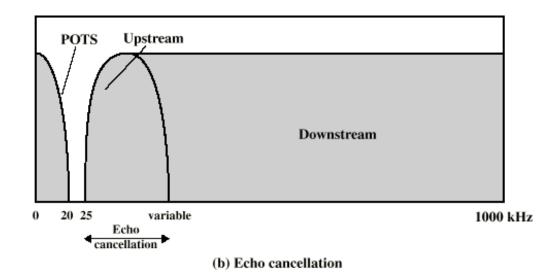
ADSL Design

- Asymmetric
 - -Greater capacity downstream than upstream
- Frequency division multiplexing
 - -Lowest 25kHz for voice
 - Plain old telephone service (POTS)
 - -Use echo cancellation or FDM to give two bands
 - —Use FDM within bands
- Range 5.5km

ADSL Channel Configuration



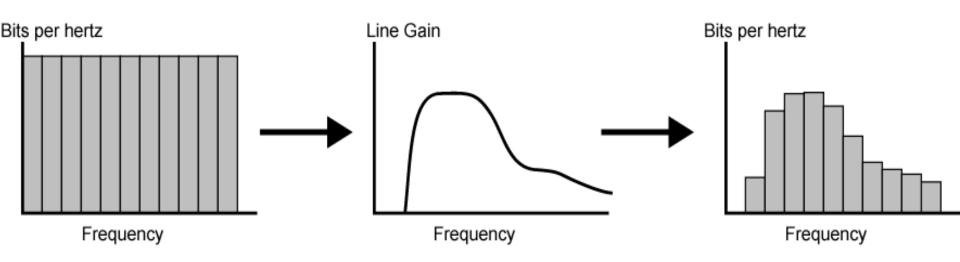
(a) Frequency-division multiplexing



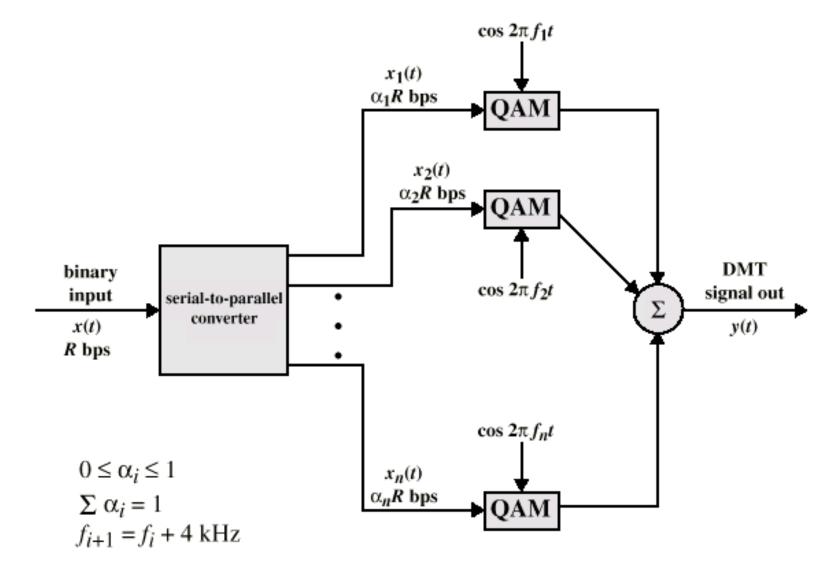
Discrete Multitone

- DMT
- Multiple carrier signals at different frequencies
- Some bits on each channel
- 4kHz subchannels
- Send test signal and use subchannels with better signal to noise ratio
- 256 downstream subchannels at 4kHz (60kbps) —15.36MHz
 - —Impairments bring this down to 1.5Mbps to 9Mbps

DTM Bits Per Channel Allocation



DMT Transmitter



xDSL

- High data rate DSL
- Single line DSL
- Very high data rate DSL

Required Reading

- Stallings chapter 8
- Web sites on
 - -ADSL
 - -SONET