Chapter 2 The Physical Layer

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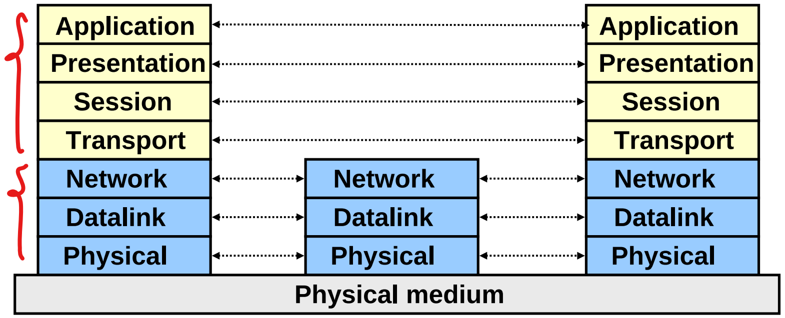
ISO OSI Reference Model

- Seven layers
  - Lower three layers are point-to-point
  - Next four layers are peer-to-peer

point 2 point

peer2peer



Physical layer

- **Protocols on physical layer specify the mechanical, electrical, functional, procedural and transmission characteristics of the interface.**
  - Mechanical characteristics
    - the types of connector and socket
    - the pin functions
    - E.g CCITT X.20,X.21,X.22; ISO 4092
- *Mechanical Characteristics*

Content

- **Concept**
- **The theoretical Basis for Data Communication**
- **Guided Transmission Media**
- **Wireless Transmission**
- **Communication Satellites**
- **The Public Switched Telephone Network**

Physical Layer

- Service: move the information between two systems connected by a physical link
- Interface: specifies how to send a bit
- Protocols: coding scheme used to represent a bit, voltage levels, duration of a bit
- Examples: coaxial cable, optical fiber links; transmitters, receivers

Media is not included in physical layer!

Limitations on tx rate and distance

- Attenuation
- Distortion
- Dispersion
- Noise

Basic Concepts

- **Spectrum** Range of frequencies of a signal [f_{min}, f_{max}]
- **Bandwidth** Width of the spectrum (f_{max} - f_{min}) (measured in Hz)
- **Capacity** Rate at which data can be transmitted (measured in bits per seconds, bps)
- **Noise** Random noise which distorts a signal (measured as ratio of signal power to noise power, units are decibels (dB))

◆ **Signal-to-Noise Ratio**

S: Signal Power. N: Noise Power

signal-to-noise ratio (db) = 10 $\log_{10}$S/N

Bandwidth and Capacity

- **Capacity of a noiseless channel (H. Nyquist, 1924)**

Capacity = 2H Log_2V bps

where : H is bandwidth

V is the number of discrete level of a signal

- **Capacity of a noisy channel (C. Shannon, 1948)**

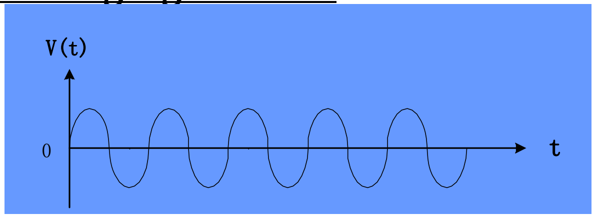
Capacity = H Log_2(1+ S/N) bps

where : S/N is signal-to-noise ratio

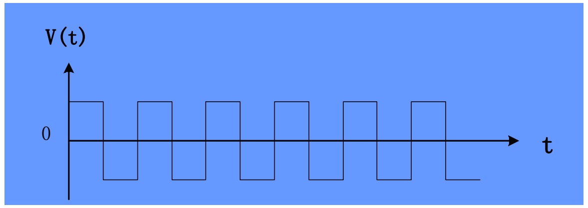
消息，信号，信道

- 消息是一方发出而另一方能够感受的信息
  (Message)
- 信号，是表达信息的形式；
  (Signal)
  Analog signal, Digital signal
- 信道，是传送信号的途径
  (Channel)

- **Analog signal wave**



- **Digtal signal wave**

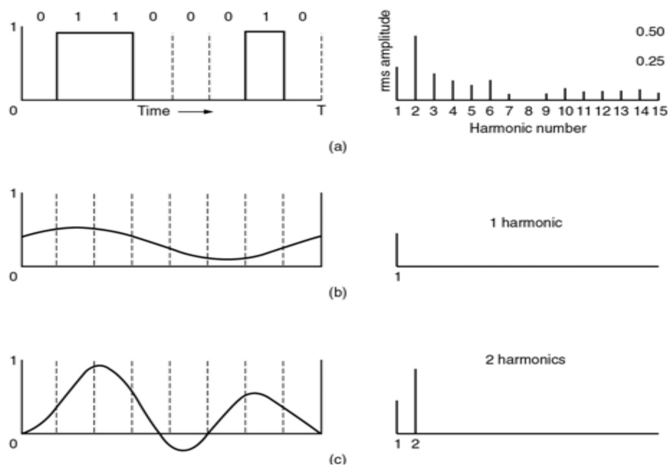


Data must be converted to signal for transmission on media

The Theoretical Basis for Data Communication

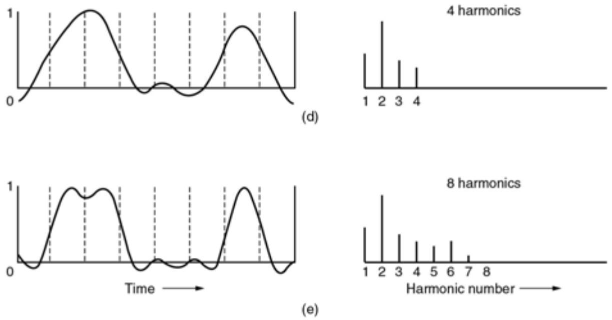
- Fourier Analysis
- Bandwidth-Limited Signals
- Maximum Data Rate of a Channel

Bandwidth-Limited Signals



- A binary signal and its root-mean-square Fourier amplitudes.
- (b) – (c) Successive approximations to the original signal.

Bandwidth-Limited Signals (2)



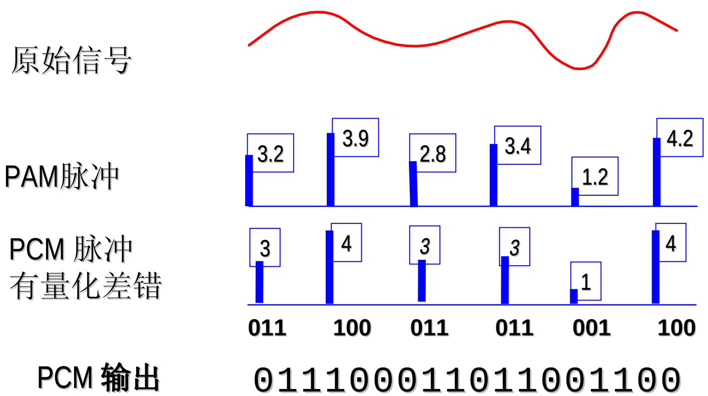
(d) – (e) Successive approximations to the original signal.

Bandwidth-Limited Signals (3)

Bps	T (msec)	First harmonic (Hz)	# Harmonics sent
300	26.67	37.5	80
600	13.33	75	40
1200	6.67	150	20
2400	3.33	300	10
4800	1.67	600	5
9600	0.83	1200	2
19200	0.42	2400	1
38400	0.21	4800	0

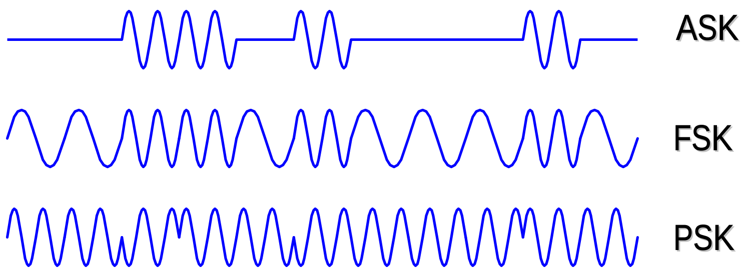
Relation between data rate and harmonics.

Nyquist Sampling Theorem
example : PCM



调制技术

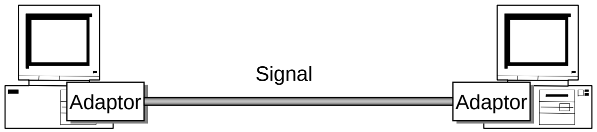
0 0 1 1 0 1 0 0 0 1 0



Encoding

specify how bits are transmitted on the physical media

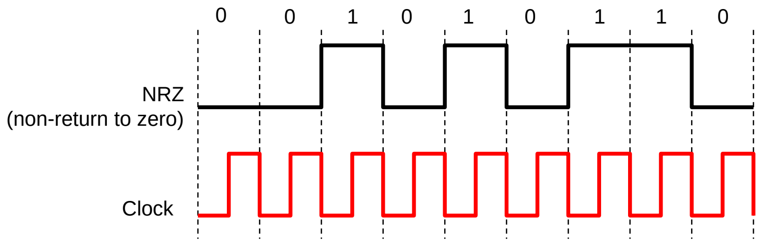
- Goal: send bits from one node to other node on the same physical media
  - This service is provided by the physical layer
- Problem: specify an robust and efficient encoding scheme to achieve this goal
- Assumption: we use two discrete signals, high and low, to encode 0 and 1



Adaptor: convert bits into physical signal and physical signal back into bits

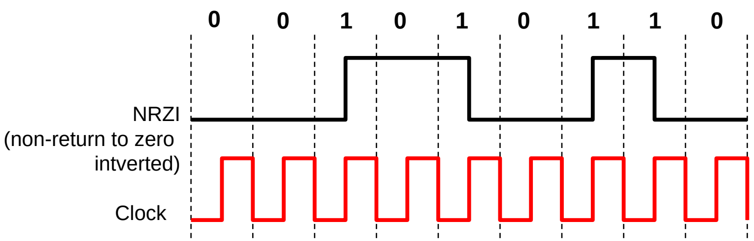
Encoding : Non-Return to Zero (NRZ)

- 1 → high signal; 0 → low signal
- Disadvantages: when there is a long sequence of 1's or 0's
  - Sensitive to clock skew, i.e., difficult to do clock recovery
  - Difficult to interpret 0's and 1's (baseline wander)



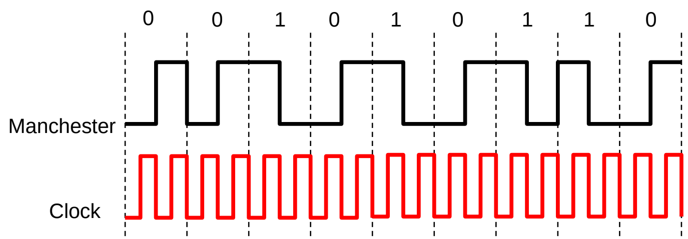
Encoding : Non-Return to Zero Inverted (NRZI)

- 1 → make transition; 0 → stay at the same level
- Solve previous problems for long sequences of 1's, but not for 0's



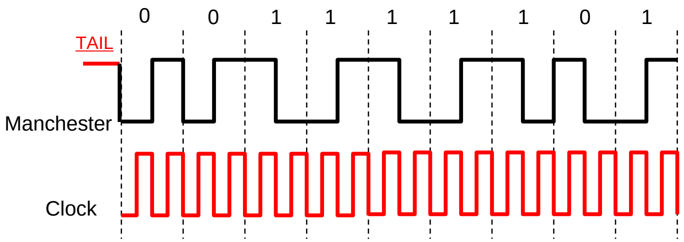
Manchester

- 1 → high-to-low transition; 0 → low-to-high transition
- Addresses clock recovery and baseline wander problems
- Disadvantage: needs a clock that is twice as fast as the transmission rate



Differential Manchester

- 1 → keep level; 0 → transit to opposite level
- Addresses clock recovery and baseline wander problems
- Disadvantage/Advantage



4-bit/5-bit

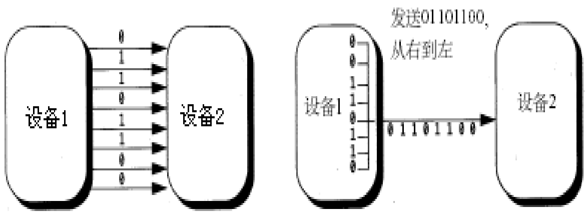
- Goal: address inefficiency of Manchester encoding, while avoiding long periods of low or high signals
- Solution:
  - Use 5 bits to encode every sequence of four bits such that no 5 bit code has more than one leading 0 and two trailing 0's
  - Use NRZI to encode the 5 bit codes

4-bit	5-bit
0000	11110
0001	01001
0010	10100
0011	10101
0100	01010
0101	01011
0110	01110
1111	01111

4-bit	5-bit
1000	10010
1001	10011
1010	10110
1011	10111
1100	11010
1101	11011
1110	11100
1111	11101

Data Transfer Type

- Parallel
- Serial



a) 并行传输 b) 串行传输

• Examples:EIA RS-232-D

- The RS-232D Serial Interface Standard added the mechanical characteristics to the RS-232C Standard. The RS-232D Standard defines:
  - The mechanical characteristics of the interface
  - The electrical characteristics of the interface
  - The function of each signal
  - Subsets of the signals for certain applications
- The European version of RS-232D is defined in:
  - V.24 - mechanical standard
  - V.28 - electrical standard

Mechanical Characteristics of the RS-232D

i. The connector is a DB25 connector. DB9 is not universally accepted.

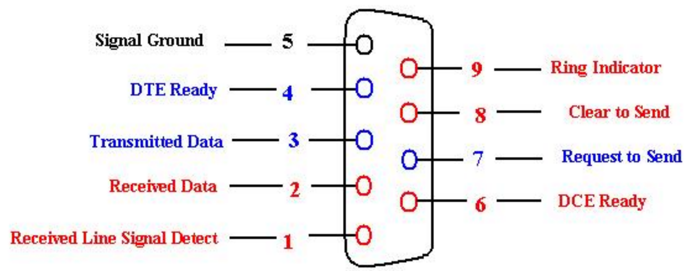
ii. The connector gender is male at the DTE and female at the DCE.

iii. The assignments of signals to pins.

iv. The maximum cable length is 50 ft.

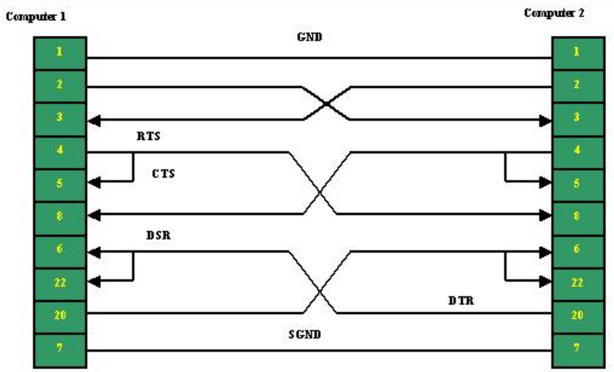
v. The maximum cable capacitance = 2500 pF. Typical cable has 50 pF/foot capacitance.

DB9

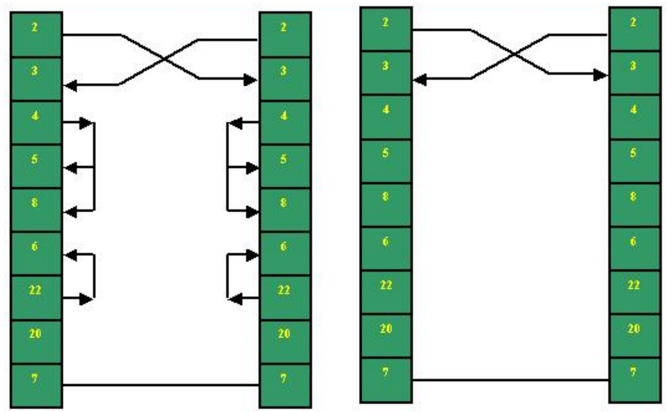


Pin designations for EIA-232 connectors from the DTE side.(DB9)

Two computers connected using RS-232-C

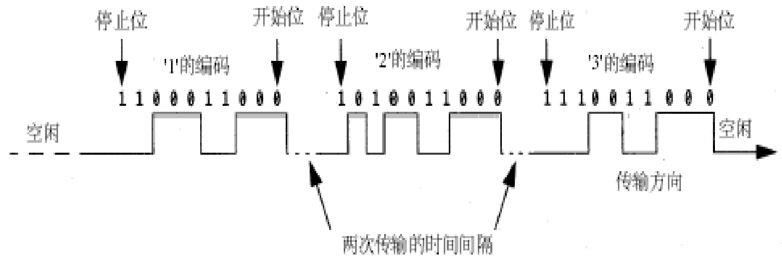


Two computers simple connected using RS-232-C



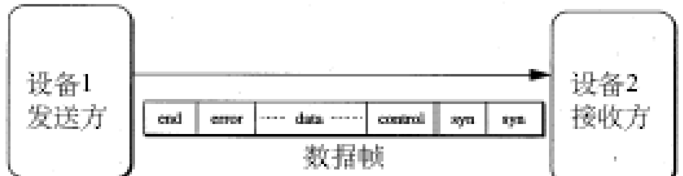
Serial Transfer

- Asynchronism



Serial Transfer

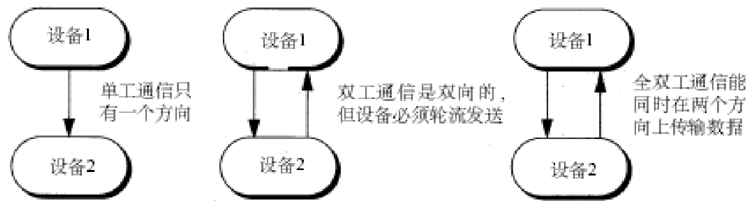
- Synchronism



syn=同步位
coutrol=控制位
data=数据位
error=错误检测位
end=帧结束位

Transmission Media

- Transmission Medium can be:
  - **Simplex**
    - Transmission in one direction only.
  - **Half-duplex**
    - Transmission in both directions; but not at the same time.
  - **Full-duplex (duplex)**
    - Simultaneous transmission in both directions.

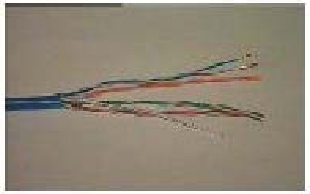


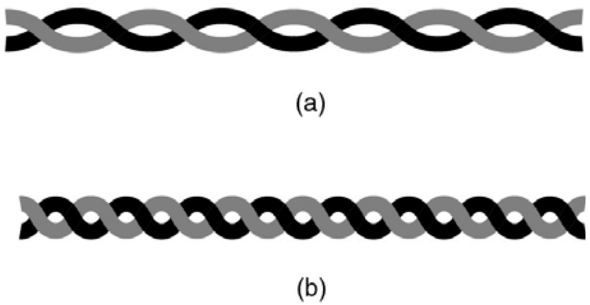
Guided Transmission Data

- Magnetic Media
- Twisted Pair
- Coaxial Cable
- Fiber Optics

Twisted Pair

- Two insulated wires are twisted around each other, and combined with others into a cable
- Used to connect telephone subscribers to switching centers and for wiring local area networks
- Different qualities:
  - Two popular varieties:
    - Category 3: 10 Mbps
    - Category 5: 100 Mbps



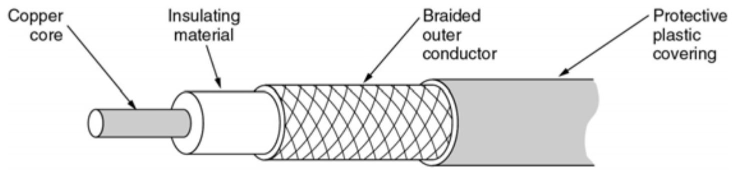


(a) Category 3 UTP.
(b) Category 5 UTP.

Coaxial Cable

- Like twisted pair a coaxial cable ("coax") has two conductors that are shielded
- Used for digital transmissions in local area networks (e.g., Ethernet) and analog analog transmissions for cable television
- Coax used for Cable TV supports a spectrum of 50 - 750 Mhz

Coaxial Cable

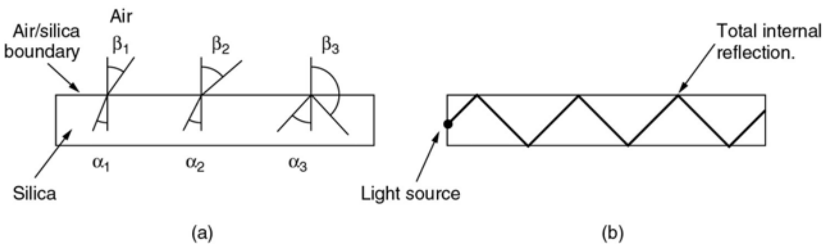


A coaxial cable.

Optical Fiber

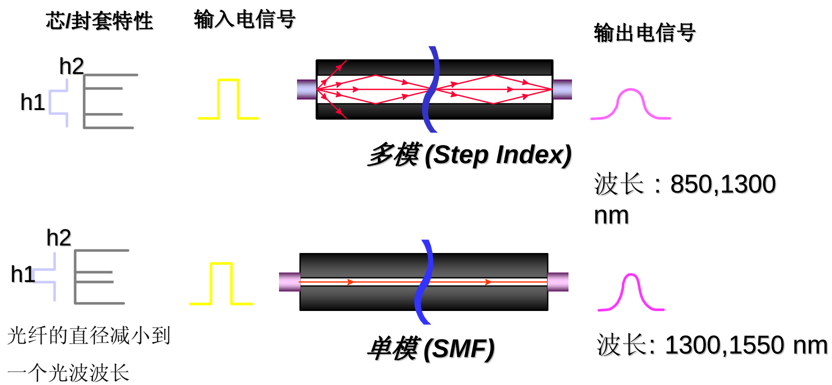
- Optical fiber is a thin, flexible medium capable of conducting an optical ray.
- Fiber is built of various glasses or plastics.
- Very high bandwidth (currently up to 10 Gbps).
- Used for long-distance trunks, local area networks, high-speed transmissions.
- Inherently unidirectional.

Fiber Optics

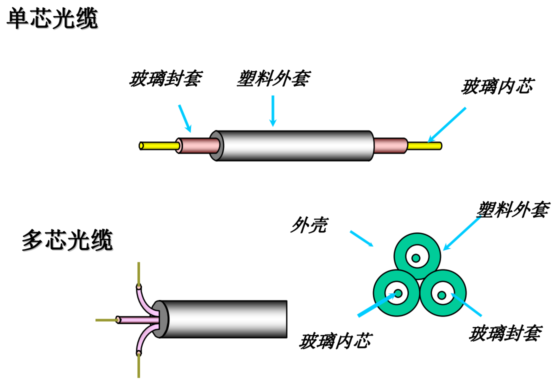


(a) Three examples of a light ray from inside a silica fiber impinging on the air/silica boundary at different angles.

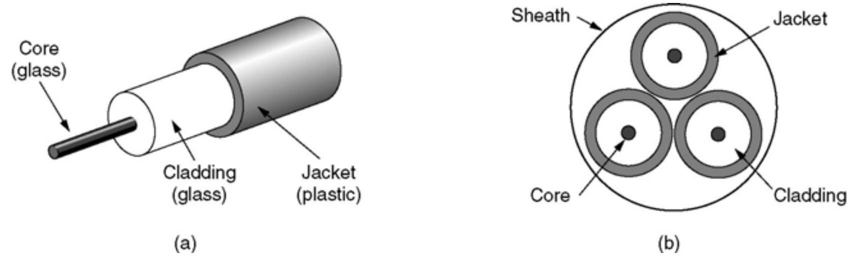
(b) Light trapped by total internal reflection.



典型的光缆

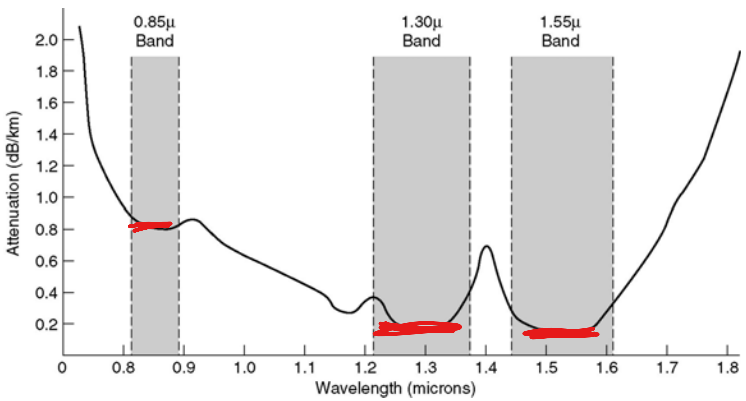


Fiber Cables



- (a) Side view of a single fiber.
- (b) End view of a sheath with three fibers.

Transmission of Light through Fiber



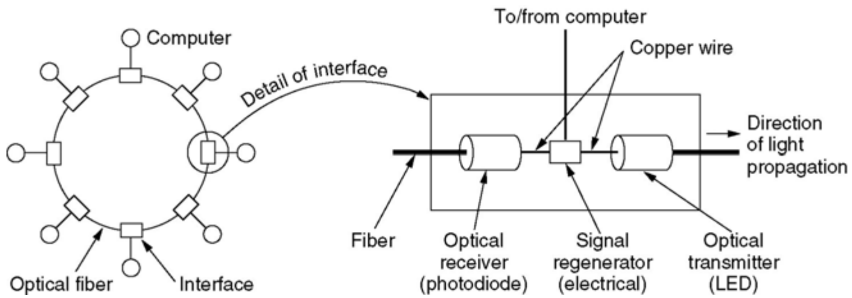
Attenuation of light through fiber in the infrared region.

Fiber Cables (2)

Item	LED	Semiconductor laser
Data rate	Low	High
Fiber type	Multimode	Multimode or single mode
Distance	Short	Long
Lifetime	Long life	Short life
Temperature sensitivity	Minor	Substantial
Cost	Low cost	Expensive

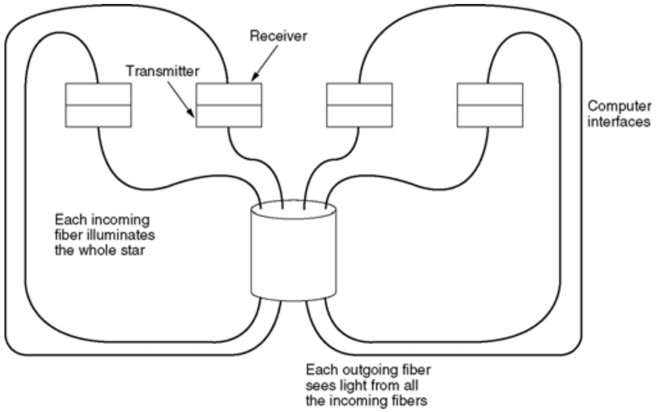
A comparison of semiconductor diodes and LEDs as light sources.

Fiber Optic Networks



A fiber optic ring with active repeaters.

Fiber Optic Networks (2)



A passive star connection in a fiber optics network.

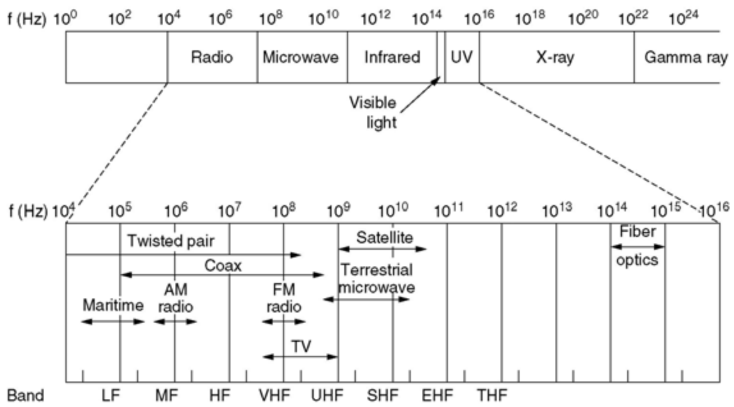
Wireless Media

- Advantage/Disvantage
- Type
- normal / microwave / satellite / infrared / laser (unguided) / Cellular networks / Satellite

Wireless Transmission

- The Electromagnetic Spectrum
- Radio Transmission
- Microwave Transmission
- Infrared and Millimeter Waves
- Lightwave Transmission

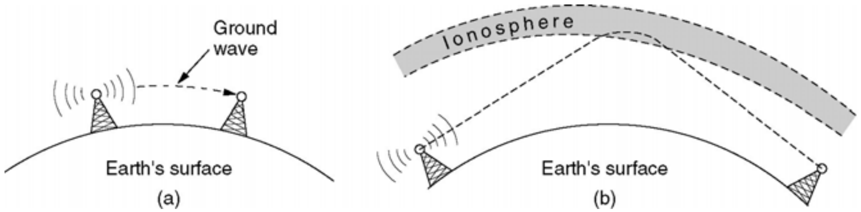
The Electromagnetic Spectrum



The electromagnetic spectrum and its uses for communication.

Other Media?

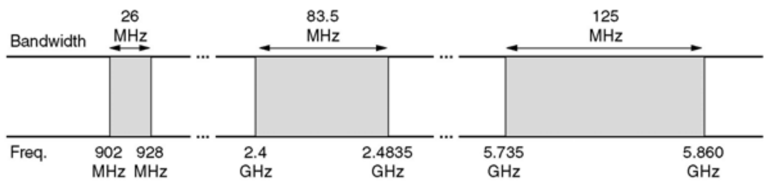
Radio Transmission



(a) In the VLF, LF, and MF bands, radio waves follow the curvature of the earth.

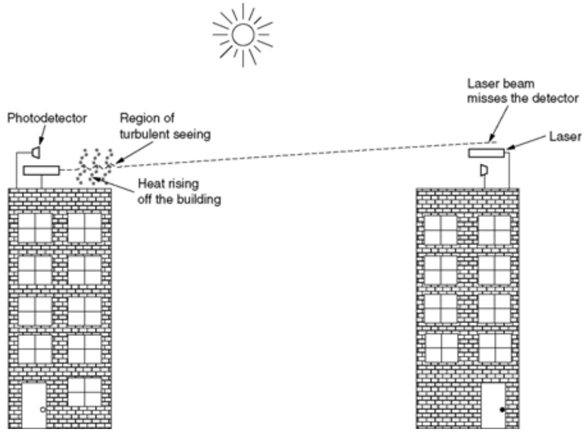
(b) In the HF band, they bounce off the ionosphere.

Politics of the Electromagnetic Spectrum



The ISM bands in the United States.

Lightwave Transmission

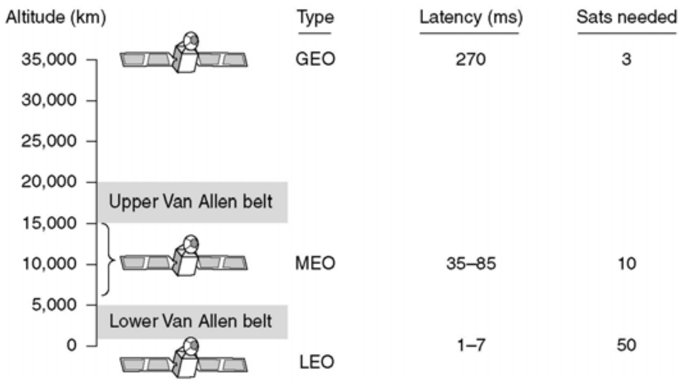


- Convection currents can interfere with laser communication systems.

Communication Satellites

- Geostationary Satellites
- Medium-Earth Orbit Satellites
- Low-Earth Orbit Satellites
- Satellites versus Fiber

Communication Satellites



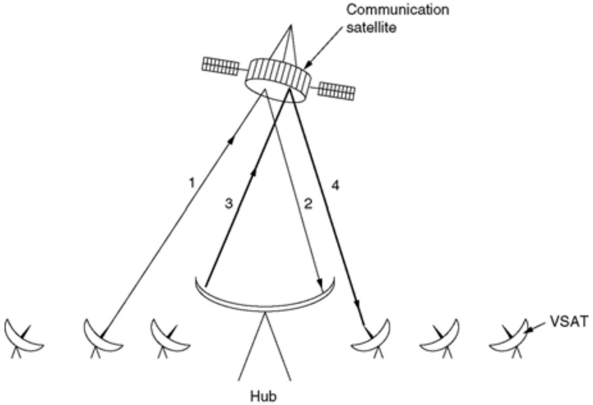
Communication satellites and some of their properties, including altitude above the earth, round-trip delay time and number of

Communication Satellites (2)

Band	Downlink	Uplink	Bandwidth	Problems
L	1.5 GHz	1.6 GHz	15 MHz	Low bandwidth; crowded
S	1.9 GHz	2.2 GHz	70 MHz	Low bandwidth; crowded
C	4.0 GHz	6.0 GHz	500 MHz	Terrestrial interference
Ku	11 GHz	14 GHz	500 MHz	Rain
Ka	20 GHz	30 GHz	3500 MHz	Rain, equipment cost

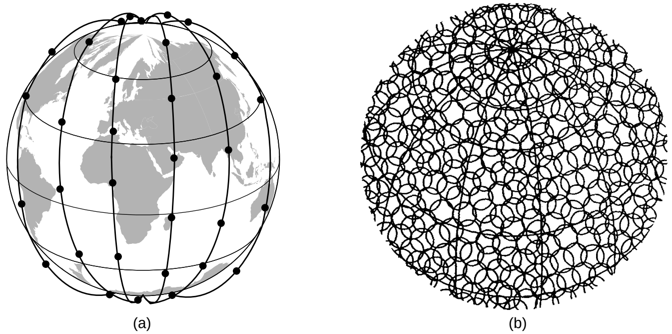
The principal satellite bands.

Communication Satellites (3)



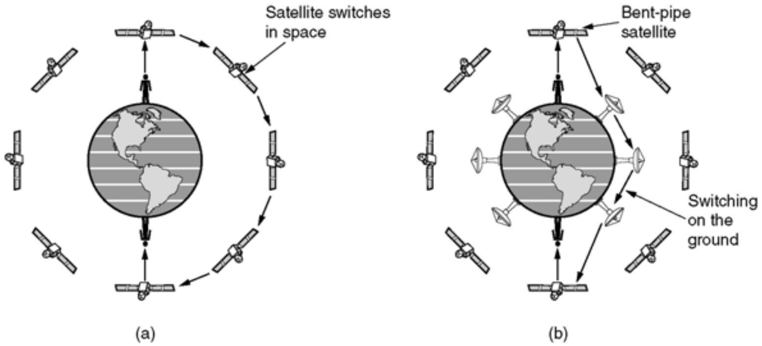
VSATs using a hub.

Low-Earth Orbit Satellites Iridium



- (a) The Iridium satellites from six necklaces around the earth.

Globalstar

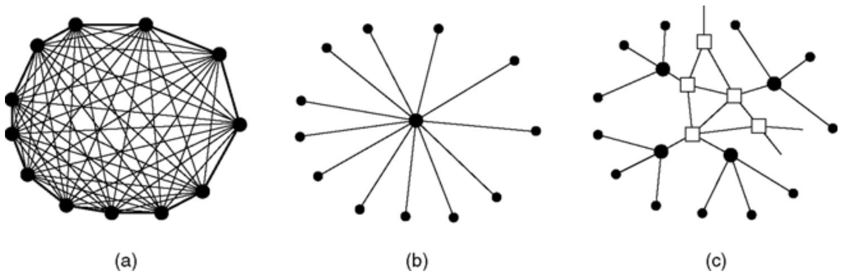


- (a) Relaying in space.
- (b) Relaying on the ground.

Public Switched Telephone System

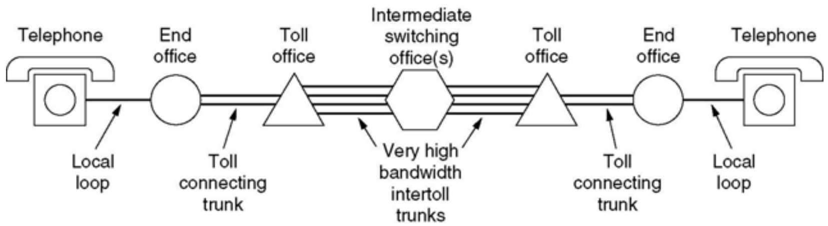
- Structure of the Telephone System
- The Politics of Telephones
- The Local Loop: Modems, ADSL and Wireless
- Trunks and Multiplexing
- Switching

Structure of the Telephone System



- (a) Fully-interconnected network.
- (b) Centralized switch.
- (c) Two-level hierarchy.

Structure of the Telephone System (2)

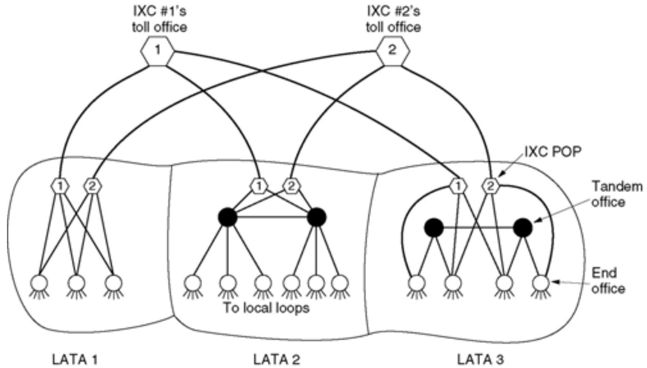


A typical circuit route for a medium-distance call.

Major Components of the Telephone System

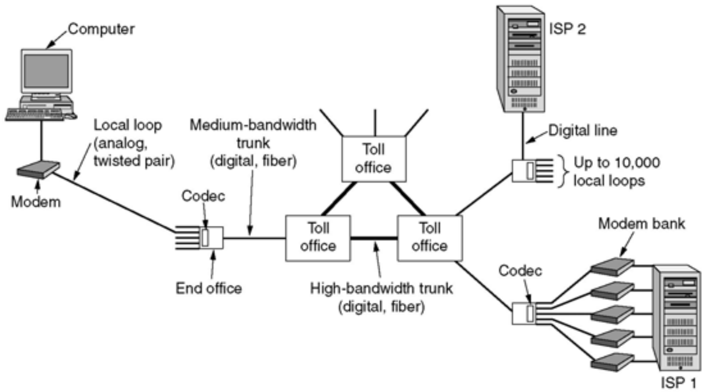
- Local loops
  - Analog twisted pairs going to houses and businesses
- Trunks
  - Digital fiber optics connecting the switching offices
- Switching offices
  - Where calls are moved from one trunk to another

The Politics of Telephones

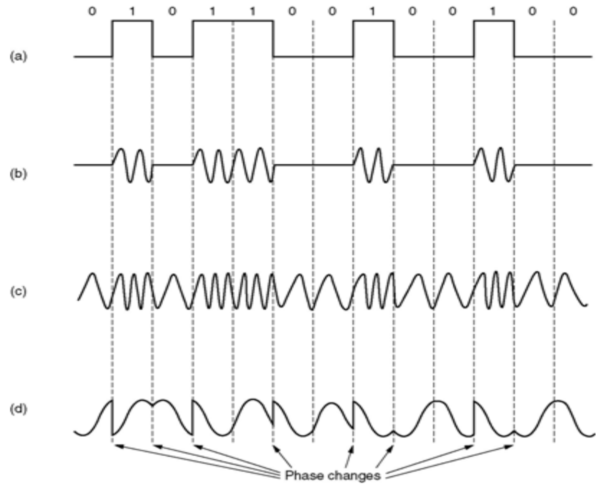


The relationship of LATAs, LECs, and IXCs. All the circles are LEC switching offices. Each hexagon belongs to the IXC whose number is on it.

The Local Loop: Modems, ADSL, and Wireless

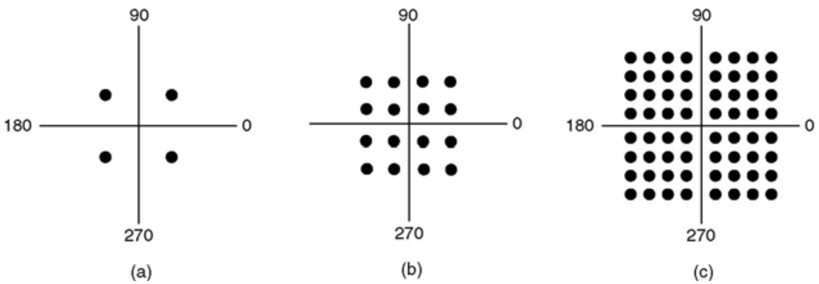


The use of both analog and digital transmissions for a computer to computer call. Conversion is done by the modems and codecs.



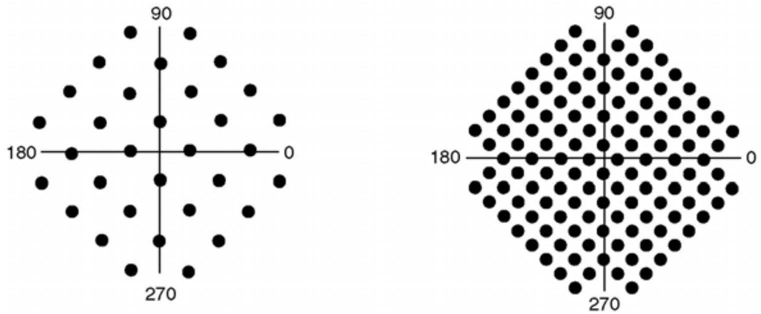
(a) A binary signal
(b) Amplitude modulation
(c) Frequency modulation
(d) Phase modulation

Modems (2)



(a) QPSK.
(b) QAM-16.
(c) QAM-64.

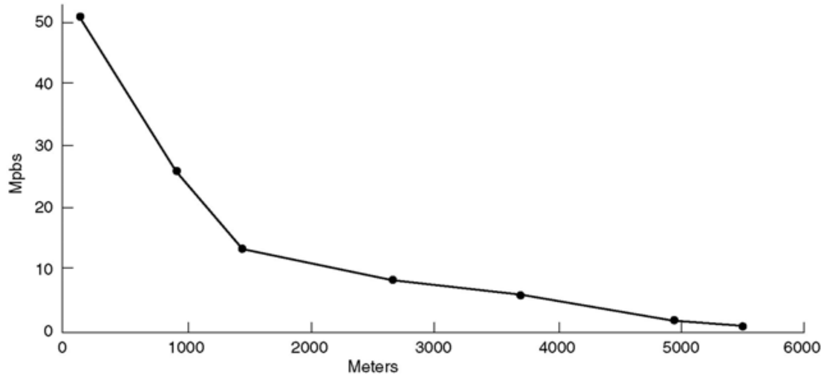
Modems (3)



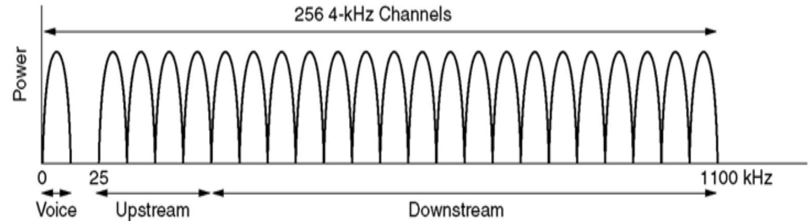
(a) (b)

(a) V.32 for 9600 bps.
(b) V32 bis for 14,400 bps.

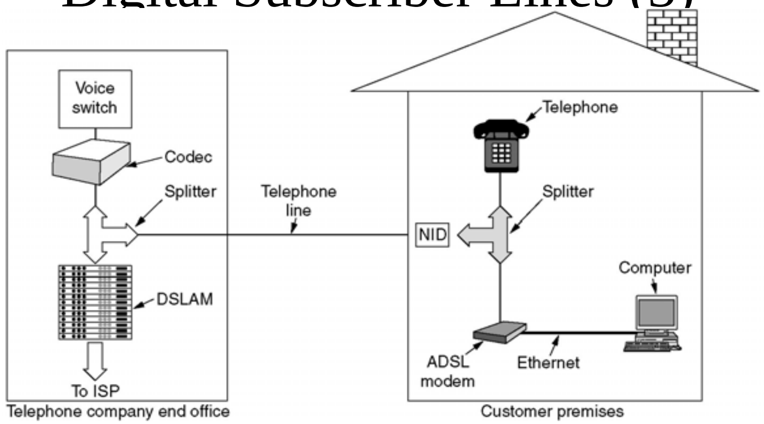
Digital Subscriber Lines



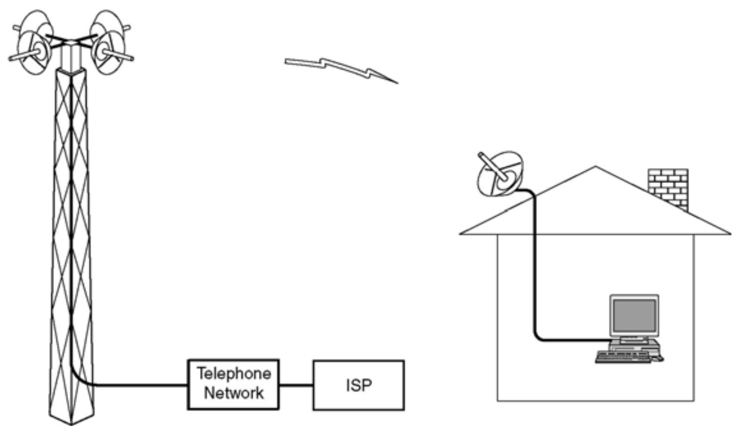
Digital Subscriber Lines (2)



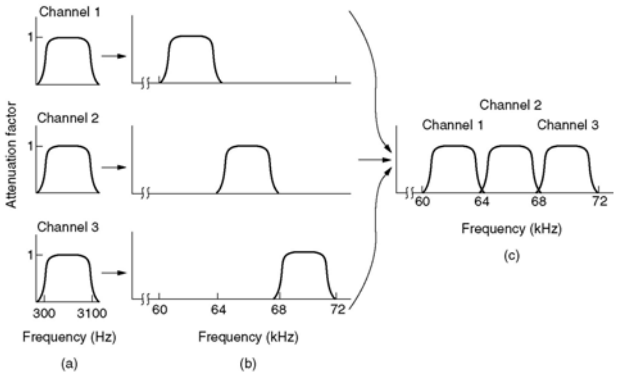
Digital Subscriber Lines (3)



Wireless Local Loops

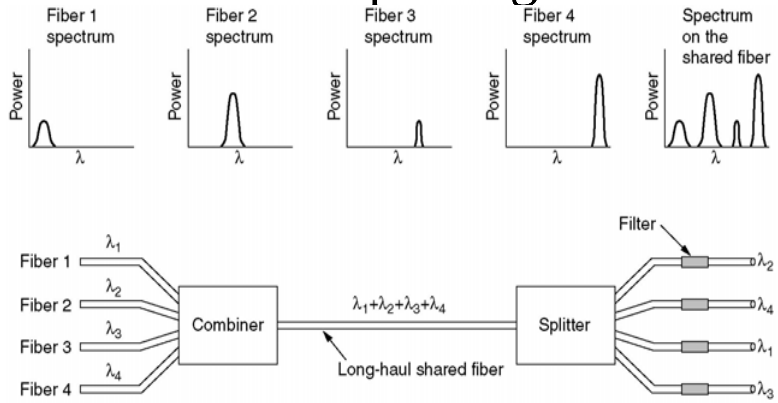


Frequency Division Multiplexing

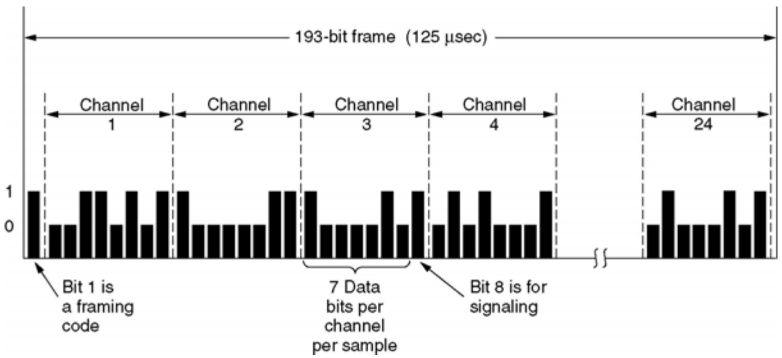


(a) The original bandwidths.
(b) The bandwidths raised in frequency.
(b) The multiplexed channel.

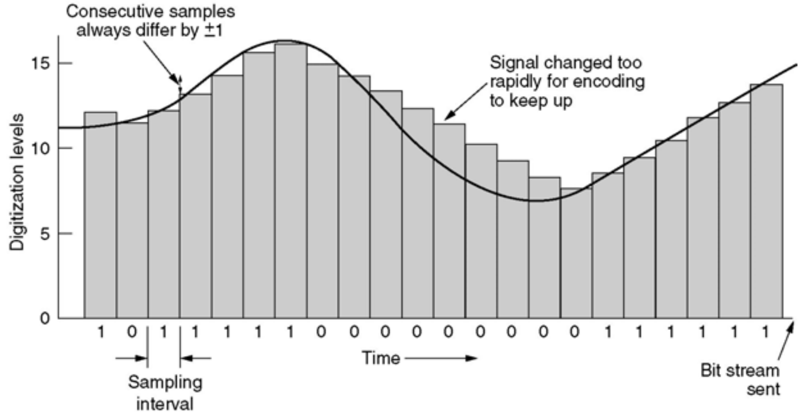
Wavelength Division Multiplexing



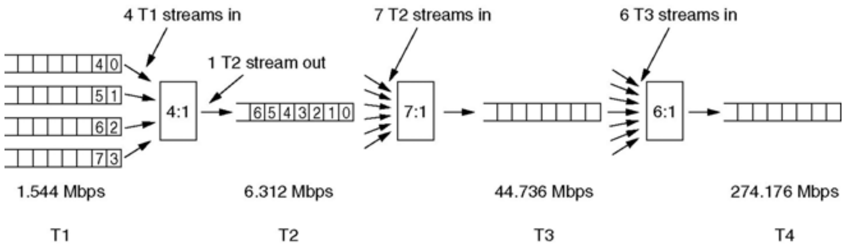
Time Division Multiplexing



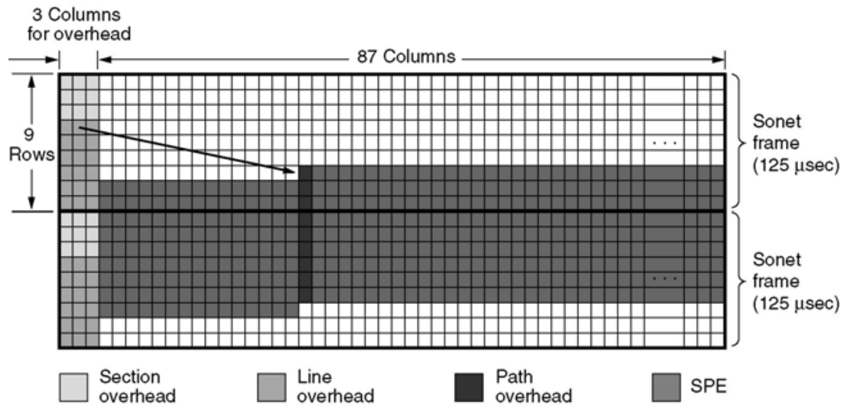
Time Division Multiplexing (2)



Time Division Multiplexing (3)



Time Division Multiplexing (4)

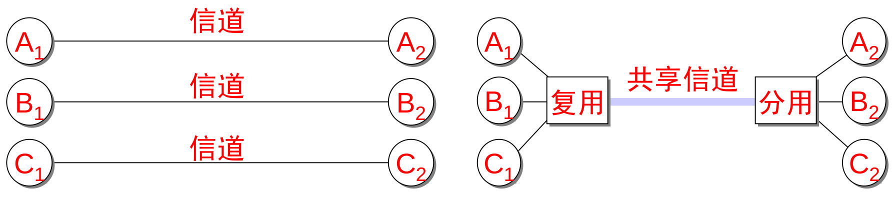


Time Division Multiplexing (5)

SONET		SDH	Data rate (Mbps)		
Electrical	**Optical**	**Optical**	**Gross**	**SPE**	**User**
STS-1	OC-1		51.84	50.112	49.536
STS-3	OC-3	STM-1	155.52	150.336	148.608
STS-9	OC-9	STM-3	466.56	451.008	445.824
STS-12	OC-12	STM-4	622.08	601.344	594.432
STS-18	OC-18	STM-6	933.12	902.016	891.648
STS-24	OC-24	STM-8	1244.16	1202.688	1188.864
STS-36	OC-36	STM-12	1866.24	1804.032	1783.296
STS-48	OC-48	STM-16	2488.32	2405.376	2377.728
STS-192	OC-192	STM-64	9953.28	9621.504	9510.912

Supplement

信道复用技术



(a) 不使用复用技术 (b) 使用复用技术

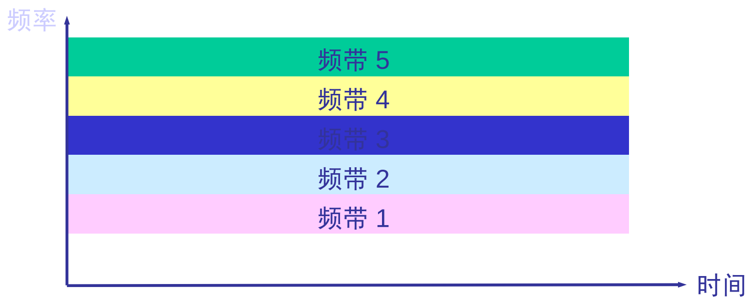
- 复用(multiplexing)是将多个信源的彼此无关的信号，组合在一条物理信道上进行传送的技术。
- 多路复用的目的：充分利用昂贵的通信线路，尽可能地容纳较多的用户传输较多的信息。

多路复用技术分类

1. 频分多路复用（FDM，Frequency Division Multiplexing）
2. 时分多路复用（TDM，Time Division Multiplexing）--同步STDM、异步ATDM
3. 波分多路复用（WDM，Wavelength Division Multiplexing）
4. 码分多路复用（CDM，Code Division Multiple）
5. 空分复用 (PDM，sPace Division Multiplexing)

频分复用 FDM

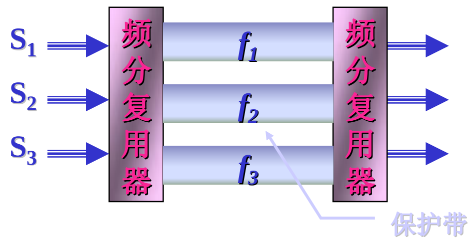
- 按照频率区分信号的方法，把传输频带分为若干个较窄的频带，每个频带构成一个子信道，独立地传输信息。用户在分配到一定的频带后，在通信过程中自始至终都占用这个频带。
- 频分复用的所有用户在同样的时间占用不同的带宽资源（请注意，这里的“带宽”是频率带宽而不是数据的发送速率）。



频分复用的用途：主要用于模拟信道的复用。如有线电视

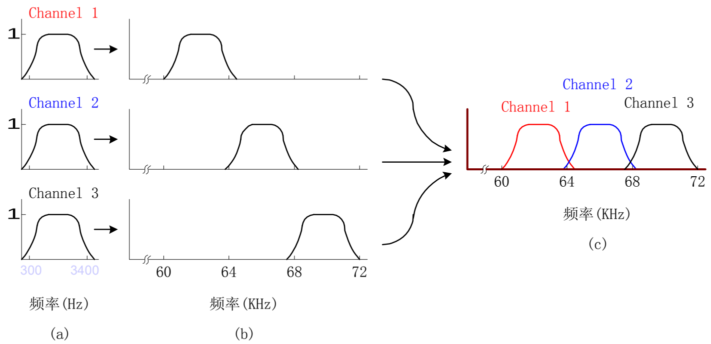
频分多路复用的实现过程

- 频分多路复用技术对整个物理信道的可用带宽进行分割，并利用载波调制技术，实现原始信号的频谱迁移，使得多路信号在整个物理信道带宽允许的范围内实现频谱上的不重叠。
- 为了避免两个相邻频段的信号互相干扰，频段之间要保留一定的隔离频带，称为保护带。



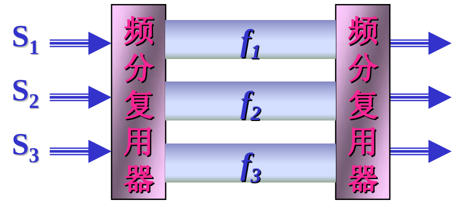
频分多路复用技术示例

三路音频模拟信号复用一个带宽为12KHz的物理信道：



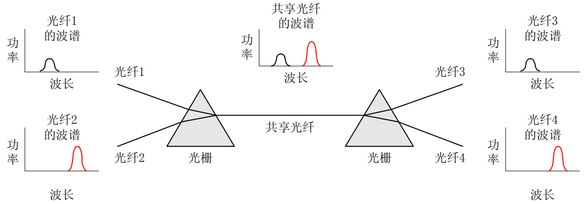
频分多路复用技术的特点

- 频分多路复用使信道在同一时刻能同时独立传送多路信号，每路信号占用不同的频带；
- 在线路上传输的是各路信号经过调制后的叠加在一起的复合信号。
- 频分多路复用技术适用于宽带网络。要求传输介质的可用带宽超过各路信源所需带宽的总和：
  B＞∑fi



波分复用 WDM

- **波分复用就是光的频分复用，它利用了光具有不同的波长的特征。**
- **原理：**
  将不同信道的信号调制成不同波长的光，利用波分复用设备（如衍射光栅）复用到光纤信道上。在接收方，采用相同设备分离不同波长的光。



- 在一根光纤上复用80路或更多路的光载波信号称为密集波分复用DWDM；

时分复用TDM

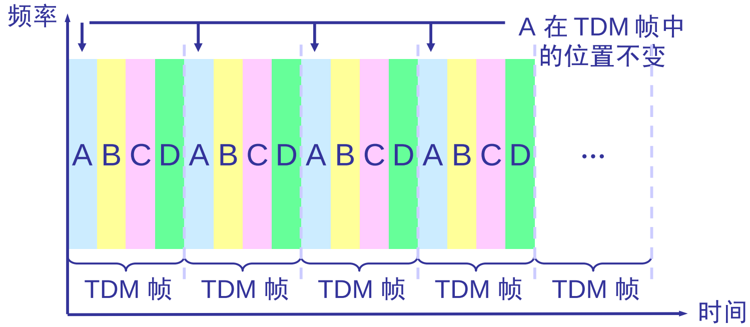
时分复用就是将提供给整个信道传输信息的时间划分成若干时间片(简称时隙)，并将这些时隙分配给每一个信号源使用，每一路信号在自己的时隙内独占信道进行数据传输。

主要用于数字信道的复用。

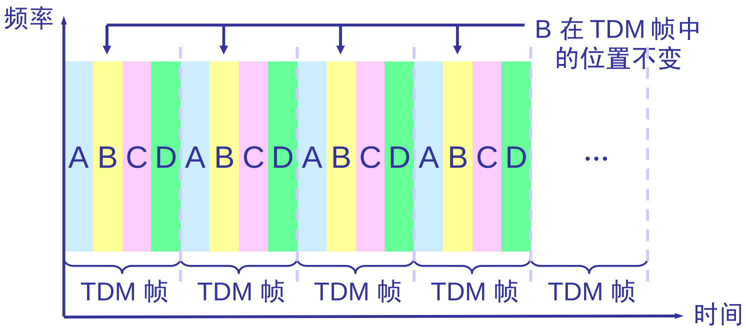
时分复用的所有用户是在不同的时间占用同样的频带宽度（整个信道的带宽）。

时分多路复用可分为：同步时分复用和异步时分复用（统计时分多路复用）

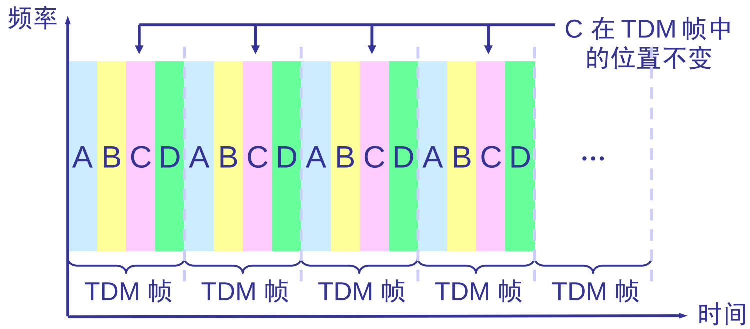
同步时分复用：时隙事先规划分配好且固定不变



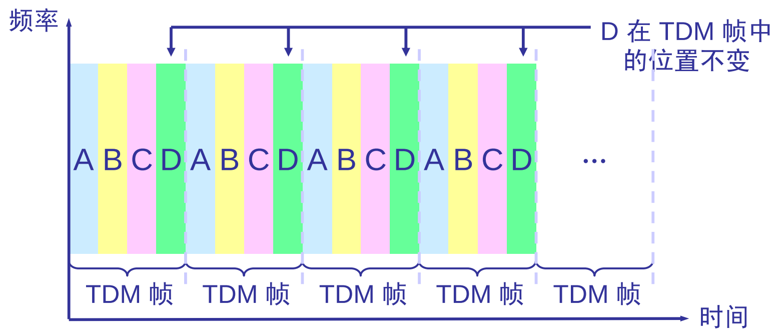
同步时分复用



同步时分复用



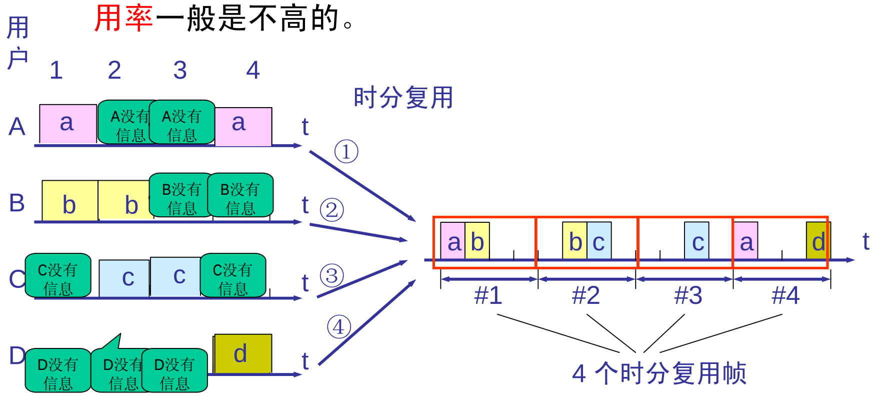
同步时分复用



同步时分复用特点

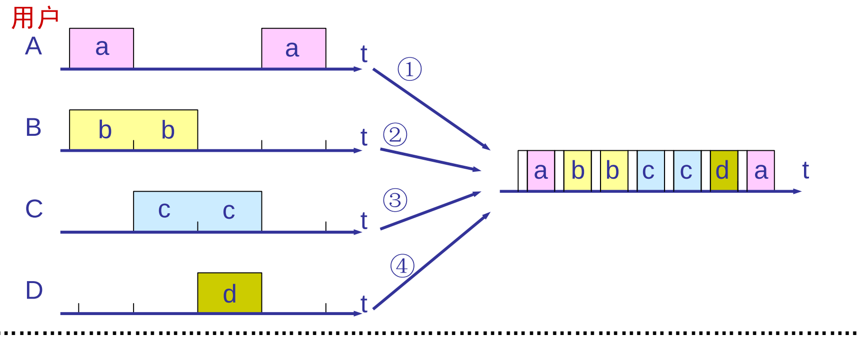
- 优点：时隙分配固定，便于调节控制，适于数字信息的传输；
- 缺点：当某信号源没有数据传输时，它所对应的信道会出现空闲，而其他繁忙的信道无法占用这个空闲的信道，因此会降低线路的利用率。

使用同步时分复用系统传送计算机数据时，由于计算机数据的突发性质，用户对分配到的子信道的利用率一般是不高的。



统计时分复用 STDM

统计时分复用又称为异步时分多路复用，允许动态地分配时间片。根据用户对时间片的需求来分配时间片，没有数据传输的用户不分配时间片。同时对每个时间片加上用户标识，以区别该时间片属于该用户。



码分复用 CDM

- **CDM是靠不同的编码来区分各路原始信号的一种复用方式。 CDM应用于多址技术即CDMA。**
- **各用户使用经过特殊挑选的不同码型，因此彼此不会造成干扰。每个用户可以在同样的时间使用同样的频带进行通信。**
- **这种系统发送的信号有很强的抗干扰能力，其频谱类似于白噪声，不易被敌人发现。**
- **采用CDMA可提高通信的语音质量和数据传输的可靠性，减少干扰对通信的影响，降低手机的平均发射功率等等。**
- **多址访问分类**
  - **码分多址：CDMA (Coding Division Multiplexing Access) (联通)**
  - **频分多址：FDMA**
  - **时分多址：TDMA**
    - **联通、移动的GSM移动电话网采用FDMA和TDMA两种方式的结合**
  - **同步码分多址：SCDMA （G3移动通信网）**
  - **宽带码分多址：WCDMA**

几种复用技术的简单对比

- **例：假设现在在开会**
  TDM(时分复用)如在同一个房间轮流发言的方式，但一次只能一个人说，一个说完，另一个继续。
  FDM(频分复用)则先将大房间隔成若干个小房间，每个小房间里的人互相交流。
  CDMA(码分多路复用)则是把所有的人放在一个大房间里，他们说着不同的语言。这样他要交流只要找自己的语言的那个，而不用担心别的语言的噪声。

……………………………………………………………………………………………

3.7 同步光纤网 SONET 和 同步数字系列 SDH

- **旧的数字传输系统存在着许多缺点。其中最主要的是以下两个方面：**
- **速率标准不统一。**
    - 北美和日本是T1：1.544Mbps（24个话路）
    - 欧洲是E1：2.048Mbps（30个话路）
  - **如果不对高次群的数字传输速率进行标准化，国际范围的高速数据传输就很难实现。**
- **不是同步传输。**
  - **在过去相当长的时间，为了节约经费，各国的数字网主要是采用准同步方式。**

同步光纤网 SONET

- 美国1988年提出了名为同步光纤网 SONET (Synchronous Optical Network) 的标准，同步光纤网的各级时钟都来自一个非常精确的主时钟，并且以51.84 Mb/s为基础定义了同步传输的线路速率等级。
- 第 1 级同步传送信号 STS-1 (Synchronous Transport Signal)的传输速率是 51.84 Mb/s（使用的帧称为STS-1帧）。更高的等级是用N个STS-1帧组成STS-N帧。
- 与第1级同步传输信号对应的光信号则称为第 1 级光载波 OC-1，OC 表示Optical Carrier。

同步数字系列 SDH

- ITU-T（国际电信联盟的电信标准化部门） 以美国标准 SONET 为基础，制订出国际标准同步数字系列 SDH (Synchronous Digital Hierarchy)。
- 一般可认为 SDH 与 SONET 是同义词。
- SDH 的基本速率为 155.52 Mb/s，称为第 **1** 级同步传递模块 (Synchronous Transfer Module)，即 STM-1，相当于 SONET 体系中的 OC-3 速率。更高的等级是用N个STM-1组成STM-N。

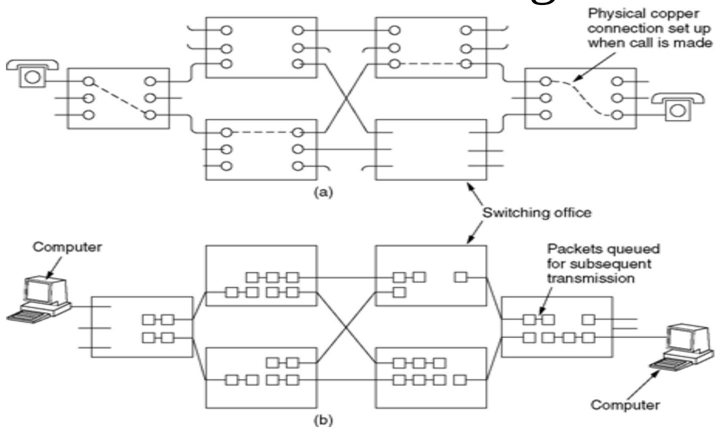
常用 SONET/SDH 数据传输率

SONET 信号	比特率 (Mbps)	SDH 信号	表示线路速率的常用近似值
STS–1 / OC–1	**51.840**	**STM–0**	
STS–3 / OC–3	**155.520**	**STM–1**	**155Mbps**
STS–12 / OC–12	**622.080**	**STM–4**	**622Mbps**
STS–48 / OC–48	**2,488.320**	**STM–16**	**2.5Gbps**
STS–192 / OC–192	**9,953.280**	**STM–64**	**10Gbps**
STS-768 / OC-768	**39,813,120**	**STM–256**	**40Gbps**

其它说明

- SONET速率标准是以STS-1速率51.840Mbps为基础的，而SDH速率标准是以STM-1速率155.520Mb/s为基础的;
- 更高等级的速率标准STM-N是将STM-1同步复用而成;
- 4个STM-1构成STM-4（622.080Mbps）
- 16个STM-1构成STM-16（2448.320Mbps， 即2.5Gb/s）
- 64个STM-1构成STM-64（约10Gbps）

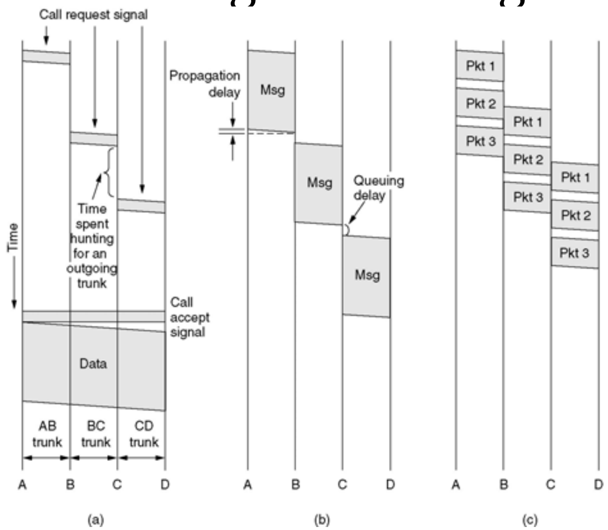
Circuit Switching



(a) Circuit switching.

(b) Packet switching.

Message Switching



(a) Circuit switching (b) Message switching (c) Packet switching

Packet Switching

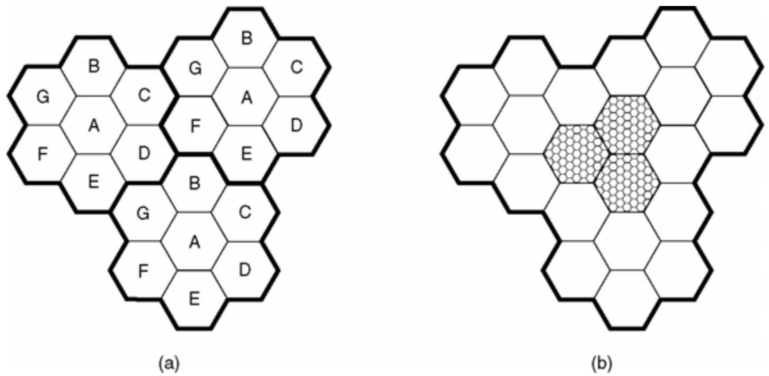
Item	Circuit-switched	Packet-switched
Call setup	Required	Not needed
Dedicated physical path	Yes	No
Each packet follows the same route	Yes	No
Packets arrive in order	Yes	No
Is a switch crash fatal	Yes	No
Bandwidth available	Fixed	Dynamic
When can congestion occur	At setup time	On every packet
Potentially wasted bandwidth	Yes	No
Store-and-forward transmission	No	Yes
Transparency	Yes	No
Charging	Per minute	Per packet

A comparison of circuit switched and packet-switched networks.

The Mobile Telephone System

- First-Generation Mobile Phones: Analog Voice
- Second-Generation Mobile Phones: Digital Voice
- Third-Generation Mobile Phones: Digital Voice and Data

Advanced Mobile Phone System



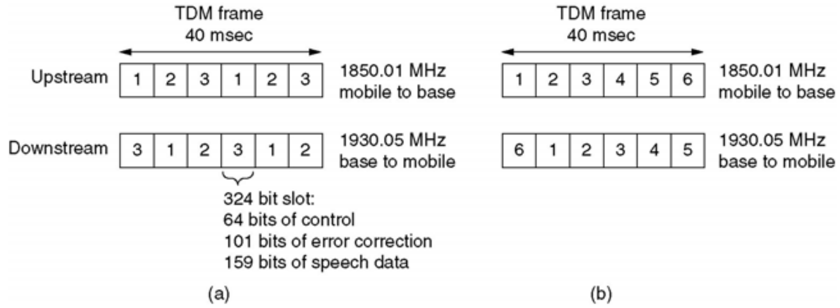
(a) Frequencies are not reused in adjacent cells.
(b) To add more users, smaller cells can be used.

Channel Categories

The 832 channels are divided into four categories:

- Control (base to mobile) to manage the system
- Paging (base to mobile) to alert users to calls for them
- Access (bidirectional) for call setup and channel assignment
- Data (bidirectional) for voice, fax, or data

D-AMPS
Digital Advanced Mobile Phone System

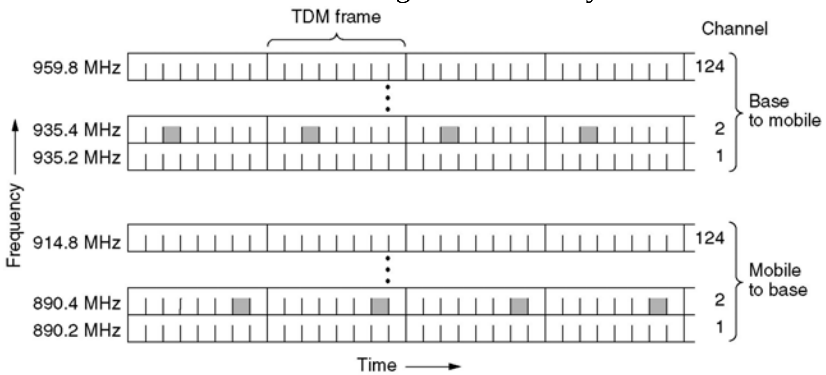


(a) A D-AMPS channel with three users.

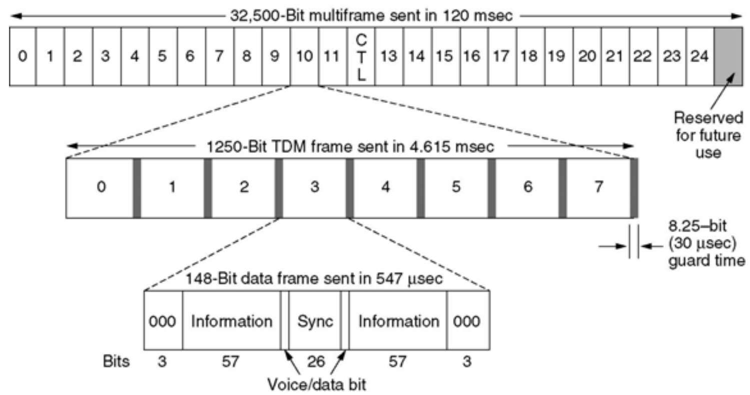
(b) A D-AMPS channel with six users.

GSM
Global System for Mobile Communications

GSM uses 124 frequency channels, each of which uses an eight-slot TDM system



GSM (2)



CDMA – Code Division Multiple

(a)		(b)
A: 0 0 0 1 1 0 1 1	→	0 0 0 1 1 0 1 1 A: (−1 −1 −1 +1 +1 −1 +1 +1)
B: 0 0 1 0 1 1 1 0		B: (−1 −1 +1 −1 +1 +1 +1 −1)
C: 0 1 0 1 1 1 0 0		C: (−1 +1 −1 +1 +1 +1 −1 −1)
D: 0 1 0 0 0 0 1 0		D: (−1 +1 −1 −1 −1 −1 +1 −1)

Six examples:

– – 1 –	C	S_1 = (−1 +1 −1 +1 +1 +1 −1 −1)
– 1 1 –	B + C 0	S_2 = (−2 0 0 0 +2 +2 0 −2)
1 0 – –	A + $\bar{B}$ 0	S_3 = (0 0 −2 +2 0 −2 0 +2)
1 0 1 –	A + $\bar{B}$ + C	S_4 = (−1 +1 −3 +3 +1 −1 −1 +1)
1 1 1 1	A + B + C + D	S_5 = (−4 0 −2 0 +2 0 +2 −2)
1 1 0 1	A + B + $\bar{C}$ + D 0	S_6 = (−2 −2 0 −2 0 −2 +4 0)

(c)

→ transmission

$S_1 \bullet C$ = (1 +1 +1 +1 +1 +1 +1 +1)/8 = 1 } 有 C
$S_2 \bullet C$ = (2 +0 +0 +0 +2 +2 +0 +2)/8 = 1
$S_3 \bullet C$ = (0 +0 +2 +2 +0 −2 +0 −2)/8 = 0 — 无 C
$S_4 \bullet C$ = (1 +1 +3 +3 +1 −1 +1 −1)/8 = 1 } 有 C
$S_5 \bullet C$ = (4 +0 +2 +0 +2 +0 −2 +2)/8 = 1
$S_6 \bullet C$ = (2 −2 +0 −2 +0 −2 −4 +0)/8 = −1 — 有 $\bar{C}$

(d)

(a) Binary chip sequences for four stations
(b) Bipolar chip sequences
(c) Six examples of transmissions
(d) Recovery of station C's signal

Third-Generation Mobile Phones: Digital Voice and Data

Basic services an IMT-2000 network should provide

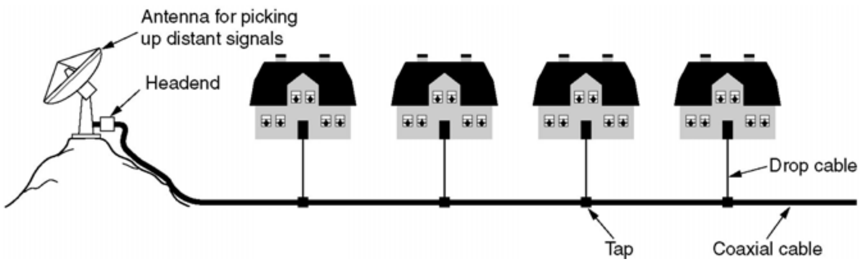
- High-quality voice transmission
- Messaging (replace e-mail, fax, SMS, chat, etc.)
- Multimedia (music, videos, films, TV, etc.)
- Internet access (web surfing, w/multimedia.)

Cable Television

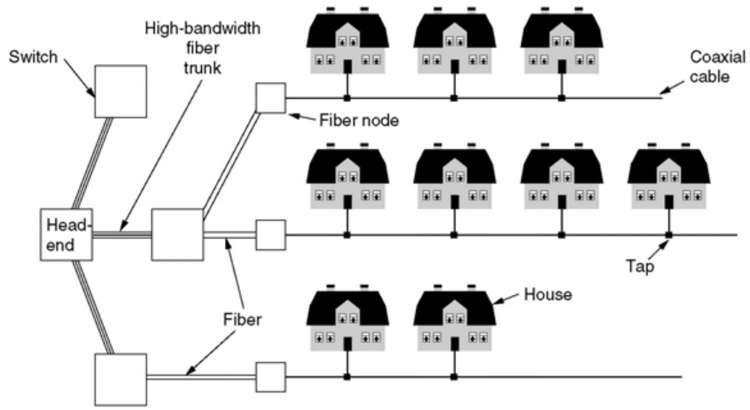
- Community Antenna Television
- Internet over Cable
- Spectrum Allocation
- Cable Modems
- ADSL versus Cable

Community Antenna Television

An early cable television system.

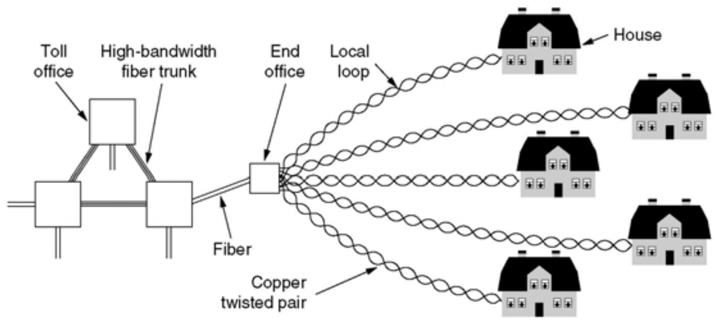


Internet over Cable



(a)

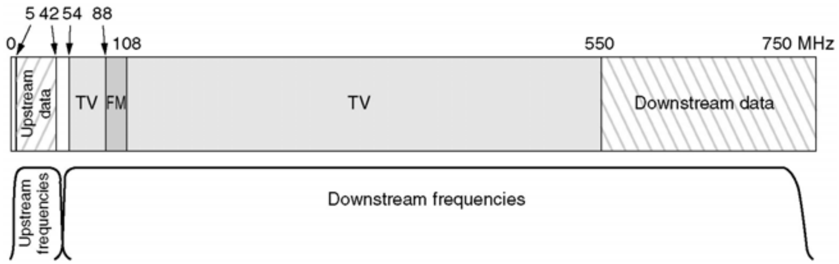
Internet over Cable (2)



(b)

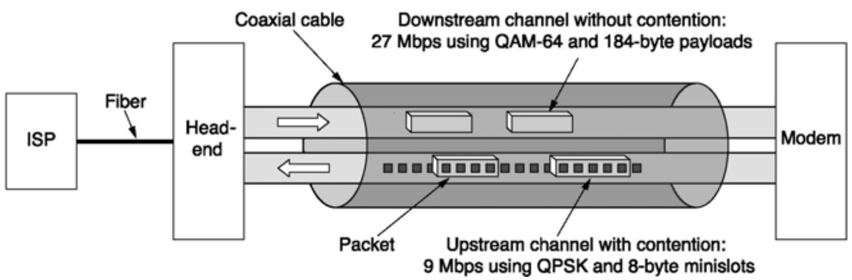
Spectrum Allocation

Frequency allocation in a typical cable TV system used for



Cable Modems

Typical details of the upstream and downstream channels in North America.



常用传输媒体的比较

传输媒体	速率	传输距离	性能(抗干扰性	价格	应用	示例
双绞线	模拟 300-3400Hz； 数字：10-100Mbps	几十公里	可以	低	模拟传输 数字传输	用户环线 LAN
50Ω 同轴电缆	10M	1公里内	较好	略高于TP	基带数字信号	LAN
75Ω 同轴电缆	300-450MHz	100公里	较好	较高	模拟传输，可分多信道混合传输电视、数据及CD音频	CATV
光纤	100M-几千Mbps	30公里	很好	较高	远距离传输	长话线路，主干网
短波	几十-几百bps	全球	一般，通信质量差	较低	远程低速通信	广播
地面微波接力	4-6GHz	几百公里	很好	低于同容量和长度的电缆	远程通信	电视
卫星	500MHz	一万八千多公里	很好	费用与距离无关	远程通信	电视、电话、数据

Examples

- RS-232-C RS-422A RS-485 etc
- Dial up modem
- TV set remote control
- Assignment 3 p177 2 4 7 32