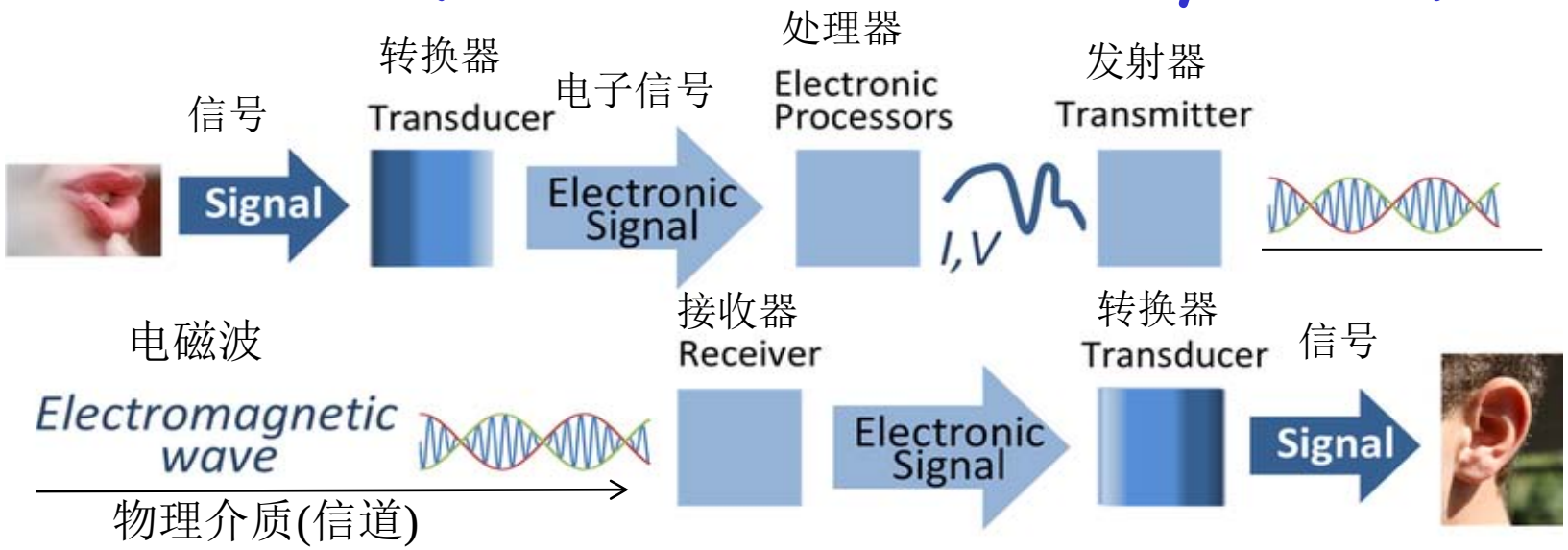
第二单元 物理层

- 通信系统
- 正弦波信号
- 频移键控
- 曼彻斯特编码
- 物理介质
- 多路复用和电路交换

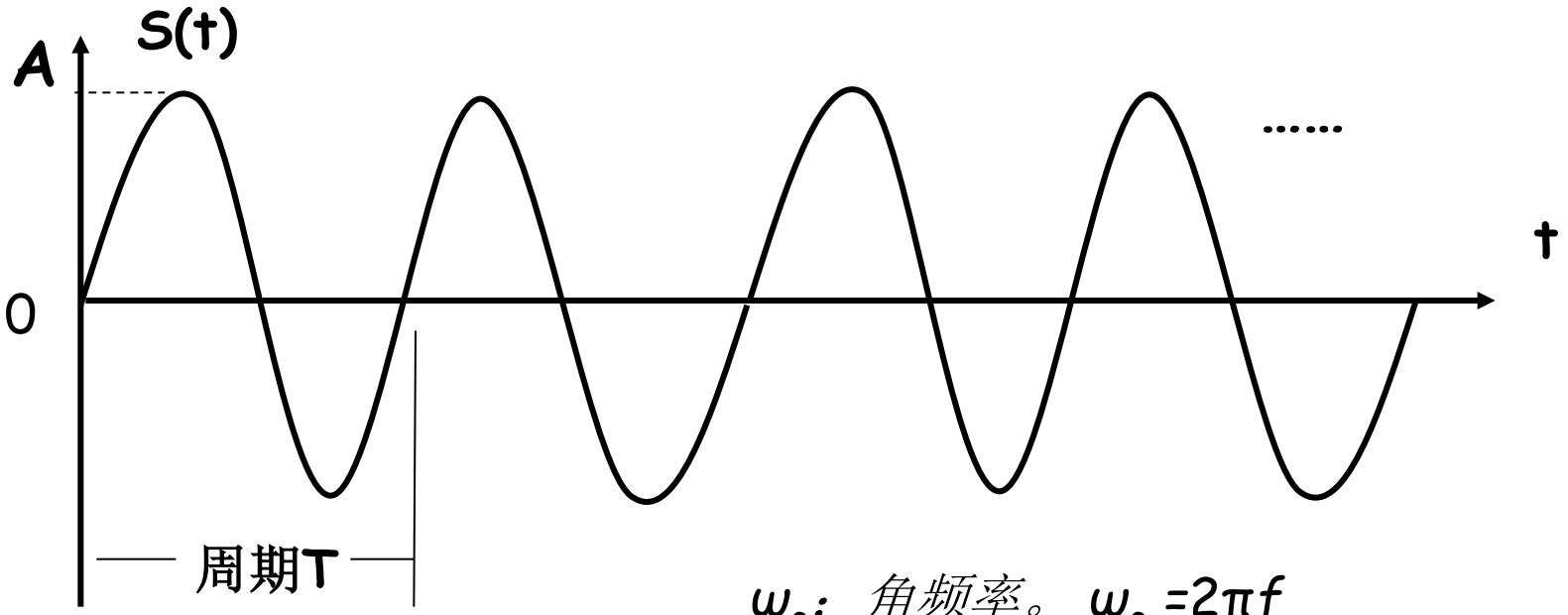
通信系统(Communication System)



Information(信息) can be interpreted as a message(data), recorded as signs(符号), transmitted as signals(信号), measured as the entropy(熵)。

- 信号(signal) : optical signal, electronic signal, radio signal
- 模拟信号(analog signal)：连续取值的信号
- 数字信号(digitial signal)：用离散值表示的信号
- 模拟传输(analog transmission): 模拟信号(analog signal), 放大器(amplifier)
- 数字传输(digital transmission): 数字信号(digital signal), 中继器(repeater)

正弦波信号(Sinusoidal signal)

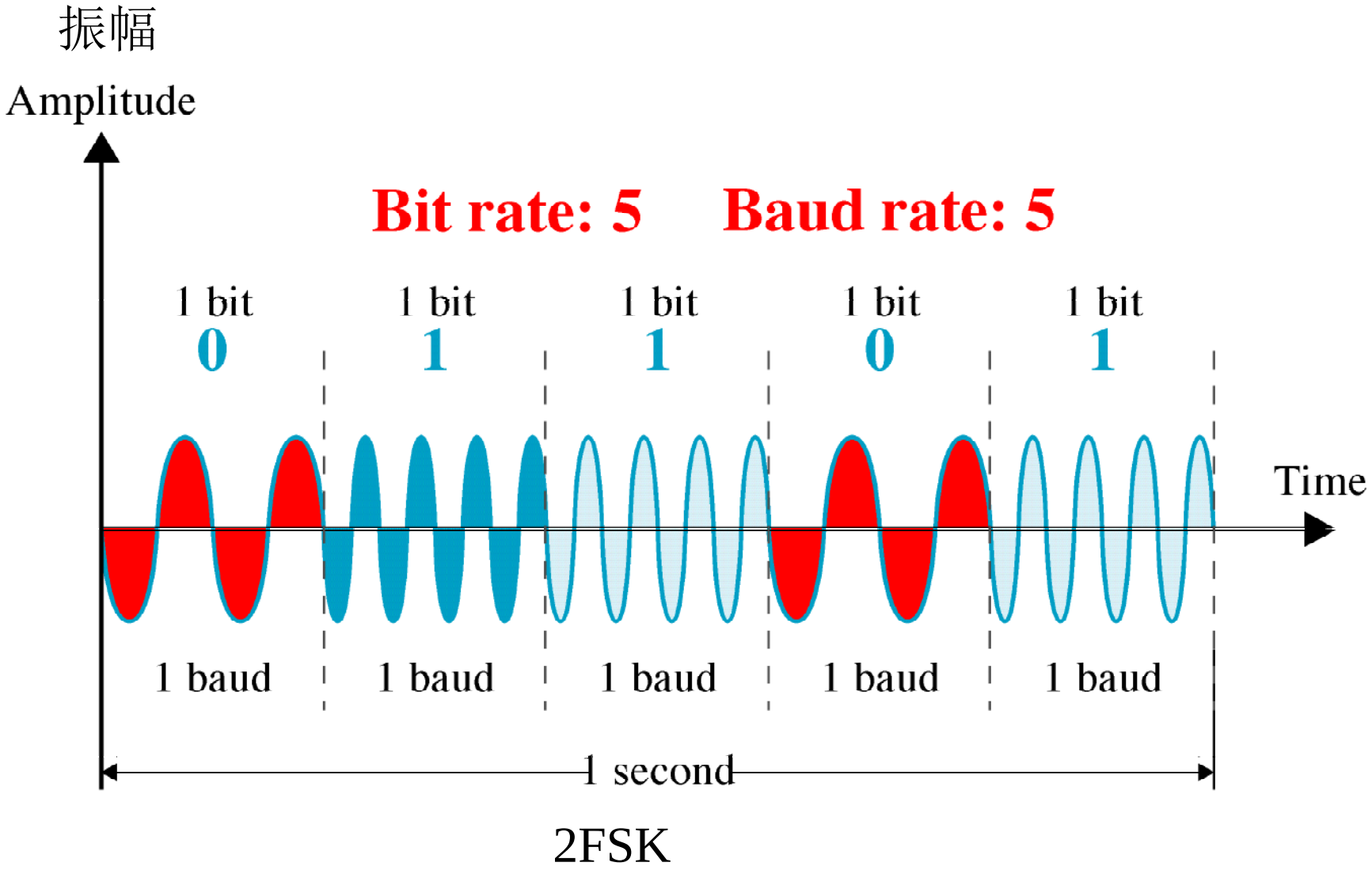


$S(t)=A\sin(\omega_c t+\varphi)$

ω_c: 角频率。 $\omega_c = 2\pi f$
f: 频率(frequency) $=1/T$
T: 周期(period)
A: 振幅(amplitude)
φ: 相位(phase)(初相)。本例为0。

载波信号(Carrier)一般采用正弦波信号

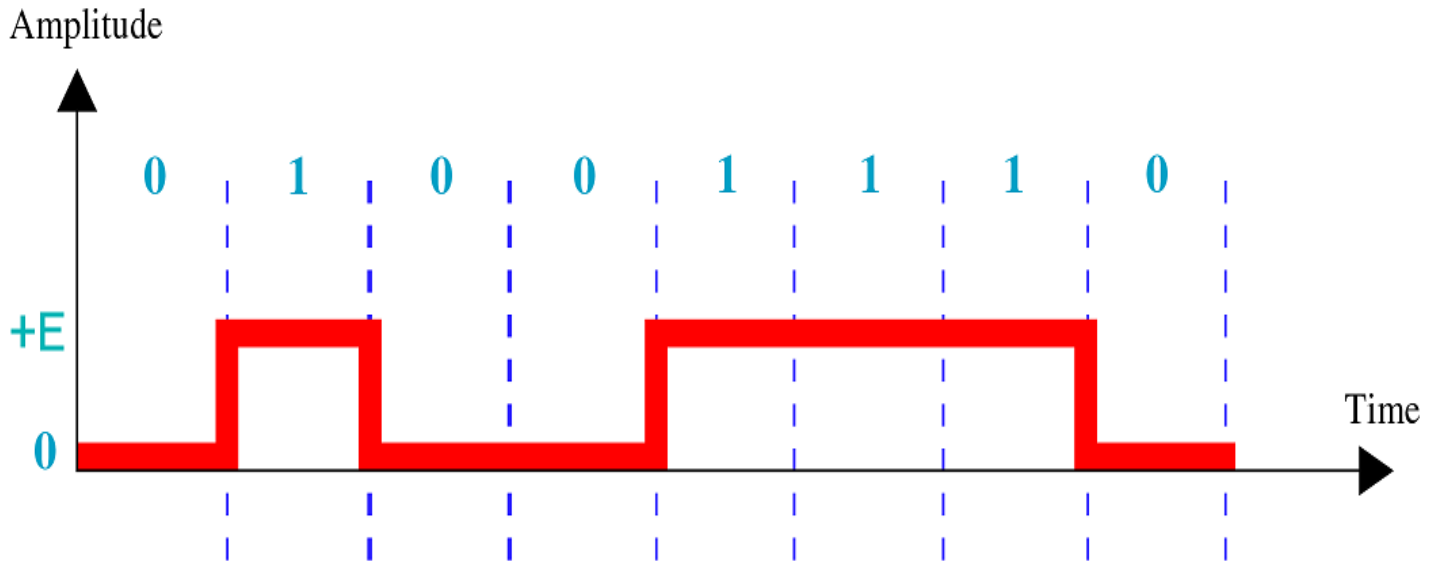
频移键控 (Frequency-Shift Keying, FSK)



2FSK

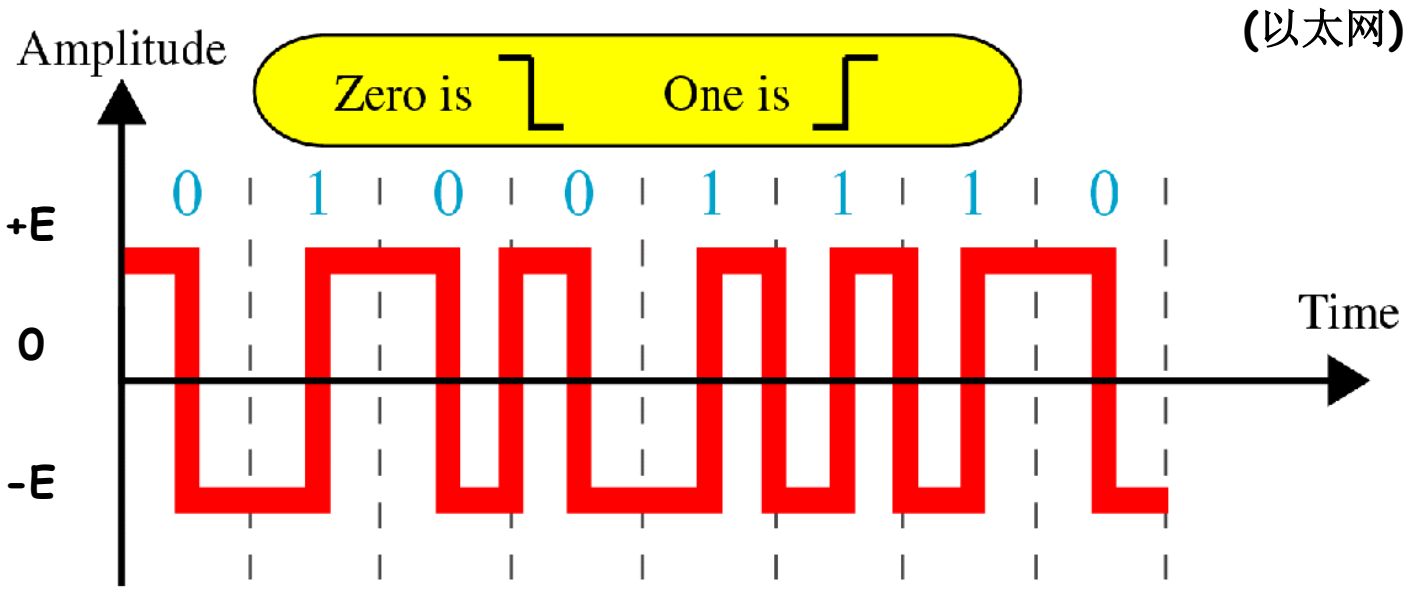
单极编码(unipolar encoding)

振幅



曼彻斯特编码(Manchester Encoding)

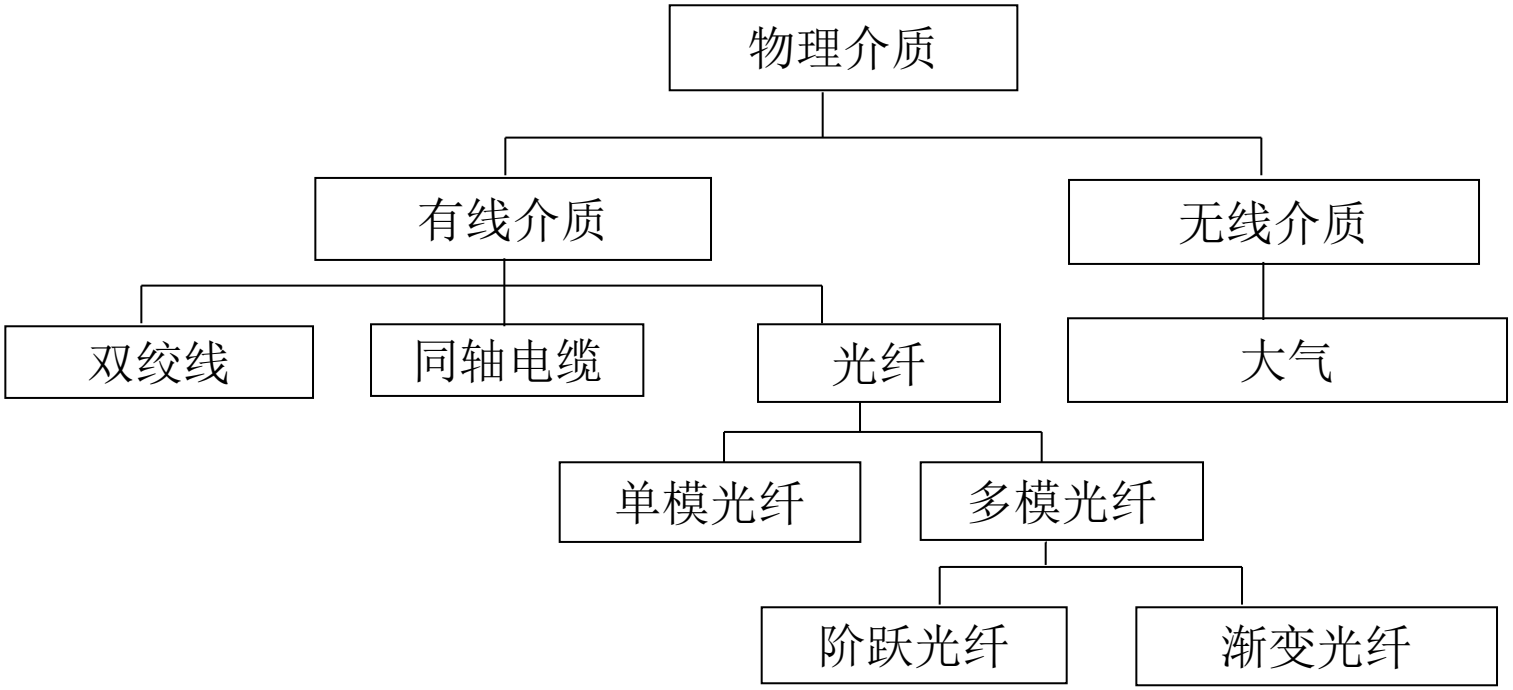
振幅



(以太网)

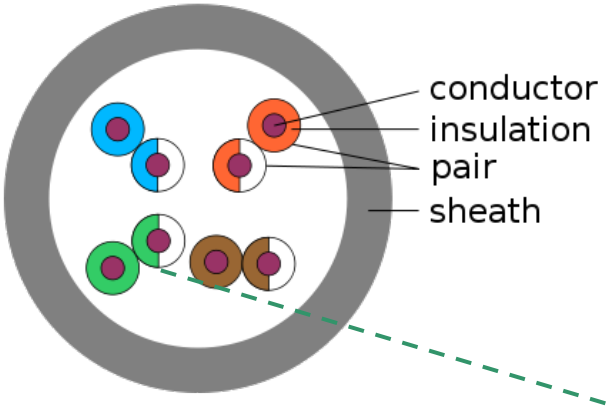
曼彻斯特码的编码规则(以太网)是：0 → 10， 1 → 01

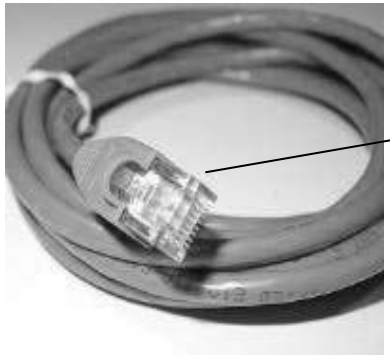
物理介质(Physical Media)

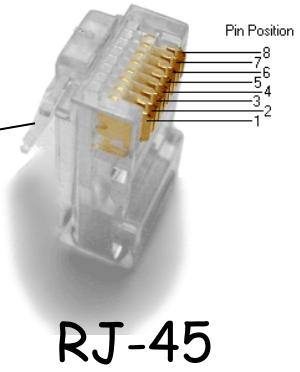


非屏蔽双绞线 (Unshielded Twisted Pair)

UTP

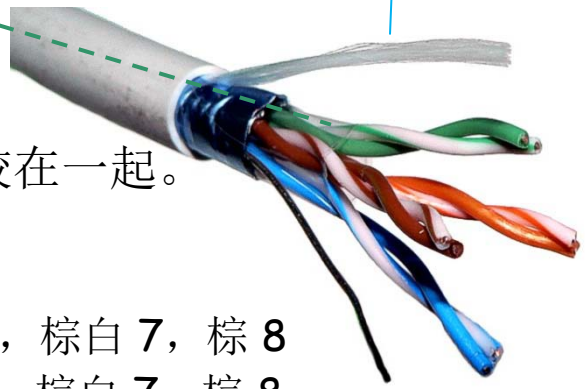






RJ-45

尼龙线



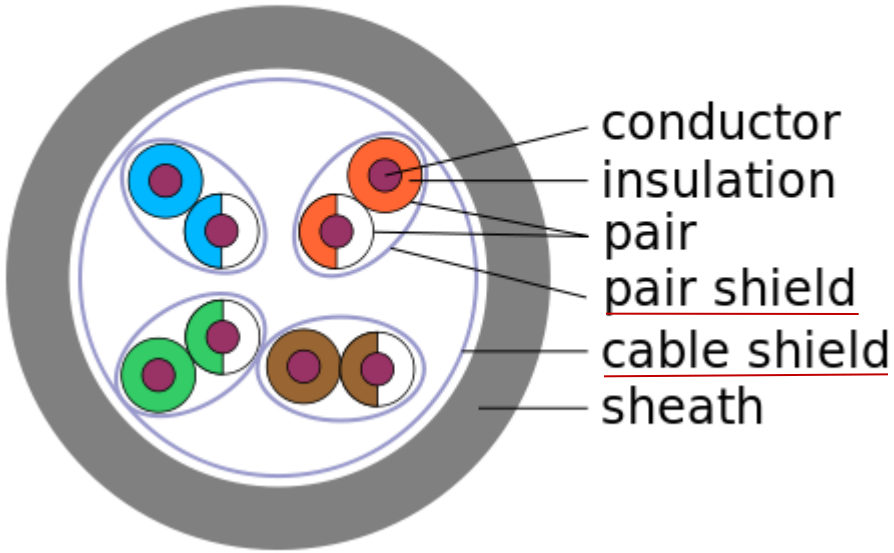
- 四对线: 绿 绿白，橙 橙白，蓝 蓝白，棕棕白
- 每对线先逆时针绞在一起，然后所有线对再逆时针绞在一起。
- 标准568A：绿白 1，绿 2，橙白 3，蓝 4，蓝白 5，橙 6，棕白 7，棕 8
- 标准568B：橙白 1，橙 2，绿白 3，蓝 4，蓝白 5，绿 6，棕白 7，棕 8

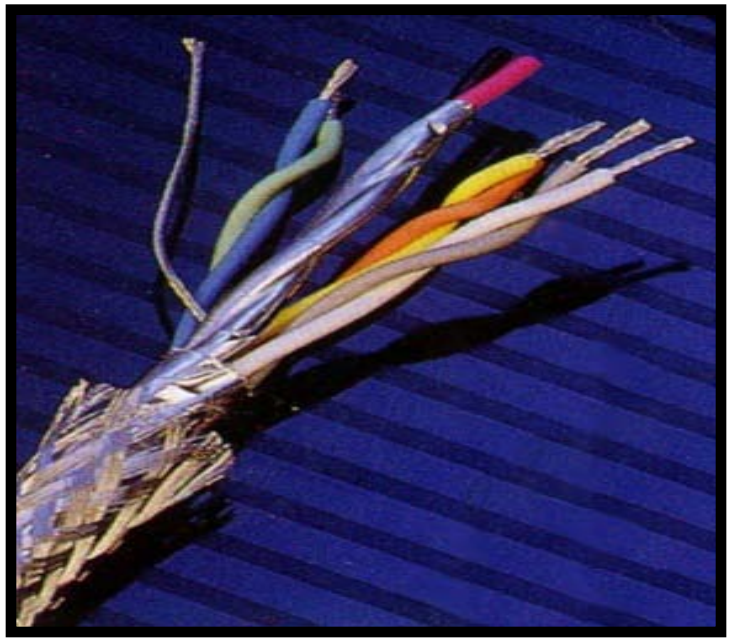
UTP Categories

UTP Category	Max Speed Rating	Description
1	—	Used for telephones, and not for data
2	4 Mbps	Originally intended to support Token Ring over UTP
3	10 Mbps	Can be used for telephones as well; popular option for Ethernet in years past, if Cat 3 cabling for phones was already in place
4	16 Mbps	Intended for the fast Token Ring speed option
5	1 Gbps	Very popular for cabling to the desktop
5e	1 Gbps	Added mainly for the support of copper cabling for Gigabit Ethernet
6	1 Gbps+	Intended as a replacement for Cat 5e, with capabilities to support multigigabit speeds

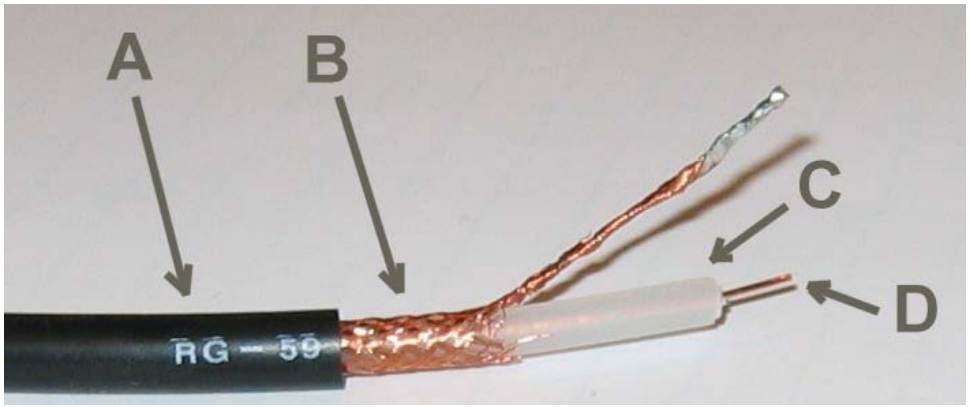
屏蔽双绞线 (Shielded Twisted Pair)

STP





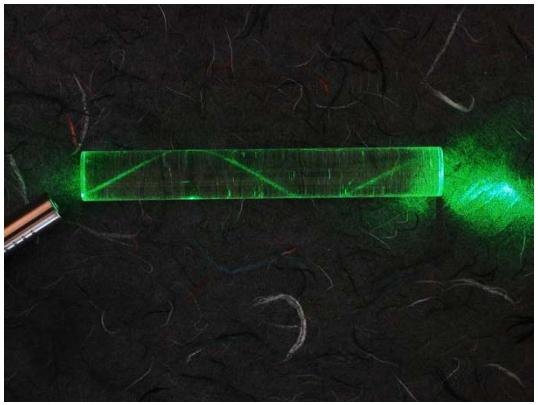
同轴电缆(Coaxial Cable)



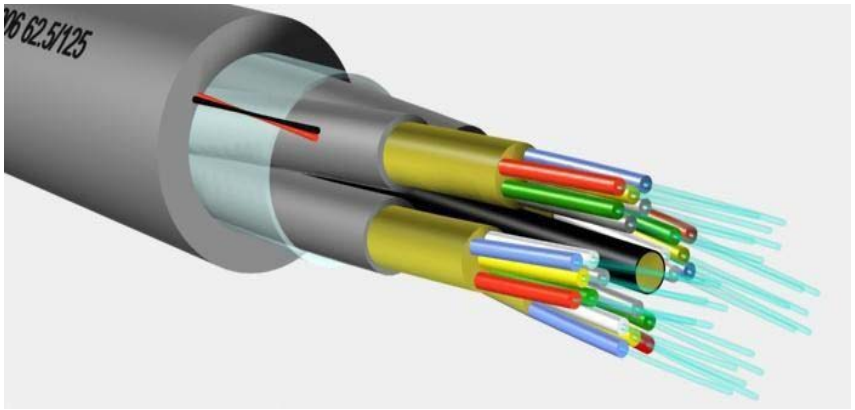
A: 外层塑料护套
B: 铜网屏蔽层(接地)
C: 内绝缘体
D: 铜芯(信号)

光导纤维 (Optical Fiber)

- 在玻璃纤维传输光脉冲，每个脉冲一比特

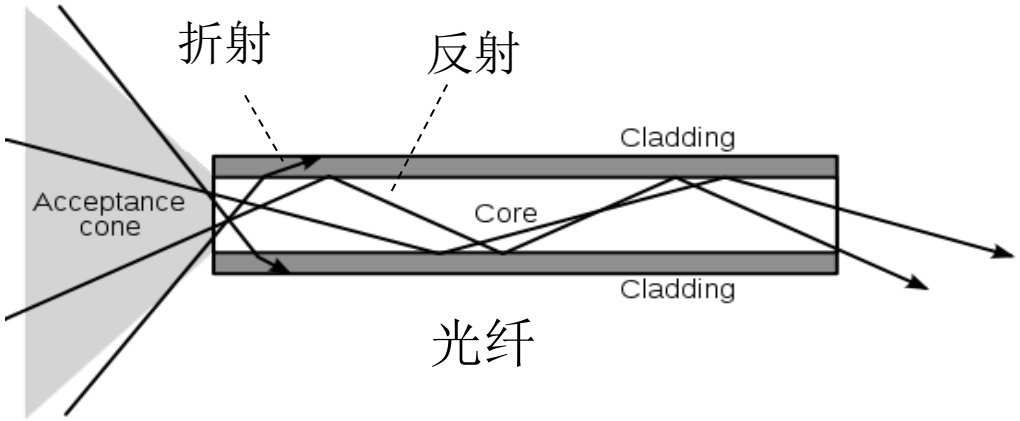


单根光纤



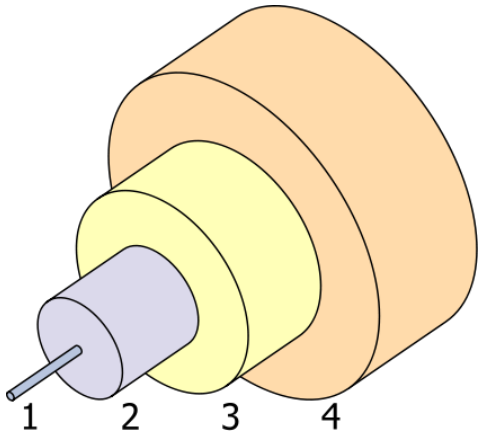
光缆

- 全反射条件: 入射角大于临界角



- 一条典型单模光纤的结构

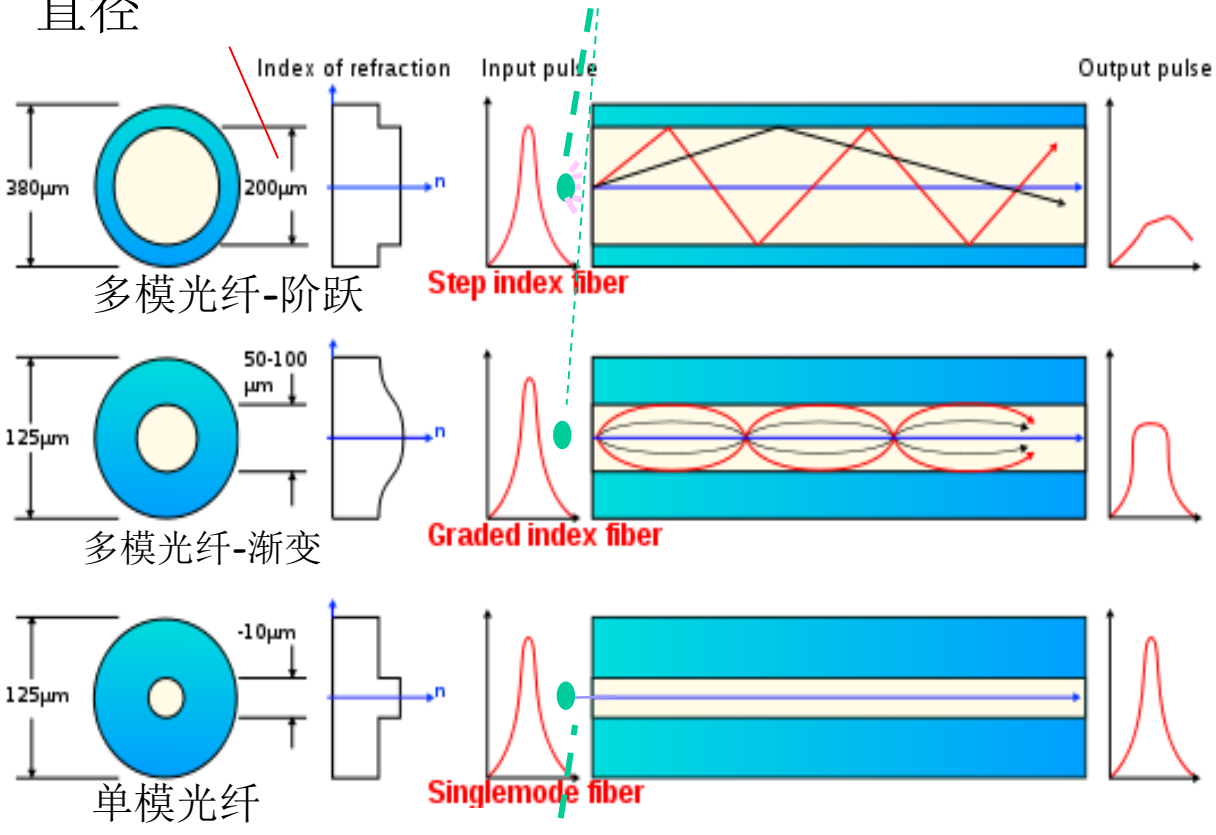
1. 纤芯: 直径8 μm
2. 覆层:直径125 μm
3. 缓冲曾:直径250 μm
4. 护套:直径400 μm



单模光纤和多模光纤

Source：发光二极管(Light Emitting Diode, LED)

直径



	DataRate	Maximum Distance
多模光纤-阶跃	low 4Gbps	5000m
多模光纤-渐变	medium	middle
单模光纤	high > 40Gbps	50km

Source：注入式激光二极管(Injection Laser Diode, ILD)

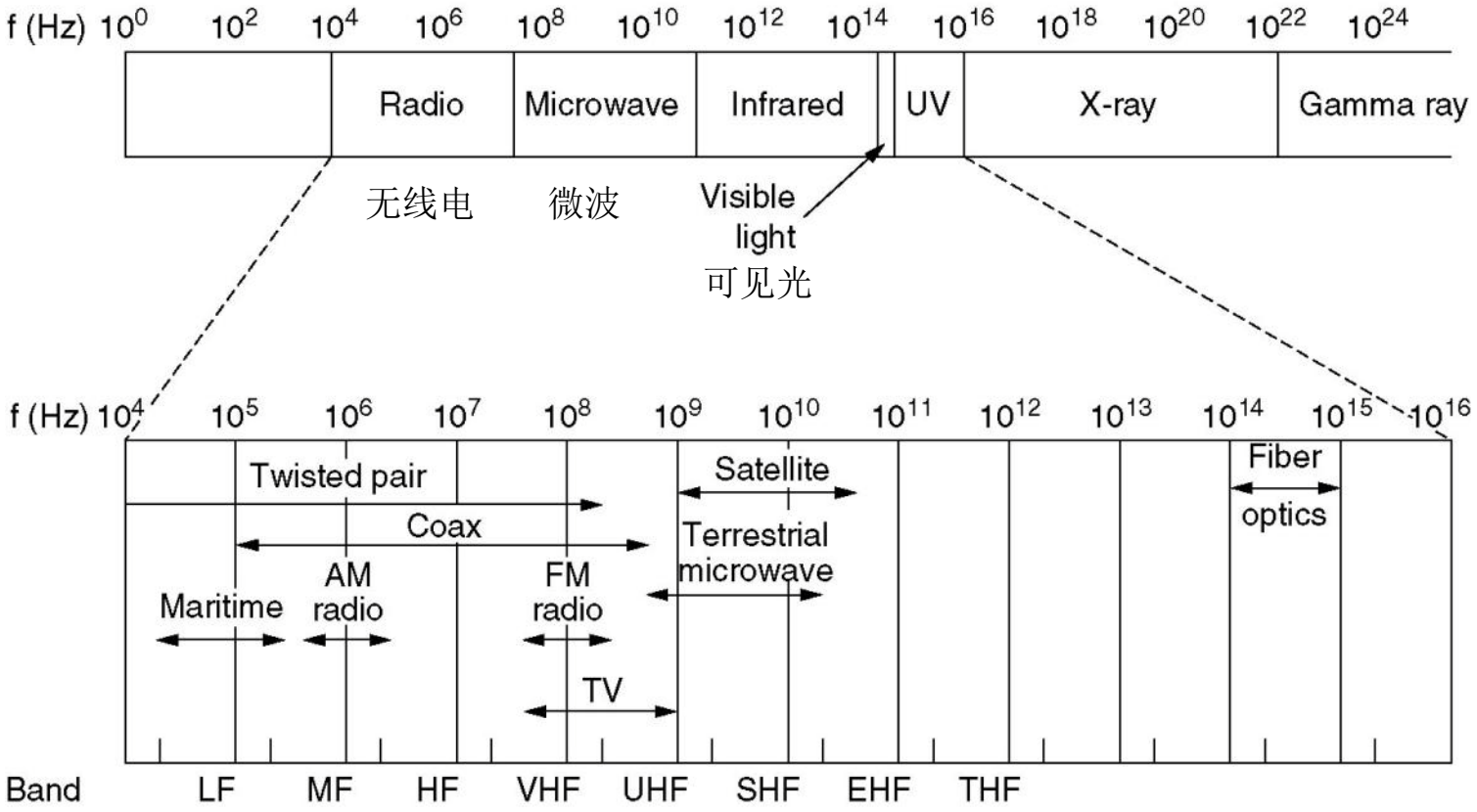
Single Mode fiber 单模光纤
Step-index fiber 阶跃光纤 graded-index 渐变光纤

无线介质

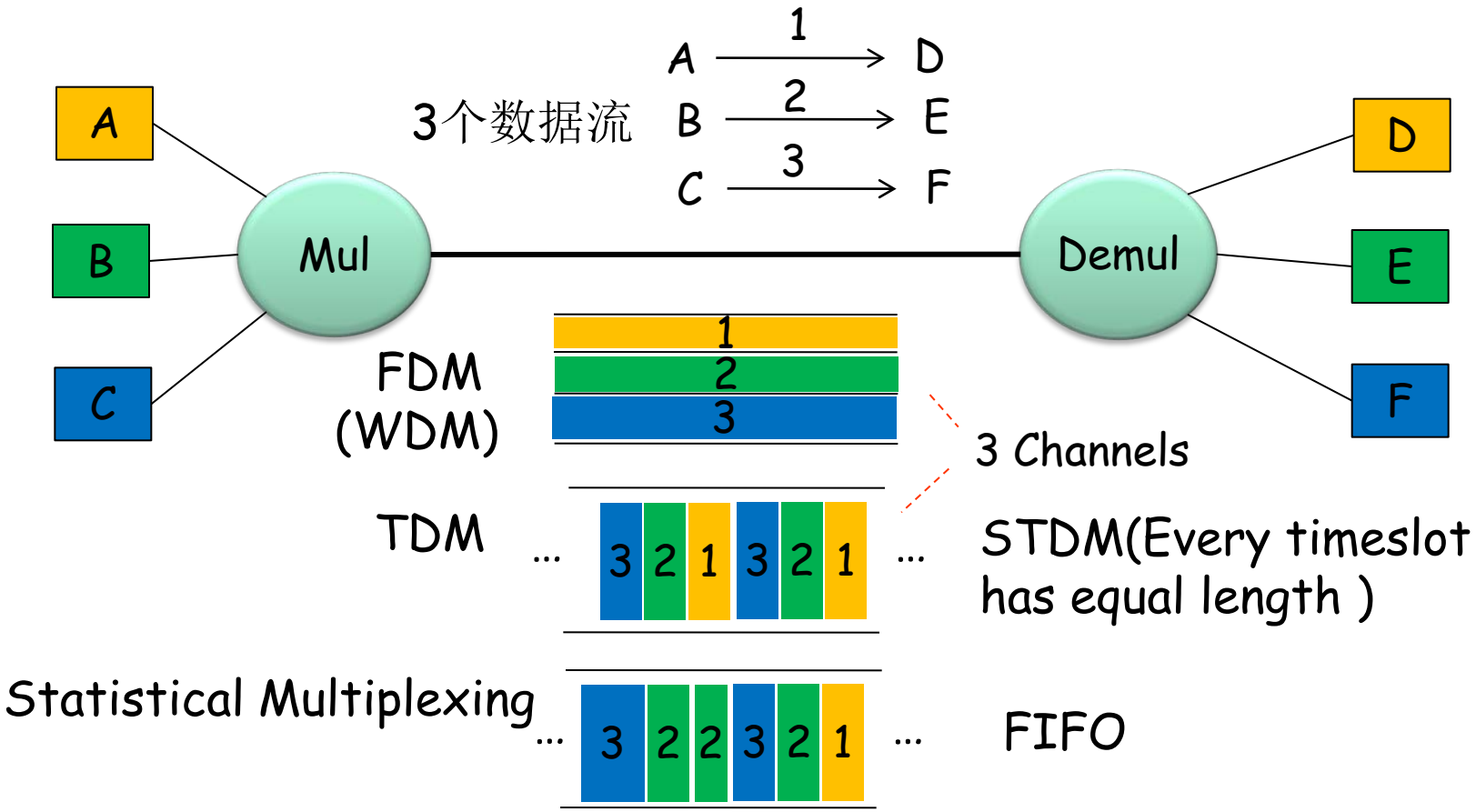
- 地面微波
  45 Mbps channels
- WiFI
  54 Mbps(802.11g),600Mbps(802.11n),
- 3G网络
  ~ 1 Mbps
- 卫星
  1 Kbps ~ 45Mbps
  270 msec 延迟

电磁谱

红外线　　紫外线　　X射线　　伽马射线



多路复用 (Multiplexing)



时分多路复用(Time Division Multiplexing) (STDM--Synchronous TDM)
频分多路复用(Frequency Division Multiplexing)
波分多路复用(Wavelength Division Multiplexing)
码分多路复用(Code Division Multiplexing)

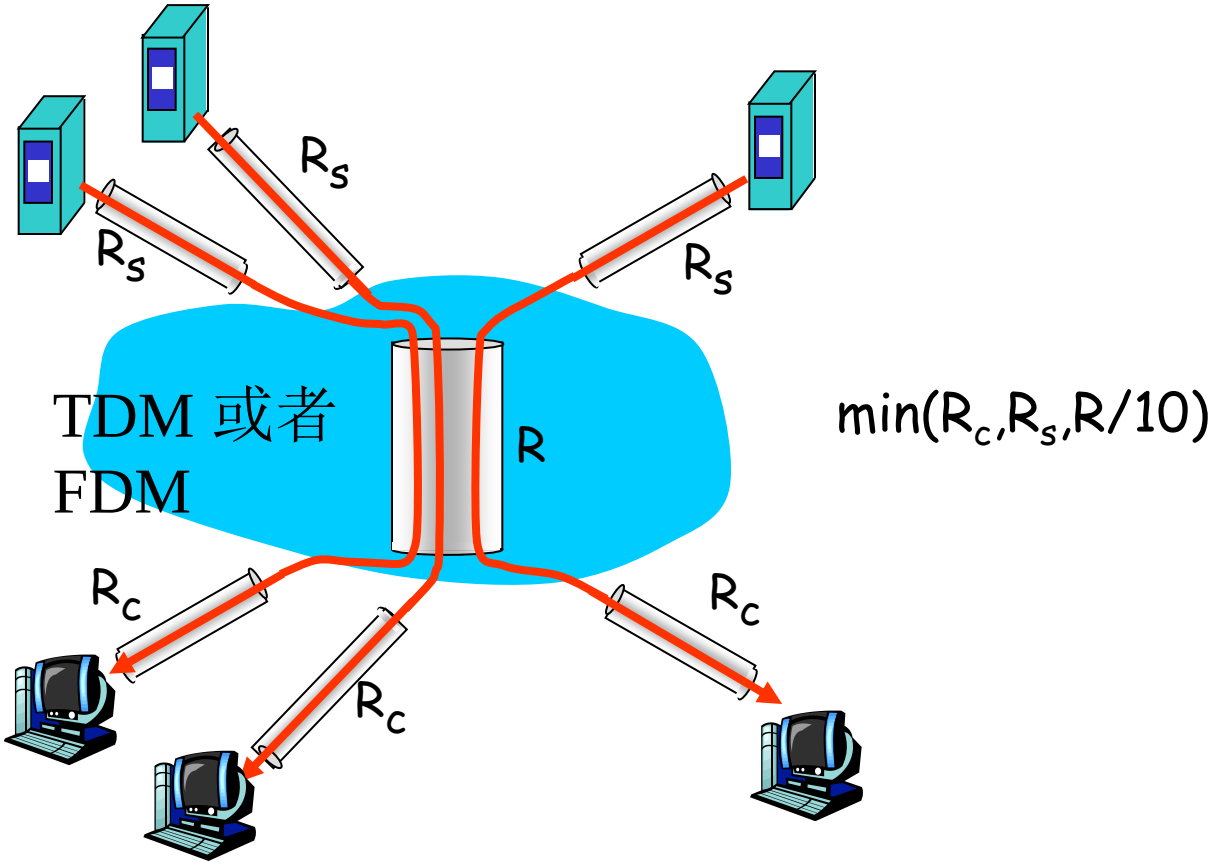
波分多路复用和统计多路复用

- 波分复用(Wavelength Division Multiplexing,WDM)是利用多个激光器在单条光纤上同时发送多束不同波长激光的技术。
- WDM的每个信号经过数据（文本、语音、视频等）调制后都在它独有的色带内传输。WDM能使电话公司和其他运营商的现有光纤基础设施容量大增。
- 制造商已推出了DWDM(Dense Wavelength Division Multiplexing)系统，也叫密集波分复用系统。DWDM可以支持150多束不同波长的光波同时传输，每束光波最高达到10Gb/s的数据传输率。这种系统能在一条比头发丝还细的光缆上提供超过1Tb/s的数据传输率。 ---维基
- 统计多路复用(Statistical Multiplexing)采用动态分配的方法共享通信链路，比如，先到先发送(FIFO)。对于多个可变速率的数据流，统计多路复用可以提高链路利用率。

电路交换技术(Circuit-Switching)采用FDM、TDM、WDM和CDM技术。

包交换技术(Packet-Switching)采用统计多路复用技术。

- 每条链路端到端的吞吐量是多少？



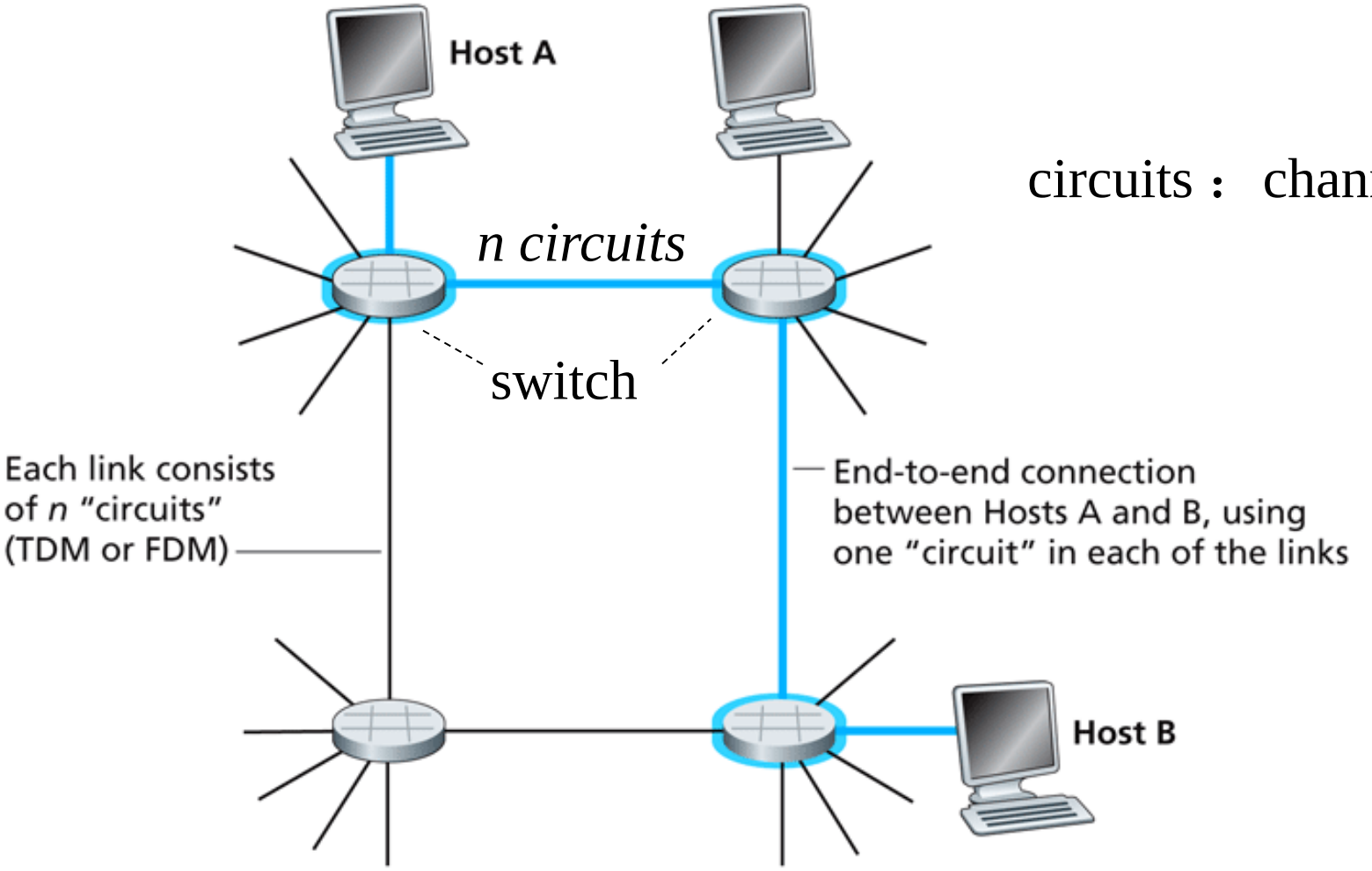
10个链接(平均)共享主干链路的带宽R(bits/sec)

- How long does it take to send a file of 640,000 bits from host A to host B over a circuit-switched network?
  - All links are 1.536 Mbps
  - Each link uses TDM with 24 slots/sec (24circuits)
  - 500 msec to establish end-to-end circuit

Let's work it out!

500ms + 640000bits/(1.536Mbps/24)
= 500ms + 640000/64000
= 500ms + 10s
= 10.5s

- What is the maximum number of simultaneous connections that can be in progress at any one time in this network?
- Suppose that all connections are between the switch in the upper-left-hand corner and the switch in the lower-right-hand corner. What is the maximum number of simultaneous connections that can be in progress?



circuits： channels

总结

- 通信系统
- 正弦波信号
- 频移键控
- 曼彻斯特编码
- 物理介质
- 多路复用和电路交换