Chapter 2: Physical layer

Lecturer: Lam Nhut Khang

9/2020

Slides are adapted from

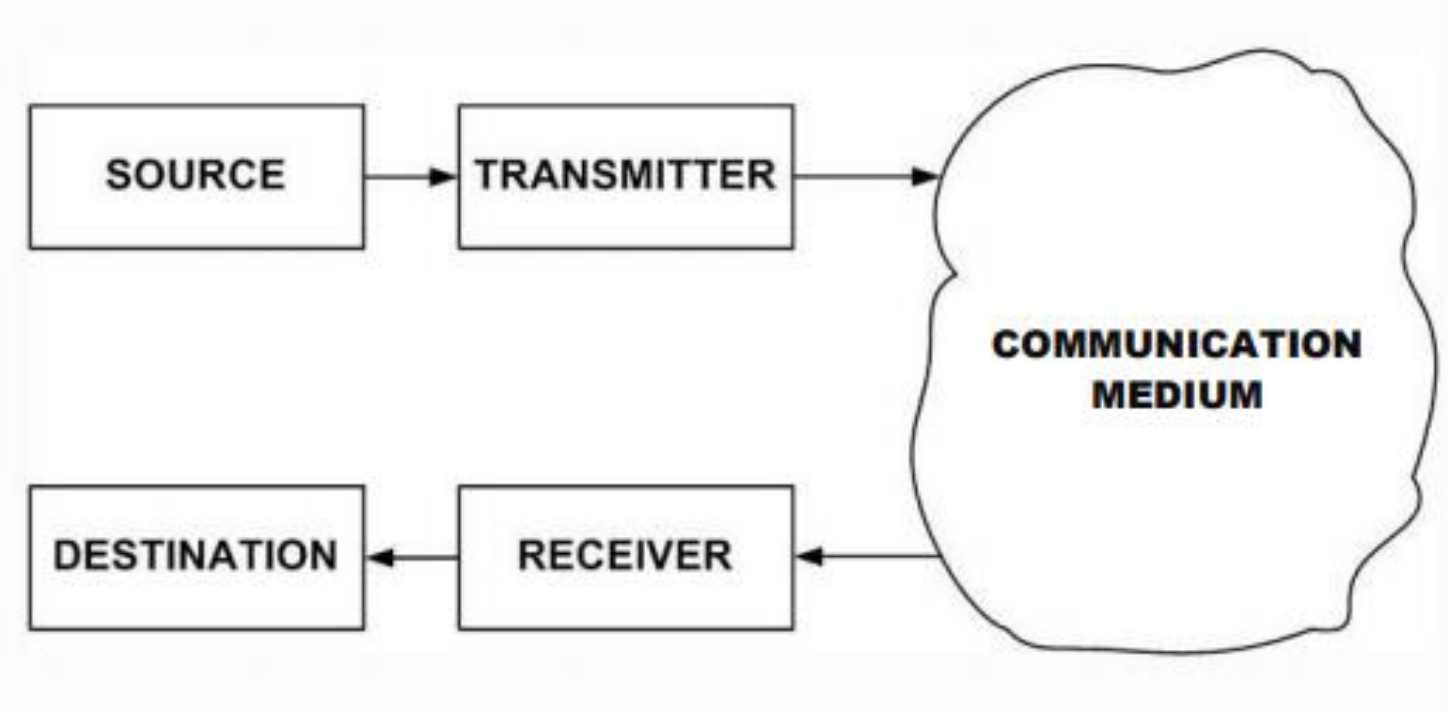
[1] Computer Networks – An Open Source Approach. Ying-dar Lin, Ren-hung Hwang, Fred Baker

[2]Computer Networking: A Top-Down Approach. 8th Edition. Jim Kurose, Keith Ross, Pearson, 2020

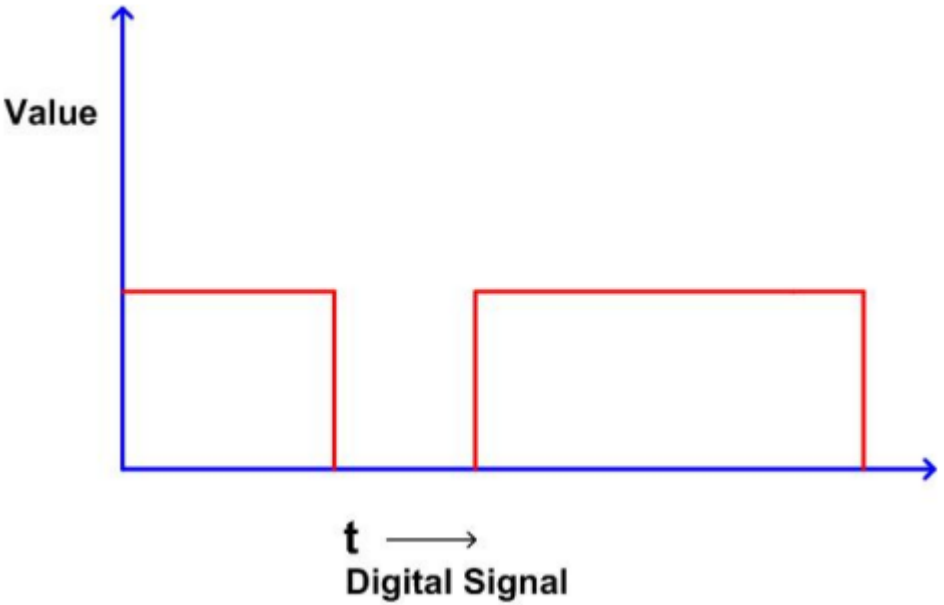
[3] Sami Rollins, Computer network's slides, University of San Francisco, www.cs.usfca.edu

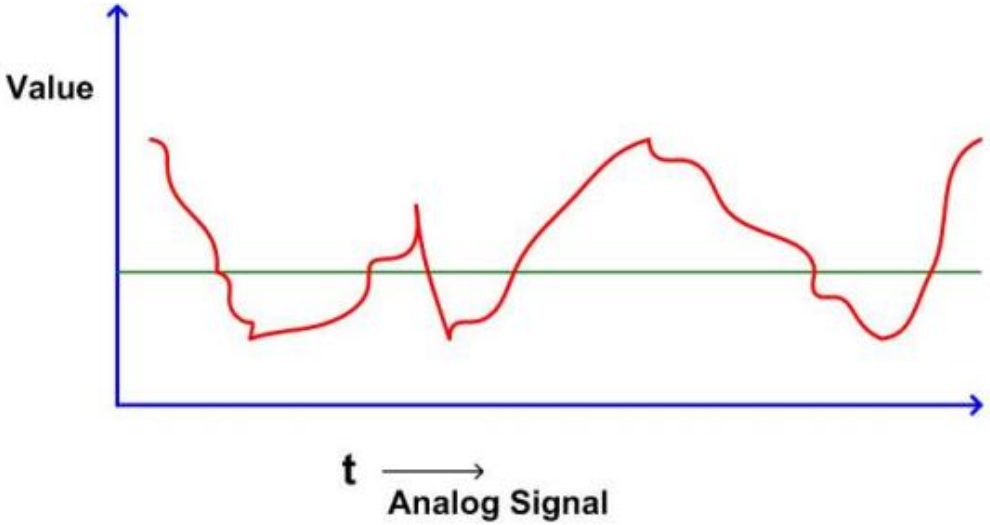
[4]Ajit Pal, CSE IIT, Kharagpur https://nptel.ac.in/course.html

Data and Signal


SOURCE
TRANSMITTER
COMMUNICATION MEDIUM
DESTINATION
RECEIVER

Signal





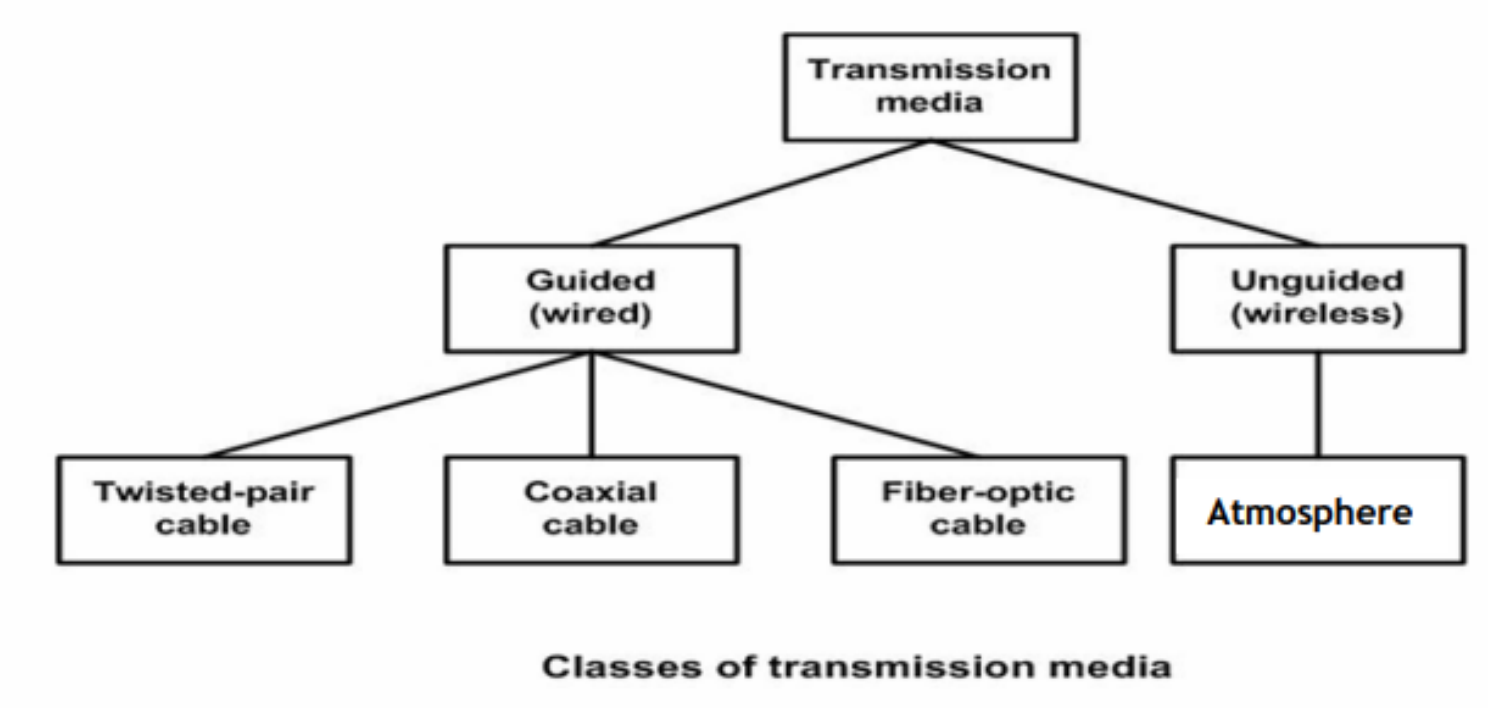
Transmission Media

Network infrastructure devices

Some examples of intermediary network devices:

- Network access devices (hubs, switches, wireless access points,…)
- Internetworking devices (routers)
- Security devices (firewalls)

Classification of the transmission media



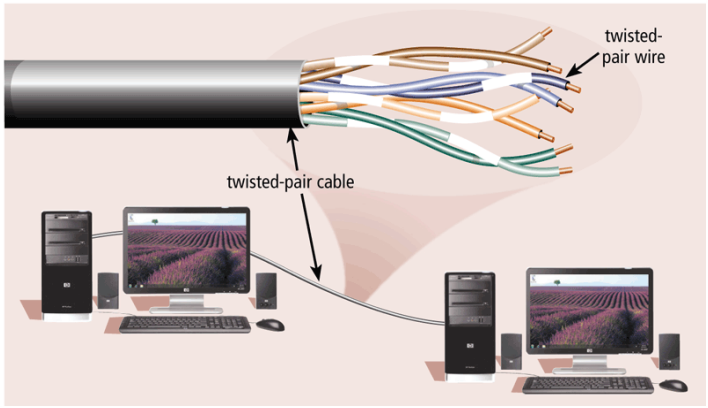
Classes of transmission media

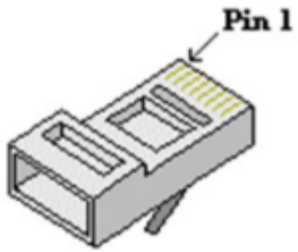
Ajit Pal, CSE IIT, Kharagpur https://nptel.ac.in/course.html

Network media

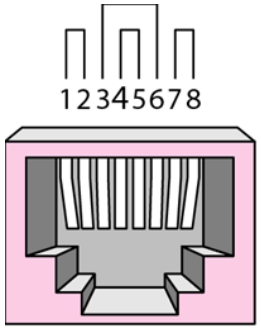
Twisted-pair cable

Twisted-pair cable

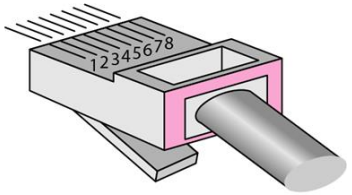




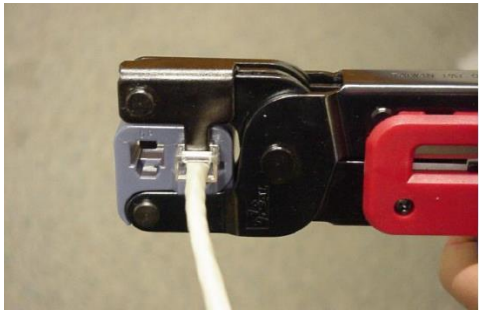
RJ-45 Plug



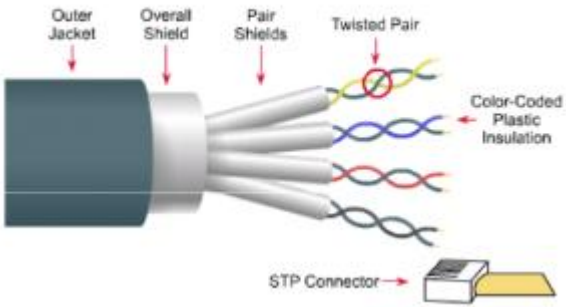
RJ-45 Female



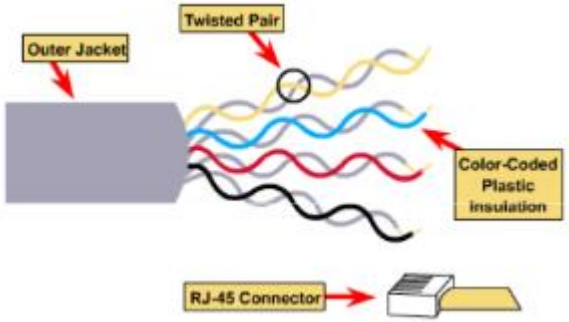
RJ-45 Male



STP (Shielded Twisted Pair)



Unshielded Twisted Pair (UTP)



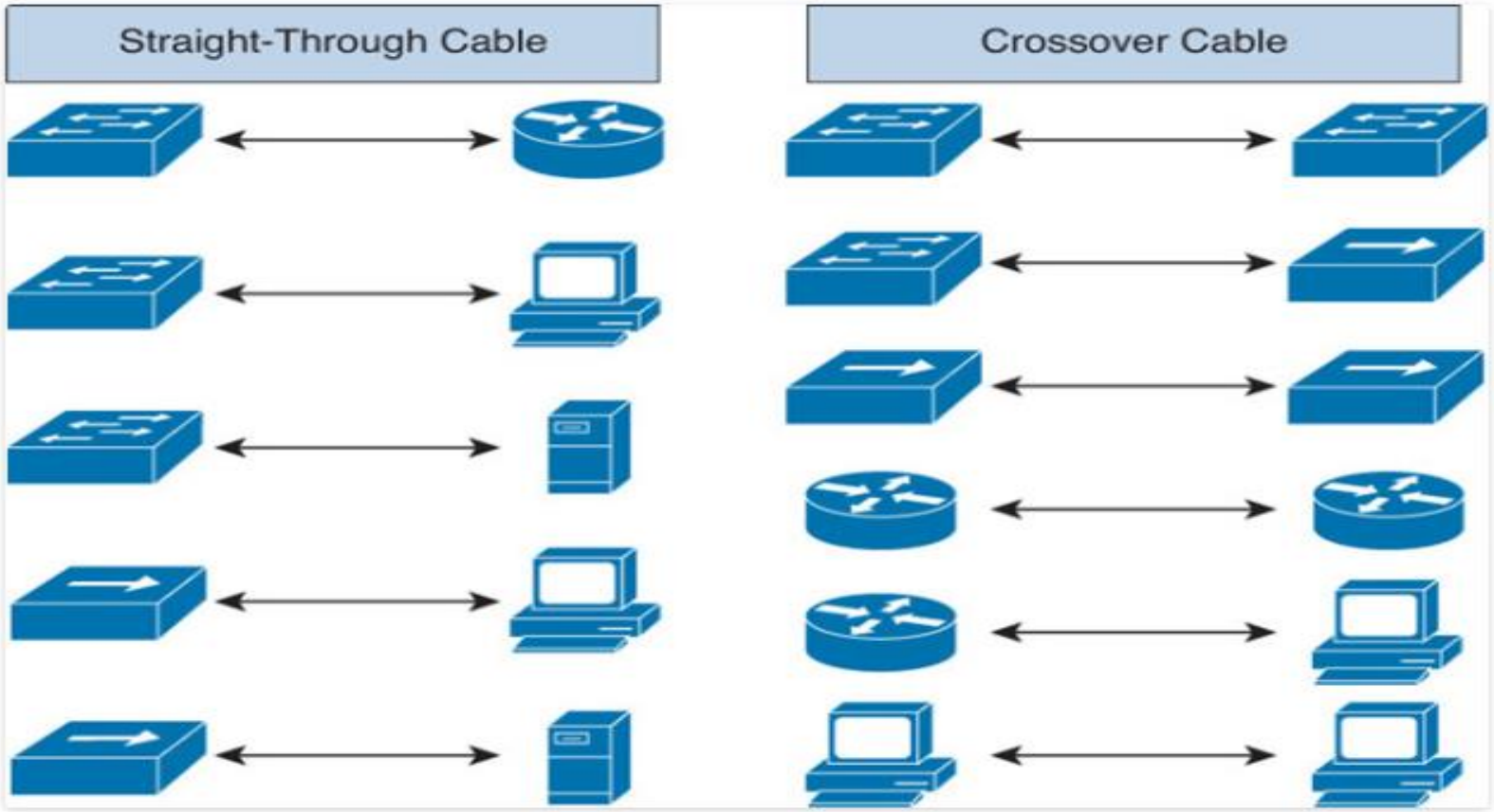
Twisted Pair

Specifications	Description
Category 1/2	For traditional phone lines. Not specified in TIA/EIA
Category 3	Transmission characteristics specified up to 16 MHz
Category 4	Transmission characteristics specified up to 20 MHz
Category 5(e)	Transmission characteristics specified up to 100 MHz
Category 6(a)	Transmission characteristics specified up to 250 MHz (Cat-6) and 500 MHz (Cat-6a)
Category 7	Transmission characteristics specified up to 600 MHz

UTP Cable Types

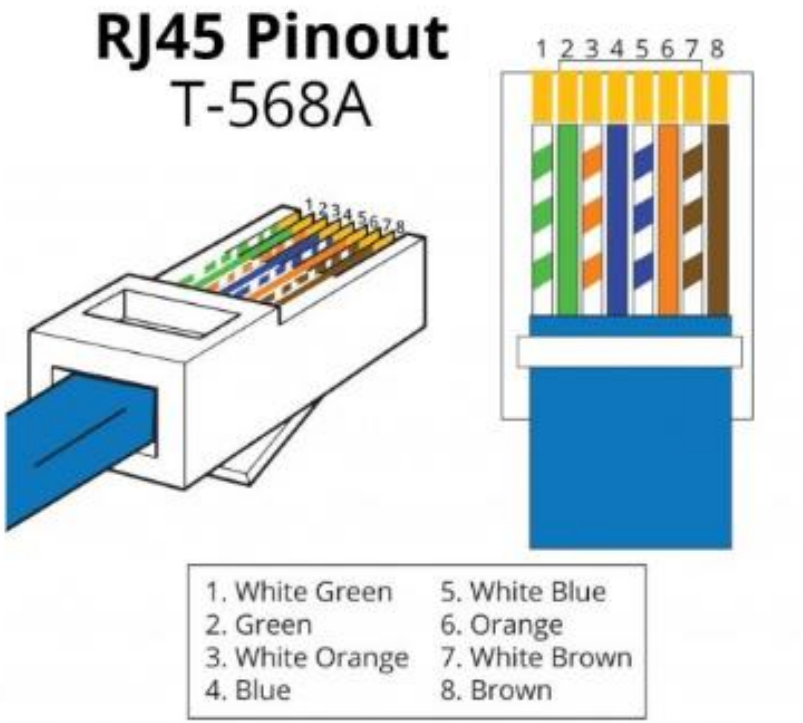
Cable Type	TIA/EIA Standard	Cable Use
Straight-through cable	Both ends the same, either 568A or 568B.	Connects a network host to a hub or switch.
Crossover cable	One end 568A, and the other 568B. It does not matter which end goes to which device.	Directly connects like devices, such as two hosts, two switches, or two routers. Also used to directly connect a host to a router.
Rollover cable (also known as a "Cisco" cable)	Cisco-proprietary.	Connects a workstation serial port to a Cisco device console port.

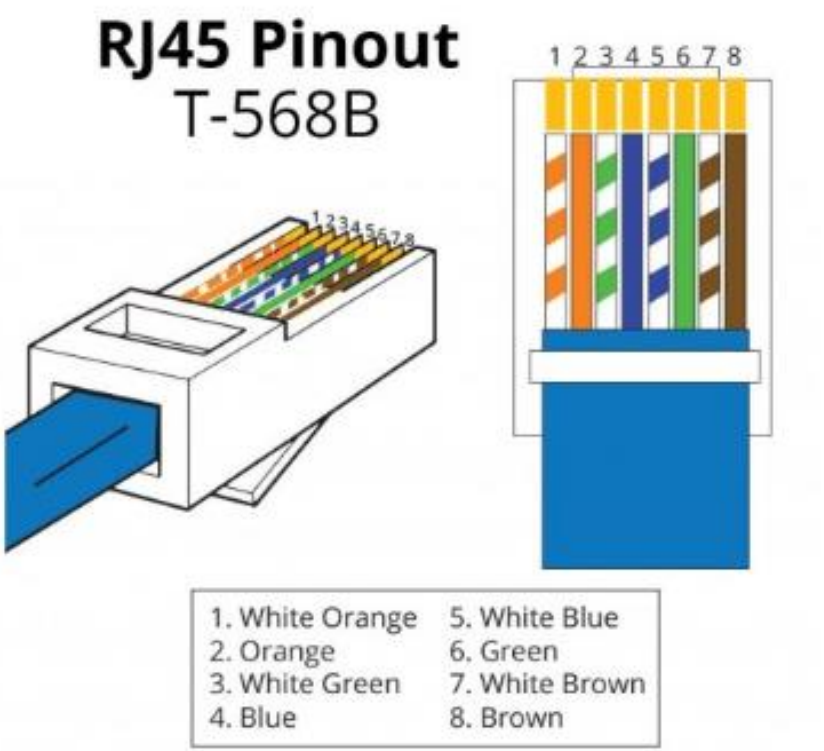
Straight Through vs Crossover Cable, which to choose?



http://www.cables-solutions.com/difference-between-straight-through-and-crossover-cable.html

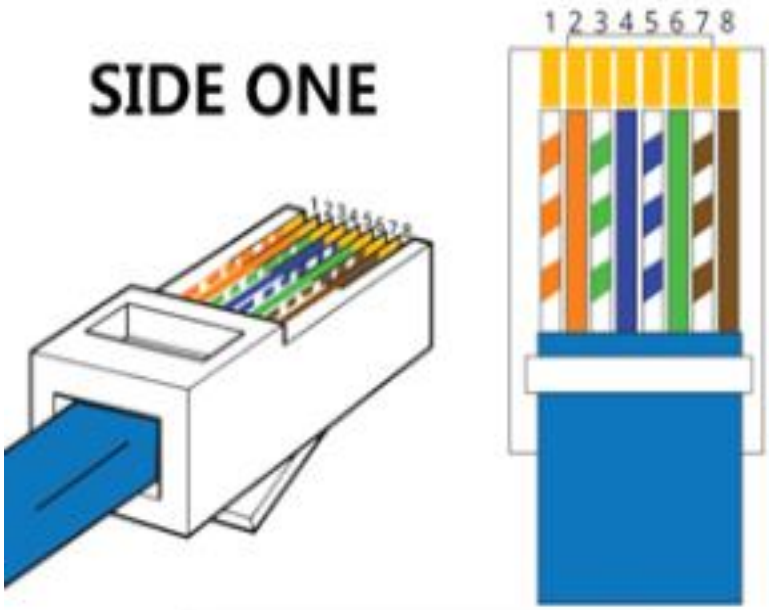
T-568A and T-568B





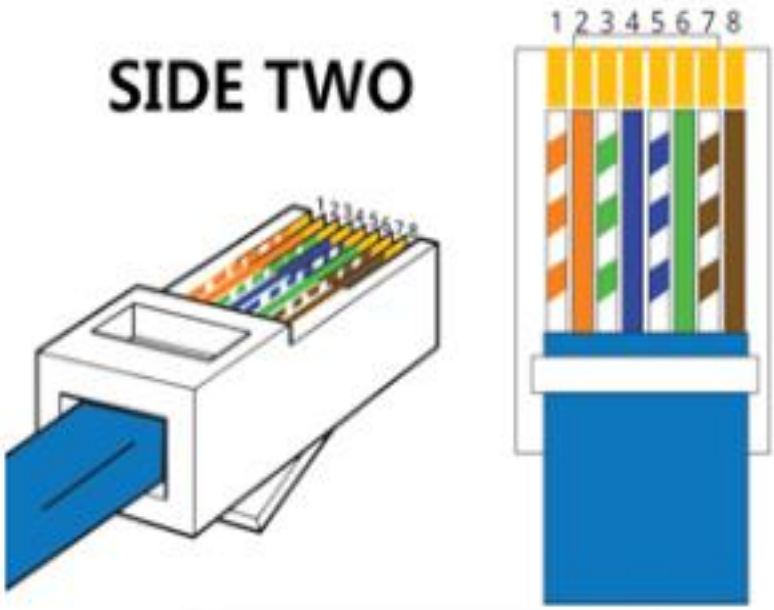
STRAIGHT-THROUGH

SIDE ONE



1. White Orange	5. White Blue
2. Orange	6. Green
3. White Green	7. White Brown
4. Blue	8. Brown

SIDE TWO



1. White Orange	5. White Blue
2. Orange	6. Green
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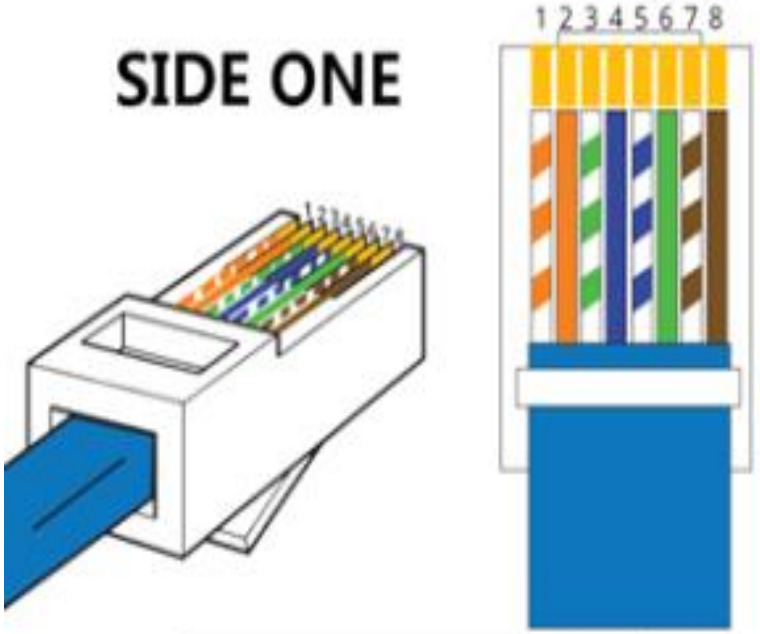
CROSSOVER

SIDE ONE



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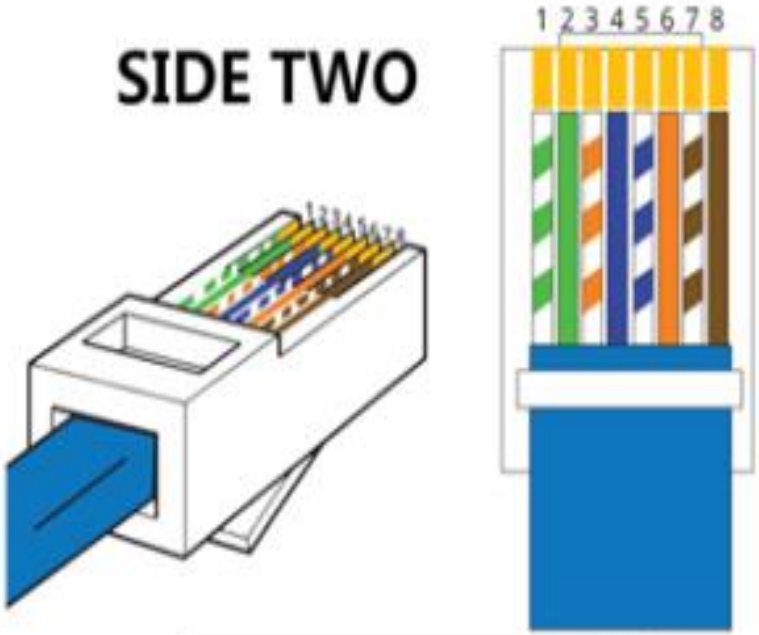
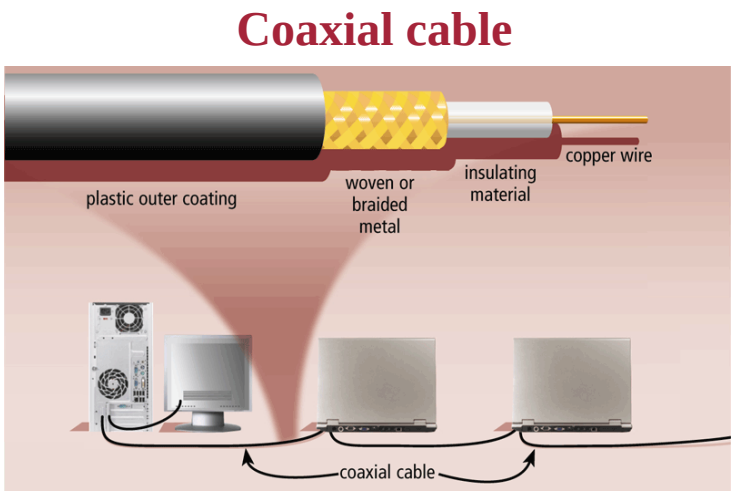
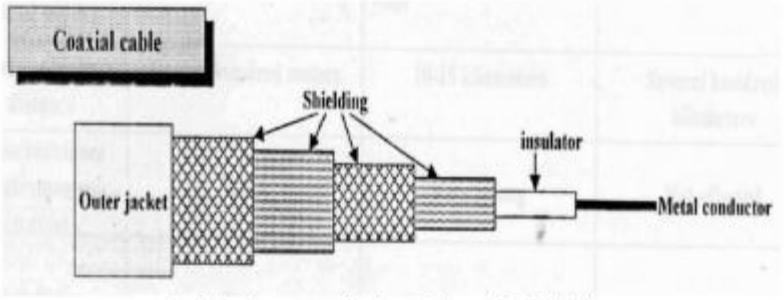
SIDE TWO



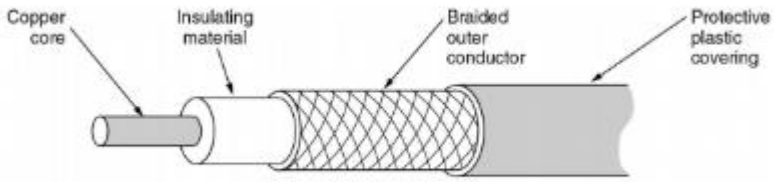
1. White Green	5. White Blue
2. Green	6. Orange
3. White Orange	7. White Brown
4. Blue	8. Brown

Coaxial cable





Thick coaxial cable (RG11)

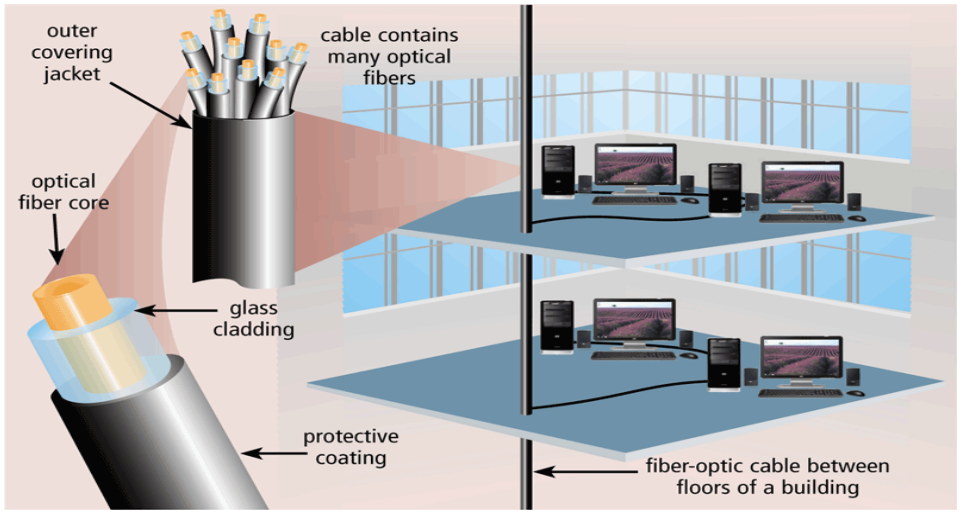


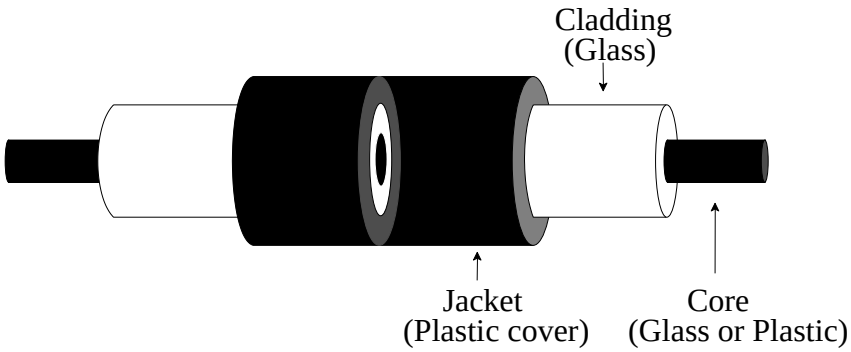
Thin coaxial cable (RG58)

Fiber-optic cable

Optical Fiber: a thin glass or plastic core is surrounded by a cladding glass with a different density

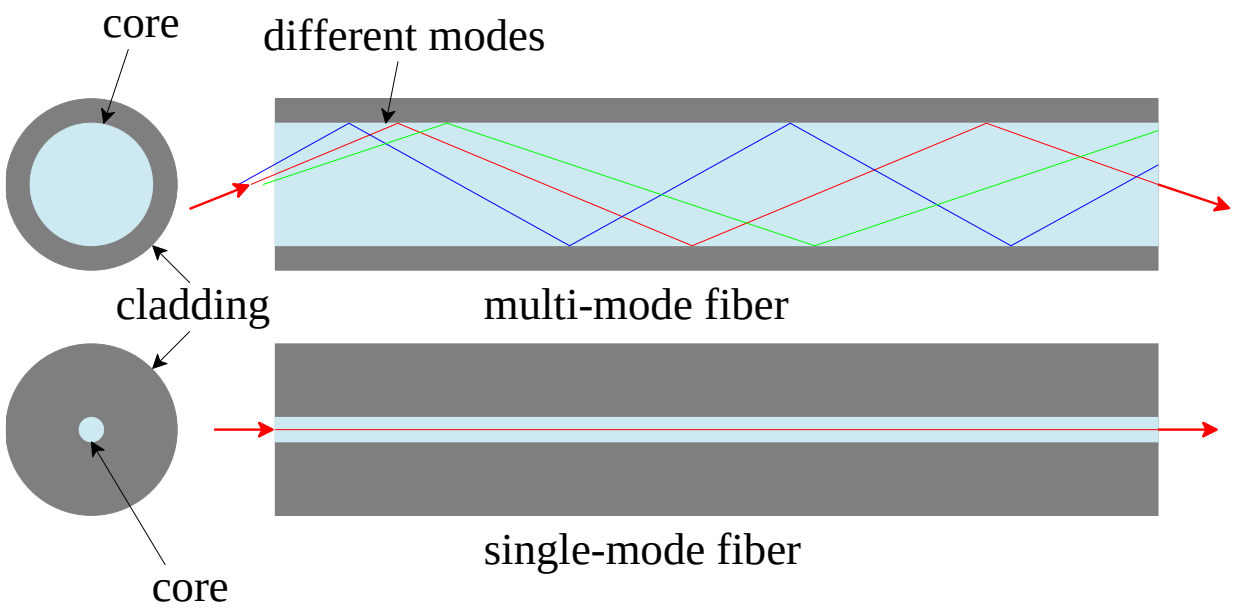
Fiber-optic cable





Fiber-optic cable

- Single-mode:
  - A fiber with a very thin core allowing only one mode of light to be carried.
- Multi-mode:
  - A fiber carries more than one mode of light



Physical media

- Bit: propagates between transmitter- receiver pairs
- Physical link: what lies between transmitter and receiver
- Guided media: signals propagate in solid media, e.g., copper, fiber, coax
- Unguided media: signals propagate freely, e.g., radio

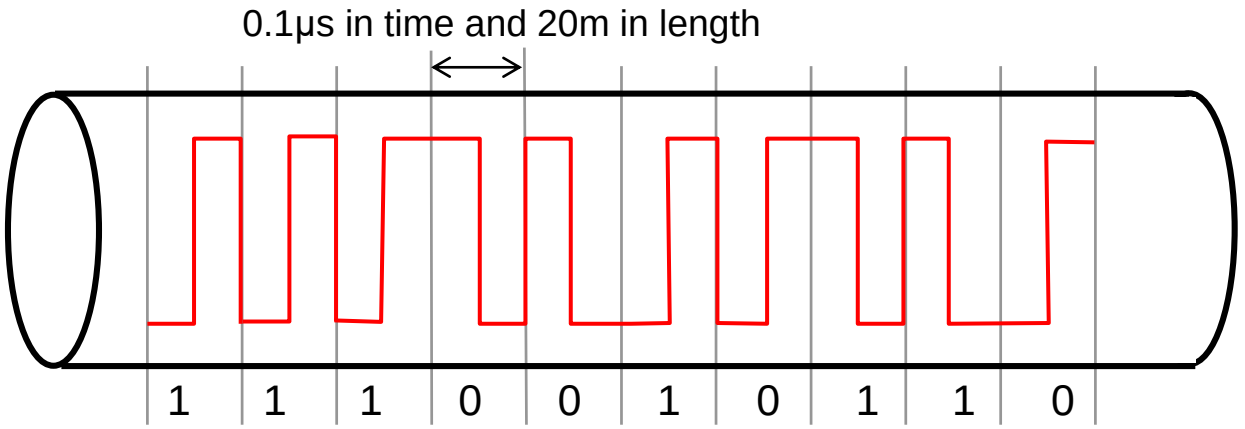
Popular Wired and Wireless Link Technologies

	Wired	Wireless
Local	Cat-5 twisted-pair Ethernet (10 Mbps ~ 1 Gbps)	2.4 GHz band WLAN (2 ~ 54 Mbps ~ 600 Mbps)
Last-mile	POTS (28.8 ~ 56 kbps) ISDN (64 ~ 128 kbps) ADSL (16 kbps ~ 55.2Mbps) CATV (30 Mbps) FTTB (10 Mbps ~)	GPRS (128 kbps) 3G (384 kbps ~ several Mbps) WiMAX (40 Mbps)
Leased-line	T1 (1.544 Mbps) T3 (44.736 Mbps) OC-1 (51.840 Mbps) OC-3 (155.250 Mbps) OC-12 (622.080 Mbps) OC-24 (1.244160 Gbps) OC-48 (2.488320 Gbps) OC-192 (9.953280 Gbps) OC-768 (39.813120 Gbps)	

Bandwidth

- The maximum amount of data that can be handled by a system in a second
- The number of bits transmitted and *contained* in the distance *propagated* by the signal in one second

1 bit time in 10Base-T = 1 / (10x10^6) = 0.1 μs
1 bit length in 10Base-T = 0.1 μs x 2 x 10^8 m/sec = 20 m

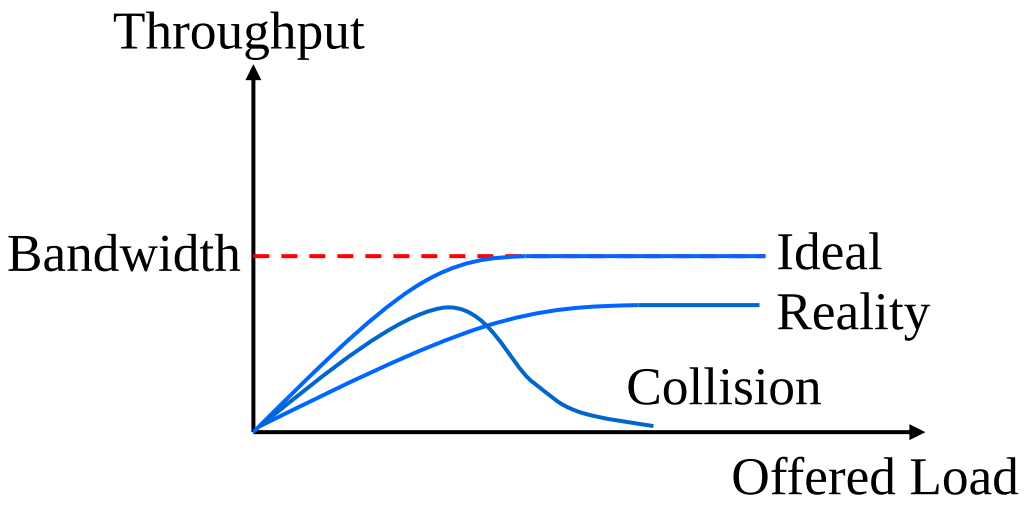


Manchester Coding for data in 10Base-T transmission

Performance Measures

For a node, link, or path

- Bandwidth, or capacity
- Offered load, or utilization
- Throughput

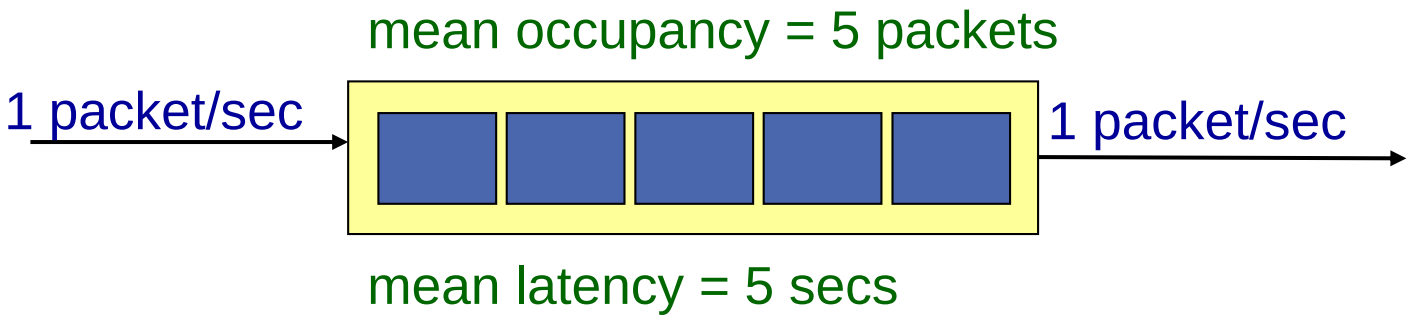


Performance Measures
Latency in a Node

- Latency (delay) in a node = queuing + processing
- In M/M/1 queuing system,

  latency = 1 / (bandwidth – offered load)
- Little's Result: How many in the box?

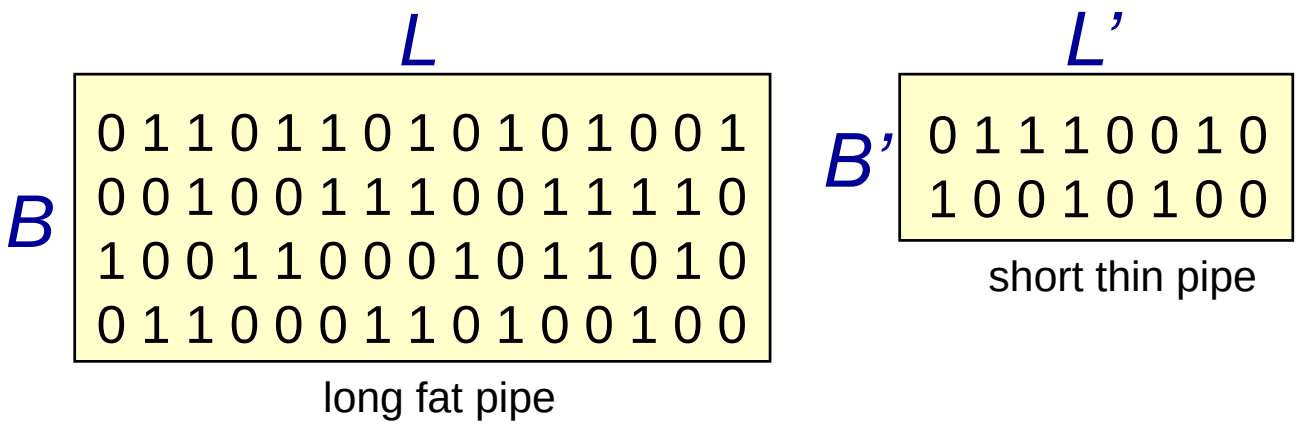
  occupancy = throughput x latency (assume no loss)



Performance Measures
Latency in a Link

- Latency (delay) in a link = queuing + transmission + propagation
- Bandwidth delay product: BDP (Little's result in a link or path!)

  Max outstanding bits in transit = bandwidth x delay



Data and Signal: Analog or Digital

Data

- Digital data – discrete value of data for storage or communication in computer networks
- Analog data – continuous value of data such as sound or image

Signal

- Digital signal – discrete-time signals containing digital information
- Analog signal – continuous-time signals containing analog information

Principle in Action:
Nyquist Theorem vs. Shannon Theorem

Nyquist Theorem:

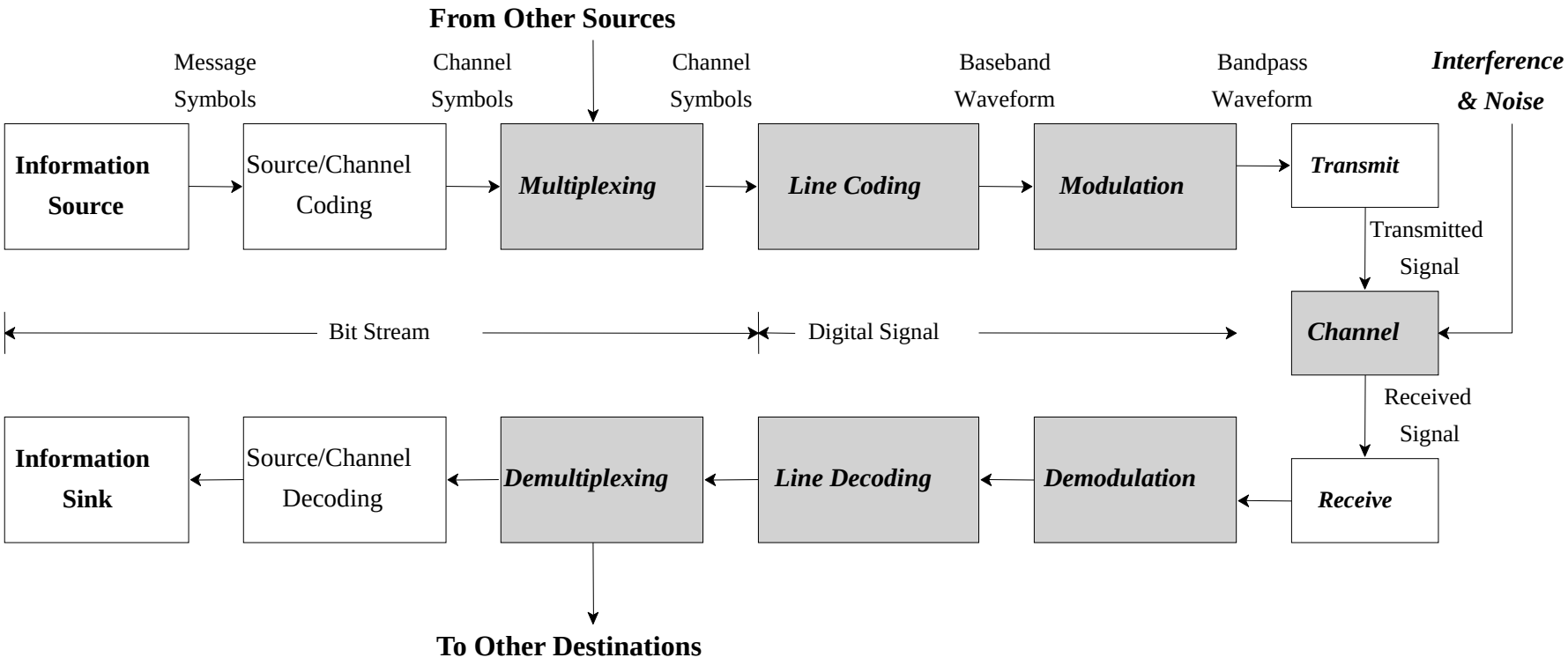
- Nyquist sampling theorem
  - $f_s \geqq 2 \times f_{max}$
- Maximum data rate for noiseless channel
  - $2 B \log_2 L$ (B: bandwidth, L: # states to represent a symbol)
  - $2 \times 3k \times \log_2 2 = 6$ kbps

Shannon Theorem:

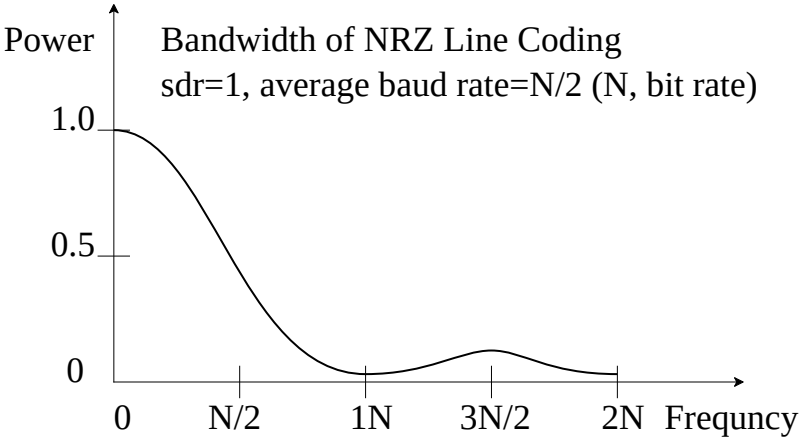
- Maximum data rate for noisy channel
  - $B \log_2 (2(1+S/N))$ (B: bandwidth, S: signal, N: noise)
  - $3k \times \log_2 (2 \times (1+1000)) = 32.9$ kbps

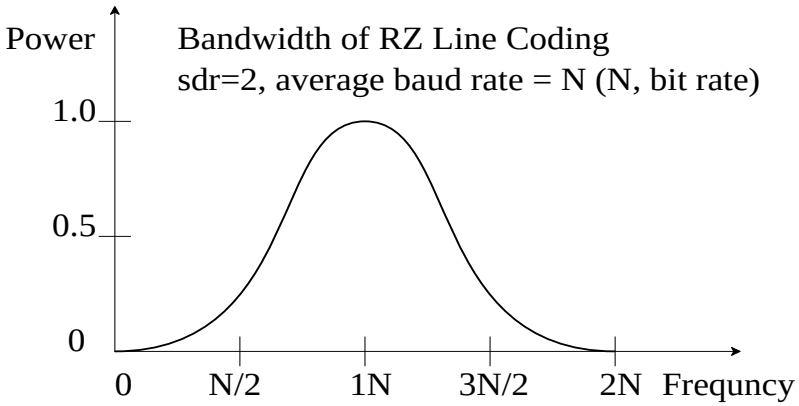
Transmission and Reception Flows

A digital communications system



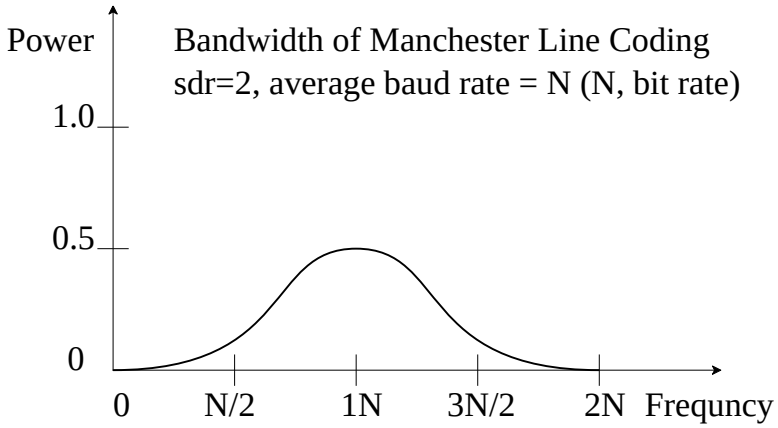
Bandwidths of Line Coding (1/3)

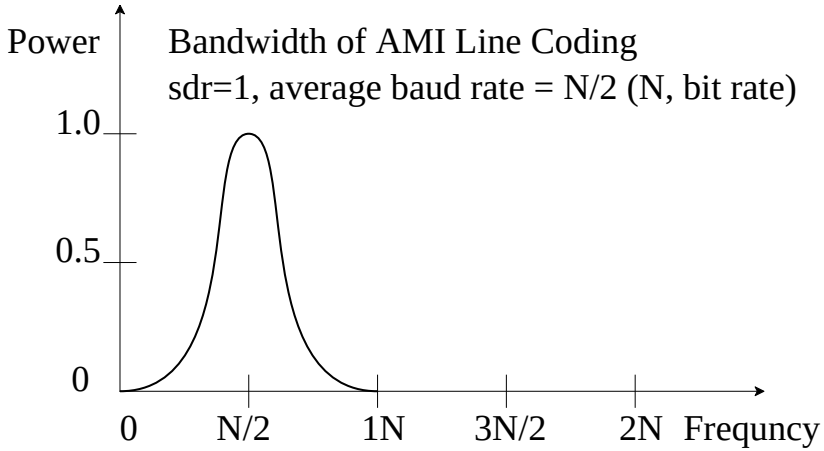




- The bandwidth of polar NRZ-L and NRZ-I.
- The bandwidth of bipolar RZ.

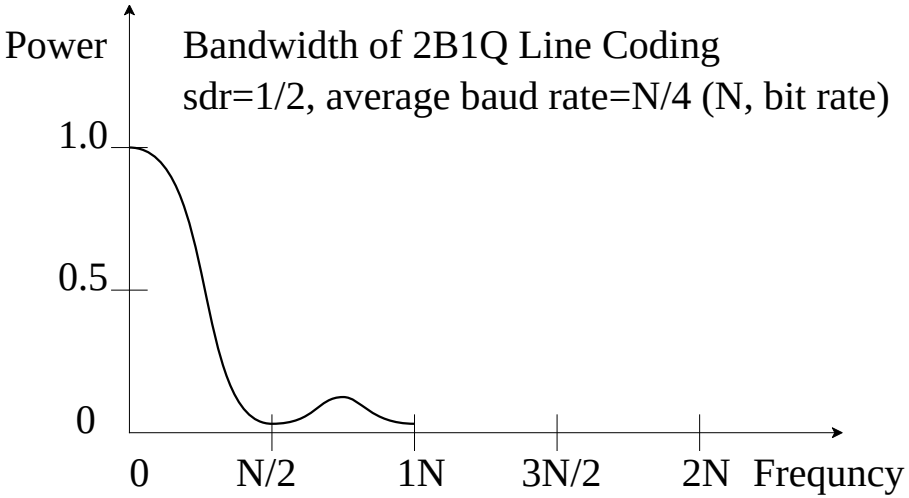
Bandwidths of Line Coding (2/3)





- The bandwidth of Manchester.
- The bandwidth of AMI.

Bandwidths of Line Coding (3/3)



The bandwidth of 2B1Q


Thank
you