

Chapter 6

Physical Layer

Redes de Computadores

Chapter 6: Physical Layer

Our goals:

- What drives our network:
 - Transmission media
 - Physical connectors
 - Cabling

Physical Layer: outline

6.1 Transmission Basics

6.2 Transmission Media

6.3 Connectors

6.4 Ethernet Physical
Layer

Transmission Basics

- Simplex Communication
 - Data flows on one directions
 - Television, Radio
- Half Duplex
 - Transmission on one direction at a time
 - Uses a turn around mechanism
 - Over – Like on walkie-talkies (two-way radio receivers)
 - Collision may happen
- Full Duplex
 - Transmission on both ways simultaneously
 - Different data paths
 - No collisions

Synchronization

- Transmitter and receiver need to be in sync
 - Need to know where to start sampling bits
 - Need to know where a frame starts and ends
- Bit synchronization
 - In-band
 - Clock extraction from data signal
 - Out-of-band clock sync
- Frame synchronization
 - Start and end of frame delimiters
 - Using special flags (e.g. 01111110)
 - Ensuring that flags do not appear on data (e.g. 5 sequential 1s at most)

Transmission Media

- Guided
 - Copper wire
 - Fibre optic cable
- Unguided
 - Wireless (Radio, Microwave)
- Information transmitted over:
 - Copper – by varying the voltage or current over time
 - Fibre optic – by pulsing light on/off over time
 - Radio waves or Microwaves – by varying the frequency or amplitude over time

Guided transmission basics

- To transmit a single bit on a copper wire, we must send some electrical signal having two discrete states to represent 0 and 1
- Examples:
 - Voltage $+5\text{v} = 1$ $0\text{v} = 0$
 - Frequency $980\text{Hz} = 1$ $1180\text{Hz} = 0$
- If a second bit follows the first
 - We need to find a mean of indicating the bit boundary or synchronizing the receiver with the transmitter to agree where a bit starts and ends

Physical Layer: outline

6.1 Transmission Basics

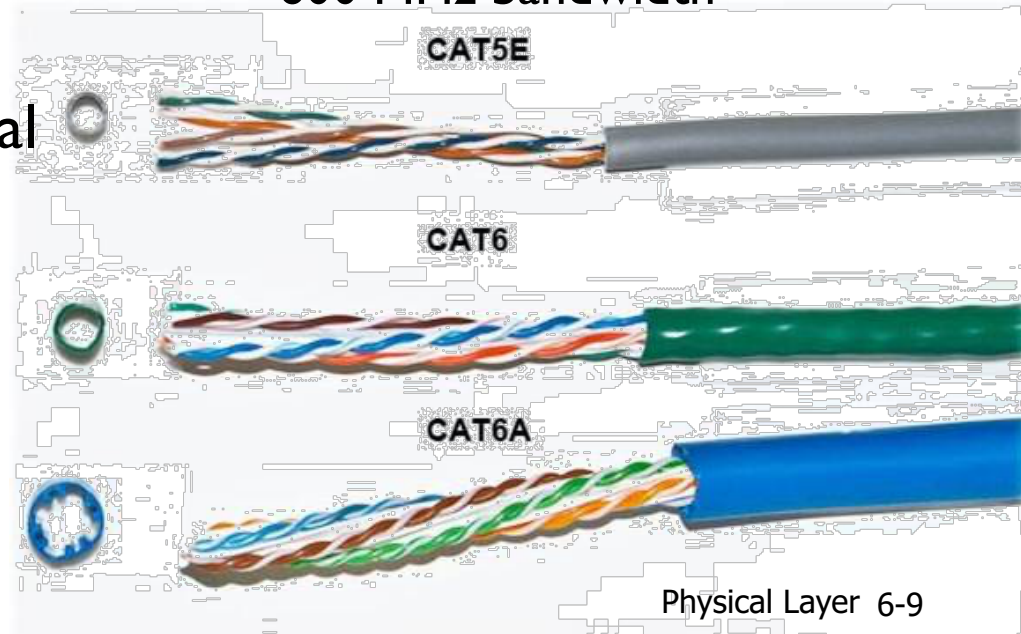
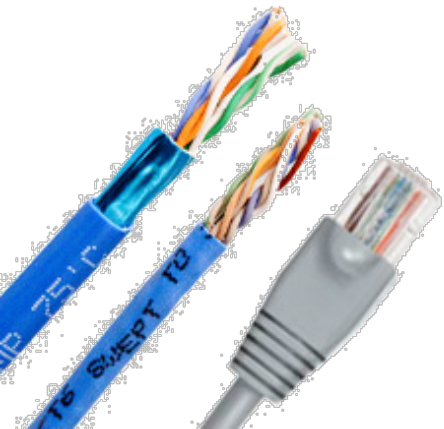
6.2 Transmission Media

6.3 Connectors

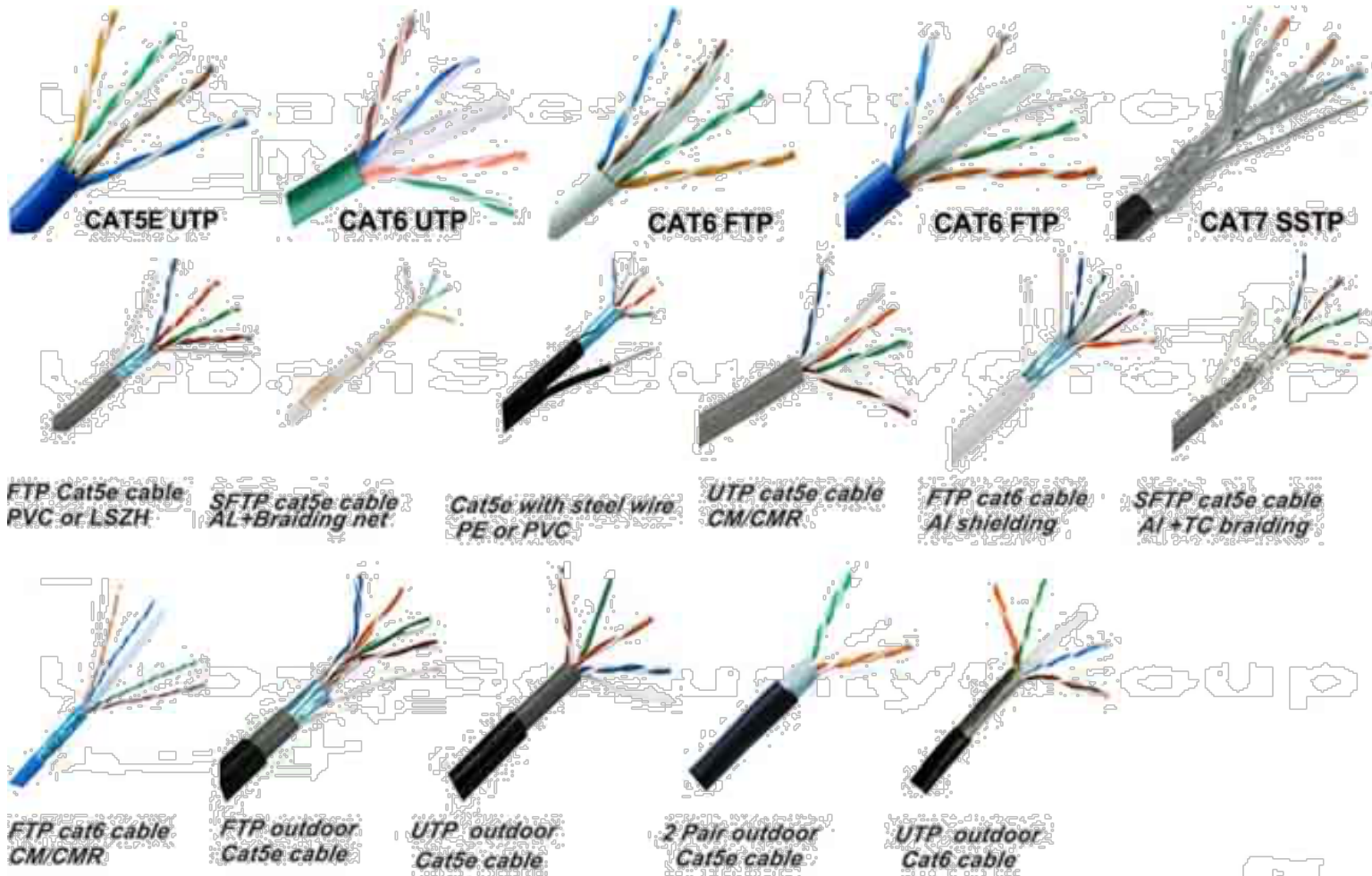
6.4 Ethernet Physical
Layer

Guided transmission media

- Where the signal is sent
 - Copper or Fibre
- Copper:
 - Twisted pair: Two or more insulated wires, twisted together in order to reduce external interference
- Cat 5/5e
 - 100 MHz bandwidth
- Cat 6
 - 250 MHz bandwidth
- Cat 7
 - 600 MHz bandwidth



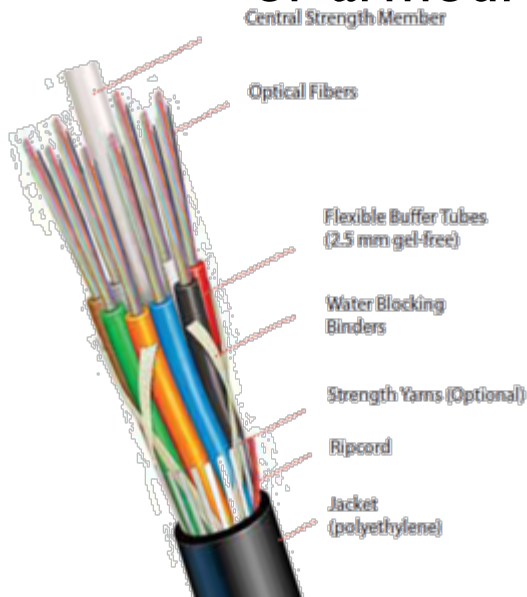
Shielding Types



Guided transmission media

■ Fibre optic cable

- Central glass core, surrounded by glass cladding of lower refractive index, in order for the light to stay in the core
- Plastic jacket on the outside
- Many fibres bundled together by another plastic sleeve or armour



Light transmission

- Source of light is usually a LED or a Laser
- The source of light transmits the light to a light detector
- The light detector is usually a photo diode
 - Converts light to electrical signals
 - Response time limits the data rate
- Fibre modes
 - Multimode
 - Light dispersed through multiple paths
 - 50-100 microns (62.5 is common) = Width of a human hair
 - Used in short distances (less than one Km)
 - OM1 to OM4 (optical mode = different windows)
 - OM3 and OM4 are for transmissions above 10Gbps
 - Single mode
 - Light travels in straight line
 - 8.3-10 microns
 - Use lasers
 - Long distances (hundreds of kilometres)

Fibre advantage

- Higher data rates
- Lower attenuation
- Not affected by power surges, electromagnetic interference, corrosive chemicals
- Difficult to tap
 - Better for security
- Thin and lightweight
- Cheaper

- Disadvantages:
 - Skills in order to make fusions
 - One way only
 - Expensive interfaces

Unguided transmission

- Radio or Microwaves
- Radio waves
 - Penetrate buildings
 - Can travel long distances
 - Omni-directional (transmit both ways)
 - Transmitter and receiver do not need to be in line of sight
 - Subject to interferences from motors and other electrical equipment

Unguided transmission

- Microwaves
 - Above 100MHz, waves travel in straight lines and can be focused on small beams using special parabolic antennas
 - Transmitters and receivers need to be aligned
 - Multiple TX and RX can be setup in parallel
 - Typically do not pass through solid objects

Physical Layer: outline

6.1 Transmission Basics

6.2 Transmission Media

6.3 Connectors

6.4 Ethernet Physical
Layer

Connectors

- Copper
 - 8P8C (AKA RJ45)
- Fiber
 - LC
 - ST
 - SC
 - E2000
 - ...
- Other Interfaces
 - AUI (10Mbit Ethernet)
 - MII (100Mbit Ethernet)
 - XAUI (10Gbit Ethernet)
 - GBIC (Gigabit Ethernet)
 - SFP/SFP+/QSFP (multi protocol: ethernet, fiber channel, etc.)
 - ...

Copper Connectors

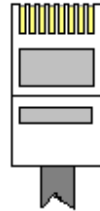
RJ-45 Male Plug



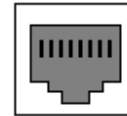
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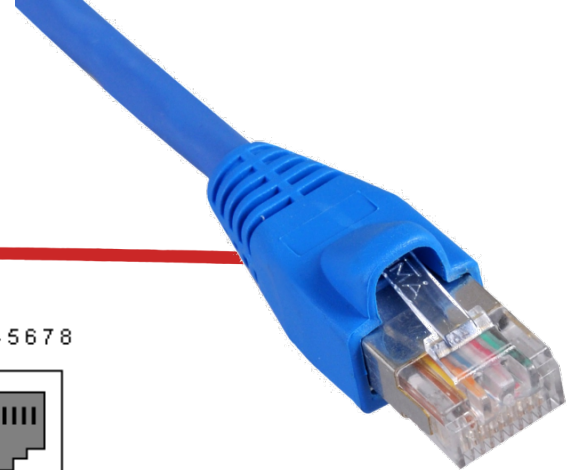
1 2 3 4 5 6 7 8



1 2 3 4 5 6 7 8

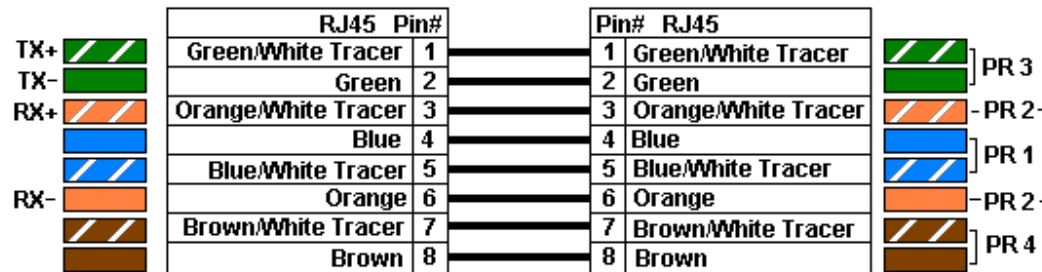


RJ-45 Female



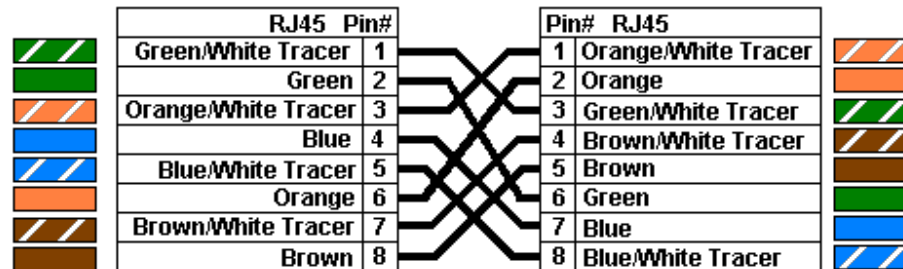
Color Standard
EIA/TIA T568A

Ethernet Patch Cable



Color Standard
EIA/TIA T568A

Ethernet Crossover Cable



"A" is earlier

Fibre Connectors



LC Connector



SC Connector



ST Connector



FC Connector



MTRJ



MU



E 2000 Connector

Transceivers



Transceivers



Physical Layer: outline

6.1 Transmission Basics

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6.4 Ethernet Physical
Layer

Ethernet Physical Layers (Copper)

- 10Base-T
 - Cat 3 or Cat 5
- 100Base-TX (AKA 100Base-T)
 - Cat 5
- 1000Base-T
 - Cat 5, 5e, 6 and 7
- 10GBase-T
 - Cat 6 = 55m
 - Cat 6a and 7 = 100m

Ethernet Physical Layers (Fiber)

- 10Base-FL
- 100Base-FX
 - Multi-mode Fibre
 - 400m Half-Duplex, 2Km Full-Duplex
- 100Base-SX
 - Retro-compatible with 10Base-FL with auto-negotiation
- 1000Base-SX
 - Multi-mode Fibre (550m)
- 1000Base-LX
 - Multi-mode Fibre (550m)
 - Single-mode Fibre (2Km to 10Km)
- 1000Base-ZX
 - Single-mode Fibre
 - Up to 100Km

Ethernet Physical Layers (Fibre)

- 10GBase-SR
 - Multi-mode (up to 400 meters with OM4 fibre)
- 10GBase-LR
 - Single-mode (10Km)
- 10GBase-ER
 - Single-mode (40Km)
- 40GBase-SR4/100GBase-SR10
 - Multi-mode (OM3 100m, OM4 150m)
- 40GBase-LR4/100GBase-LR4
 - Single-Mode (10Km)
- 100GBase-ER4
 - Single-Mode (40Km)

Chapter 6: Summary

- Transmission basics
 - Communication modes
 - How to synchronize a receiver with a transmitter
- Guided vs unguided transmission
- Transmission media
 - Cabling
 - Copper vs Fibre
- Connectors
- Ethernet Physical Layers