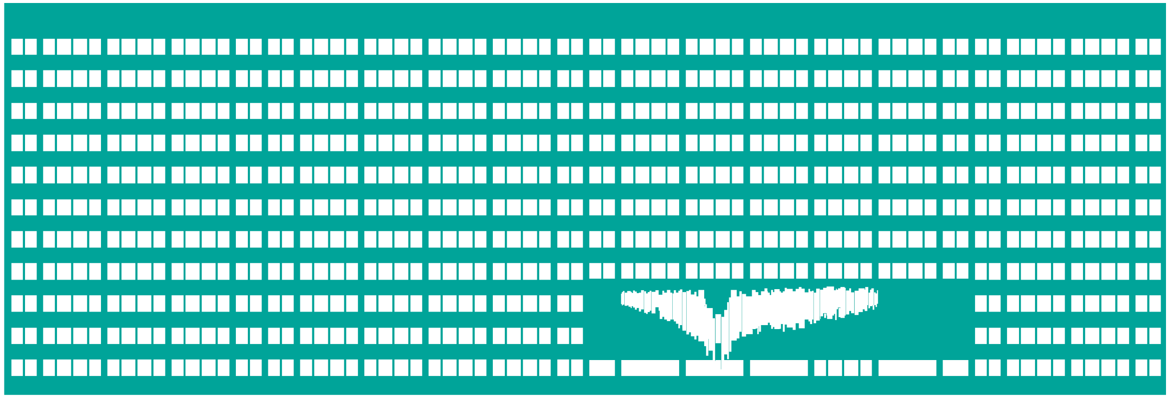
VSB TECHNICAL UNIVERSITY OF OSTRAVA | FACULTY OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE | DEPARTMENT OF COMPUTER SCIENCE

Transmission Media



Computer Networks
Lecture 1

Classification of Media Types

- Copper (Metalic)
    - Coaxial cable
    - Twisted pair
        - Shielded
        - Unshielded
- Optical
    - Multimode
    - Singlemode
- Wireless

Coaxial cables (1)

- Dominated in computer networks for a long time
  - Special cables (e.g. RG-58 for 10Base2 Ethernet)
  - 75-Ohm CaTV cable (Internet over cable TV)
- Good parameters in a wide frequency range
  - may be used for both baseband and broadband transmission
- Expensive

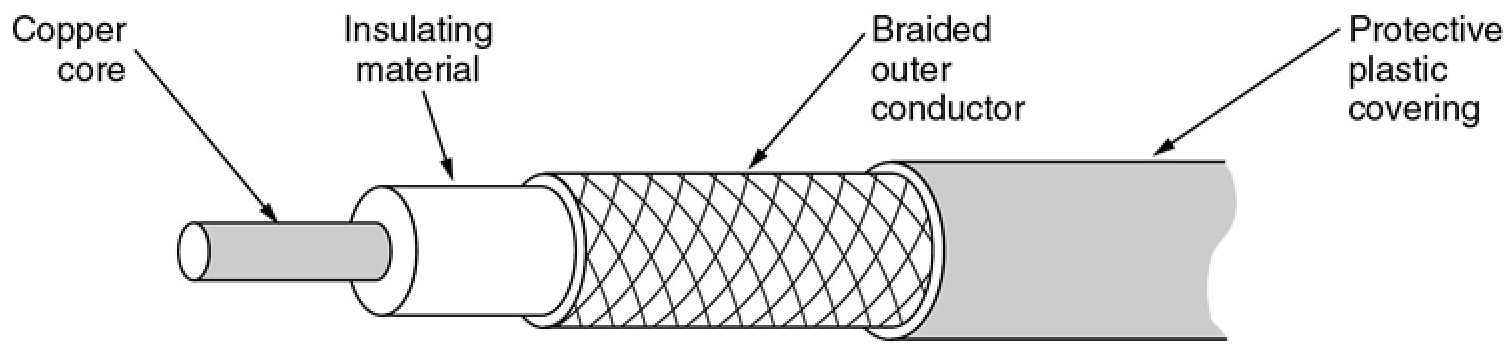
Coaxial Cables (2)

Usage options

- Baseband (0-150 MHz)
  - Modulation is not used
  - Reach limited to hundreds of meters to kilometers due to electrical characteristics

- Broadband (50-750MHz)
  - Carries modulated signal(s)
  - Cable lengths of a few kilometers are common

Anatomy of the Coaxial Cable

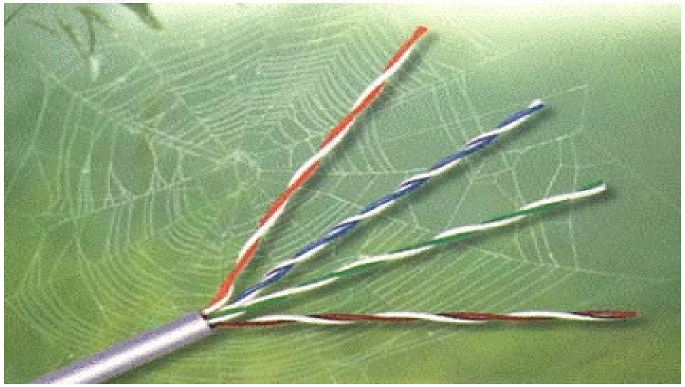


Other cabling system components:

- BNC crimp connectors
- T-connectors
- terminators

Twisted Pair (1)

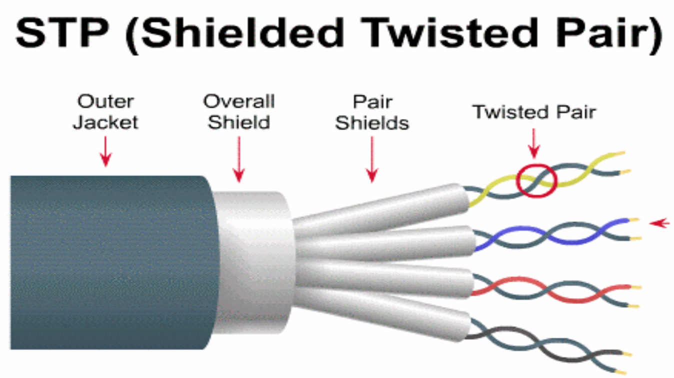
- Cheaper than coaxial cabling
- Started to be used to utilize existing telephone wirings (US)
  - worse parameters than coaxial cable
- Differential mode transmission over a balanced pair
  - the receiver detects a difference between two levels



Twisted Pair (2)

- The cable contains 4 twisted pairs
- Typically used in LANs for baseband transmissions
  - Typical reach of 100m (1Gbps)
  - The applicable bit rate depends on the quality of the cable (the TP category)
  - The pairs are also twisted one around the others

Shielding of the TP Cable



- Shielding prevents the electromagnetic interference
- Various shielding options
  - can be applied to individual pairs and/or to the collection of pairs
- The shield have to be grounded at both ends
  - there is a need to sustain shielding all the way through between the devices

EIA/TIA 568 TP Categories (1)

- Every category defines parameters up to the upper frequency that increases with the number of the category
- Relates to cables as well as to the other components of the cabling system
  - connectors, patch-panels, jacks
  - the cable may be untwisted no more than 0,5" (13 mm) from its termination

EIA/TIA 568 TP Categories (2)

- Cat1 – 1 MHz
  - POTS, never a standard
- Cat2 – 4 MHz
  - 4Mbps IBM Token Ring cabling system
  - never a standard
- Cat3 – 16 MHz - 10 MHz
  - voice, 10BaseT Ethernet
- Cat4 – 20MHz
  - 16Mbps Token Ring, never widely installed
- Cat5 – 100 MHz
  - Commonly used for 100BaseT Ethernet
- Cat5E – new parameters (FEXT, …)
  - Usable for Gigabit Ethernet

EIA/TIA 568 TP Categories (3)

- Cat6 – 250 MHz
  - 10Gbps Ethernet / limited cable length
- Cat6a – 500 MHz
  - suitable for 10Gbps Ethernet / full 100m
- Cat7 – 600Mhz (screened)
  - Individual pairs and the whole cable are shielded
  - special connectors (backward compatible) - GG45
- Cat7a – 1GHz
  - considered for 40G/100G Ethernet
- Cat8 – up to 2GHz
  - 30-36m maximum distance, for data centers

Examples of TP Cable Parameters

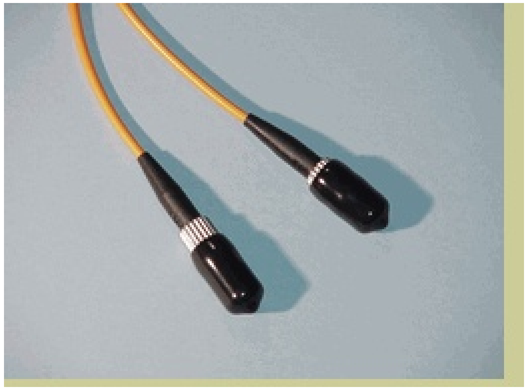
- Most important measured parameters:
  - Propagation delay
  - Delay skew
  - Attenuation (insertion loss)
  - Return loss (reflections)
  - Near/Far End Crosstalk (NEXT,FEXT)
  - DC loop resistance
- Calculated parameters:
  - ACR (Attenuation/Crosstalk Ratio)

- Defined for a frequency range of the particular cable category

See http://en.wikipedia.org/wiki/Copper_cable_certification for detailed explanation

Optical Fiber

- Supports very high transfer rates
  - tens of Gbps
- Resilient against noise and signal tapping (eavesdropping)
- The reachable distance depends on the required bitrate
  - Mb/s*km ≈ const
- Multimode or singlemode



See http://www.thefoa.org/tech/ref/basic/fiber.html

Geometrical Optics
A Reminder of Basic Terms (1)

- Index of refraction
  - A ratio between a propagation velocity of light in vacuum and in a particular medium
    - 1.6 for glass
  - depends on the wavelength => results in dispersion
- Law of reflection

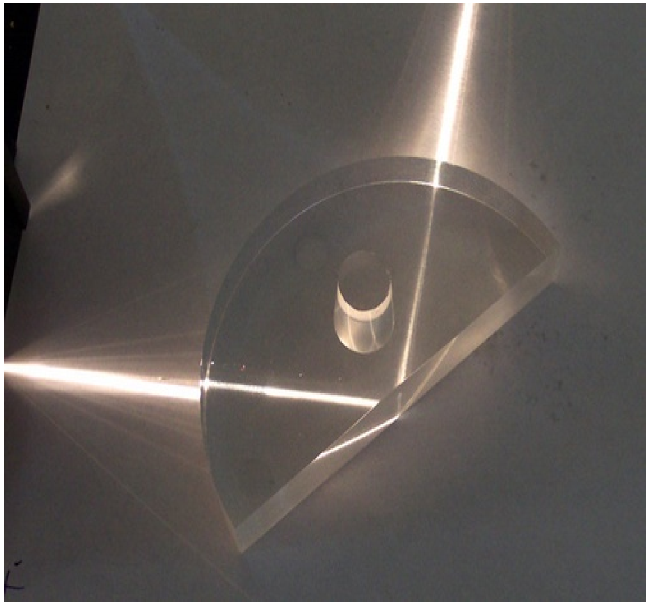
$$\alpha_1 = \alpha_2$$

Geometrical Optics
A Reminder of Basic Terms (2)

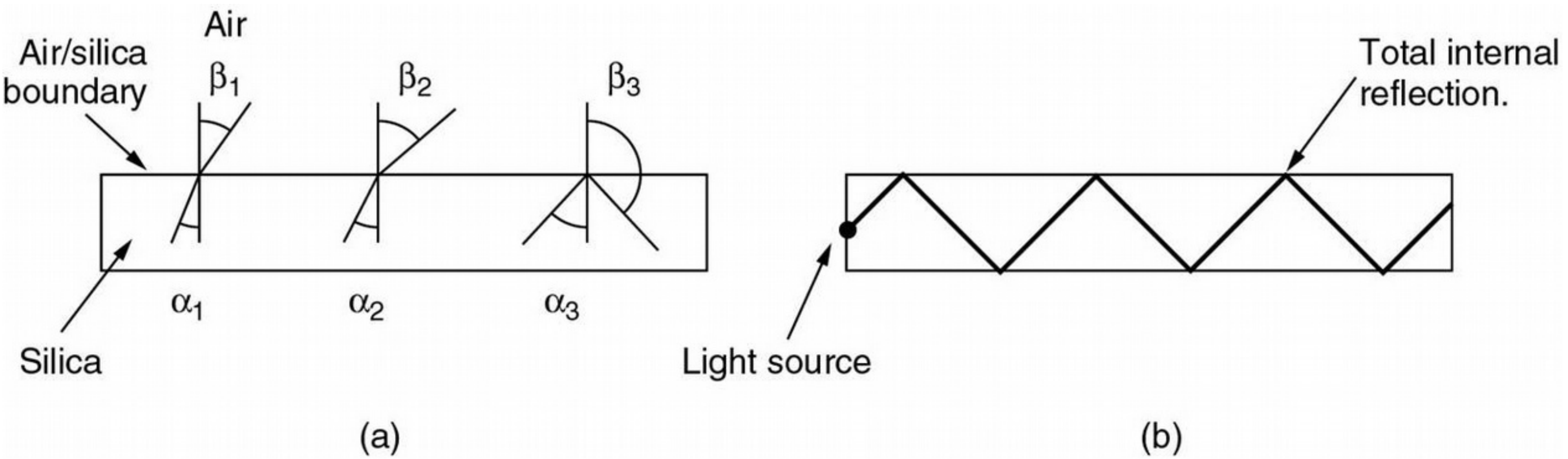
- Snell's law:

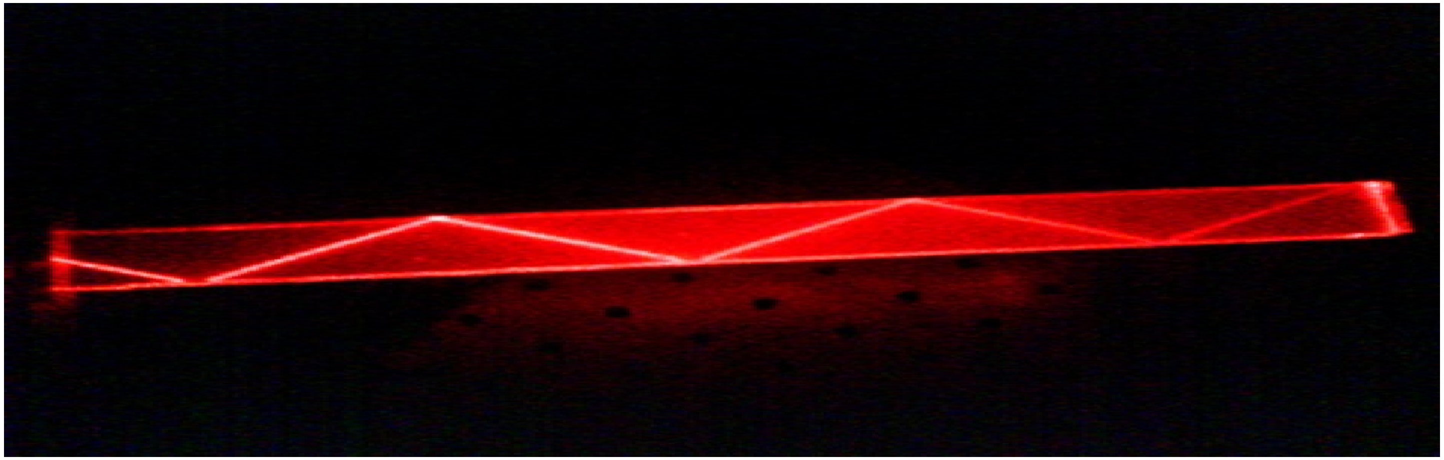
  $$\sin(\alpha_1)/\sin(\alpha_2) = n_2/n_1$$

- When reaching a critical angle, total reflection occurs

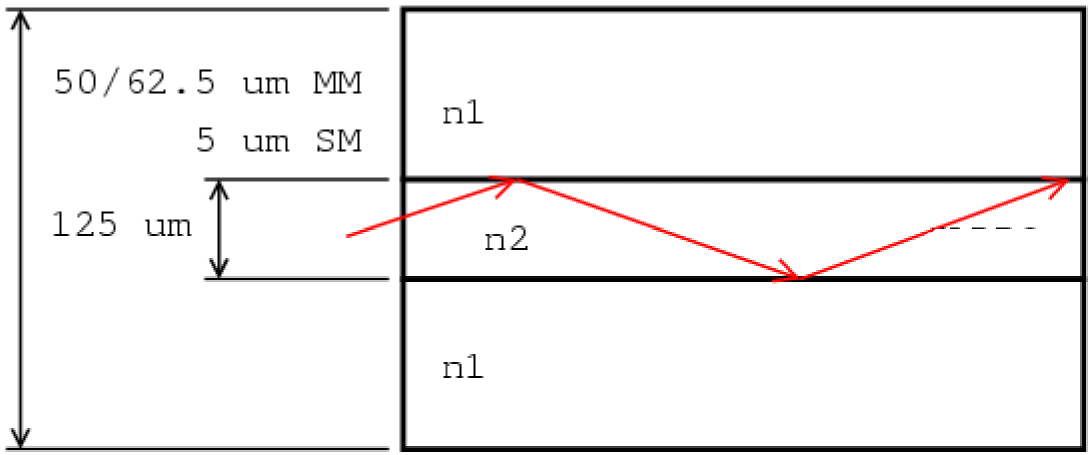


Propagation of an Optical Signal in a Multimode Optical Fiber (1)



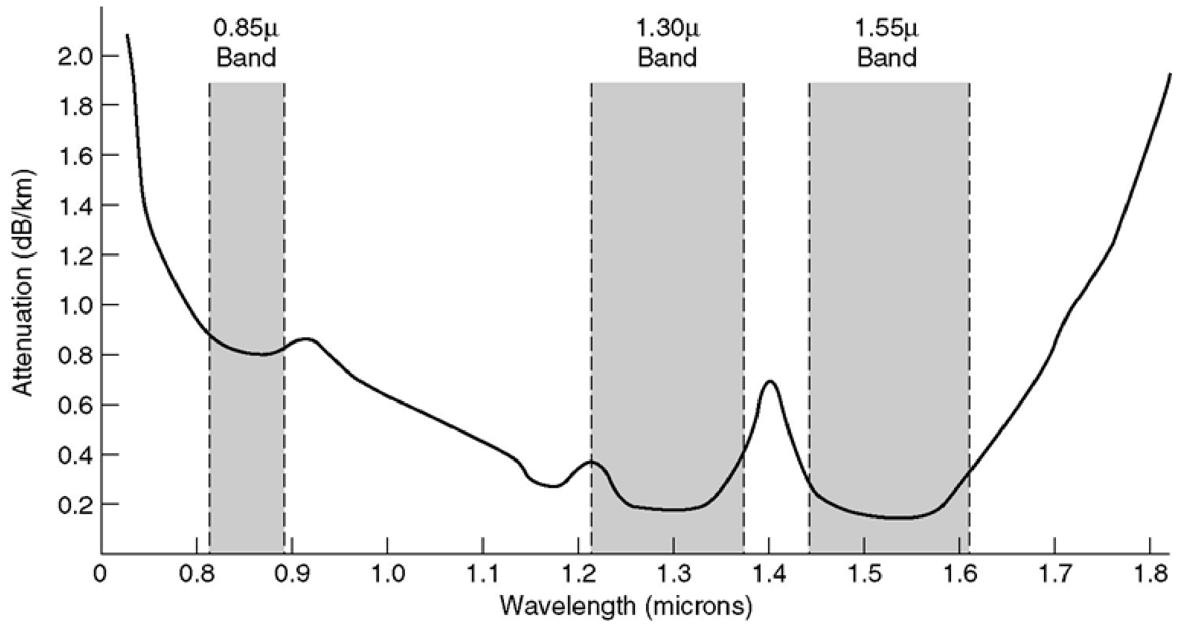


Propagation of an Optical Signal in a Multimode Optical Fiber (2)



Numerical aperture – range of angles over which the system can accept the light.

Utilizable Frequency Ranges of the Optical Fiber



- The chosen frequency has to be compatible with technology of production of light sources and detectors (LEDs, PIN photodiodes)
- Multiple ranges may be used in parallel (WDM/DWDM systems)

Limitations of the Optical Fiber

- Just the 2-level data encoding
  - light/darkness

- Attenuation is not the main issue

- The main cause of the bit rate limitation is the dispersion that causes the deformation of (a rectangular) signal may lead to overlapping of the neighboring pulses

The Chromatic Dispersion

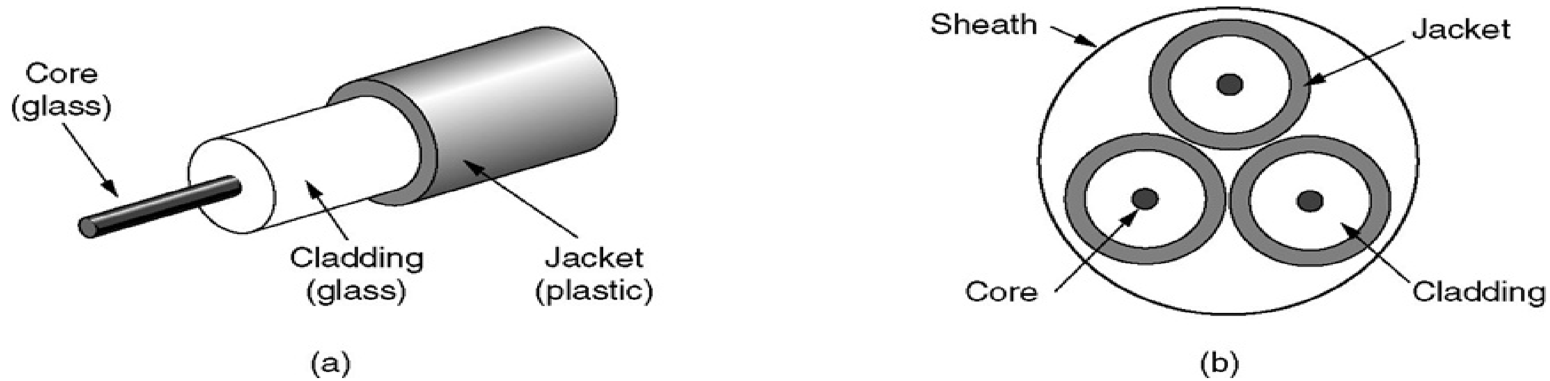
- Various frequencies travel with various speeds
- We try to use light sources with a narrow band of frequencies of the emitted light (laser)

The Modal Dispersion

- Multiple light rays enter the fiber under various angles to the fiber axis
- Each of them then reflects within a fiber under a different angle
- Paths of the rays have different lengths, that causes a delay skew and thus the deformation of the received signal
    - Can be reduced by gradient-index fiber in that rays follow sinusoidal paths

=> can be avoided by usage of the single-mode fibers

Optical Fiber Cables



- Cable contains at least 2 fibers
  - commonly more for future use
- Polymer strength members
- Various cable types
  - MM, SM, WDM, DWDM, ...
  - indoor/outdoor
  - for horizontal/vertical mounting
  - …

Joining of Optical fibers (1)

- Fiber cleaving

- Fusion splicing, mechanical splicing
  - Splice protectors
- The handling is easier for MMF due to the higher diameter of the core
  - the higher absolute deviation does not cause so much loss as with SMF

Joining of Optical fibers (2)

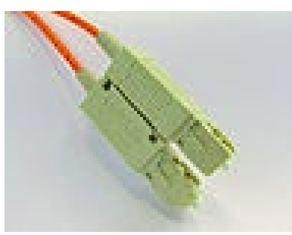
- Mechanical Splice

- Fusion Splicer

Optical Connectors

- ST, SC, FC, LC, MT-RJ and others
  See: http://en.wikipedia.org/wiki/Optical_fiber_connector

- Commonly available as a prefabricated pigtails



Structured Cabling

Structured Cabling

- Originally, various network technologies required different cabling
- Today, we use a generic cabling system that is independent on the application and the particular network technology
  - designed and installed at the building without a knowledge of particular networking technologies
    - the same philosophy as with power cabling
    - expected operating life of ca 15 years

- Integrates various services
  - telephony, LAN, alarm system, …

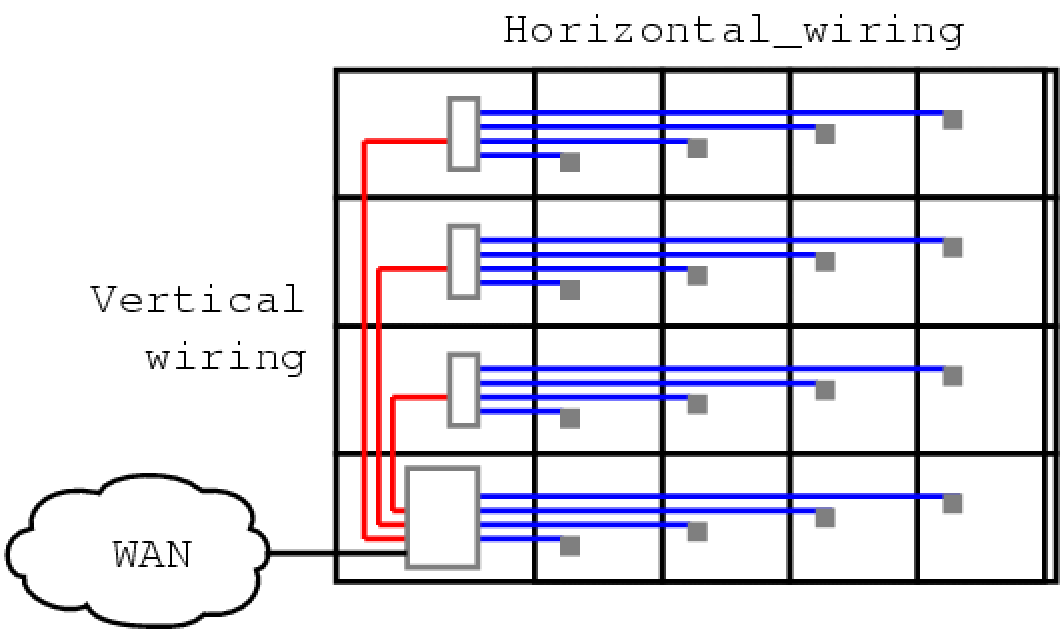
Advantages of the Generic Cabling System

- The network technology can be upgraded in the future without changes in the cabling
- Changes in the network may be accomplished rather easily
  - as the cabling structure is general
    - The installation investment is little bit higher compaed to the ad-hoc cabling designated just for the current needs

Structured Cabling Standards

- Commercial Building Wiring Standard
  - EIA/TIA 568 – now ANSI/TIA-568-D, EN 50173
- The similar standard exists for residential buildings
  - TIA 570-A-1998, now ANSI/TIA-570-D
- Defines general terminology, topology, cable types, cable lengths, connectors and other cabling system components

Basic Terminology of the Structured Cabling System



- Horizontal and Backbone cabling
- Telecommunication Closet (TC)
- Main Crossconnect (MC)
- Point of Presence (POP)
  - a demarcation point between the building and the connection provider

Horizontal Cabling: Selected basic requirements for copper cables

- At least UTP Cat 5E/6A nowadays depending on the standard
- RJ-45 connectors, defined wiremaps
- 100m maximum distance between active network devices
    - 90 + 3 + 6 m
- at least 2 outlets per 10m^2 of the office area
    - much more are necessary in practice nowadays

Usage of the Structured Cabling

Network devices and stations may be interconnected in a flexible manner using patch cords on appropriate patch panels