University of Nottingham
UK | CHINA | MALAYSIA

COMPUTER NETWORKS

AY2022-2023 Spring Semester

COMP1047 Systems & Architecture

Ying Weng

Computer Networks Part-4. Transmission Media

Transmission Media

Concept of a Channel

- **In order to communicate, a number of channels are employed to deliver services to the users**
- **In terms of the physics underlining propagation channels are divided into two categories**

Unguided wave channels

audio channel
atmospheric channel
free space channel

} *Propagation through wave diffraction*

Guided wave channels

twisted wire pairs
coaxial cables
optical fibre cables

} *Propagation through wave guidance*

Twisted Pair Cables

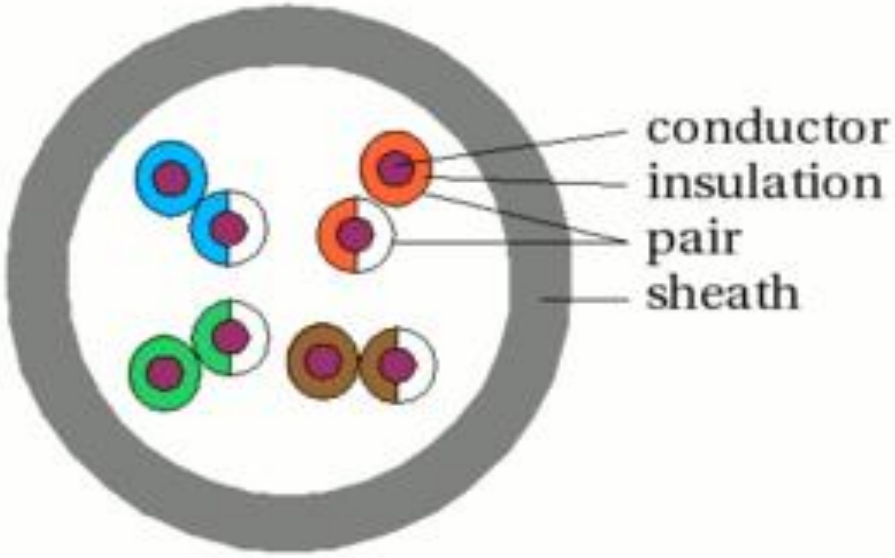
- This is perhaps to most wide spread medium in the world.
- A thin-diameter wire (22 to 26 gauge) commonly used for telephone and network cabling.
- The wires are twisted around each other to minimize interference from other twisted pairs in the cable(Alexander Graham Bell invented this and was awarded a patent for it in 1881).
- The actual diameter for the AWG (American Wire Gauge) 22 to 26 is given below:

AWG	Diameter (inch)	Diameter (mm)	Stranded metric equivalent	AWG	Diameter (inch)	Diameter (mm)	Stranded metric equivalent
22	0.0253	0.6438	7/0/25	**25**	0.0179	0.4547	
23	0.0226	0.5733		**26**	0.0159	0.4049	7/0.15
24	0.0201	0.5106	1/0.5, 7/0.2, 30/0.1				

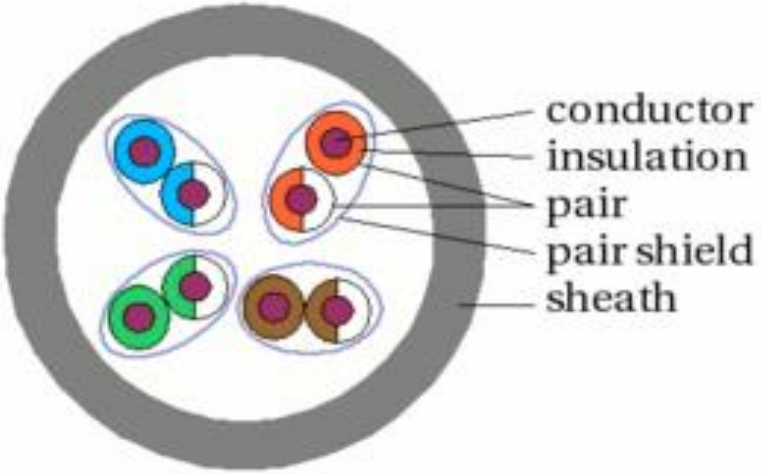
Twisted Pair Cables

There is a large number of variants and the most important are the unshielded and shielded cables.

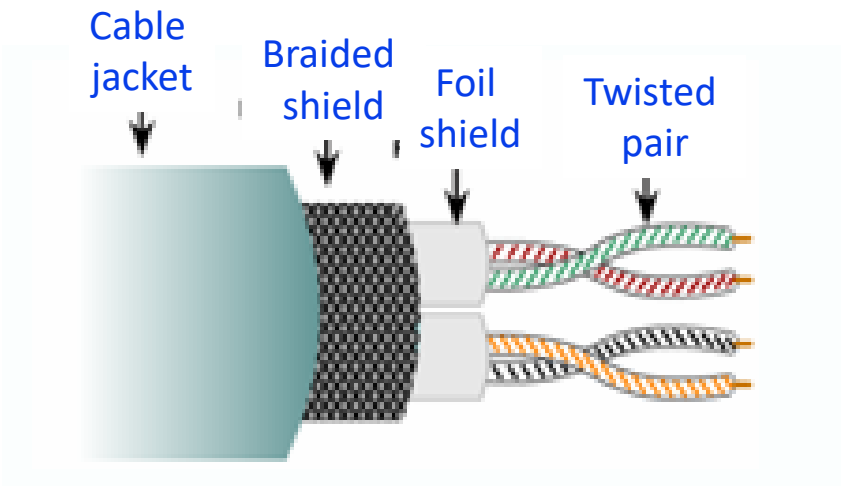
UTP Unshielded Twisted Pair



STP Shielded Twisted Pair



Twisted Pair Cables



- A view of a shielded and screened twisted pair.

Twisted Pair Cables

The features of channels

❑ Twisted Pair Cables

○ From the transmission view point, the parameters will influence the performance are

[1] DC resistance

- This is the resistance provided by the twisted pair for very low frequencies, essentially DC.
- This quantity is useful for identifying faults and maintaining the connection between the central office (CO) and the subscribers.
- It also known as Loop Resistance and expressed in ohms/ mile or km.

[2] Impedance

- This is the *complex resistance* provided by the twisted pair over a range of frequencies.
- It is a measure of the ability of the twisted pair to propagate the signal energy without reflections (losses).

Twisted Pair Cables

The performance and use of twisted pair cables

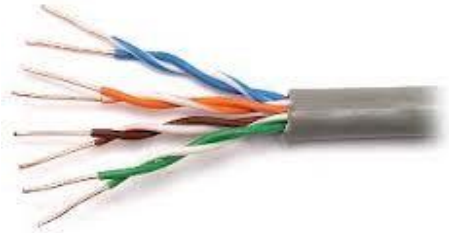
ANSI Category	Maximum data rate	Usual application
CAT 1	Up to 1 Mbit/s (1 MHz)	Analogue voice (POTS) Integrated Services Digital networks. Basic Rate Interface in ISDN Doorbell wiring
CAT 2	4 Mbps	Mainly used in the IBM Cabling System for Token Ring networks
CAT 3	16 Mbps	Voice and data on 1-BASE-T Ethernet
CAT 4	20 Mbps	Used in 16 Mbps Token Ring Otherwise not used much
CAT 5	100 Mbps 1000 Mbps (4 pair)	100 Mbps TPDDI 155 Mbps ATM
CAT 5E (ISO Class D)		100 Mbps TPDDI 155 Mbps ATM
CAT 6 (ISO Class E)	Up to 400 MHz	Super-fast broadband applications (proposed standard). Used with GigE (1000 Mbps or 1 Gbps)
CAT 7 (ISO Class F)	600-700 MHz	Even faster broadband applications (proposed standard)

Twisted Pair Cables

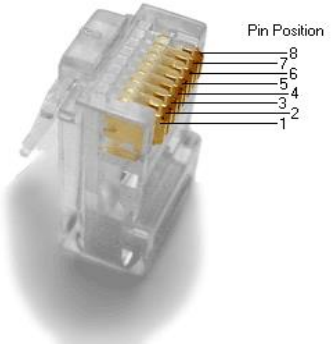
Cat-5 Cable

One of the most common types of twisted pair cable is category 5 (Cat 5).

- Typically used in structured cabling for computer networks such as Ethernet.
- Suitable for Fast Ethernet (100Mb/s) and Gigabit Ethernet (1Gb/s) [4 pairs]
- Standards exist for cables made of Cat-5 cable (e.g. Using a 8P8C plug supporting 4 twisted pairs)



8 conductor, 4 pair, 100Ω Cat-5 cable



8P8C Modular Plug

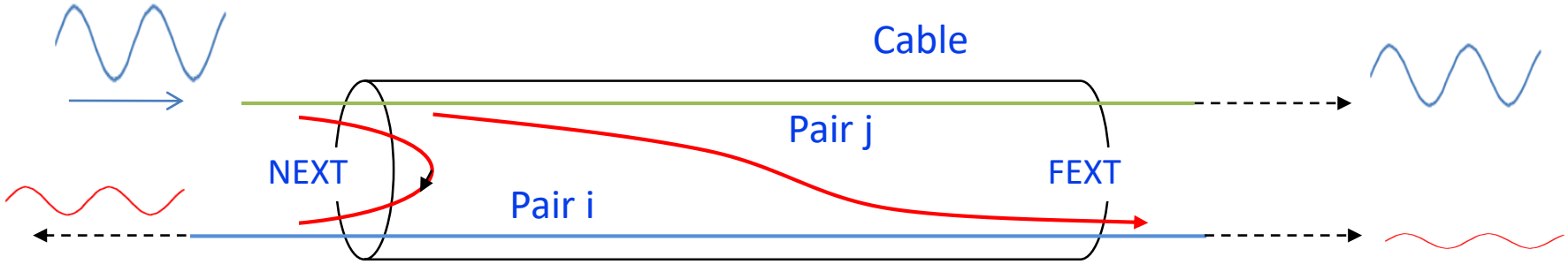
Standardised Cat-5 cable

Twisted Pair Cables - Crosstalk

There are two classes if interference;

Near End Crosstalk,(NEXT), and Far End Crosstalk, (FEXT).

The design, manufacture and installation of twisted pair cables aim at minimising both.



The crosstalk to pair i due to pair j.

A similar situation exists for crosstalk on pair j from pair i

Twisted Pair Cables

Advantages

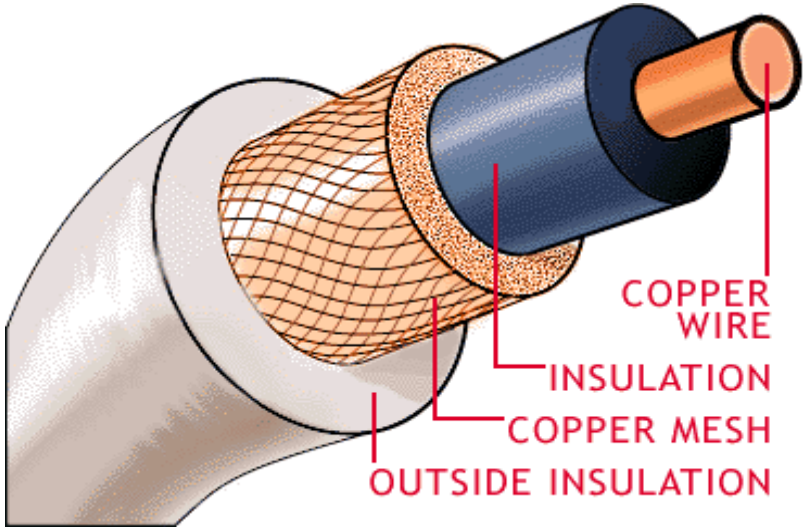
- It is a thin flexible cable and easy to use.
- Most new buildings come with CAT5 UTP already wired into the building structure or run between floors.
- UTP is small so it does not fill up the wiring ducts.
- UTP cost is less per unit that any other type of LAN cable.

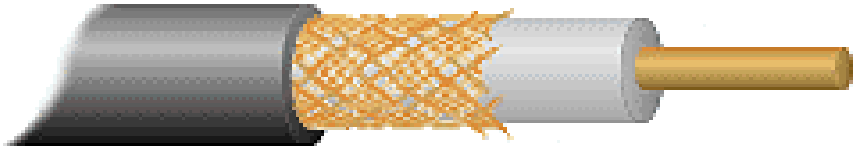
Disadvantages

- The susceptibility of twisted pair to electromagnetic radiation depends on the twisting schemes staying intact during installation.
- Because of this feature twisted pairs have stringent requirements for maximum pulling tension as well as minimum bend radius.
- The fragility of twisted pair cables makes the installation practices very important.

Coaxial Cables

- This is the first broadband medium that was introduced at the end of 1936 between New York and Philadelphia.
- The first “regular” installation connected Minneapolis, Minn., and Stevens Point, Wis., in 1941. This L1 coaxial-cable system could carry 480 telephone conversations or one television program.
- In UK the first coaxial was installed in 1936 carrying 40 channels between London and Birmingham.





A typical coaxial cable

Coaxial Cables

❑ Coaxial cable losses

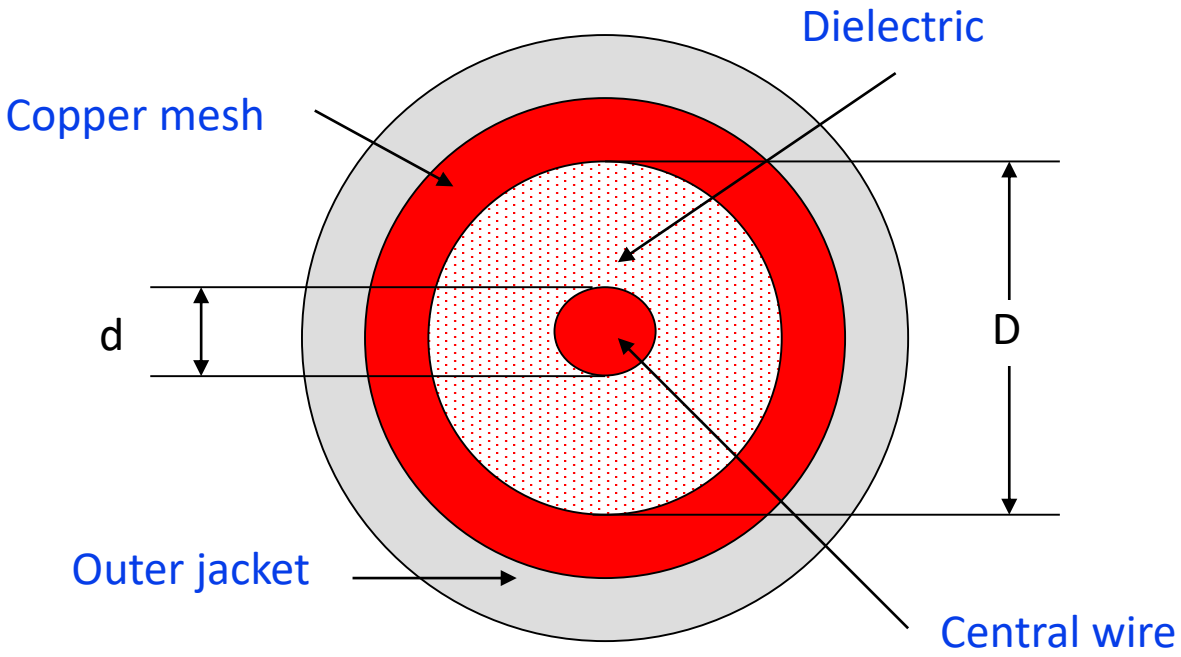
- The power loss caused by a coax cable is referred to as attenuation. It is defined in terms of decibels per unit length, and at a given frequency. Obviously the longer the coax cable, the greater the loss, but it is also found that the loss is frequency dependent, broadly rising with frequency, although the actual level of loss is not linearly dependent upon the frequency.
- For virtually all applications the minimum level of loss is required. The power is lost in a variety of ways:

✓ Resistive loss
✓ Dielectric loss
✓ Radiated loss

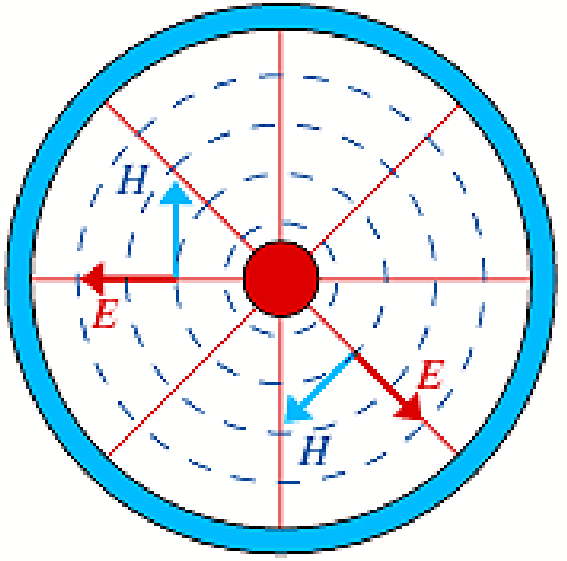
- Of all these forms of loss, the radiated loss is generally the least important as only a very small amount of power is generally radiated from the cable. Accordingly most of the focus on reducing loss is placed onto the conductive and dielectric losses.

Coaxial Cables

Coaxial Cable



Cross section of a coaxial cable



The field pattern of a coaxial cable; mode TM01

Fibre To The x - FTTx

- The demand for more and more bandwidth has continue unabated
- The question therefore is *where do we go from here?*

Fibre To The x - FTTx

- The medium that will replace copper must have strong attributes especially to be *future proofed*
- No matter what the future requirements on bandwidth will be the medium should be able to support the services
- *At this moment in time the only medium that provide an element of confidence for the future is the optical fibre*

Optical Fibres

- This technology is the ultimate at the moment in terms broad bandwidth and low loss.
- Optical fibre cables are now extensively used in long distance transmission systems (MANs and long-haul transmission).
- The main application where the fibre is still not extensively used in some countries is the access network, so called Fibre To The x (FTTx).

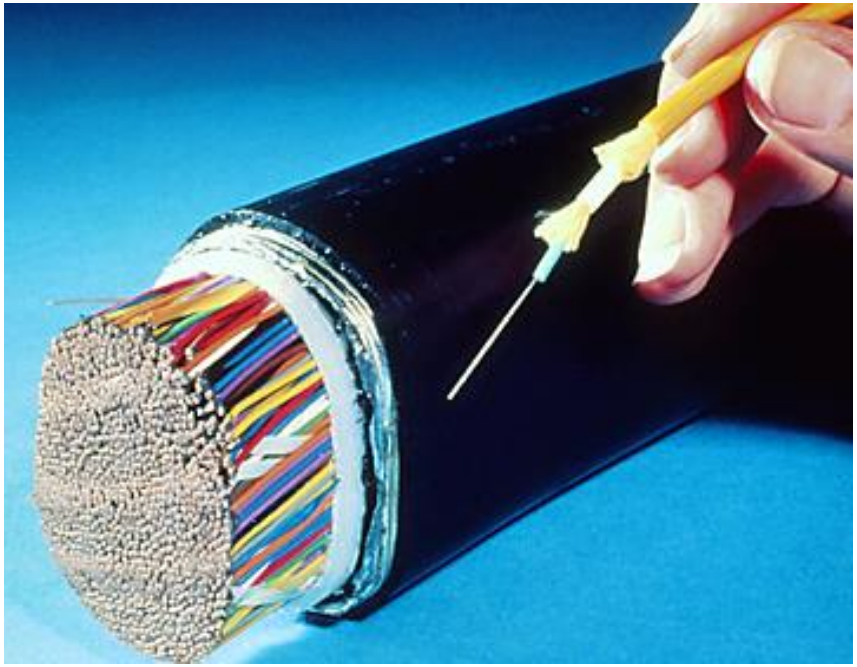
Fibre To The x - FTTx

- The industry today has earmarked the penetration of fibre into the access network as "*FTTx*" (Fibre To The x)
- The FTTx covers a number of technologies and protocols
  - For example: some of today's digital subscriber line (DSL) and hybrid fibre coax (HFC) networks qualify as FTTx networks due to their use of fibre in the access, as does a passive optical network (PON)
  - Hence, it is best when referring to a deep fibre penetration network to refer to its actual architecture
- The most common architectures are
  - ***FTTHome*** (***FTTH***)
  - ***FTTBuilding*** (***FTTB***)
  - ***FTTCurb*** (***FTTC***)
  - ***FTTNode*** (***FTTN***)

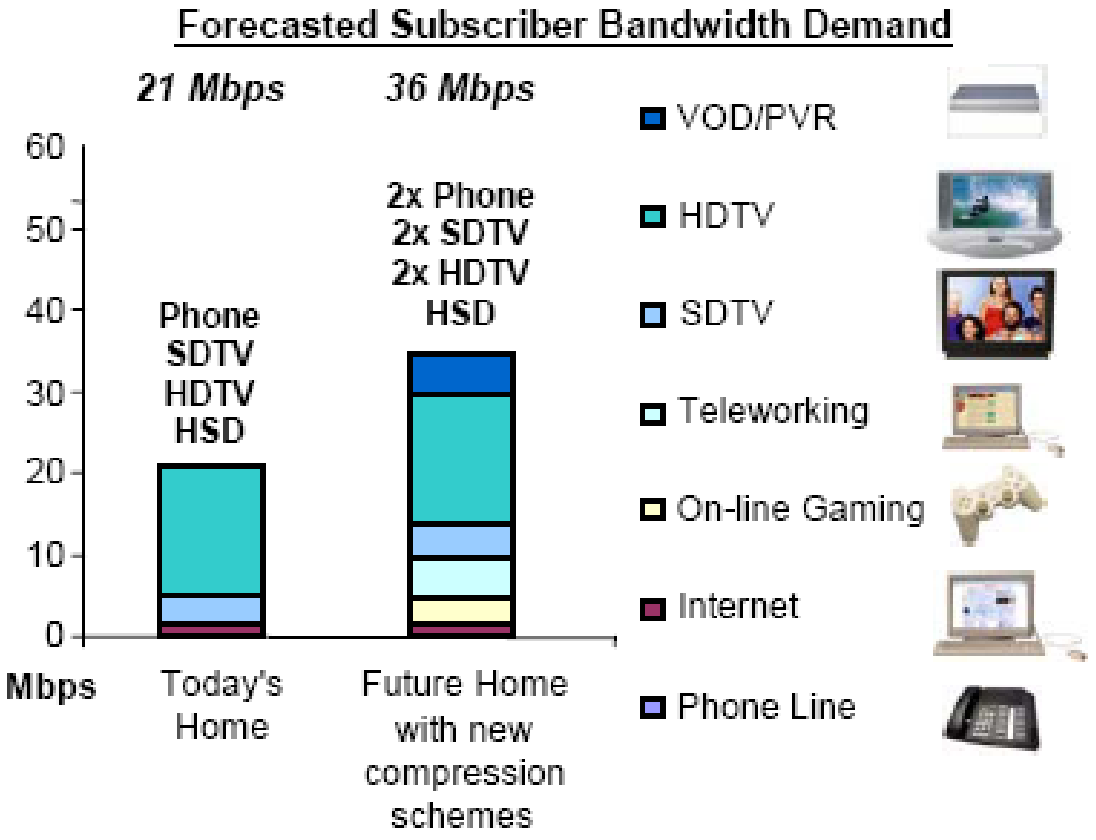
Fibre To The x - FTTx

The question of size !!!

- A single copper pair is capable of carrying 6 phone calls
- A single fibre pair is capable of carrying over 2.5 million simultaneous phone calls (64 channels at 2.5 Gb/s)
- A fibre optic cable with the same information-carrying capacity (bandwidth) as a comparable copper cable is less than 1% of both the size and weight



Fibre To The x - FTTx

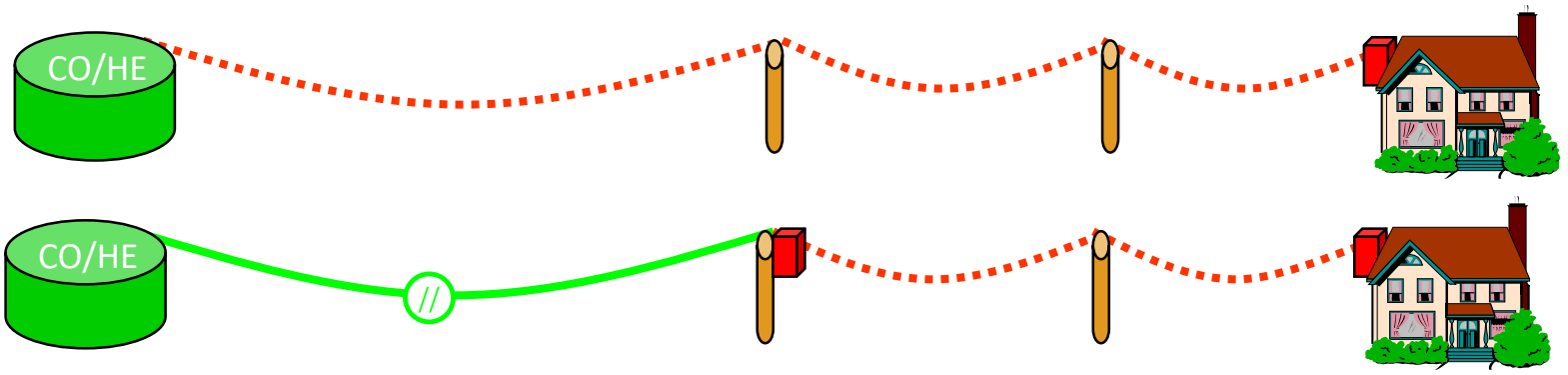


- The projected bandwidth requirements for home services .

VOD: video on demand
SDTV: standard definition television
HSD: high speed data

PVR: personal video recorder
HDTV: high definition television

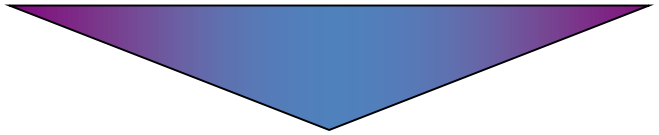
Fibre To The x - FTTx

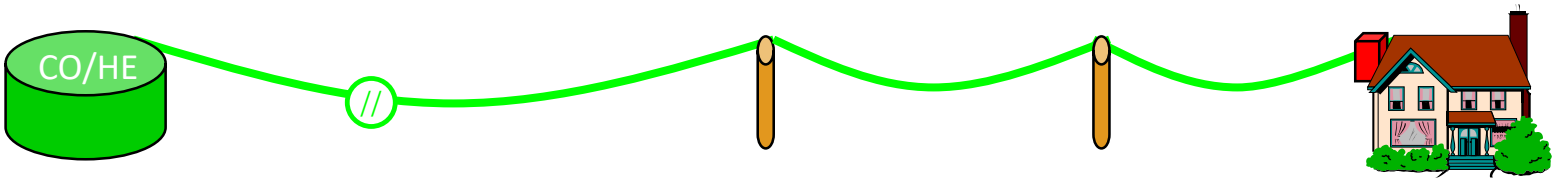


Old networks: optimised for voice

24 kbps - 1.5 Mbps

Note: network may be aerial or burried. The figure refers to an aerial network.



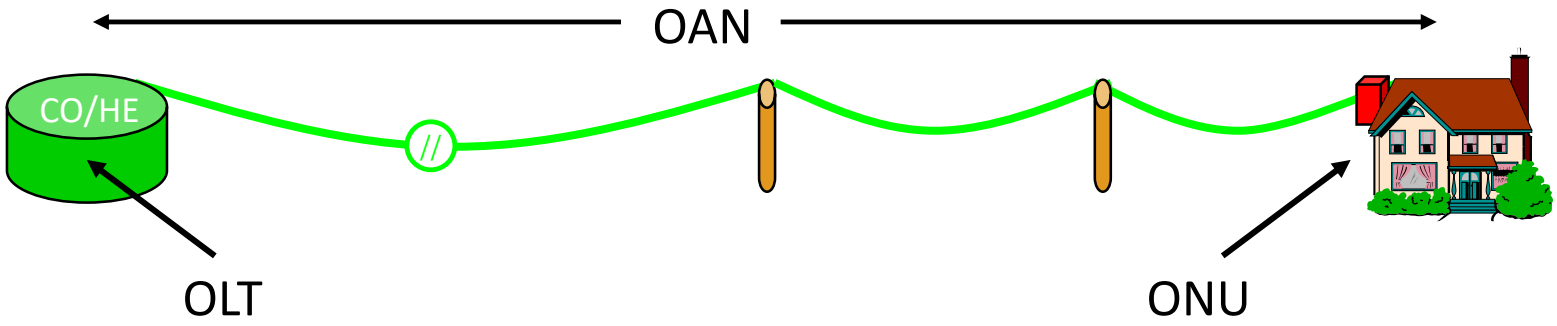


Optical networks: optimised for voice, video and data

19 Mbps - 1 Gbps +

CO/HE: central office/ head end

Fibre To The x - FTTx



- An OAN in which the ONU is on or within the customer's premise
- Although the first installed capacity of a FTTH network varies, the *upgrade capacity of a FTTH network exceeds all other transmission media*

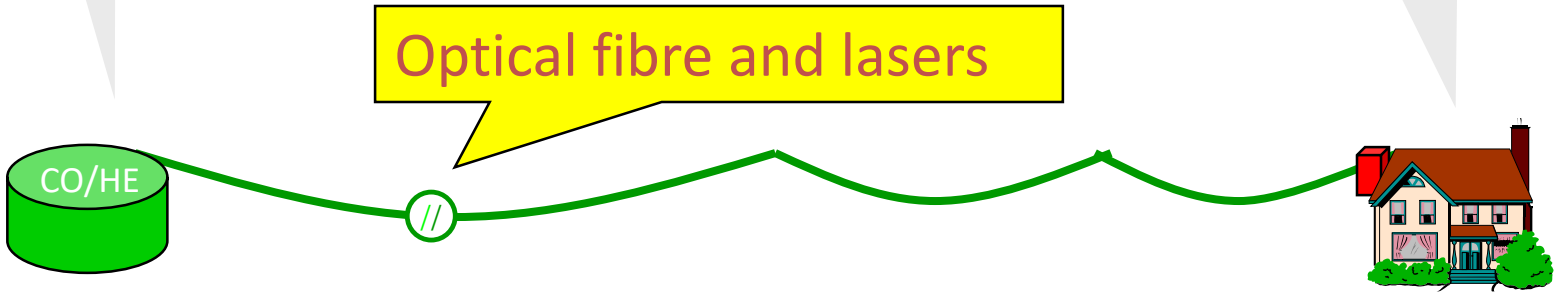
OAN: Optical Access Network *ONU: Optical Network Unit* *OLT: Optical Line Termination*

Fibre To The x - FTTx

Transport
- ATM?
- Ethernet?

Philosophy
- Retail
- Wholesale

Architecture (Electronics)
- PON?
- Active node?
- Hybrid?



Technical considerations

PON: passive optical network

Fibre To The x - FTTx

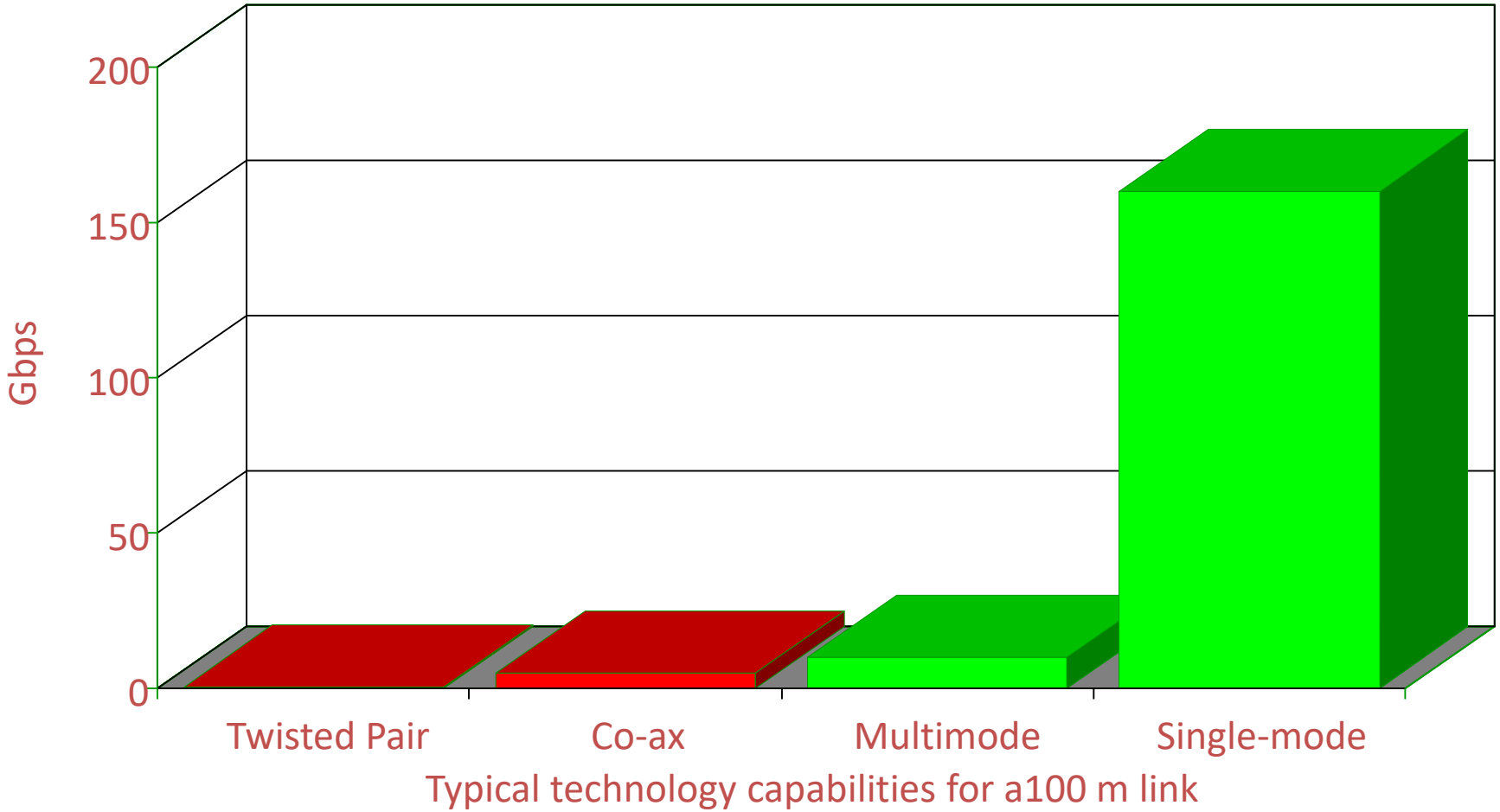
❑ *Features of optical fibre*

- *Enormous information carrying capacity*
- *Easily upgradeable*
- *Ease of installation*
- *Allows fully symmetric services*
- *Reduced operations and maintenance costs*

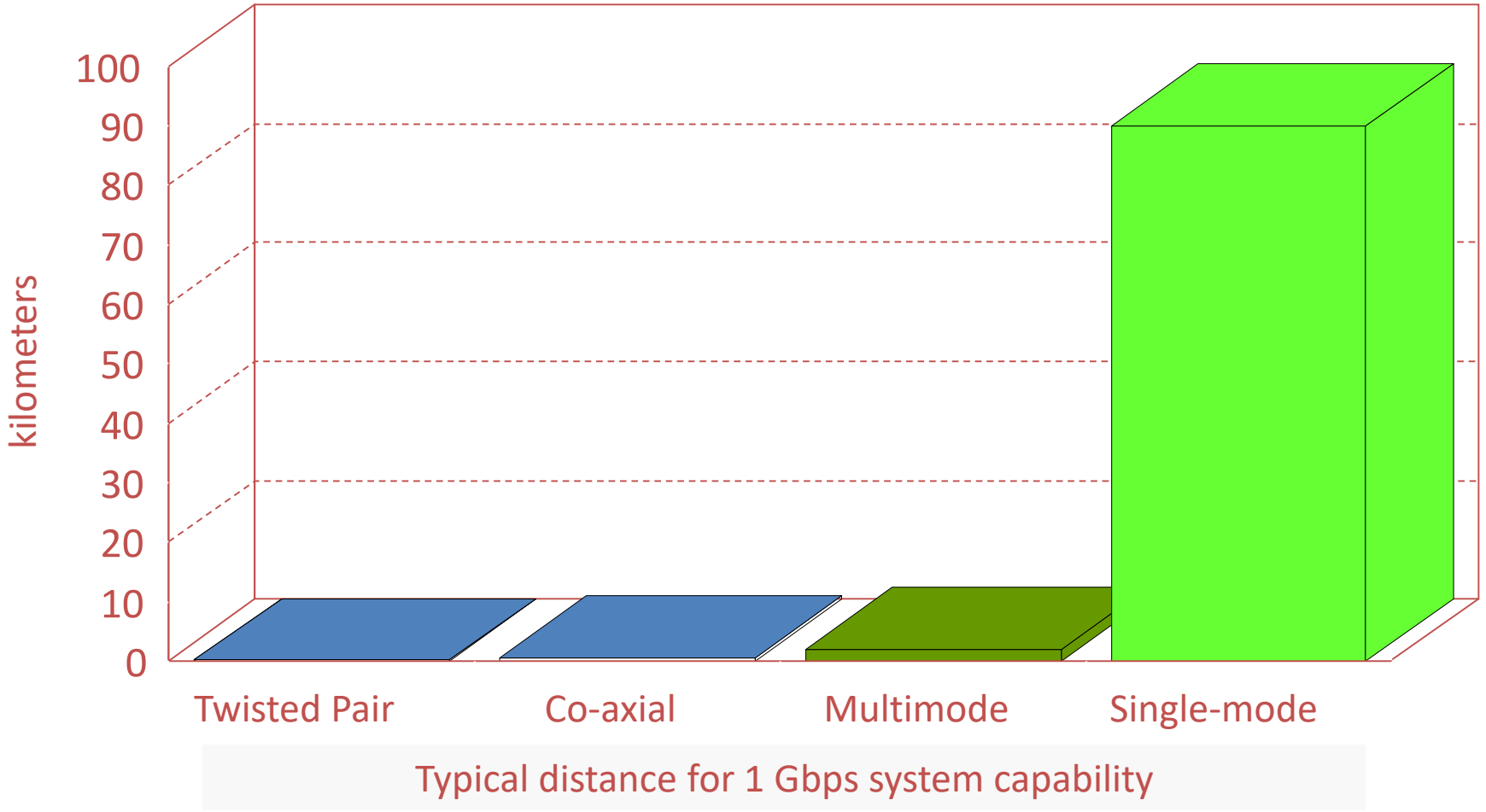
❑ Benefits of optical fibre

- Very long distance
- Very less signal attenuation
- Strong, flexible, reliable
- Allows small diameter and light weight cables
- Secure
- Immune to EMI (electromagnetic interference)

Fibre To The x - FTTx

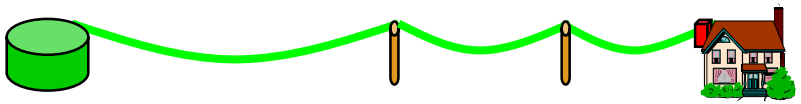


Fibre To The x - FTTx



Fibre To The x - FTTx

The differences between the two key technologies



- Glass
  - Uses light for transmission
  - Transparent
  - Dielectric material-nonconductive
  - EMI immune
  - Low thermal expansion
  - Brittle, rigid material
  - Chemically stable

- Copper
  - Uses electricity for transmission
  - Opaque
  - Electrically conductive material
  - Susceptible to EMI
  - High thermal expansion
  - Ductile material
  - Subject to corrosion and galvanic reactions

EMI: Electromagnetic Interference


Thank you