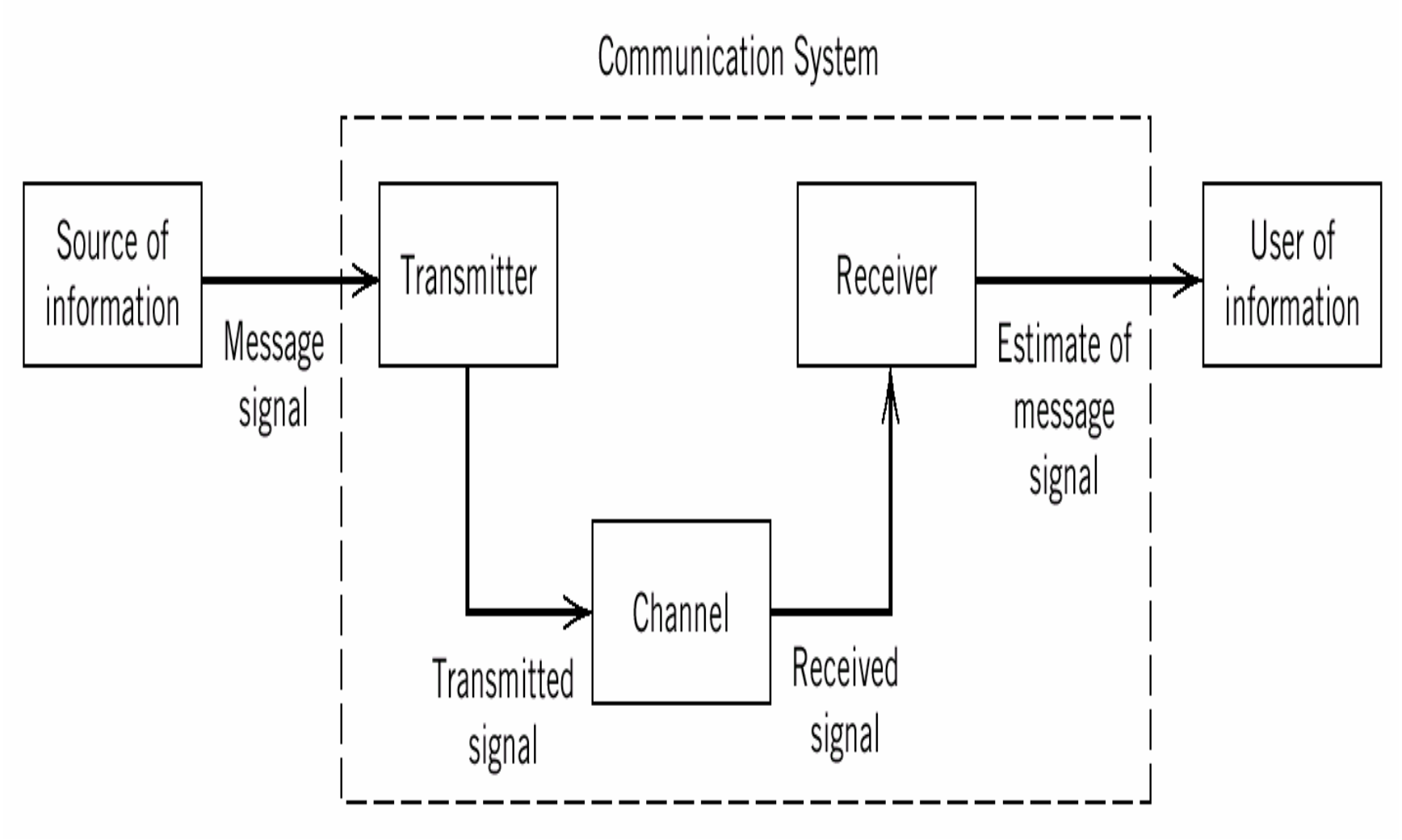
Optical fiber communications

Topics

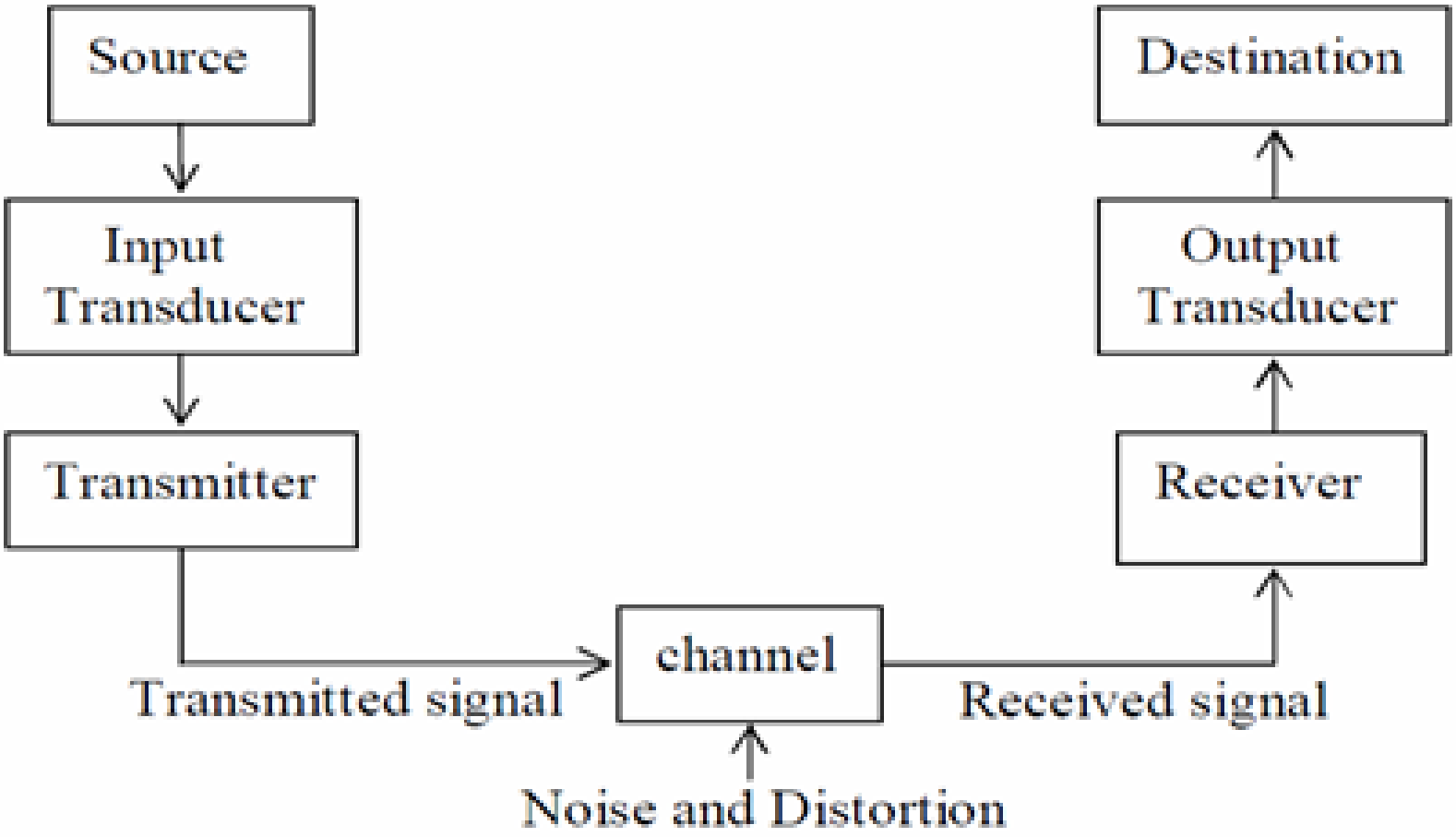
- What is optical fiber?
- Typical block diagram of communication system.
- Communication channel types.
- Advantages and disadvantages of optical fiber.
- Comparison between optical fiber as transmission media and copper based transmission media.
- Optical fiber structure.
- FTTx schemes.
- SEA ME WE series.

Typical block diagram of communication system

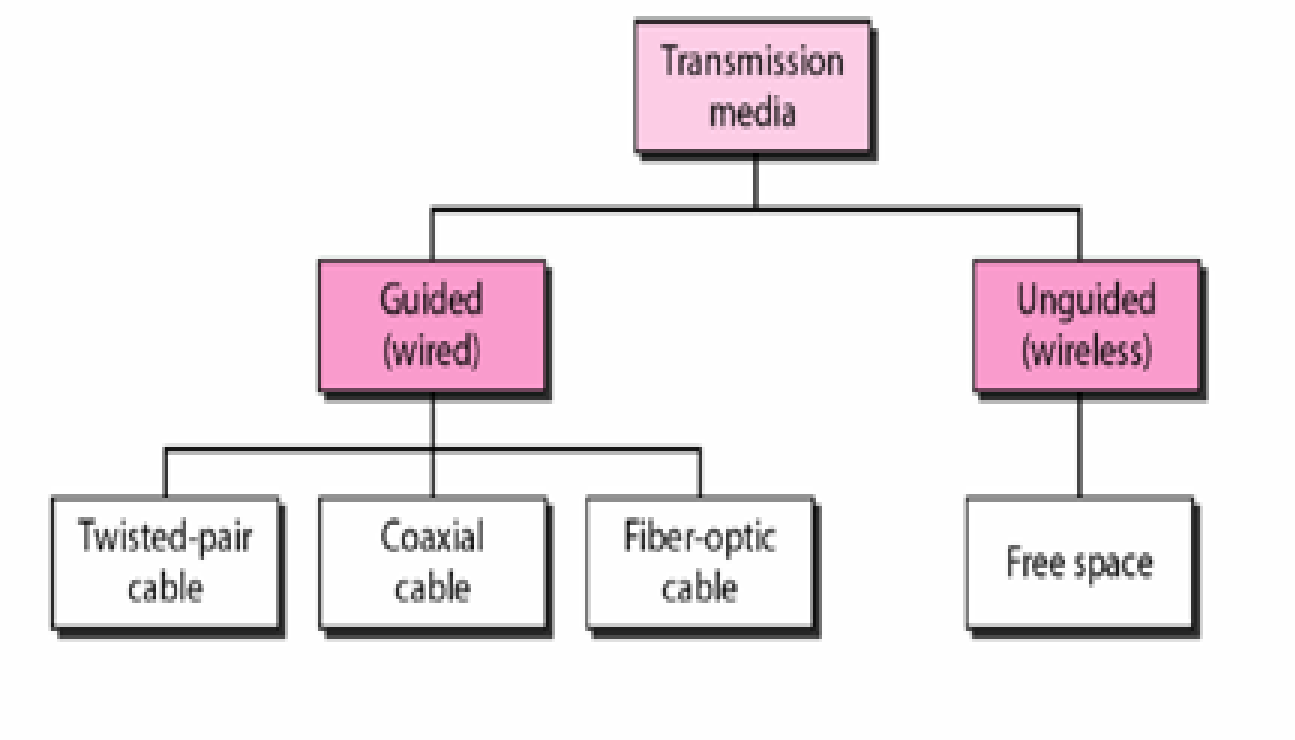
Typical block diagram of communication system



Typical block diagram of electrical communication system



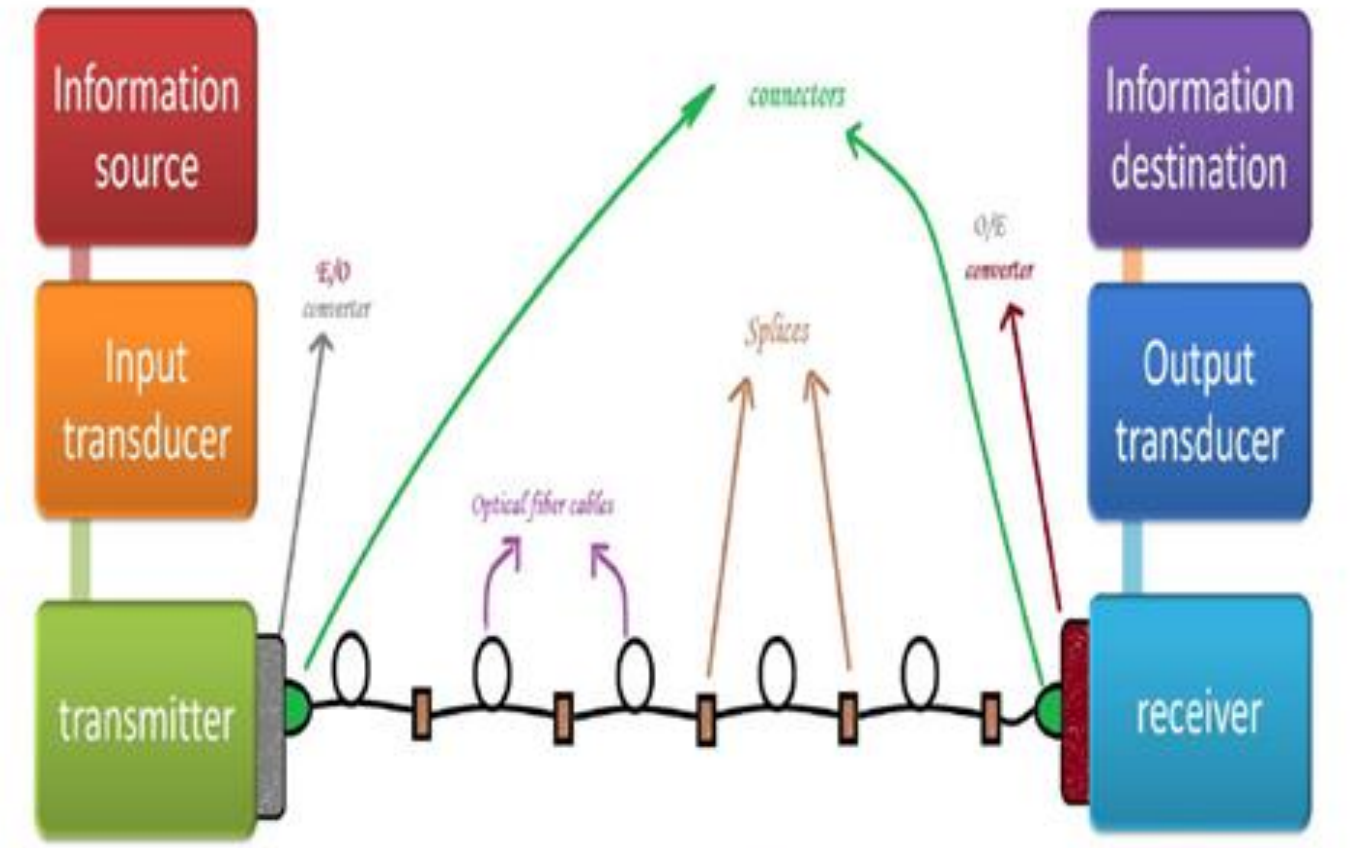
Communication Channel Types



What is optical fibers?

Optical fiber is **transmission medium** made of glass i.e. silica with **cladding** with a material of a little lower refractive index. The refractive index of the **core** is increased by doping the silica with GeO2. The cladding is pure silica. A plastic **cover** is utilized to protect the fiber from moisture and abrasion. Optical fiber carry information from one point to another in the form of **light**.

Typical block diagram of optical fiber communication system



Typical block diagram of an optical fiber communication system

Advantages of optical fiber

- **Low transmission loss and Long distance signal transmission** Optical fiber has low transmission loss **(0.2dB/km)** while copper is **(0.2dB/m).** This means that optical fiber can reach a very long distance up to 200 km without need of repeaters.
- **Light weight and small size** Optical fibers are small in size and lighter in weight while copper based cables are bulky and heavy weight.

Advantages of optical fiber

- **Large Bandwidth** Optical fibers have higher bandwidth than copper pairs based cables. Thus, Optical fibers can transmit more information than copper based cables. Thus, its capacity is a lot higher than copper based cables.
- **Signal Security:** Optical fibers Cables are more secure and can not be tapped while copper based cables are easy to be tapped.

Advantages of optical fiber

- **Immunity to electromagnetic interference (EMI) and no crosstalk:** Optical fibers are invulnerable to noises and immune to electromagnetic interference. No flash risks are available since they are made of dielectric. They are more erosion safe than copper cables.
- Optical fiber is made of **abundant and cheap raw material**. Glass (made of sand) which is the material used in optical fibers is cheaper than copper.

Advantages of optical fiber

- Optical fiber is **more resistive to environmental extremes**. They can operate over long temperature variations.

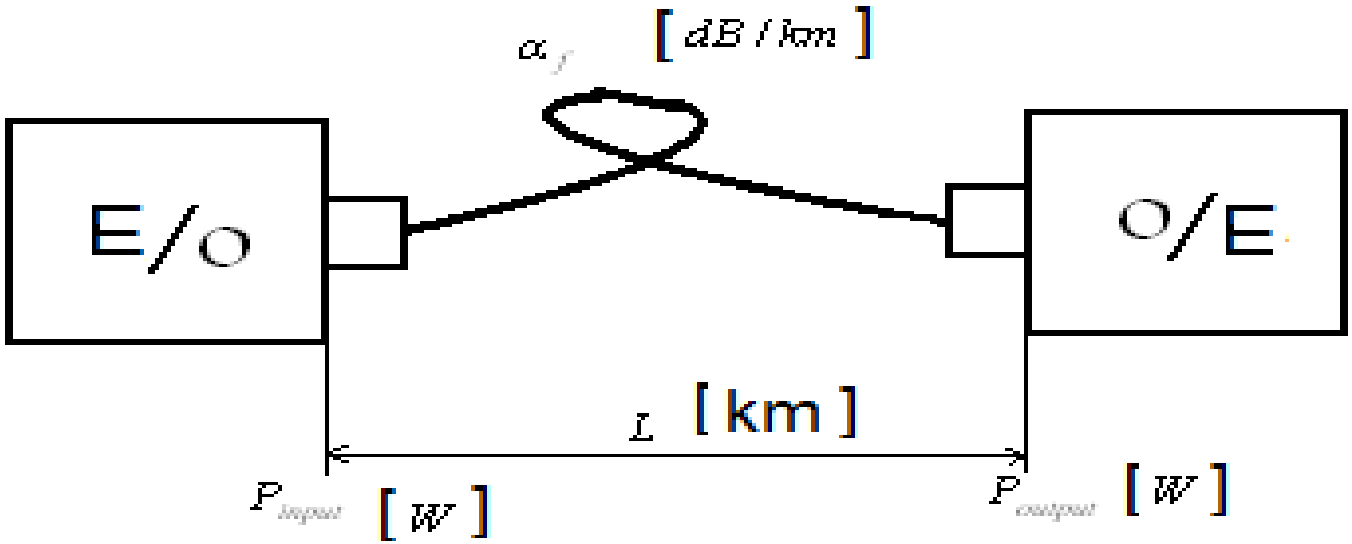
Disadvantages of optical fiber

- Optical fiber needs care when handling or maintained.
- Optical fiber requires expensive equipment for interfacing and specialized tools for maintenance and repairing.

Comparison between optical fiber as transmission medium and copper based transmission media

P.O.C.	Optical fiber(O.F.)	Copper based transmission media
Transmission loss	Lower(0.2 dB /km)	Higher (0.2 dB/m)
Economic	More economic	Less economic
Size	Smaller size	Bulky
Weight	Light weight	Heavy weight
Bandwidth	Huge(large)	Less (narrow)
Data rate	Higher	Lower
Capacity	Higher	Lower
Feasibility to be stolen	Not feasible to be stolen	Feasible to be stolen
Security	More secure(difficult to be tapped)	Not secure(easy to be tapped)

Calculation of attenuation in optical fiber communication link



Signal degradation in optical fiber

$$\alpha_t = \alpha_f L + (n-1)\alpha_s + 2\alpha_c + \alpha_{ICL} + \alpha_{OCL}$$

Where

α_t is total attenuation (dB)

α_f is optical fiber attenuation coefficient(dB/km).

L is optical fiber link length(km).

n is number of sections.

α_s is splice attenuation coefficient(dB/splice).

α_c is connector attenuation coefficient(dB/ connector)

$\alpha_J = \alpha_C + \alpha_S$

α_j is joint attenuation coefficient(dB/ joint)

α_{ICL} is input coupling loss (ICL)(dB).

α_{OCL} is output coupling loss (OCL)(dB).

Signal degradation in optical fiber

$$\alpha_t = 10\log\frac{P_{in}}{P_{out}} = P_{in}\big|_{dBm} - P_{out}\big|_{dBm}$$

α_t is total attenuation.

P_{in} is input optical power launched into optical fiber by transmitter.

P_{out} is output optical power at the receiver.

Bell and decibel units

Bell and deciBel units are used to deal with very large quantities and very small quantities since multiplication is changed into addition and division is changed into subtraction

$$Bel = \log\frac{P_1}{P_2}$$

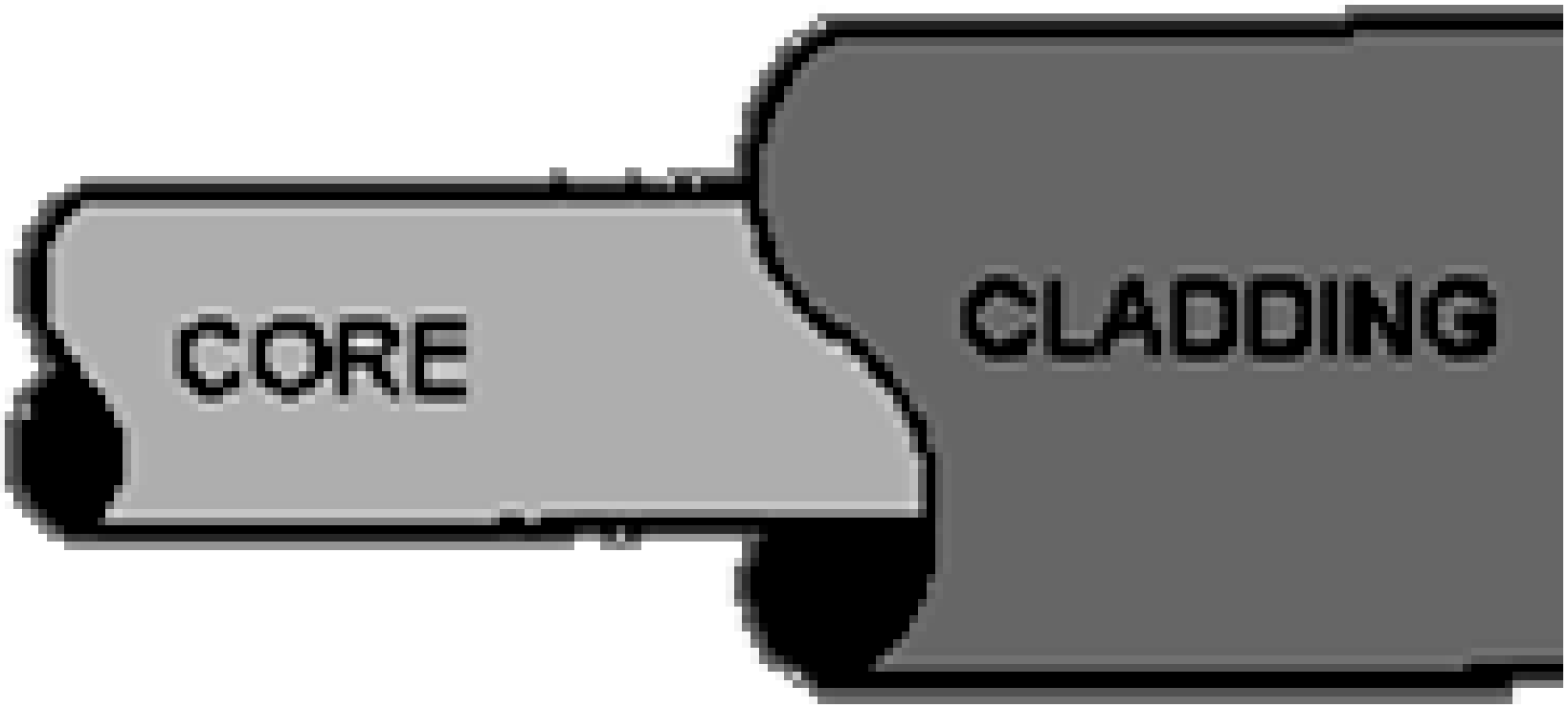
$$dB = 10\log\frac{P_1}{P_2}$$

$$dB_W = 10\log\frac{P}{1W}$$

$$dB_m = 10\log\frac{P}{1mW}$$

P	100 m W	10 m W	2 m W	1 m W	0.5 mW	0.1 m W	0.01 m W	0.001 m W
dB_m	20	10	+3	0	-3	-10	-20	-30

Optical fiber structure



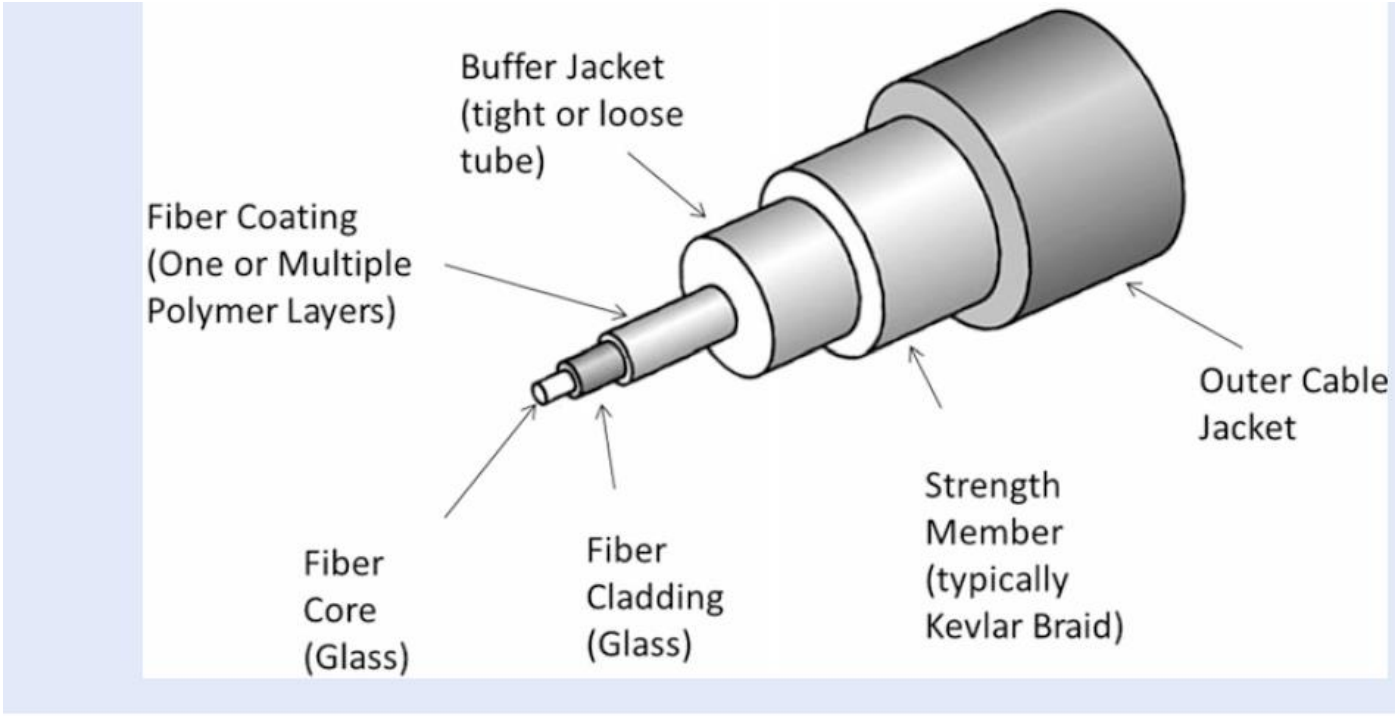
Optical fiber structure

The optical fiber cable is made of the following:

Core: physical medium that transmits light signals from transmitter to receiver. The core is either made of glass whose width is in microns. The bigger the core, the more light the cable can convey, which increases the transfer rate.

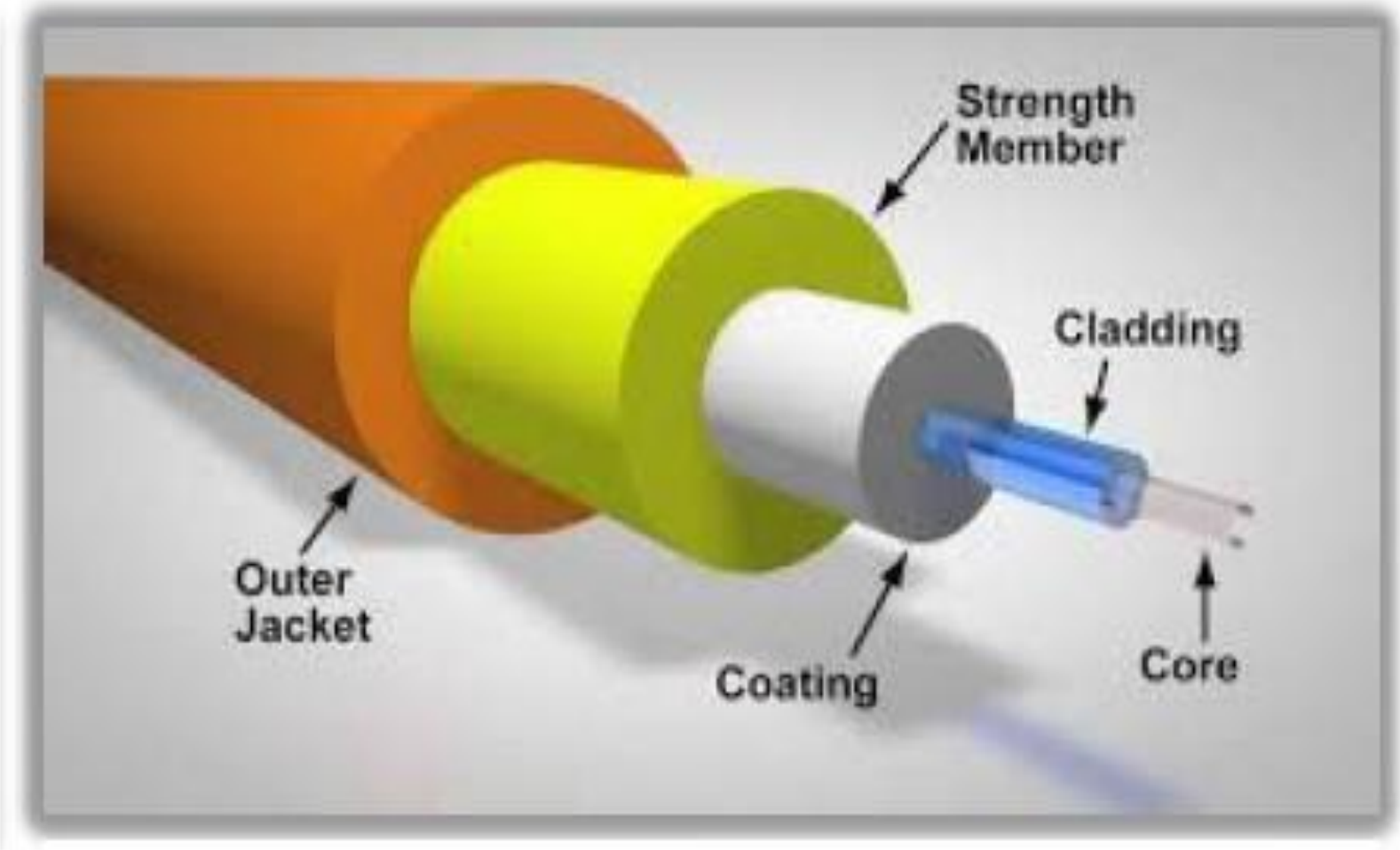
Cladding: it is expelled over the core and fills in as the limit that contains the light waves, empowering information to go through the length of the Fiber.

Optical fiber structure



Schematic of an optical fiber

Optical fiber structure



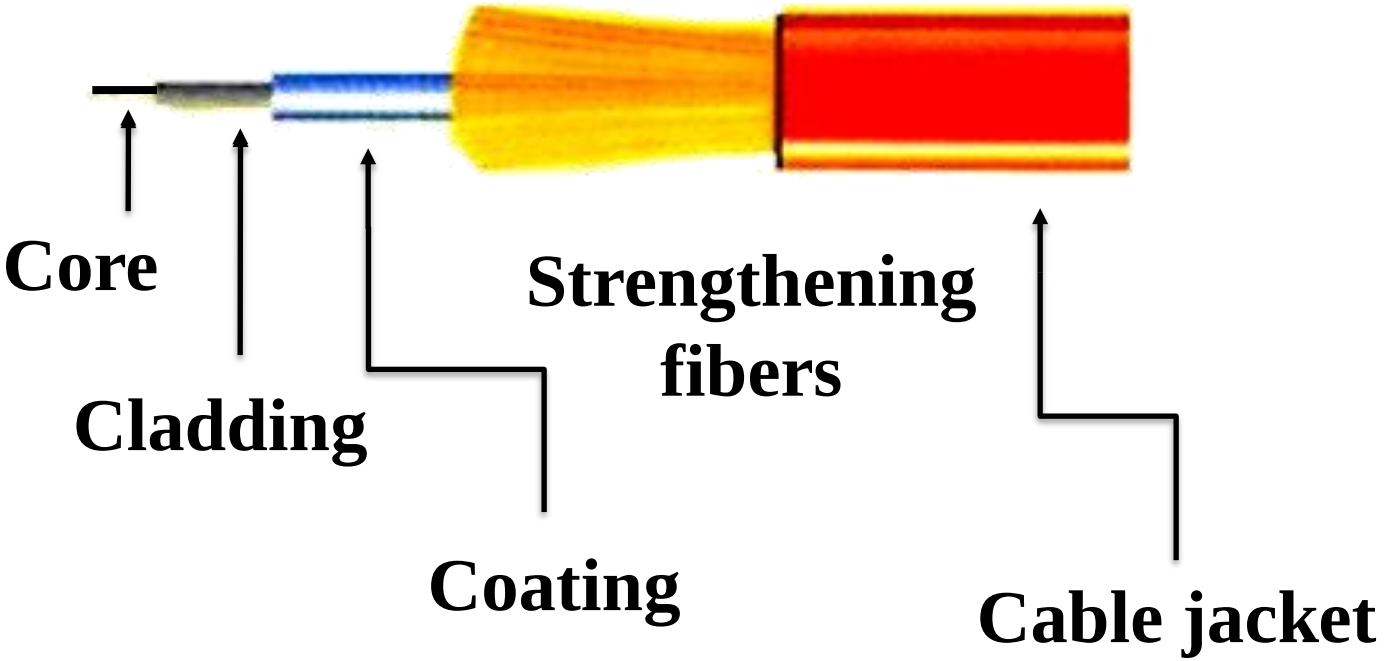
Optical fiber structure

Coating: a plastic cover over the cladding to strengthen the fiber core, help retain stuns, and give additional protection against extreme cable curves.

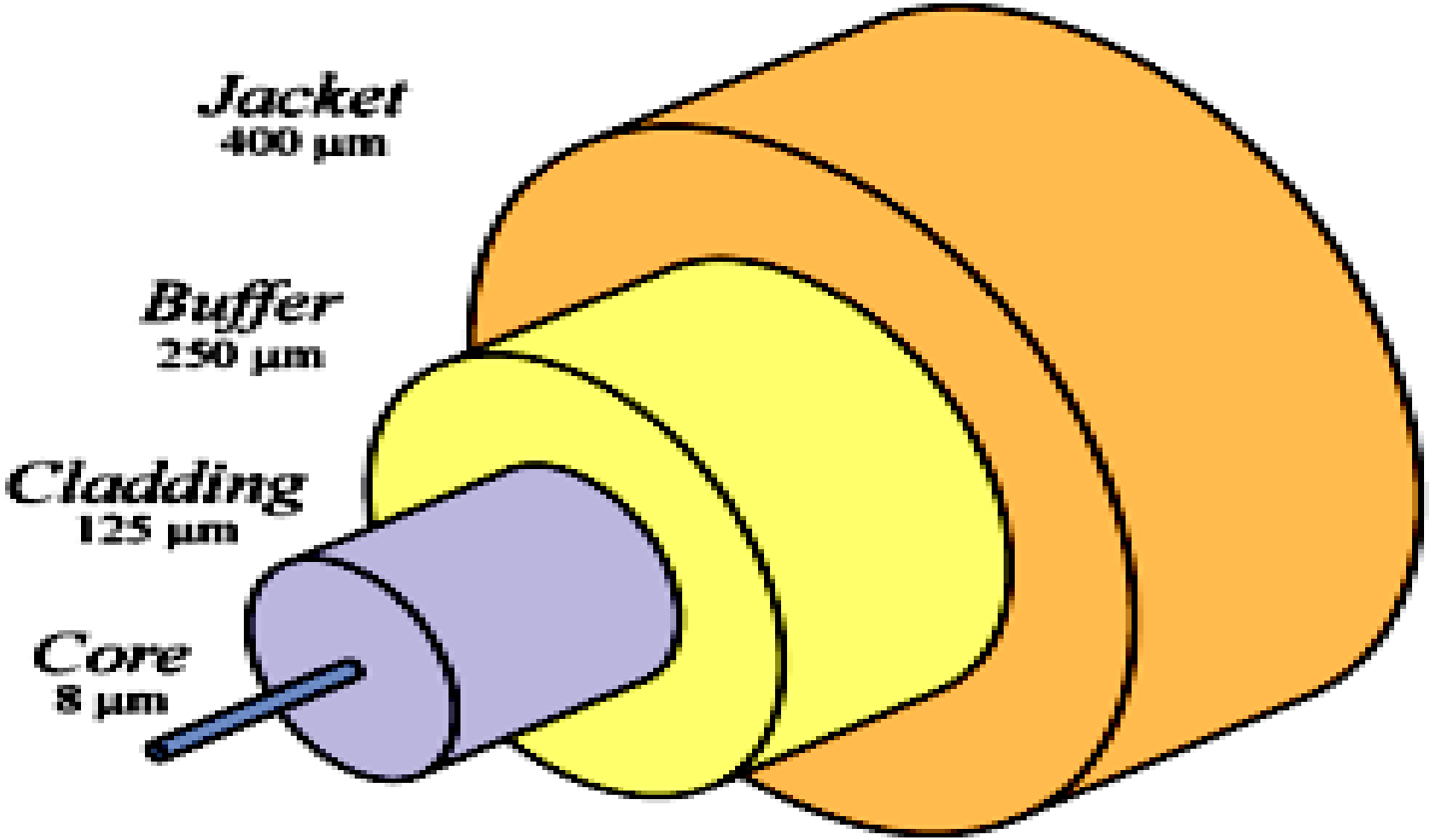
Strengthening member: helps ensure the core against pounding powers and over the top strain during establishment. It lowers cross-talk between the Fibers.

Jacket: outer layer or **sheathing** of the Cable. It shields the cable from natural perils.

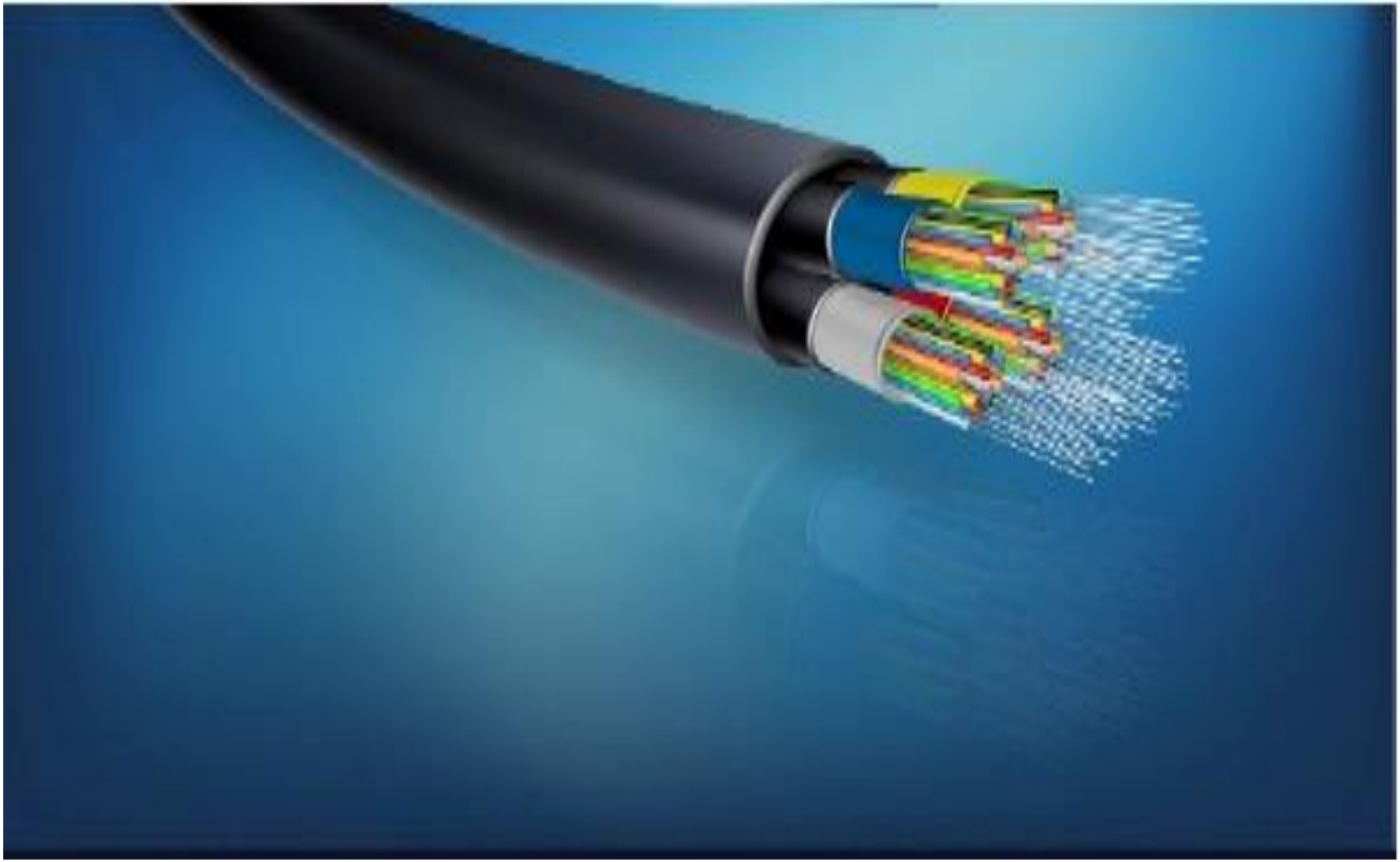
Optical fiber structure



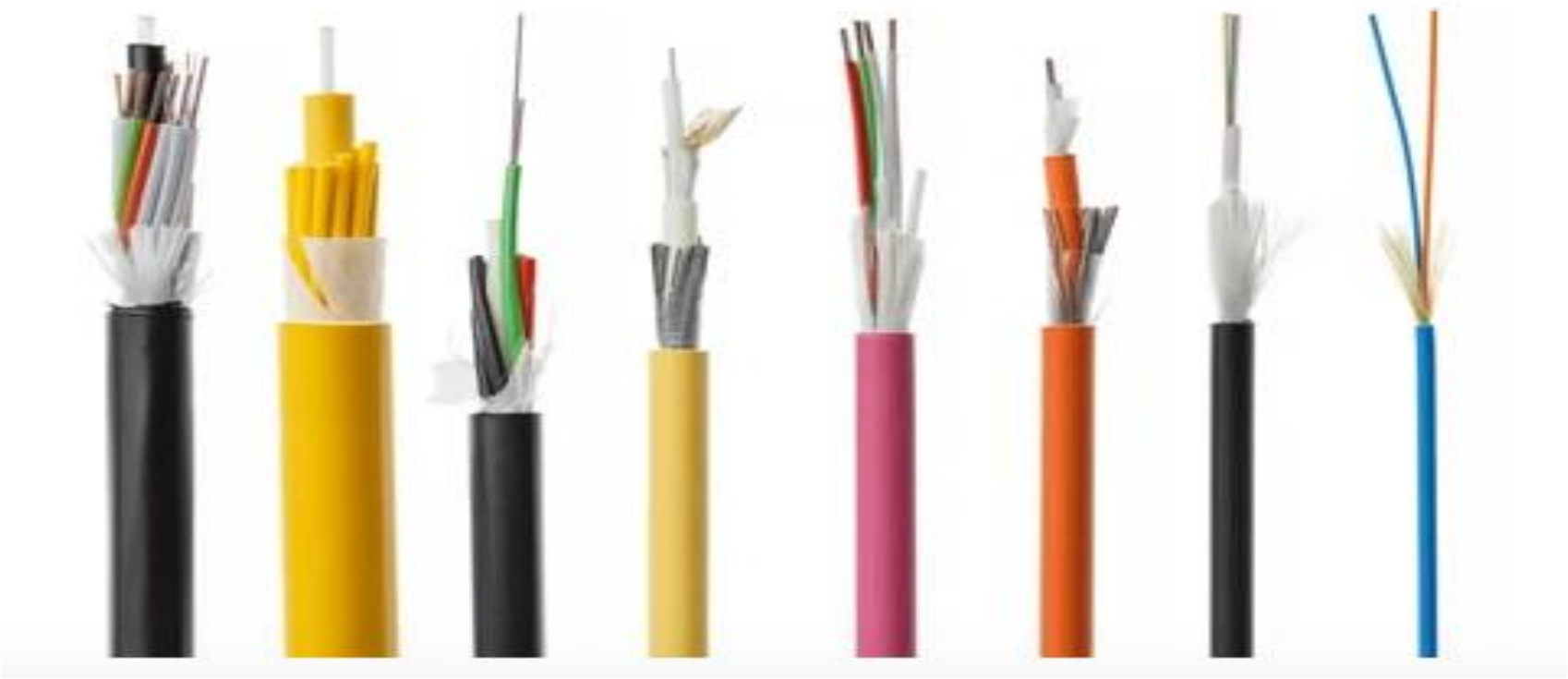
Optical fiber structure



Optical fiber cable



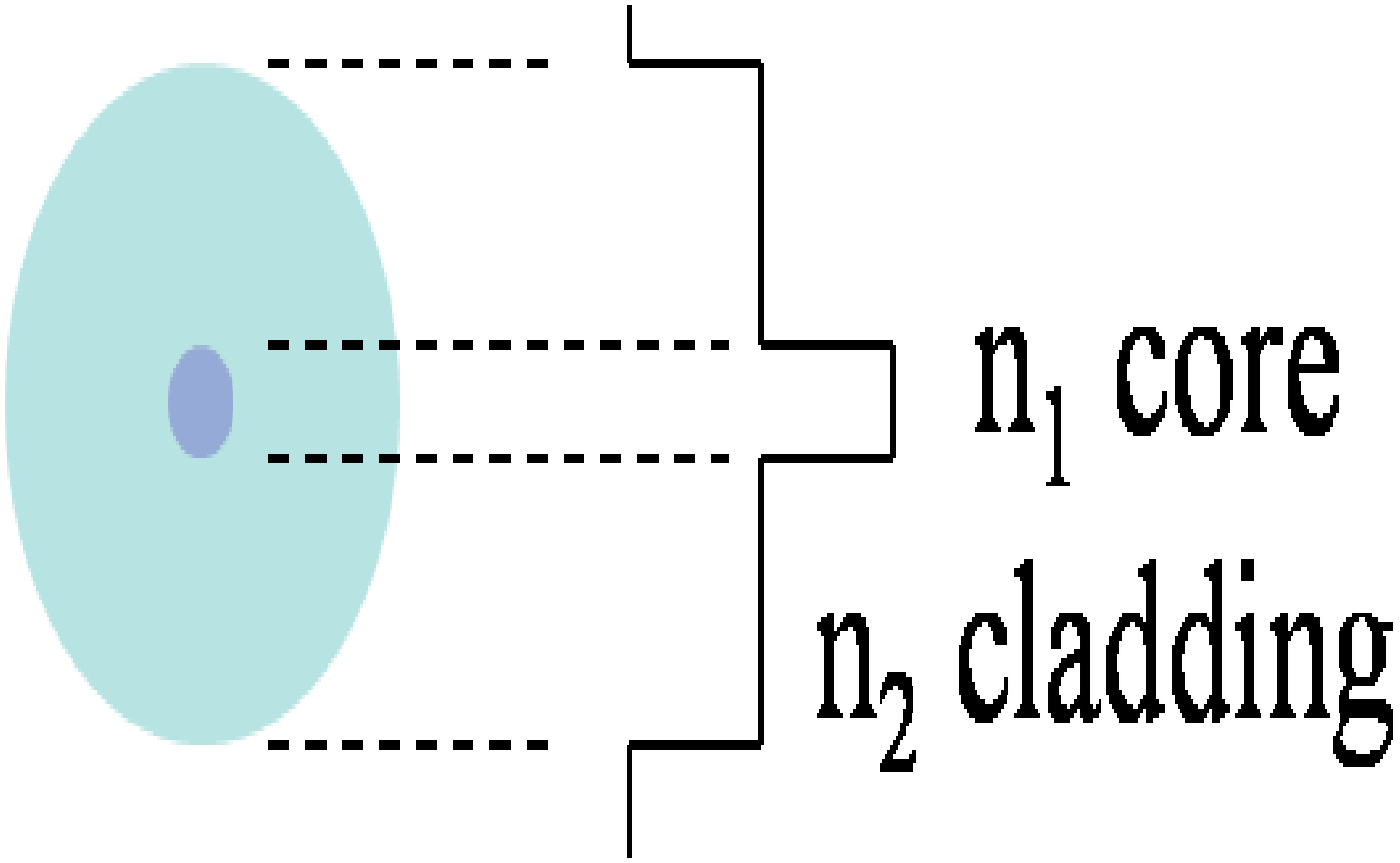
Optical fiber is described by a(b/c)
where
a is number of fibers in the cable
b is the core diameter in microns
c is the cladding diameter in microns



Optical fiber structure

core is cylindrical of dielectric material. Light propagates mainly along the core of the fiber. The core is surrounded by a another cylindrical called **cladding**. The cladding is made of the same dielectric material. It may be glass but the cladding has an index of refraction (n2), which is less than the refraction index of the core (n1).

Optical fiber structure



The Cladding

- It protects the fiber from absorbing surface contaminants.
- It adds mechanical strength.
- It reduces scattering loss at the surface of the core.
- It reduces loss of light from the core into the surrounding air.

Buffer

- it is made of a plastic and is elastic in nature which prevents abrasions.
- It is used to protect optical fiber from physical damage.
- It prevents the optical fiber from scattering losses caused by microbends.

The Jacket

It provides extra environmental and mechanical protection. It posses: high abrasion resistance, stable performance over temperature.

FTTx schemes

It is a family of wiring arrangement between the central office (C.O.) and the subscriber resident and it contains:

Fiber to the node (FTTN): in this connection fiber is connected from the C.O to cabinet within one mile distance from the subscriber resident.

Fiber to the curb (FTTC): in this connection fiber is connected from the C.O. to cabinet within 200 meters from the subscriber resident.

Fiber to the building (FTTB): in this connection fiber is connected from the C.O. to entrance of the subscriber building.

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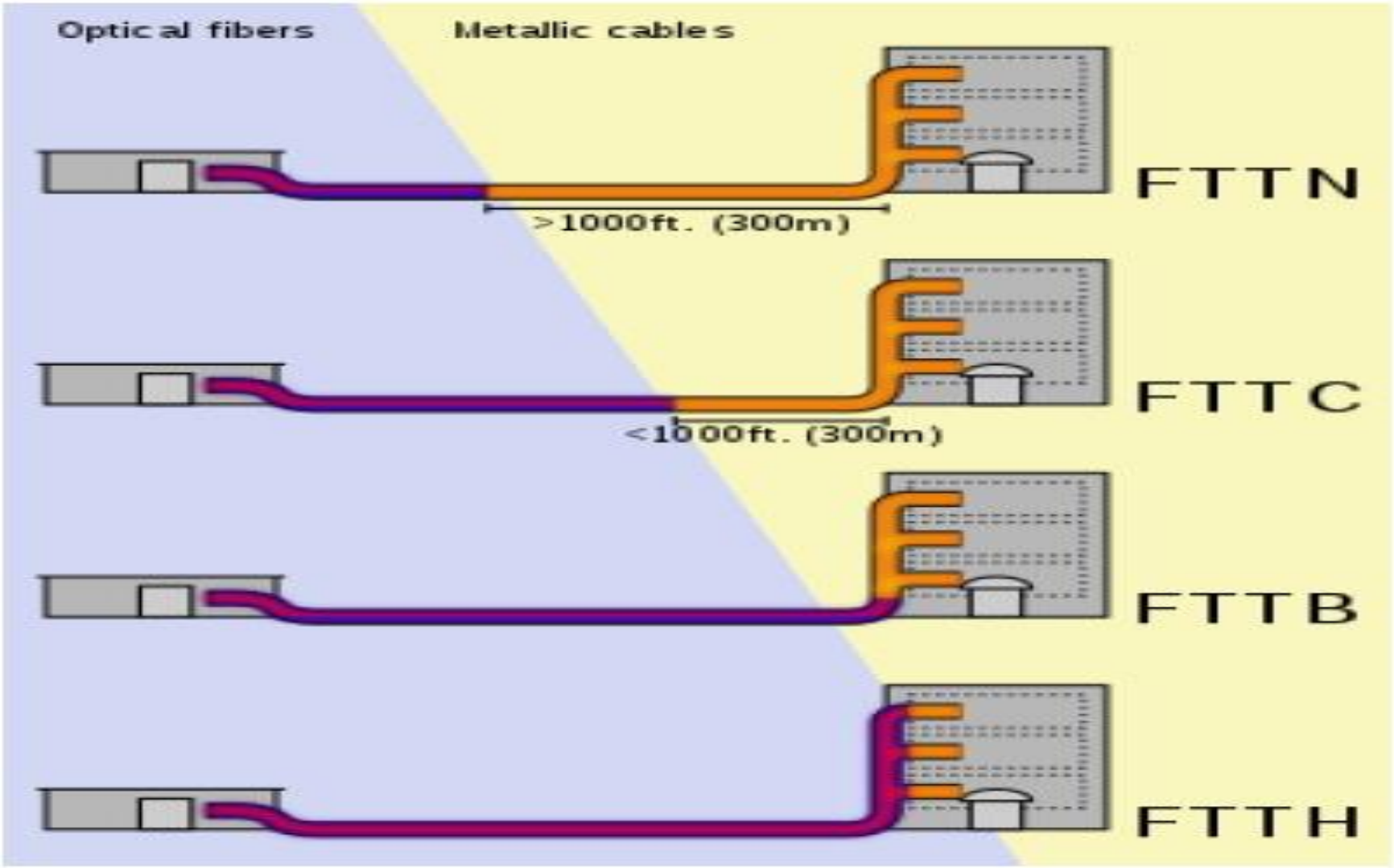
FTTx schemes

Fiber to the home (FFTH): It means optical fiber from the central office (C.O.) to the subscriber resident junction box.

The closer the optical fiber is connected to the subscriber resident, the better the connection because the degree of proximity decides the data speed rate. Therefore FTTH can offer the **highest bandwidth** and the **highest data rate** but on the other hand it is the **most expensive**. While the other connections can offer **fewer data rates** but with **less cost.**

FTTx schemes



Conclusions

The closer the optical fiber reach to the subscriber resident, the better the connection since the degree of proximity determines the data rate. Thus FTTH offers the highest bandwidth and the highest data rate but it is the most expensive. While the others (such as FTTN and FTTC) offer less data rates but with less cost. There is a trade of between cost and performance.

SEA ME WE series

SEA ME WE stands for South East Asia - Middle East -West Europe .it is family of submarine cables (SEA ME WE 1,2,3,4,5,6 and 7).

First member was made of copper while the other members were made of optical fiber. The first member becomes obsolete; the second member was a replacement of it. The fourth member is a redundant (or a complement) of the third member.

SEA ME WE series

These cables transfer large volume of data and information on a global scale. These cables carry telephone, internet, multimedia and various broadband applications.

Each member of the series is identified by the following:

- The cable length in kilometer.
- The cable capacity in Mbps, Gbps and Tbps.
- The cable path, the countries it serves and the number of landing points