

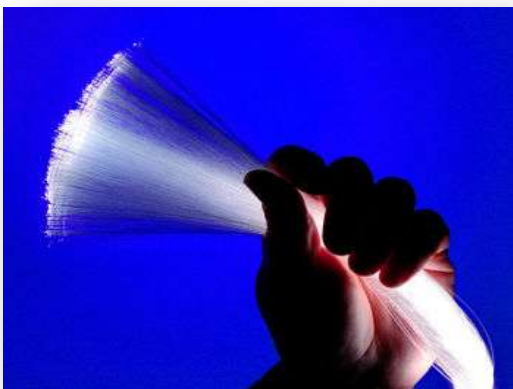
# High Speed Optical Network

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The network means the communication between two objects or among the number of objects. Several communication medias are used out of which optical media is the leading one. For network, we need one media either wired or wireless. Through wireless media, we cannot transfer huge data with high speed. Therefore, wired media is the only solution for high-speed data transmission. Now we have two options, one is copper wire and another is optical fiber. Through copper wire, we can transfer data upto 1 Gbps in addition, we have interference noise problem. However, through optical fiber we can transfer with the speed 10 Gbps or more. Truly speaking, there is no limit of the speed through optical fiber. The high-speed optical network is used for backbone network with high bandwidth and hassle free network. It is the future network solution.

Optical networks provide a high-capacity telecommunications network based on fiber optical technologies. Optical networks address increasing bandwidth issues as well as provide a higher capacity and reduce overall costs. Optical fiber can be used as a medium for telecommunication and networking because it is flexible and can be bundled as cables. It is especially advantageous for long-distance communications, because light propagates through the fiber with little attenuation compared to electrical cables.



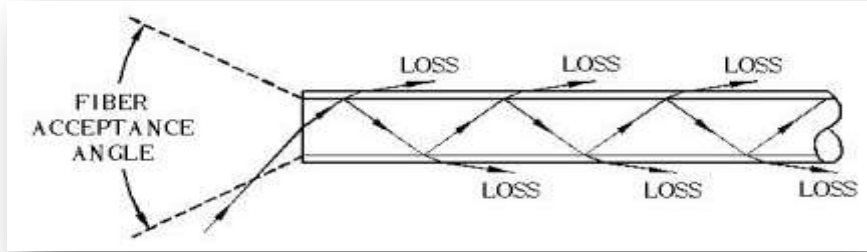
Optical Fiber: Outer View



Optical Fiber : Cross Section View

## Principle of Operation

An optical fiber is a cylindrical dielectric waveguide that transmits light along its axis, by the process of total internal reflection. The fiber consists of a core surrounded by a cladding layer. To confine the optical signal in the core, the refractive index of the core must be greater than that of the cladding. The boundary between the core and cladding may either be abrupt, in step-index fiber, or gradual, in graded-index fiber.

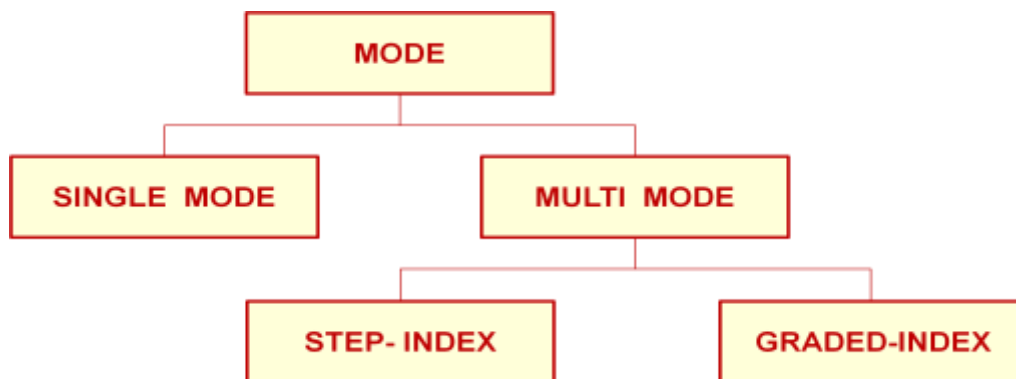


**Figure:** Ray of Light through Optical Fiber

When light traveling in a dense medium hits a boundary at a steep angle (larger than the "critical angle" for the boundary), the light will be completely reflected. This effect, known as total internal reflection, is used in optical fibers to confine light in the core. Light travels along the fiber bouncing back and forth off of the boundary. Because the light must strike the boundary with an angle greater than the critical angle, only light that enters the fiber within a certain range of angles can travel down the fiber without leaking out. This range of angles is called the acceptance cone of the fiber. The size of this acceptance cone is a function of the difference in refractive indices between the fiber's core and cladding.

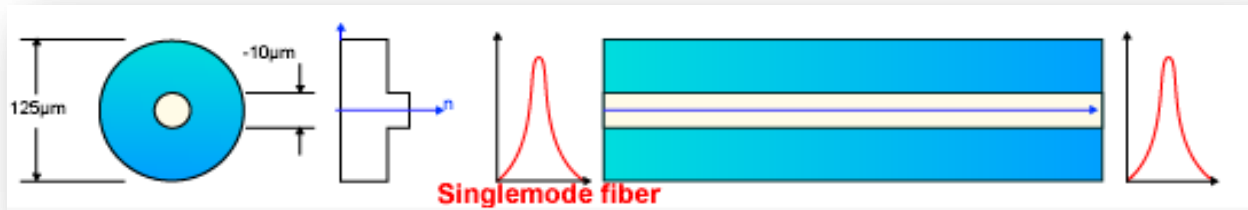
### Propagation Mode

Current technology supports two modes for propagating light along optical channels, each requiring fiber with different physical characteristics. The hierarchical structure is as follows:



**Single mode** - Fiber with a core diameter less than about ten times the wavelength of the propagating light cannot be modeled using geometric optics. Instead, it must be analyzed as an electromagnetic structure, by solution of Maxwell's equations as reduced to the electromagnetic wave equation. As an optical waveguide, the fiber supports one or more confined transverse modes by which light can propagate along the fiber. Fiber supporting only one mode is called

single-mode or *mono-mode* fiber. It is a highly focused source of light that limits beams to a small range of angles, all closed to the horizontal.



**Figure: Single Mode Fiber**

**Multimode Fiber-** Fiber with large (greater than 10 μm) core diameter may be analyzed by geometric optics. Multiple beams from a light source move through the core in different paths. Such fiber is called multimode fiber, from the electromagnetic analysis.

In a **step-index** multimode fiber, rays of light are guided along the fiber core by total internal reflection. In this fiber, the density of the core remains constant from the center to the edges. A beam of light moves through this constant density in a straight line until it reaches the interface of the core and the cladding. At the interface, there is an abrupt change to a lower density that alters the angle of the beam's motion. Some beams of light in the middle travel in straight lines through the core and reach the destination without reflecting or refracting. Some beams of light strike the interface of the core and cladding at an angle and reflect back into the core and off the other side, bouncing back and forth down the channel until they reach the destination. Therefore, the two set of beams traverse different path length, which means that different beams arrive at the destination at different times. This distortion limits the available data rate and makes multimode step-index cable inadequate for certain precise application.

In **graded-index** fiber, the index of refraction in the core decreases continuously between the axis and the cladding. The word index here refers to the index of the refraction. In graded-index fiber, therefore, is one with varying densities. Density is higher at the center of the core and decreases gradually to its lower at the edge. This causes light rays to bend smoothly as they approach the cladding, rather than reflecting abruptly from the core-cladding boundary. The resulting curved paths reduce multi-path dispersion because high angle rays pass more through the lower-index periphery of the core, rather than the high-index center. Careful placement of the receiver at one of these intersections allows the signal to be reconstructed with far greater precision.

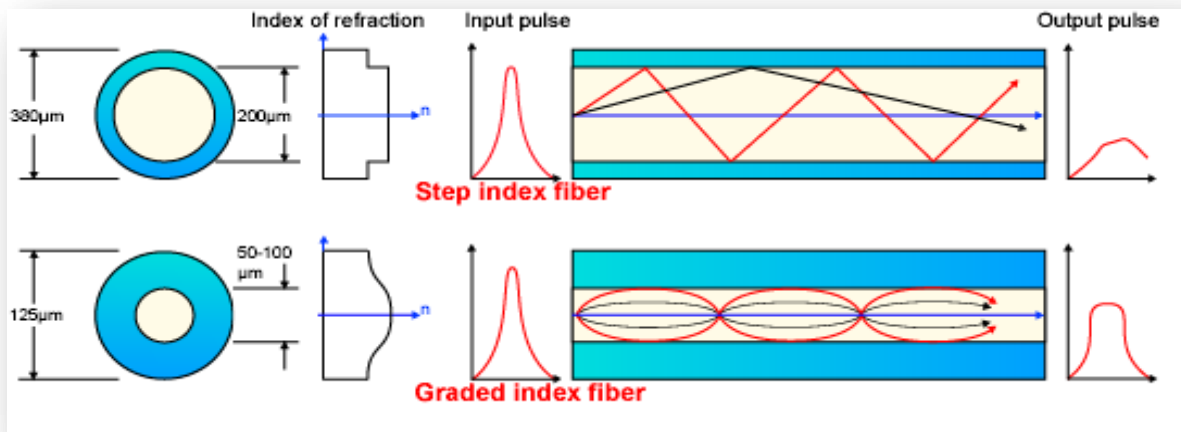


Figure: Multi Mode Fiber

### Applications

**High Speed Backbone Network – FDDI:** Fiber distributed data interface (FDDI) provides a standard for data transmission in a local area network that can extend in range up to 200 kilometers. FDDI uses optical fiber as the primary transmission medium. In particular, security, reliability, and performance all are enhanced with optical fiber media because fiber does not emit electrical signals.

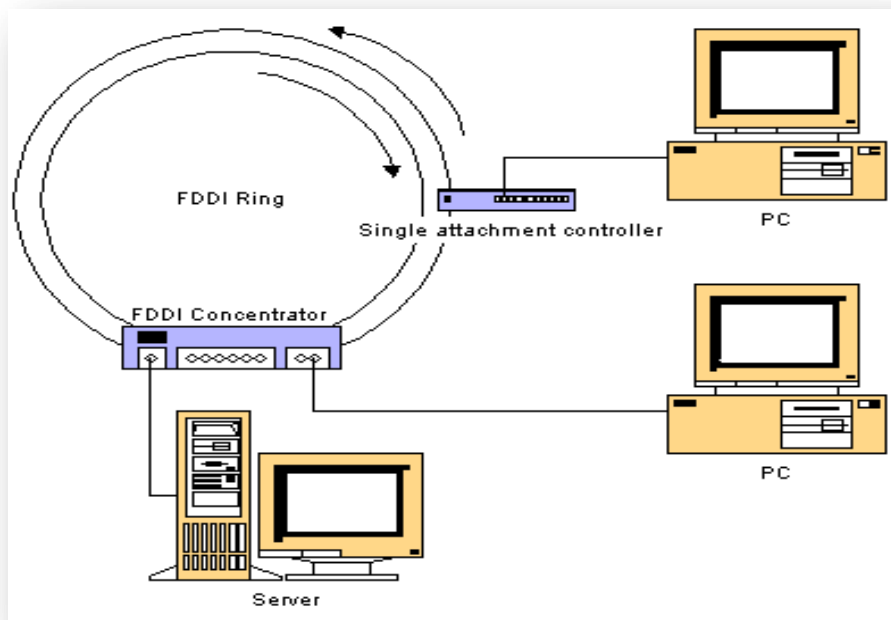
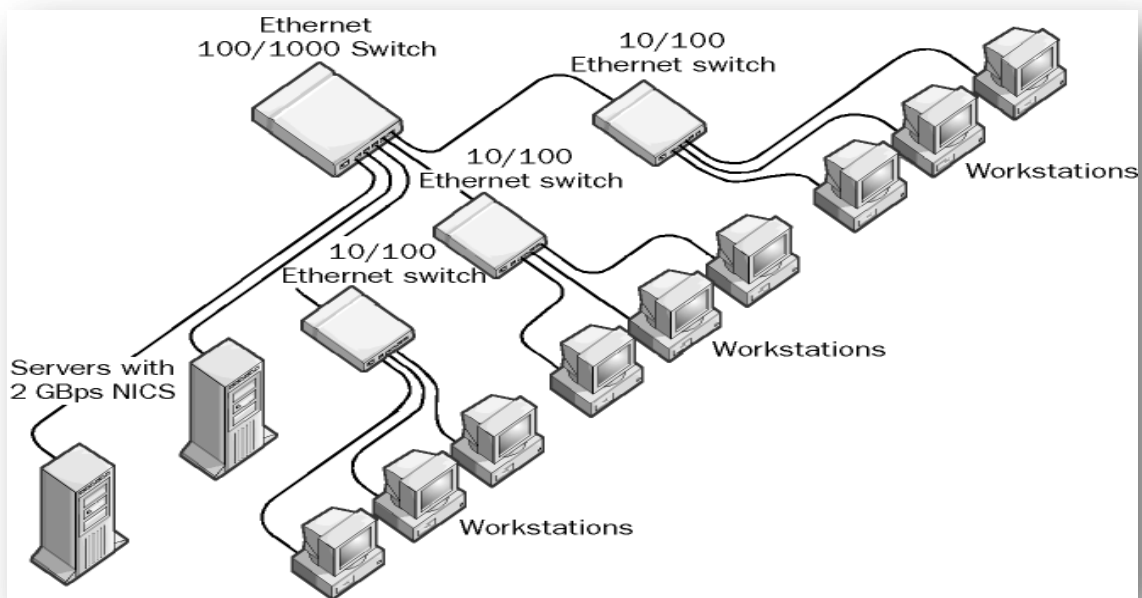


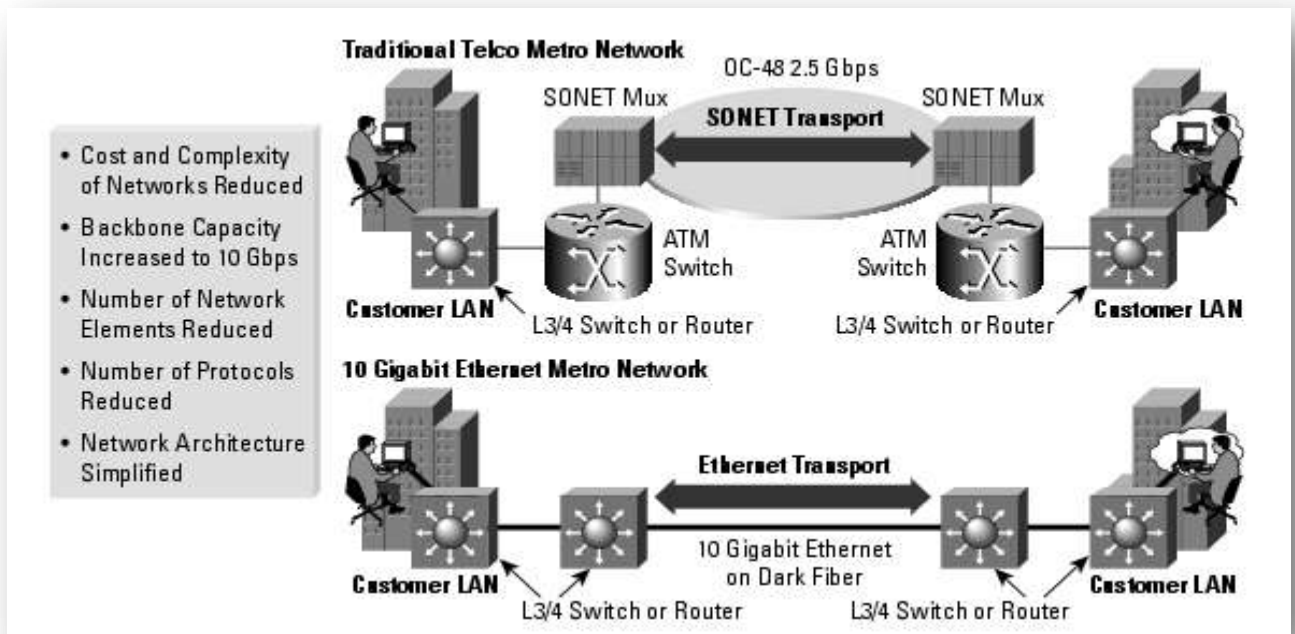
Figure: FDDI Network using Optical Fiber

**Gigabit Ethernet:** Gigabit Ethernet, a transmission technology based on the Ethernet frame format and protocol used in local area networks (LANs), provides a data rate of 1 billion bits per second (one gigabit). Gigabit Ethernet is defined in the IEEE 802.3 standard and is currently being used as the backbone in many enterprise networks. Gigabit Ethernet is carried primarily on optical fiber. Existing Ethernet LANs with 10 and 100 Mbps cards can feed into a Gigabit Ethernet backbone



**Figure: Gigabit Ethernet**

**10 Gigabit Ethernet:** 10-Gigabit Ethernet (10GBASE-FX), being standardized in IEEE 802.3ae, is a telecommunication technology that offers data speeds up to 10 billion bits per second. Built on the Ethernet technology used in most of today's local area networks (LANs), 10-Gigabit Ethernet is described as a "disruptive" technology that offers a more efficient and less expensive approach to moving data on backbone connections between networks while also providing a consistent technology end-to-end



**Figure: 10 Gigabit Ethernet**

**Advantages** – The major advantages offered by optical fiber

- **Noise Resistance:** Fiber-optic transmission uses light rather than electricity, so noise cannot be propagated. External light is the only possible interference, which is blocked by jackets.
- **Less Signal Attenuation:** Through fiber-optic a signal can run for miles without requiring regeneration. Therefore, attenuation is very less.
- **Higher Bandwidth:** Fiber-optic can support dramatically higher bandwidths. It removes the barrier of medium limitation.

**Future Scope** – Getting the most out of limited bandwidth will be more and more essential as wireless demands increase in the near future. We can get the most of wireless capacity and bandwidth by splitting wireless signals into separate components and then using optical fiber to carry wireless signals to their destination where they are re-integrated.

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