1.3. Telecommunications Networks

- Public networks, cross public land and owned by telecommunications carriers, offers leased lines to enterprises.
- Private (enterprise) networks cross public land, leased.
- Local area networks (LANS) are within buildings.
- Metropolitan area networks (MANS) span a campus or metropolitan area.
- Wide area networks (WANS) span larger distances.

Access network - reaches out from carrier’s central office into individual homes and businesses. Typically twisted pair (copper) or coax due to large cost and uncertain return on investment. Optical fiber is provided to some businesses. Twisted pair has 4 kHz of voice-grade bandwidth, but may carry data at Mb/s using digital subscriber loop (DSL) technology. Coax is about 10x better.

Local exchange network - interconnects central offices in a metropolitan area.

Interexchange network - long-haul network that interconnects cities and major traffic hubs.

Undersea networks - connects continents, several 1000’s of km.

Each of these networks may be owned and operated by different entities.

1.4. Telephone Networks

The telephone industry was developed over a hundred years ago to handle voice communications. The basic structure of this network is shown in the figure, and forms the basis for transport of all voice and data communications.
All voice lines from the home or office eventually connect to a central office (CO), either directly or through a remote terminal (RT). When an RT is used, the local network is divided into a distribution network (home to RT) and a feeder network (RT to CO). All CO’s are connected to one another by optical fiber to form a regional network or metropolitan network. If you place a call within your region (typically defined by the area code), your central office routes your call to the nearest central office in the area you are calling using an intra-LATA (local access and transport area) connection. This type of regional call is handled by the local exchange carrier (LEC). End offices are connected to tandem central offices, which facilitates the long distance service by linking tandem central offices to tandem switches using point of presence (POP), which allows equal access to your telephone line for any long distance carrier. The tandem switches and their links make up the long distance network. Tandem switches are distributed throughout the country and are fully interconnected in a mesh network architecture. Interexchange carriers (IXCs) are the long distance companies. Each IXC operates its own tandem central offices and tandem switches, where its the job of the POP protocol to route your call to the appropriate IXC.

1.4.1. Access network

Access networks in the telephone system are primarily based upon copper twisted pair wire connections. There are approximately one billion telephone sets installed globally, nearly all of which are connected by twisted pair. The connection from the customer premises to an RT or CO is called a subscriber line. Subscriber lines were originally designed to transmit low frequency analog voice signals of about 4 kHz bandwidth. The attenuation limited average distance for a subscriber
Distance and bandwidth limitations in copper wire have led to remote-control architecture where thousands of subscriber lines are terminated at a remote terminal, which is then connected to an end central office by fiber. This arrangement allows the access network carrier to shorten the length of the subscriber lines to allow more bandwidth, and hence establish a better connection. Many approaches have been taken to extend the bandwidth of the subscriber lines to allow for data communications, for example, the many “high-speed” modem technologies that exist. Other approaches include ISDN (integrated-services digital network), whose basic rate is 144 kbit/sec, and broadband ISDN operating as high as 620 Mb/sec. Another technology is xDSL (digital subscriber line), where x stands for asymmetric (A), high speed (H), very high speed (V), and universal (U). ASDL can transmit up to 6 Mbit/sec downstream from to central office to the customer. VSDL might exceed 20 Mb/sec. To some extent, these approaches are impeding the proliferation of optical access networks, but the cost of replacing all of the twisted pair is probably the major impediment.

1.4.2. Transport network

Transport networks gather all of the signals from millions of customers, and are therefore very high bandwidth. Transport networks now span the globe, and are either terrestrial or submarine (undersea). These networks transmit signals in digital form only.

A tandem central office gathers signal from thousands of subscribers, multiplexes them and sends the high bit rate signal along to the tandem switch. Note that many central offices are connected to a single tandem switch. The tandem switch futher multiplexes the signals it receivers and sends the data to another tandem switch located somewhere else in the country. Tandem switches operate at many Tb/sec.