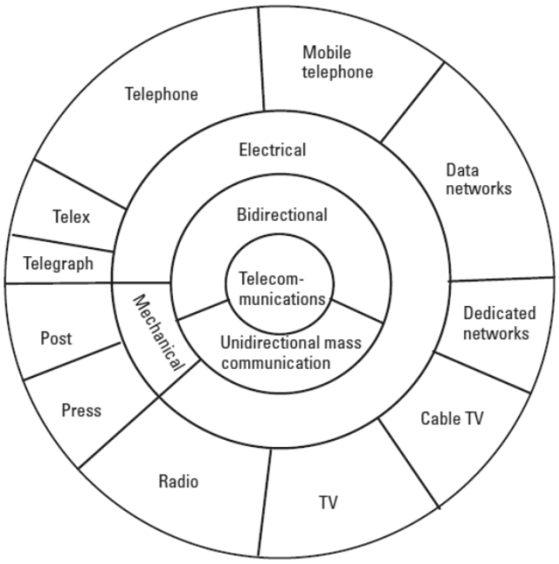
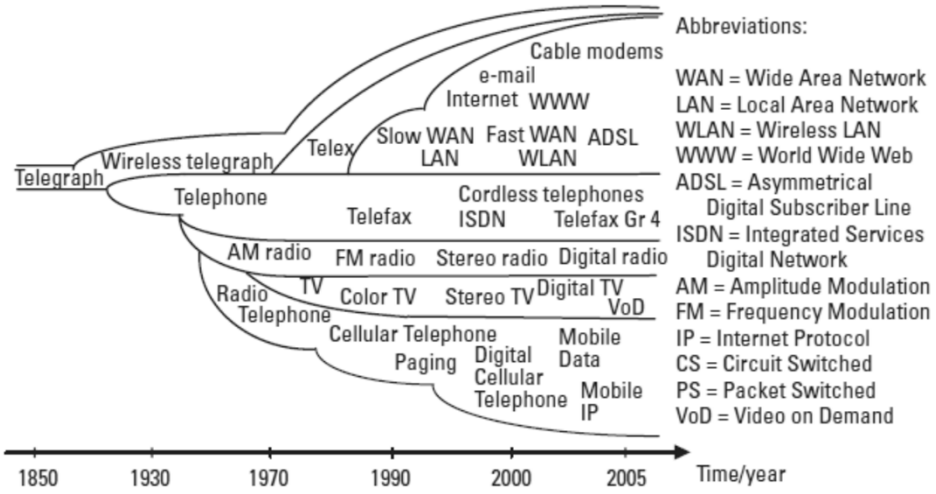
INTRODUCTION TO TELECOMMUNICATIONS

Telecommunications



Historical Perspective



Historical Perspective

Year	Development
1800–1837	Preliminary developments: Volta discovers the primary battery; Fourier and Laplace present mathematical treatises; Ampere, Faraday, and Henry conduct experiments on electricity and magnetism; Ohm's law (1826); Gauss, Weber, and Wheatstone develop early telegraph systems.
1838–1866	Telegraphy: Morse perfects his system; Steinhill finds that the earth can be used for a current path; commercial service is initiated (1844); multiplexing techniques are devised; William Thomson calculates the pulse response of a telegraph line (1855); transatlantic cables are installed.
1845	Kirchoff's circuit laws.
1864	Maxwell's equations predict electromagnetic radiation.

Historical Perspective

Year	Development
1876–1899	*Telephony:* Alexander Graham Bell perfects acoustic transducer; first telephony exchange with eight lines; Edison's carbon-button transducer; cable circuits are introduced; Strowger devises automatic step-by-step switching (1887); Pupin presents the theory of loading.
1887–1907	*Wireless telegraphy :* Heinrich Hertz verifies Maxwell's theory; demonstrations by Marconi and Popov; Marconi patents complete wireless telegraph system (1897); commercial service begins, including ship-to-shore and transatlantic systems.
1904–1920	*Communication electronics:* Lee De Forest invents the Audion (triode) based on Fleming's diode; basic filter types devised; experiments with AM radio broadcasting; the Bell System completes the transcontinental telephone line with electronic repeaters (1915); multiplexed carrier telephony is introduced: H. C. Armstrong perfects the superheterodyne radio receiver (1918); first commercial broadcasting station.

Historical Perspective

Year	Development
1920–1928	Carson, Nyquist, Johnson, and Hartley present their transmission theory.
1923–1938	*Television:* Mechanical image-formation system demonstrated; theoretical analysis of bandwidth requirements; DuMont and others perfect vacuum cathode-ray tubes; field tests and experimental broadcasting begin.
1931	Teletypewriter service initiated.
1934	H. S. Black develops the negative feedback amplifier.
1936	Armstrong's paper states the case of *frequency modulation* (FM) radio.
1937	Alec Reeves conceives *pulse code modulation* (PCM).
1938–1945	Radar and microwave systems developed during World War II; FM used extensively for military communications; hardware, electronics, and theory are improved in all areas.

Historical Perspective

Year	Development
1944–1947	Mathematical representations of noise developed; statistical methods for signal detection developed.
1948–1950	C. E. Shannon publishes the founding papers on information theory.
1948–1951	Transistor devices are invented.
1950	*Time-division multiplexing* (TDM) is applied to telephony. Hamming presents the first error correction codes.
1953	Color TV standards are established in the United States.
1955	J. R. Pierce proposes satellite communication systems.
1958	Long-distance data transmission system is developed for military purposes.
1960	Maiman demonstrates the first laser.
1961	Integrated circuits are applied to commercial production.
1961	Satellite communication begins with Telstar I.

Historical Perspective

Year	Development
1962–1966	Data transmission service offered commercially; PCM proves feasible for voice and TV transmission; theory for digital transmission is developed; Viterbi presents new error-correcting schemes; adaptive equalization is developed.
1964	Fully electronic telephone switching system is put into service.
1965	Mariner IV transmits pictures from Mars to Earth.
1966–1975	Commercial satellite relay becomes available; optical links using lasers and fiber optics are introduced; ARPANET is created (1969) followed by international computer networks.
1976	Ethernet LAN invented by Metcalfe and Broggs (Xerox)
1968–1969	Digitalization of telephone network begins.
1970–1975	PCM standards developed by CCITT.
1975–1985	High-capacity optical systems developed; the breakthrough of optical technology and fully integrated switching systems; digital signal processing by microprocessors.

Historical Perspective

Year	Development
1980–1983	Start of global Internet based on TCP/IP protocol
1980–1985	Modern cellular mobile networks put into service, NMT in Northern Europe, AMPS in the United States, OSI reference model is defined by *International Standards Organization* (ISO). Standardization for second generation digital cellular systems is initialized.
1985–1990	LAN breakthrough; *Integrated Services Digital Network* (ISDN) standardization finalized; public data communications services become widely available; optical transmission systems replace copper systems in long-distance wideband transmission; SONET is developed. GSM and SDH standardization finalized.
1989	Initial proposal for a Web-linked document on the *World Wide Web* (WWW) by Tim Berners-Lee (CERN)

Historical Perspective

Year	Development
1990–1997	The first digital cellular system, *Global System for Mobile Communications* (GSM), is put into commercial use and its breakthrough is felt worldwide; deregulation of telecommunications in Europe proceeds and satellite TV systems become popular; Internet usage and services expand rapidly because of the WWW.
1997–2001	Telecommunications community is deregulated and business grows rapidly; digital cellular networks, especially GSM, expand worldwide; commercial applications of Internet expand and a share of conventional speech communications is transferred from *public switched telephone network* (PSTN) to Internet; performance of LANs improves with advance of gigabit-per-second Ethernet technologies.
2001–2005	Digital TV starts to replace analog broadcast TV; broadband access systems make Internet multimedia services available to all; telephony service turns to personal communication service as penetration of cellular and PCS systems increases; second generation cellular systems are upgraded to provide higher rate packet-switched data service.

Historical Perspective

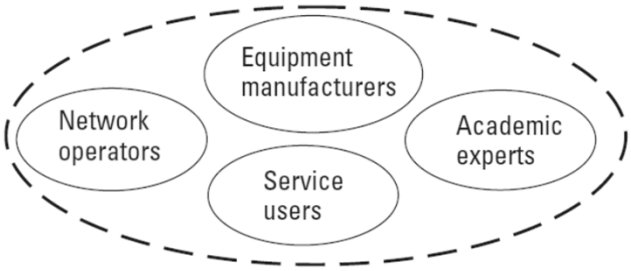
Year	Development
2005–	Digital TV will replace analog service and start to provide interactive services in addition to broadcast service; third generation cellular systems and WLAN technologies will provide enhanced data services for mobile users; location-based mobile services will expand, applications for wireless short haul technologies in homes and offices will increase; global telecommunications network will evolve toward a common packet-switched network platform for all types of services.

Standardization

- To design and build networks effectively, standards are necessary to achieve interoperability, compatibility, and required performance in a cost-effective manner.
  - Standards enable competition
  - Standards lead to economies of scale in manufacturing and engineering
  - Political interests often lead to different standards in Europe, Japan, and the United States.
  - International standards are threats to the local industries of large countries but opportunities to the industries of small countries.
  - Standards make the interconnection of systems from different vendors possible.
  - Standards make users and network operators vendor independent and improve availability of the systems.
  - Standards make international services available.
- Examples of international standardization:
  - International telephone numbering and country codes
  - Connectors and signals for PC, printer, and modem interfaces
  - Television and radio systems

Standards Organizations

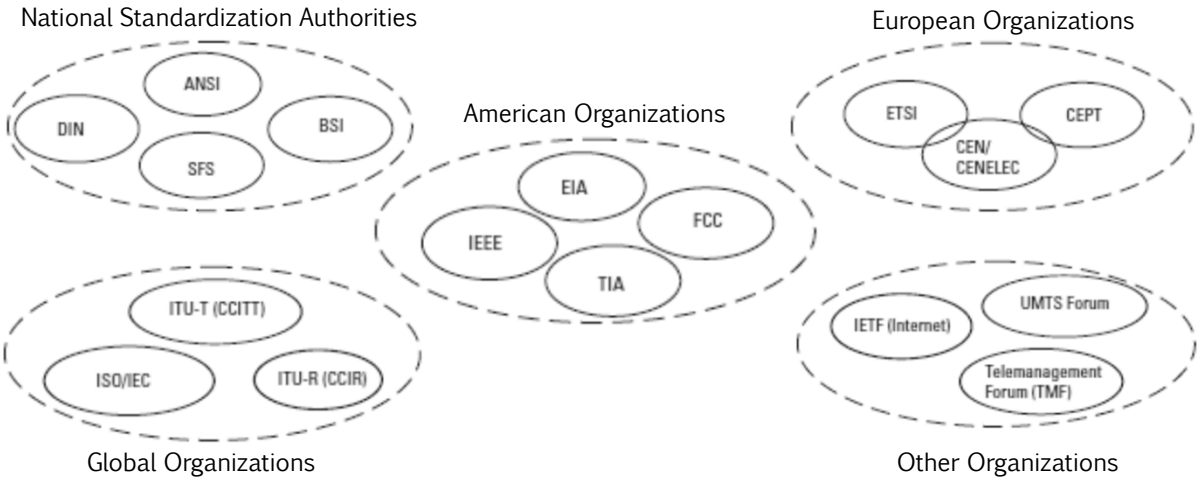
- Many organizations are involved in standardization work. We look at them from two points of view:
  - the players in the telecommunications business involved in standardization
  - the authorities that approve official standards.



Standards Organizations

- Network operators support standardization for these reasons::
  - To improve the compatibility of telecommunications systems;
  - To be able to provide wide-area or even international services;
  - To be able to purchase equipment from multiple vendors.
- Equipment manufacturers participate in standardization for these reasons:
  - To get information about future standards for their development activities as early as possible;
  - To support standards that are based on their own technologies;
  - To prevent standardization if it opens their own markets.
- Service users participate in standardization for these reasons:
  - To support the development of standardized international services;
  - To have access to alternative system vendors (multivendor networks);
  - To improve the compatibility of their future network systems.

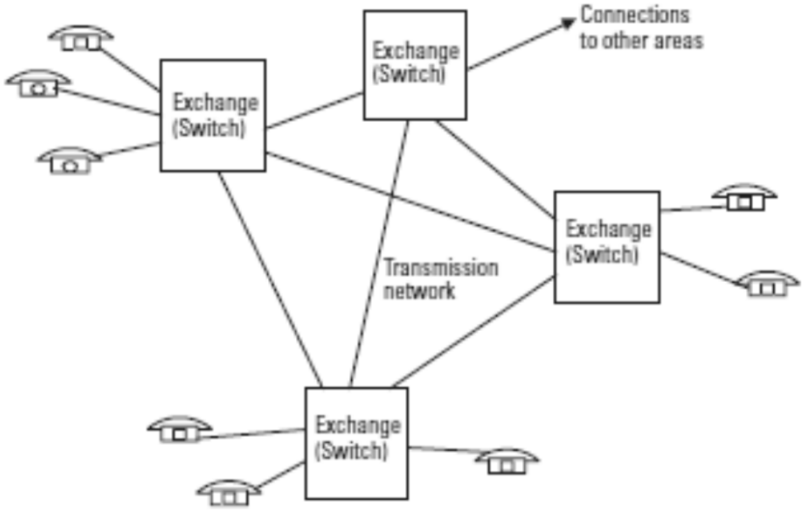
Standards Organizations



Basic Telecommunications Network

- The basic purpose of a telecommunications network is to transmit user information in any form to another user of the network.
- The three technologies needed for communication through the network are
  - transmission
  - switching
  - Signaling
- Transmission systems use four basic media for information transfer from one point to another:
  - Copper cables, such as those used in LANs and telephone subscriber lines;
  - Optical fiber cables, such as high-data-rate transmission in telecommunications networks;
  - Radio waves, such as cellular telephones and satellite transmission;
  - Free-space optics, such as infrared remote controllers.

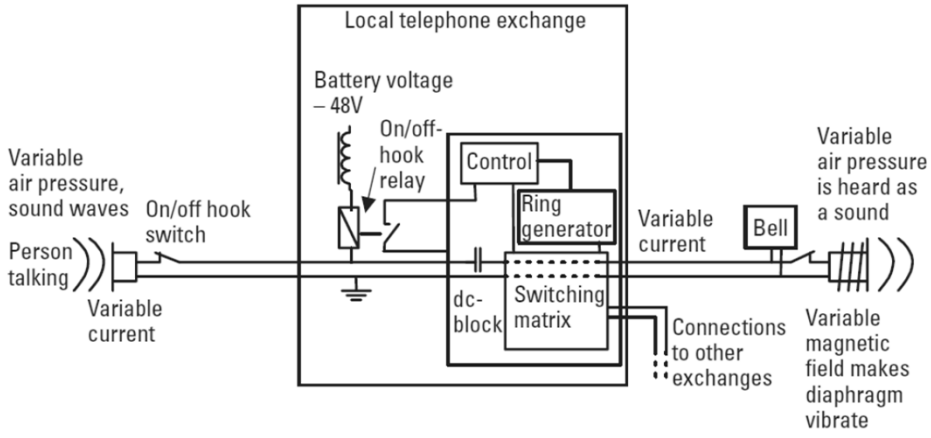
Basic Telecommunications Network



Basic Telecommunications Network

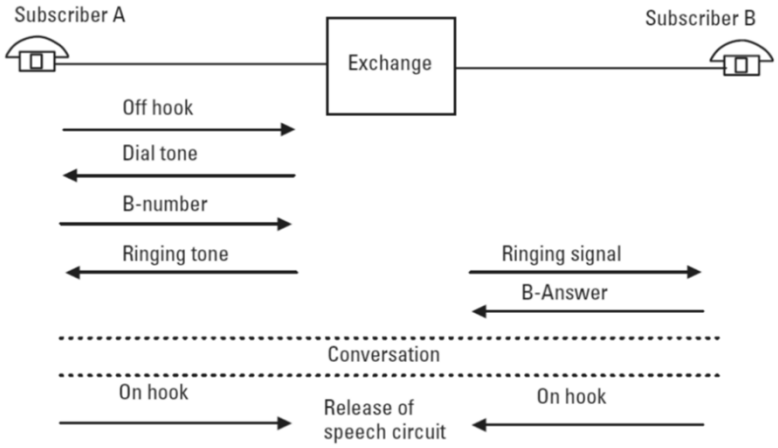
- Signaling is the mechanism that allows network entities (customer premises or network switches) to establish, maintain, and terminate sessions in a network.
  - Off-hook condition: The exchange notices that the subscriber has raised the telephone hook (dc loop is connected) and gives a dial tone to the subscriber.
  - Dial: The subscriber dials digits and they are received by the exchange.
  - On-hook condition: The exchange notices that the subscriber has finished the call (subscriber loop is disconnected), clears the connection, and stops billing.

Operation of a Conventional Telephone



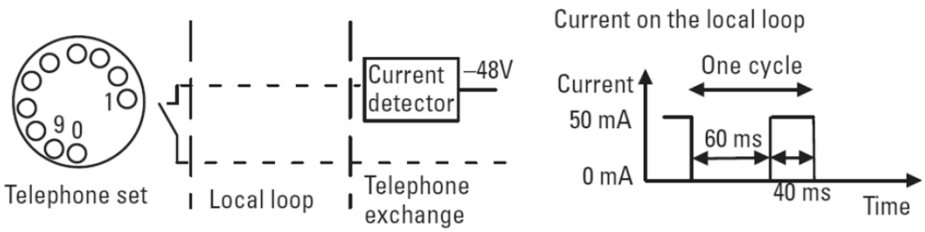
Operation of a Conventional Telephone

Subscriber signaling



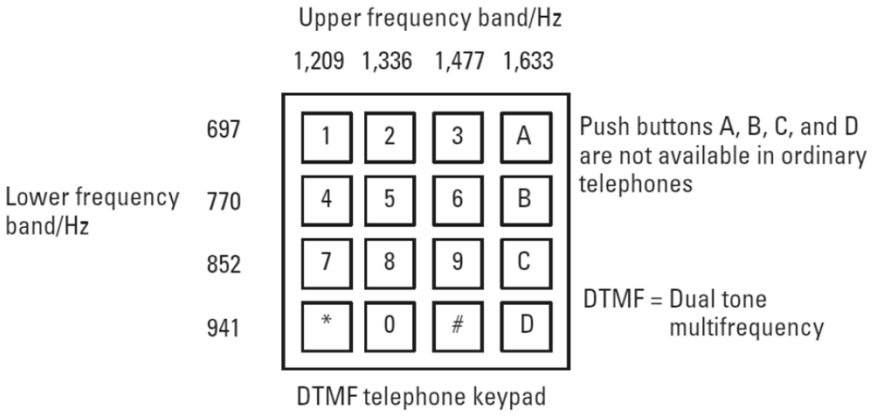
Operation of a Conventional Telephone

Rotary Dialing



Operation of a Conventional Telephone

Tone Dialing



Telephone Numbering

- The numbering is hierarchical, and it has an internationally standardized country code at the highest level