

Elements of Digital Communications

History of Long-Distance Communication (LTE, 2016)

The term “long-distance communication” arose in the technology of transmission of electrical signals over wire communications lines. People tend to create methods and improvements in order to relay information.

- **Smoke Signals** – This is one of the oldest forms of long-distance communication for transmitting information. American Indians used this as a distress signal. This was also used in the Great Wall of China to relay messages of incoming threats.
- **Pigeon Courier** – This form is often used by ancient Persians, Romans, and Greeks to send messages using a bird as a courier.
- **Semaphore Flags** – In 1792, Claude Chappe developed a messaging system that uses flags as methods of communication.
- **Pony Express** – In 1860, this mail service delivers messages, newspapers, and mails using relays of horse-mounted riders.
- **Electrical Telegraph** – It revolutionized long-distance communication by sending electric signals (Morse code) in between two (2) stations.
- **Wireless Telegraphy (Radio)** – It is a transmission of electric current projected into space in the form of radio waves.
- **Telephone** – It is an instrument designed for the simultaneous transmission of human voice.

Notable Advancements in Digital Communication

These are the following generations that digital communications has been revolutionized by newer technologies. (LTE, 2016)

- **1st Generation (1G)** – This generation uses analog wireless technology in communications.
- **2nd Generation (2G)** – In this generation, Cellphones are upgraded from analog to digital. In this generation, the concept of Code Division Multiple Access (CDMA) and Global System for Mobiles (GSM) were implemented. It is the generation where Short Message Service (SMS), General Packet Radio Service (GPRS), and Packet Switching Network (PSN) is introduced.
- **3rd Generation (3G)** – This generation uses a new technology called Universal Mobile Telecommunication Systems (UMTS) in which it can render multimedia services along a line with streaming. Evolved High-Speed Packet Access (HSPA+) is established in this generation.
- **4th Generation (4G)** – The key technologies that have made in this generation are Multiple Input Multiple Output (MIMO) and Orthogonal Frequency Division Multiplexing (OFDM). The two (2) important 4G standards are WiMAX (Worldwide Interoperability for Microwave Access) and LTE (Long-Term Evolution).
- **5th Generation (5G)** – This generation rolls out faster data transfer speeds up to 10 times faster than 4G. It is presently happening like the Internet of Things (IoT), autonomous smart systems, and beamforming.

Data Representation

Data is a piece of information that can be analog or digital. It can be in the form of a number, character, text, audio, or video. It can be created, deleted, stored, or transferred. It has two (2) forms:

- **Analog data** refers to continuous information.
 - Example: human voice
- **Digital data** takes on discrete values.
 - These **bits** can be a file, information, or instruction.
 - These consist of ones and zeros (1's and 0's).

Digital communication means communication through data bits (as in electric currents and voltages switching on or off). It is decoding information into a binary code and transmitting it in the form of a signal.

- For example, words are translated into binary by giving each letter a number in a defined format (such as ASCII code) transmitted in analog or digital signals.
- This series of data bits can be stored in a **file**.

Information Theory

According to Claude Shannon, information theory is a representation of the conditions and parameters affecting the transmission and processing of information. It overlaps heavily with communication theory, but it is more oriented toward the fundamental limitations on the processing and communication of information and less oriented toward the detailed operation of devices.

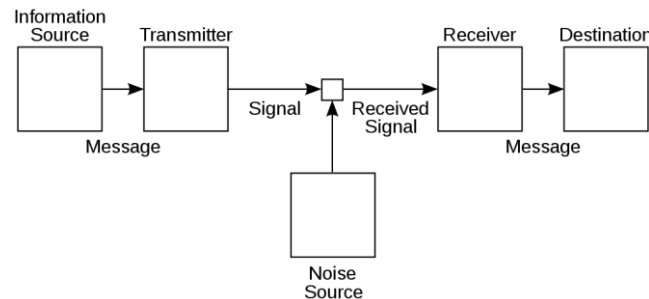


Figure 1. Block Diagram of Shannon's Information Theory

Source: <https://www.britannica.com/science/information-theory/Classical-information-theory>

Data communication refers to the exchange of data between a source and a receiver in a network. It enables the movement of electronic or digital data between two (2) or more nodes, regardless of geographical location, technological medium, or data contents.

- A **source** that generates the information
Examples: computers, smartphones, tablets (terminal devices)
- A **source encoder** that converts the information into an electrical form called message signal
Example: modem
- A **transmitter** that is used to convert the message signal into a form acceptable to the channel
Examples: amplifiers and antennas
- A **channel** which is the path or link that connects the transmitter and the receiver
Example: may be in physical medium space such as wires or radio frequency (RF) signals
- A **receiver** performs an inverse function of that of the transmitter to recover the message signal
Examples: filters and antennas
- A **source decoder** converts the electrical signal back to a form acceptable to the receiver
Example: modem
- A **sink** is the user of the information generated by the source
Example: computers, smartphones, tablets (terminal devices)

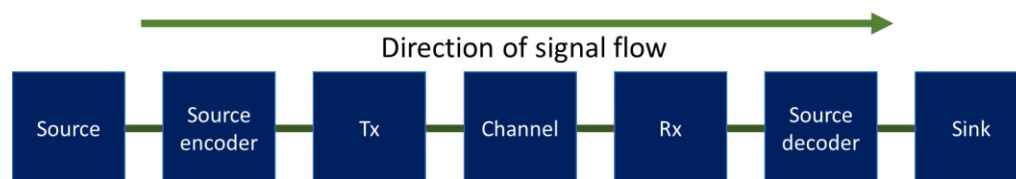


Figure 2. Block Diagram of Data Communication Network Model

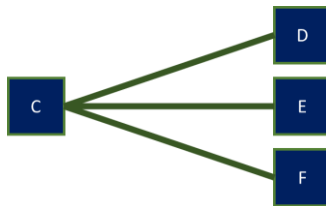
Data Communications Network Topology

These are the physical or logical layouts of devices that belong in a network.

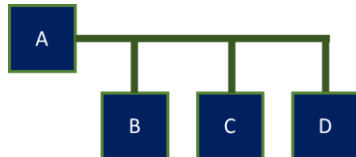
- **Point-to-Point (P2P) topology** – It is a link that permanently connects two (2) nodes or network devices.



- **Point-to-Multipoint topology** – One (1) node is connected to multiple nodes, each in a P2P manner.



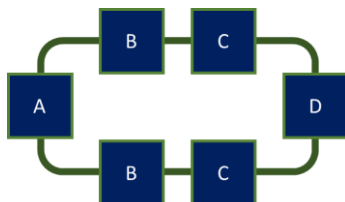
- **Multidrop topology** – All nodes are interconnected by a single link with one (1) node that is the master node and the other nodes are secondary or slave nodes.



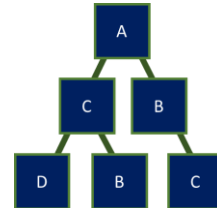
- **Bus topology** – It is like the multidrop topology with the exception that there is no master–slave relationship; all nodes are peers. The line terminator is used to prevent a signal that comes to the end of a transmission line from bouncing back and corrupting other signals on the line.



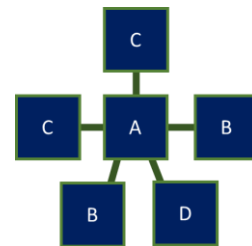
- **Ring topology** – The nodes are connected serially in a P2P manner with the last node connected to the first node to form a loop.



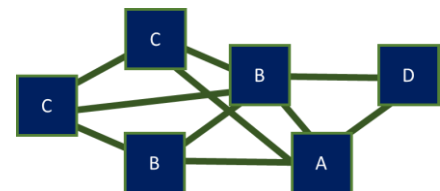
- **Tree topology** – It is formed by connecting multiple buses to form a system of branching links with no closed loop.



- **Star topology** – It is a topology in which each node is connected in a P2P manner to a central node called a hub.



- **Mesh topology** – The network nodes are interconnected arbitrarily. Generally, users are connected to only a subset of the nodes, and another set of internal nodes provides a switching facility that moves data from one node to another until it reaches its destination.



Data Communications Geographical Coverage

- **Personal area networks (PANs)** are networks that interconnect devices within the reach of an individual, usually within a range of 10 meters. These devices are usually cellphones, tablets, and laptops.



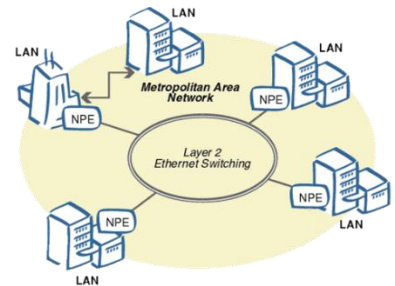
Source: <https://images.app.goo.gl/zoYfWKT7s4X7YneM7>

- **Local area networks (LANs)** cover small geographical areas, typically a building, a floor, or a campus. Examples include the Ethernet and token ring networks.



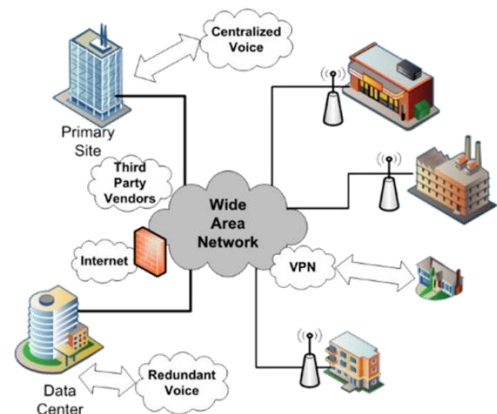
Source: <https://images.app.goo.gl/SVxYrqe9AniMFATs5>

- **Metropolitan area networks (MANs)** interconnect LANs in a campus or metropolitan area. An example includes the fiber distributed data interface (FDDI).



Source: <https://images.app.goo.gl/GzaXYb9AeRrhi4gB6>

- **Wide area networks (WANs)** cover much larger areas such as a country (e.g., public switched telephone network [PSTN]) or the globe (e.g., the Internet).



Source: <https://images.app.goo.gl/Pse6FaSTaxJKg9Bs6>

References:

- Ibe, O. (2018). *Fundamentals of data communication networks* (1st ed.). Wiley & Sons, Inc.
- Britannica. (n.d.). Classical information theory. In *Britannica Encyclopedia*. Retrieved April 13, 2020 from <https://www.britannica.com/science/information-theory/Classical-information-theory>
- Kurose, F., & Ross, K. (2017). *Computer networking: A top-down approach* (7th ed.). Pearson.
- LTE [LTE]. (2016, July 11). *1.1 - Evolution of communication - Stone age to modern age* [Video]. YouTube. <https://www.youtube.com/watch?v=oxTUC5I22LU>
- LTE [LTE]. (2016, July 12). *1.2 - Evolution of communication - From 1G to 4G & 5G* [Video]. YouTube. https://www.youtube.com/watch?v=2nsEAW_SirQ
- Sklar, B. (2017). *Digital communication: Fundamentals and applications* (2nd ed.). Prentice Hall.
- Speidel, J. (2019). *Introduction to digital communications*. Springer Nature.