Network Protocols

- A network protocol is a system of digital message formats and rules for exchanging those messages in or between computing systems and in telecommunications. A protocol may have a formal description.
- Protocols may include signaling, authentication and error detection and correction capabilities.
- A protocol definition defines the syntax, semantics, and synchronization of communication; the specified behavior is typically independent of how it is to be implemented.
- A protocol can therefore be implemented as hardware or software or both.

Network Protocols

- Data formats for data exchange.
- Address formats for data exchange.
- Address mapping.
- Routing.
- Detection of transmission errors
- Acknowledgments
- Loss of information - timeouts and retries.
- Direction of information flow
- Sequence control.
- Flow control

OSI Model

- The Open Systems Interconnection model (OSI model) is a product of the Open Systems Interconnection effort at the International Organization for Standardization.
  - It is a prescription of characterizing and standardizing the functions of a communications system in terms of abstraction layers.
  - Similar communication functions are grouped into logical layers.
  - An instance of a layer provides services to its upper layer instances while receiving services from the layer below.

OSI Model

- Layer 1: physical layer
- Layer 2: data link layer
- Layer 3: network layer
- Layer 4: transport layer
- Layer 5: session layer
- Layer 6: presentation layer
- Layer 7: application layer

Layer 1: physical layer

- The physical layer defines electrical and physical specifications for devices.
- In particular, it defines the relationship between a device and a transmission medium, such as a copper or optical cable.
- This includes the layout of pins, voltages, cable specifications, hubs, repeaters, network adapters, host bus adapters (HBA used in storage area networks) and more.

Layer 2: data link layer

- The data link layer provides the functional and procedural means to transfer data between network entities and to detect and possibly correct errors that may occur in the physical layer.

Layer 3: network layer

- The network layer provides the functional and procedural means of transferring variable length data sequences from a source host on one network to a destination host on a different network, while maintaining the quality of service requested by the transport layer (in contrast to the data link layer which connects hosts within the same network).
- The network layer performs network routing functions, and might also perform fragmentation and reassembly, and report delivery errors.

Layer 4: transport layer

- The transport layer provides transparent transfer of data between end users, providing reliable data transfer services to the upper layers.
- The transport layer controls the reliability of a given link through flow control, segmentation/desegmentation, and error control.

Layer 5: session layer

- The session layer controls the dialogues (connections) between computers.
- It establishes, manages and terminates the connections between the local and remote application.
- It provides for full-duplex, half-duplex, or simplex operation, and establishes checkpointing, adjournment, termination, and restart procedures.

Layer 6: presentation layer

- The presentation layer establishes context between application-layer entities, in which the higher-layer entities may use different syntax and semantics if the presentation service provides a mapping between them.
- This layer provides independence from data representation (e.g., encryption) by translating between application and network formats.
- This layer formats and encrypts data to be sent across a network.
- It is sometimes called the syntax layer.

Layer 7: application layer

- The application layer is the OSI layer closest to the end user, which means that both the OSI application layer and the user interact directly with the software application.
- This layer interacts with software applications that implement a communicating component.
- Application-layer functions typically include identifying communication partners, determining resource availability, and synchronizing communication.

The Internet

- The Internet is vast collection of smaller networks that have decided to communicate with one another.
- No single person or company owns the Internet.
- A wide area network made of smaller networks which are owned and managed by persons or organizations.
- The Internet is defined by how connections are made between the networks.

The Internet

- The Internet Backbone
  - High capacity data route that transfers traffic.
  - Owned by large telecommunication companies.
  - High redundancy with multiple carriers to prevent data loss.
- The Internet Service Provider
  - Company that provides individuals and other companies access to the Internet.
  - Connect directly to the backbone or connect to other ISPs who connect to the backbone.

The Internet

- Many technologies to connect to the Internet.
  - Using a phone modem to dial-up a computer that is permanently connected to the Internet – upto 64kbps which is the limit of analog voice communication.
  - A digital subscriber line (DSL) to transfer data over copper phone lines to and from the phone company's premises – 10+ Mbps.
  - Connect via the cable modem using cable TV wires used for TV -- ~10 Mbps.
  - Fiber to the Home – Connection using Fiber Optics installed in each home – 100+ Mbps.

Open Systems and Protocols

- The Internet exists because of Open Systems and Protocols.
- Originally networks were proprietary and did not inter-operate with each other due to differences.
- An Open System is one based on a common model of network architecture and a suite of protocols used in its implementation.
- The ISO Open System Interconnection (OSI) Reference Model.

The TCP/IP model

- The TCP/IP model (Transmission Control Protocol/Internet Protocol) is a descriptive framework for the Internet Protocol Suite of computer network protocols created in the 1970s by DARPA, an agency of the United States Department of Defense.
- It evolved from ARPANET, which was an early wide area network and a predecessor of the Internet. The TCP/IP Model is sometimes called the Internet Model.

The TCP/IP model

- The TCP/IP model and related protocols are maintained by the Internet Engineering Task Force (IETF).
- The IETF conducts standard-setting work groups, open to any individual, about the various aspects of Internet architecture.
  - Resulting discussions and final standards are published in a series of publications, each called a Request for Comments (RFC), freely available on the IETF web site.
  - The principal methods of networking that enable the Internet are contained in specially designated RFCs that constitute the Internet Standards.

The TCP/IP model

- The TCP/IP model describes a set of general design guidelines and implementations of specific networking protocols to enable computers to communicate over a network.
- TCP/IP provides end-to-end connectivity specifying how data should be formatted, addressed, transmitted, routed and received at the destination.
- Protocols exist for a variety of different types of communication services between computers.

The TCP/IP model

- Architectural principles more important than layering.
- Architectural Principles
  - End-to-End Principle : a classic design principle of computer networking which states that application specific functions ought to reside in the end hosts of a network rather than in intermediary nodes, provided they can be implemented "completely and correctly" in the end hosts.
  - Robustness Principle : “Be liberal in what you accept, and conservative in what you send.” -- That is, it must be careful to send well-formed datagrams, but must accept any datagram that it can interpret.

The TCP/IP model

- The TCP/IP protocol loosely defines a four-layer model, with the layers having names, not numbers.
  - Link Layer
  - Internet Layer
  - Transport Layer
  - Application Layer
- The Internet Protocol Suite and the layered protocol stack design were in use before the OSI model was established.
- As per the IETF Internet protocol and architecture development is not intended to be OSI-compliant.

Link Layer

- The Link Layer (or Network Access Layer) is the networking scope of the local network connection to which a host is attached.
- This is the lowest component layer of the Internet protocols, as TCP/IP is designed to be hardware independent. As a result TCP/IP is able to be implemented on top of virtually any hardware networking technology.
- The Link Layer is used to move packets between the Internet Layer interfaces of two different hosts on the same link.

Internet Layer

- The Internet Layer solves the problem of sending packets across one or more networks.
- In the Internet Protocol Suite, the Internet Protocol performs two basic functions:
  - Host addressing and identification: This is accomplished with a hierarchical addressing system
  - Packet routing: This is the basic task of getting packets of data (datagrams) from source to destination by sending them to the next network node (router) closer to the final destination.

Transport Layer

- The Transport Layer's responsibilities include end-to-end message transfer capabilities independent of the underlying network, along with error control, segmentation, flow control, congestion control, and application addressing.
  - End to end message transmission or connecting applications at the transport layer can be categorized as either connection-oriented, implemented in Transmission Control Protocol (TCP), or connectionless, implemented in User Datagram Protocol (UDP).

Application Layer

- The Application Layer refers to the higher-level protocols used by most applications for network communication.
- Data coded according to application layer protocols are then encapsulated into one or (occasionally) more transport layer protocols (such as the Transmission Control Protocol (TCP) or User Datagram Protocol (UDP)), which in turn use lower layer protocols to effect actual data transfer.

Higher Level Protocols

- Protocols built on top of TCP/IP.
  - Simple Mail Transfer Protocol (SMTP) – Protocol used to specify the transfer of electronic mail.
  - File Transfer Protocol (FTP) – Protocol that allows a user to transfer files from one computer to another – secure version is SFTP.
  - Telnet – Protocol used to log into a computer from a remote computer – secure version is Secure Shell ie. SSH.
  - Hypertext Transfer Protocol (HTTP) – Protocol defining the exchange of World Wide Web documents.

Higher Level Protocols

- All the protocols mentioned are built on TCP.
- Protocols using UDP are also available.
  - Not popular as UDP lacks the reliability of TCP.
- High-level protocols are assigned a port number.
  - Port is a numeric designation which corresponds to a protocol.
  - Servers and routers use the port number to help control and process network traffic.

Higher Level Protocols

Protocol	Port
Echo	7
File Transfer Protocol (FTP)	21
Telnet	23
Simple Mail Transfer Protocol (SMTP)	25
Domain Name Service (DNS)	53
Gopher	70
Finger	79
Hypertext Transfer Protocol (HTTP)	80
Post Office Protocol (POP3)	110
Network News Transfer Protocol (NNTP)	119
Internet Relay Chat (IRC)	6667

MIME Types

- MIME – Multipurpose Internet Mail Extension.
  - Standard for attaching or including multimedia or otherwise specially formatted data with other documents like email.
- Applications can decide how to deal with data based on the MIME type.
- Exist for files created my many application programs as well as data from different content areas.