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CYBERSECURITY FULLSTACK COURSE
[BATCH 29]

CYBERSECURITY FUNDAMENTALS

INSTRUCTOR
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# FOUNDATIONS OF COMMUNICATION SYSTEMS
# [THE EVOLUTION OF THE INTERNET & NETWORKING MODELS]

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## INTRODUCTION

This article aims at discussing Communication systems, its components, evolution of Internet, and networking models.

## WHAT IS COMMUNICATION?

Communication is the act of exchanging or sharing data or information between two or more parties. This exchange of information or data happens over some sort of media or channels of communication. This information sharing can be *local* or *remote*. Local communication occurs face to face, while remote communication takes place over a distance.

Before the advent of digital communication, communication in Africa and Nigeria to be precise took some form of traditional ways such as town criers, blowing of trumpets, setting bush on fire to communicate danger etc.

In this article we will explore a form of communication, a modern form of communication called digital communication.

Before I proceed, let me quickly define the term "*telecommunication*" which includes *telephony*, *telegraphy*, and *television*. Telecommunication simply means communication at a distance, *tele* – is a Greek work for "*far*".

### What is Digital Communication?

Digital communication is the exchange of data and/or information between people, systems and/or devices via digital channels.

### Communication System

A communication system is a collection of devices, software, and services that allow people to send and receive information.

### Components of a Communication System

There are five (5) basic components of a communication system. These include message, sender, receiver, medium and protocol.

- **Message: -** is the information (data) to be communicated. Popular forms of information include text, numbers, pictures, audio, and video.
- **Sender: -** is a device that sends data messages. It can be a computer, workstation, telephone handset, video camera and so on.
- **Receiver: -** is the device that receives the message. It can be a computer, workstation, telephone handset, television and so on.

- **Medium: -** this is the transmission or physical path by which a message travels from sender to receiver. Some examples of transmission medium include twisted-pair wire, coaxial cable, fiber optic cable and radio waves.
- **Protocol: -** these refer to set rules that govern data communications. It represents an agreement between the communicating devices.

Figure 1 below demonstrates components of communication systems.

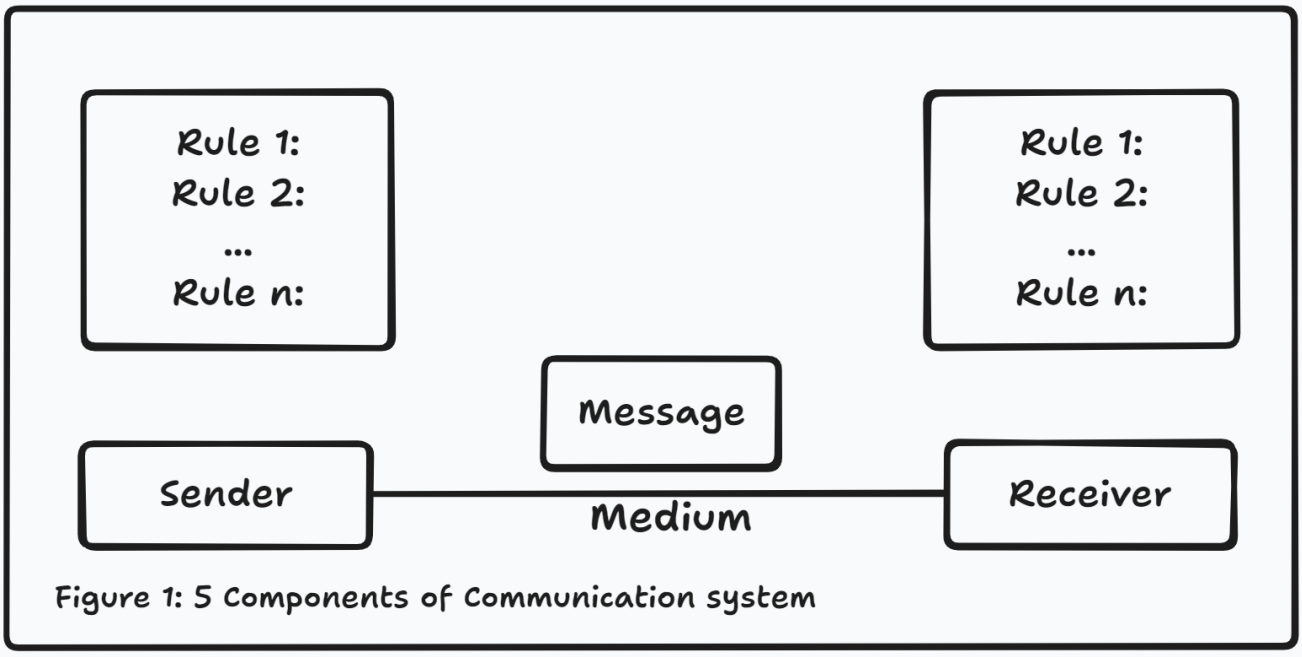


Figure 1: 5 Components of Communication system

## WHAT IS THE INTERNET?

The Internet is a global network of interconnected computers and devices that enable communication and sharing of information. The name Internet is believed to be coined from "*Interconnected Network*" in some texts it is believed to be a short form of "*International Network*".

### How old is the Internet?

What we now enjoy today as Internet started just 42 years ago. January 1st, 1983, is considered the day the Internet was born with the ARPANET officially adopted the TCP/IP Protocol, making it the standard way for computers to communicate across networks.

### A brief history of the internet

The history of the Internet can be broken down into three (3) phases. The early development of the Internet (1967 - 1969), the invention and adoption of TCP/IP (1972 - 1983), and the invention of the World Wide Web (WWW) by Tim Berners-Lee in 1989.

## The Early Development of the Internet (1967 - 1969)

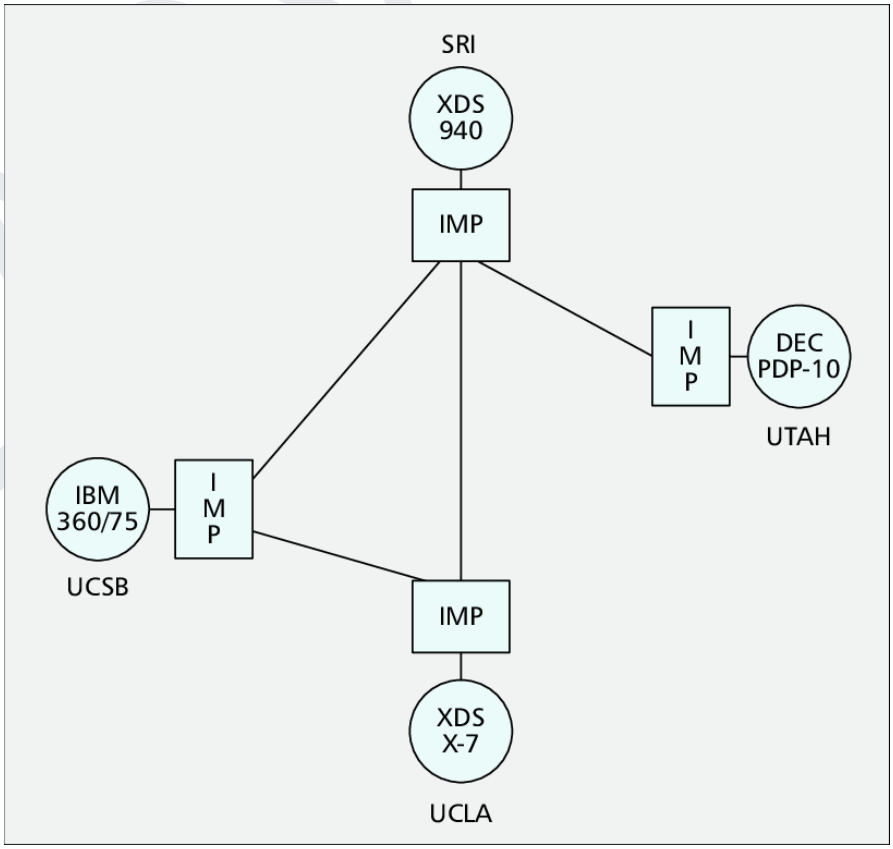
In the mid – 1960s, mainframe computers in research organizations were standalone devices – computers from different manufacturers were unable to communicate with one another. The Advanced Research Project Agency (ARPA), a US agency in the Department of Defense (DoD) was interested in finding a way to connect computers so that the researchers they funded could share their findings thereby:

- Reducing cost and
- Eliminating duplication of efforts.

So, in 1967, at an Association for Computing Machinery (ACM) meeting, ARPA presented its ideas for ARPANET (Advanced Research Project Agency Network) a small network of connected computers. The idea was that each host computer not necessarily from the same manufacturers would be attached to a specialized computer called an Interface Message Processor (IMP).

The IMPs in turn would be connected to one another. Each IMP had to be able to communicate with other IMPs as well as with its own attached host.

By 1969, ARPANET was a reality. Four nodes at the University of California at Los Angeles (ULCA), The University of California at Santa Barbara (UCSB), Standard Research Institute (SRI), and the University of Uttah, were connected via the IMPs to form a network. A software called Network Control Protocol (NCP) provided communication between the hosts.



The figure above shows the ARPANET in 1969

## The Invention and Adoption of TCP/IP (1972 - 1983)

In 1972, Vint Cerf and Bo Kahn both of whom were part of the core ARPANET group, collaborated on what they called the *Internetting Project*. Cerf and Kahn's landmark 1973 paper outlined the protocols (TCP) included concepts such as encapsulation, the datagrams, and the function of the gateway.

Shortly thereafter, the Authorities planned to split TCP into two protocols:

i. Transmission Control Protocol and
ii. Internetworking Protocol (IP)

IP would handle datagram routing while TCP would be responsible for high-level functions such as segmentation, reassembly, and error detection. The internetworking protocol became known as TCP/IP.

As mentioned earlier, ARPANET run on a software called Network Control Protocol (NCP) which had limited address space of 256 – a constraint that became evident as the network grew, even extending Internationally to University College London. To address this limitation, TCP/IP, which offered 32-bit address space capable of supporting approximately 4 billion hosts, was adopted on January 1st, 1983, by ARPA which eliminated the need for IMPs enabling the creation of networks of networks. The Internet as we know today.

## The Invention of the World Wide Web (WWW) by Tim Berners-Lee (1989)

In 1989 a British Computer Scientist named Tim Berners-Lee while working at CERN (*Conseil Européen pour la Recherche*) a European Organization for Nuclear Research invented the World Wide Web (WWW) – to address the challenges in managing and sharing information within the organization and with external collaborators. Drawing inspiration from his earlier ENQUIRE system and Ted Nelson's hypertext concept, Berners-Lee envisioned a decentralized system allowing documents to be linked across multiple computers, supporting various media types beyond text. By the end of 1990, he had developed the first web browser, *WorldWideWeb*, and an HTTP server at CERN. The technology was released to other research institutions in January 1991 and to the public on August 23, 1991. CERN made the web protocols and code royalty-free in 1993, facilitating its widespread adoption.

## NETWORK MODELS

You could recall that I mentioned earlier – in the early development of internet I mentioned that computers manufactured by different manufacturers could not be connected in a network – this challenge in addition to lack of modularity in early designs of network, problems with troubleshooting

and others mandated stakeholders to develop standards and protocols to guide communications over a network this gave raise to network models.

## What are Network Models?

Network models refer to the structured representation of how devices communicate and interact with each other over a network. These models help in organizing and streamlining the flow of data, ensuring efficient communication and resource sharing – think of a network model as a blueprint that defines the rules, protocols and methodologies governing the exchange of information between connected devices.

## Types of Network Models

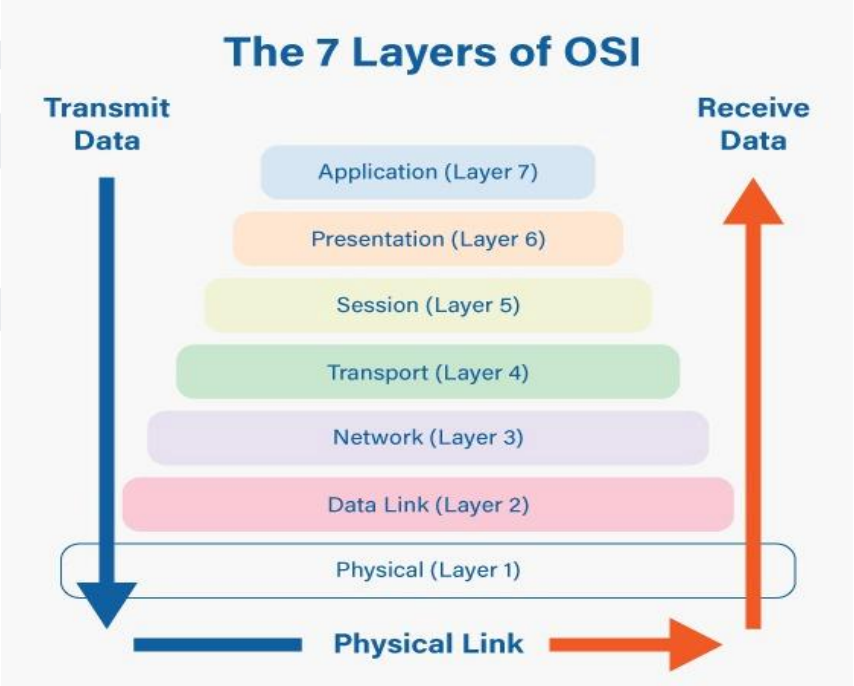
There are many types of network models such as Client-Server Model, Peer-to-Peer Model, hybrid model, Cloud Computing model, SDN Model, OSI Model, and the Internet Model.

In this context we will narrow our focus to just two OSI models and the internet model.

## The OSI Model

The Open Systems Interconnection (OSI) Model is a conceptual framework designed to define communication between different systems without requiring changes to the logic of the underlaying hardware and software. The OSI model is not a protocol, it is a model for understanding and designing network architecture that is flexible, robust and interoperable.

The OSI model is a layered framework for the design of network systems that allows communication between all types of computer systems. It consists of seven separate but related layers, each of which defines a part of the process of moving information across a network. See figure below.



## Layers in the OSI Model and their Functions

In this section we will briefly describe the functions of each layer in the OSI model.

### Layer 1 – Physical Layer

The physical layer coordinates the functions required to carry a bit stream over a physical medium. It deals with the mechanical and electrical specifications of the interface and transmission medium. It also defines the procedures and functions that physical devices and interfaces must perform for transmission to occur.

The physical layer is also concerned with the following:

- Physical characteristics of interfaces and medium
- Representation of bits.
- Data rate.
- Synchronization of bits
- Line configuration
- Physical topology and
- Transmission mode.

### Layer 2 – Data Link Layer

Data link layer is responsible for the movement of data from one node to another. Data link layer is responsible for the following:

- Framing
- Physical addressing (MAC Address)
- Flow control
- Error control
- Access control

### Layer 3 – Network Layer

The network layer is responsible for the source-to-destination delivery of a packet across multiple networks. It is responsible for:

- Logical addressing (IP Addressing)
- Routing

### Layer 4 – Transport Layer

The transport layer is responsible for process-to-process delivery of the entire message. A process is an application program running on a host. It is also responsible for:

- Service point addressing (ports)

- Segmentation and reassembly
- Connection control
- Flow control
- Error control

### Layer 5 – Session Layer

This layer is responsible for:

- Dialog control and
- Synchronization.

### Layer 6 – Presentation Layer

The presentation layer is concerned with the syntax and semantics of the information exchanged between two systems.

It is responsible for:

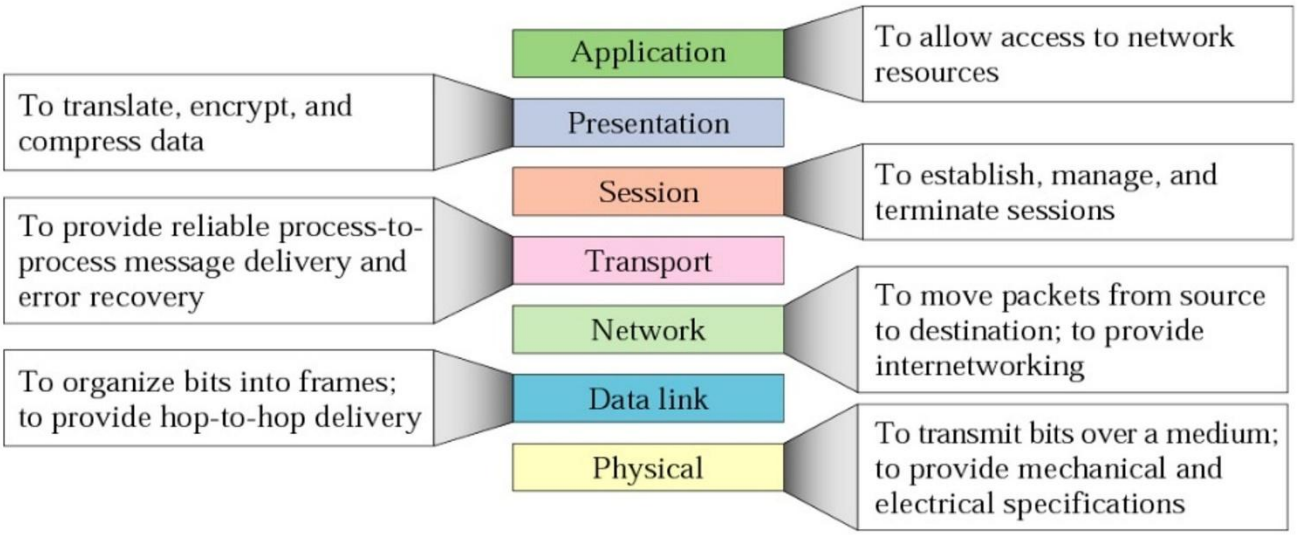
- Translation
- Encryption
- And compression

### Layer 7 – Application Layer

The application layer enables the user, whether human or software, to access the network. It provides user interfaces and support for services such as electronic mail, remote file access and transfer, shared database management, and other types of distributed information services. It is responsible for the following:

- Network virtual terminal
- File transfer access and management
- Mail services
- Directory services

The figure below summarizes the layers in OSI model.

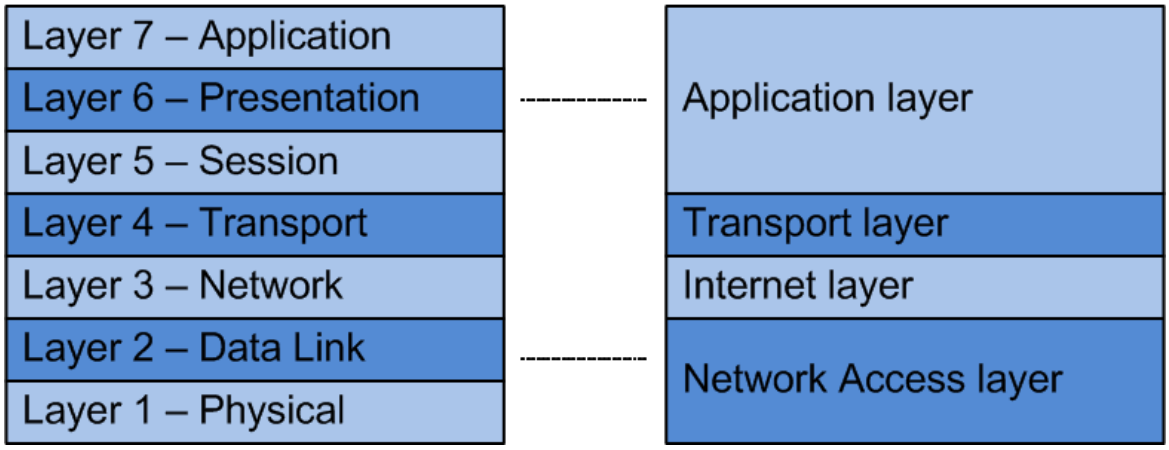



## The Internet Model

The internet model also called TCP/IP Model was developed prior to the OSI model. Therefore, the layers in the TCP/IP model do not exactly match those in the OSI model. The original TCP/IP model was defined as having four layers. The TCP/IP Model is a practical model used for internet communication.

## Layers of the Internet Model

i. Network Access Layer (Physical & Data Link in OSI)
ii. Internet Layer (Equivalent to OSI's Network layer)
iii. Transport Layer (Same as OSI Transport layer)
iv. Application Layer (Combines OSI's Application, Presentation, and Session layers)



## SUMMARY

This article discusses communication systems, their components, the evolution of the Internet, and networking models.

Communication is the exchange of information, which can be local (face-to-face) or remote (over a distance). Traditional communication methods in Nigeria included town criers and fire signals, but today, digital communication enables data exchange between people, systems, and devices.

A communication system consists of five key components: message, sender, receiver, medium, and protocol.

The Internet, a global network, originated from ARPANET in 1969, evolving through three phases:

- Early Development (1967–1969): ARPA connected computers for research collaboration.
- TCP/IP Adoption (1972–1983): Vint Cerf and Bob Kahn introduced TCP/IP, enabling global connectivity.
- World Wide Web (1989): Tim Berners-Lee developed the WWW, revolutionizing information sharing.

Network Models standardize communication and ensure interoperability. The OSI Model defines a seven-layer framework for communication, including Physical, Data Link, Network, Transport, Session, Presentation, and Application layers.

The Internet Model (TCP/IP), developed earlier, has four layers: Network Access, Internet, Transport, and Application.

These models play a crucial role in modern networking, ensuring seamless data transmission across diverse systems.

## REFERENCES

*A short history of the Web*. (2025, January 30). CERN. https://home.cern/science/computing/birth-web/short-history-web#:~:text=Tim%20Berners-Lee%2C%20a%20British,and%20institutes%20around%20the%20world.

Meynell, K. (2018, October 19). *Final report on TCP/IP migration in 1983 - Internet Society*. Internet Society. https://www.internetsociety.org/blog/2016/09/final-report-on-tcpip-migration-in-1983/

Petrova, B. (2025, January 8). *How do OSI Model layers work in computer networking? - ClouDNS Blog*. ClouDNS Blog. https://www.cloudns.net/blog/how-do-osi-model-layers-work-in-computer-networking/

Wikipedia contributors. (2025, February 22). *World Wide web*. Wikipedia. https://en.wikipedia.org/wiki/World_Wide_Web#:~:text=The%20model%20was%20later%20popularized,programs%20on%20their%20server%20computer.