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# Introductory Chapter: Recent Trends in Communication Networks

Pinaki Mitra

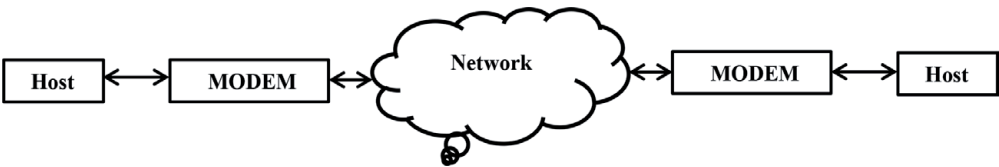
## 1. Introduction

With the emergence of distributed computing platforms and computer networks in the last few decades, there is almost no stand-alone computer anymore. In the last few decades, stand-alone computers in a distributed system communicate in order to share computing power. Communication in computer networks was initially aiming at resource sharing, but nowadays it serves to a variety of functions including computing power sharing. There has been plenty of research works in the area of communications focusing on the development of new networking protocols, transmission media, and different generations of communication technology.

**Figure 1** shows the communication between two hosts in its simplest form. Hosts in computer networks are no longer confined to computers; they can be cell phones, tablets, smart sensors, and so on. In **Figure 1**, the function of the modem is to perform modulation and demodulation.

During the course of time, different types of networks evolved. The initially existing telephone network was used for the purpose of computer communication. This was circuit-switched. There was no buffering in intermediate nodes. Subsequently message-switched network evolved that used the concept of storing in buffer and forwarding. Then packet-switched network came, where messages are fragmented into small-sized packets that can be stored in primary memory, unlike earlier messages that needed secondary storage. Subsequently, we had frame relay, ATM, and virtual circuit packet switching that is a combination of circuit switching and packet switching.

Moreover, a variety of multiplexing techniques are used in data communications. Some commonly used multiplexing techniques are frequency division multiplexing or FDM, time division multiplexing or TDM, and statistical time-division multiplexing. Frequency-division multiplexing used modulation at sender end and demodulation at the receiving end. But it was not very popular like TDM. But in the recent generation of communication, networks are using orthogonal



**Figure 1.**  
*Illustration of data communication in computer networks.*

frequency-division multiplexing (OFDM). Also in communication technology, we had the development of GSM, spread spectrum, and CDMA.

Another aspect of data communication which has witnessed a variety of developments is the technology of the transmission media. It can be either wired or wireless. For wired transmission media, we had twisted pair, coaxial, and fiber-optic cables. Research had been carried out to reduce signal distortion due to attenuation, delay, and interference of different types of noise. Equalization techniques are used to avoid different distortions. In wireless communication, we use microwave communication or satellite communication using geostationary satellites.

The next important issue related to the communication network is the development of network protocols. Initially, we had seven-layered ISO/OSI protocols. After that five-layered TCP/IP protocol evolved. The purpose of these protocols was to ensure error control, flow control, and routing and congestion control. In these protocols, there is a virtual communication between corresponding layers in two different nodes. This takes place through the appending of packet headers, while the information moves down the layer at the source node and removal/stripping of the packet header by the corresponding layer, while the information flows up in the destination node. With recent developments of the Internet of things (IOT), a modified version of TCP/IP protocol evolved named 6LoWPAN. These protocols are not only implemented in the communicating nodes/computers of the communication network but also at routers and switches.

With the increased use of communication networks in day to day life, they became susceptible to attacks from malicious users. There are usually two different types of attacks, namely, passive attacks and active attacks. In passive attacks, the transmitted information is leaked to the eavesdropper but the transmitted message remains unaltered. This can be avoided by using sophisticated encryption and decryption methodologies. In contrast, active attacks involve modification of message content, masquerade, non-repudiation, and denial of service. The modification of message content can be handled using different error detection and error correction methods. There had been several works related to different types of coding in the field of communication research. Non-repudiation can be handled by the cryptographic technique of digital signatures or message authentication code (MAC). Denial of service involves flooding of networks with garbage packets from malicious users. Several machine learning techniques for outlier or anomaly detection are used to detect such attacks.

Performance evaluation of different communication techniques can be carried out using the following four quality of service or QoS parameters. They are throughput, packet loss, delay, and jitter/delay variation. We have to suitably adjust the trade-off between these parameters to optimize the quality of service.

Nowadays, we use several mini handheld devices that use the features of the mobile communication network. These devices usually have very limited storage, computing power, and energy. For this purpose, several types of research had been carried out to reduce the computation and communication overheads without compromising accuracy, security, etc. Another important difference in the area of the mobile communication networks is unlike earlier networks whose topology is always fixed; here we have to handle the problem of variable topology. The inter-connecting link between two nodes of the network may or may not exist during the course of time. Usually, each node in the network has a limited transmission range. Connections are established between two mobile nodes that are within the range. These links will cease to exist when these two nodes go out of range of each other. These networks are also called MANET or mobile ad hoc networks. There are several issues that are different for routing of packets in MANET as compared to fixed interconnection networks. Several types of research had been carried out

for the design of routing protocols in MANET that are also susceptible to various attacks. A recent development in the area of MANET is the vehicular ad hoc networks (VANET). Since a huge amount of data and computation is involved here, several techniques from big data analytics are employed to improve efficiency.

Recently the development of multimedia had enhanced developments of various existing disciplines of computing like operating systems, database, and communication. Multimedia data involves a mixture of image, text, audio, video, and graphics data. These are usually referred to as multimedia content. In the field of operating systems, the advent of multimedia had led to the development of real-time operating systems. Different scheduling algorithms like the earliest deadline first or EDF and rate monotonic algorithm or RMA are adopted for these applications. In the field of the database due to multimedia, we had seen the development of object-relational DBMS where we can efficiently perform content-based retrieval. In the area of communication, the advent of multimedia had led to video on demand. The communication protocol that is used for multimedia communication is RTP that usually runs over UDP that is a simplified version of TCP. We had seen the development of different types of a content distribution network or CDN for this purpose. Since in communication video data involve large uplink/downlink bandwidth, research had been carried out to transmit these data as a mix of different definitions. High-definition video is meant for nodes having large bandwidth for downlink purposes. Medium-definition video is meant for nodes having moderate bandwidth for downlink purposes. Low-definition video is meant for nodes having low bandwidth for downlink purposes. In content distribution network in addition to four quality of service, an additional parameter is introduced that measures the user's feeling or experience of the displayed video satisfying the bandwidth constraint. This is also known as the Quality of Experience (QoE). Usually, this parameter is quantified using peak signal-to-noise ratio or PSNR value of the displayed video stream.

Recent developments in different branches of communications technologies have led to hybrid technologies such as mobile satellite communication (SATCOMM) which are finding their applications in several environments such as unmanned aerial vehicle (UAV) systems.

In recent years, there has been a fruitful interaction between computer network technology and other emerging technologies. Computer networks are now used to provide cloud services. They are interacting with fog computing technology to build content delivery networks. The latter networks provide a lot of services including social networking, digital cinema, etc. But with the development of the ecosystem of these networks, a variety of challenges and requirements are raised among which one can refer to security and specially copyright protection issues.

For recent developments related to communication and networks readers are suggested to refer to [1–4]. For recent developments in the area of network security, readers are suggested to refer to [5].

## **2. Conclusion**

In the field of computers with the advent of the Internet, the topic of computer communication gained significant importance. Different modulation and demodulation techniques evolved for improved long-distance communication. Switching techniques handled efficient data transmission. Different generations of communication networks like 3G, 4G, 5G, and so on evolved in the course of time. Different communication network protocols evolved. These networks got susceptible to various types of attacks. The theory of cryptography and coding theory evolved to handle many

such problems. More recently with the advancement of mobile technologies and IoT, these algorithms had to take into consideration limited resources like battery power, storage, and processor capabilities. This had led to the development of new communication technologies for resource-constrained devices. Also in MANET due to time-varying interconnection, there is a necessity to maintain proper integrity and consistency in the distributed data. Due to large volume of data efficient computational techniques from big data analytics are adopted. Also in the recent development of multimedia communication, different adaptive streaming of multimedia content over different types of networks had evolved that would optimize different quality of service and quality of experience parameters. The book addresses these issues that arise in present-day research in the field of communication and networking and also presents several possible directions for future research.

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