A SURVEY OF COMPUTER NETWORKING THEORY AND PRACTICE

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***ABSTRACT**:* In a computer network system, the many computers are connected to one another in order to facilitate the exchange of digital information. A computer network is, in its most basic form, a collection of devices that are connected to one another via links. Distributed processing, in which a task is split up and carried out simultaneously among multiple computers, is utilised by computer networks. An assault on a network's resources is consistently one of the most difficult obstacles it must overcome. The idea of computer networks is examined in depth in this research study. A computer network consists of a collection of devices that are connected to one another via links. Hosts in personal computers, phones, and servers, in addition to networking devices, can all be considered nodes in a network. Access to the World Wide Web for applications, shared use of application and storage servers, printers, and fax machines, and use of email and instant messaging programmes are all made possible through the use of computer networks. Sharing of information across many computer networks allows for the completion of a vast array of jobs. There are open systems and closed systems, the two primary categories of systems. An open system can be quickly connected to the network and is immediately ready for communication when it does so. On the other hand, a closed system cannot be simply joined to another network due to the requirement of adequate authentication.

KEYWORDS: Computer networks, Protocols, Types of networks, Topology, Nodes, Data transfer.

1. INTRODUCTION

A network of computers, servers, printers, routers, and switches that are all connected to one another and able to exchange information with one another is called a computer network. A computer network's principal function is to enable users in different locations to share data and resources with one another. Depending on their scale, location, topology, and communication protocols, computer networks fall into a number of distinct categories. Local Area Networks (LANs), Wide Area Networks (WANs), Metropolitan Area Networks (MANs), Storage Area Networks (SANs), and Wireless Networks are all examples of popular types of networks. Local area networks (LANs) are networks that connect devices inside a single building or campus. Since these networks are more localized and contain fewer nodes, they are more efficient and dependable than wide area networks. File and printer sharing, as well as email and other forms of online communication, rely heavily on them. On the other hand, wide-area networks (WANs) link offices located in various cities or even in other countries. These networks connect devices across a wider geographic region than LANs do and make use of a variety of technologies, including leased lines, satellite connections, and virtual private networks. Wide area networks (WANs) are widely employed for teleconferencing, video conferencing, and cloud computing. MANs are quite similar to LANs, except they connect numerous LANs across a greater area, such as a city or metropolitan region. Data backup, data replication, and disaster recovery are just some of the storage-related tasks that SANs are designed to handle. Wireless networks eliminate the requirement for wiredconnections between nodes by employing radio waves. The simplicity and adaptability of these networks are contributing to their rising popularity. Wi-Fi, short for "wireless fidelity," refers to a specific form of wireless network that is widely deployed in many different settings. Data transmission and exchange in computer networks is made possible by a combination of physical connection of devices and numerous communication protocols and technologies. Among them are Ethernet, Wi-Fi, TCP/IP, DNS, FTP, HTTP, and a plethora of others. The effectiveness, safety, and dependability of a computer network depend on its design, configuration, and administration. When planning and managing a network, security must always be a top priority. It entails taking precautions to prevent hackers, thieves, viruses, and other security risks from gaining access to the network. Firewalls, anti-malware programmes, IDS/IPS, and encryption are only a few of the standard security methods used today. In conclusion, a computer network is a sophisticated system that enables devices to interact with one another and share data and other resources. Different sizes, topologies, and technology characterise the many distinct varieties of networks. Network performance, security, and dependability all improve with well-thought-out planning, setup, and maintenance.

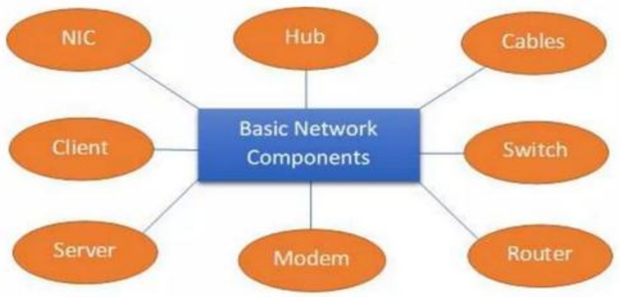

Fig. 1: Components of Computer Network

2. COMPONENTS OF A COMPUTER NETWORK

2.1 NIC (National interface card)

A network interface controller, often known as a NIC, is a piece of hardware that acts as a conduit for information to go between a computer and another piece of hardware. The hardware addresses are kept in the NIC, and the data-link layer protocol uses these addresses to identify the system that is connected to the network [3]. The NIC is responsible for storing the hardware addresses. This makes it possible for the data to be transmitted to the correct destination. The wireless NIC and the wired NIC are the two varieties of network interface card (NIC) that are available.

- All contemporary laptops make use of wireless network interface cards (NIC), and a connection is established by means of an antenna that makes use of radio wave technology.
- Cables are what facilitate the flow of data through the medium using the Wired NIC.

2.2 Hub

In computer networking, a hub is a device used to connect numerous computers to a LAN. Once it has received a data packet from one device, it will send it on to every other device that is linked to it. This means that data transmission from two devices connected to the hub at the same time can cause collisions and degrade network performance. Hubs were widely used in the first stages of the networking revolution since they were low-cost and simple to set up. However, because to technological advancements that have made switches more reasonably priced and efficient, they have become less frequent in recent years. A switch is a smarter device that only sends data to the intended recipient, which greatly improves network speed by decreasing congestion. However, hubs still have a place, especially in low-traffic environments where price is a factor. The ability to easily monitor network traffic and identify issues makes them valuable for troubleshooting as well.

2.3 Router

In computer networking, a router is a device used to link and route data across several nodes on separate networks. Like a traffic cop, it directs the flow of information between networks like the Internet and a company's internal LAN.

In order to determine the optimal routing for each incoming data packet, routers look at its destination IP address. Routing tables, which hold data about the networks linked to the router and the paths to reach them, are used to make these determinations. Network address translation (NAT) is a feature of routers that enables numerous LAN devices to share a single external IP address.

Routers not only forward data between networks, but can offer additional security functions like firewalls. They can prevent hackers from gaining access to a system and protect a network from malicious software.

Routers can be purchased as physical devices, as network switches that also do routing, or as computer or server-based software. They play a crucial role in today's computer networks by facilitating communication between devices and networks and granting users access to the internet and other external networks.

2.4 Modem

A modem is a gadget that allows a computer or other device to connect to the internet via a telephone line. The name "modem" is an abbreviation for "modulator-demodulator," which is what it does.

A modem is a device that takes digital information from a computer and changes it into an analogue signal suitable for transmission over a telephone or cable connection. Using the preexisting telecommunications infrastructure, this enables computers and other devices to connect with each other over great distances.

The modem you need will vary based on the network you're connecting to. Connecting to the web via a regular phone line requires a dial-up modem, whereas connecting via a cable TV network calls for a cable modem. DSL modems, which employ digital subscriber lines (DSL) to deliver broadband Internet access over regular phone lines, are another option.

ISPs are the ones who supply modems, which can be standalone devices or components of larger networking devices. Some modems additionally provide extra functionality, such Wi-Fi or a phone line.

When it comes to connecting computers and other devices to the internet and facilitating long-distance communication, modems play a crucial role.

2.5 Switches

A switch is a computer networking device that connects numerous devices on a LAN and controls the flow of data between them. Switches are smarter than hubs and can just send data to the device that needs it, rather than broadcasting all incoming packets to all connected devices.

To determine which port should receive an incoming data packet, switches check its destination MAC address. Hubs, which can lead to collisions and slow down network traffic, are avoided, which both reduces congestion and increases performance.

Separate units, network cards that double as switches, and scalable, modular switches are just a few of the various types of switches available. The ability to adjust settings like virtual local area networks (VLANs) and Quality of Service (QoS) prioritisation is one way to classify whether or not they are managed.

In order for computers to talk to one another via a local area network (LAN) and for data-intensive activities like video streaming and online gaming to go smoothly, switches are an essential part of today's networks. Access to the network can also be restricted using security measures like MAC address filtering.

2.6 *Cables*

Today's communication and infrastructure networks simply cannot function without cables. They enable the transmission of information, energy, and signals between various entities. Copper, aluminium, and fibre optic strands are just a few examples of the materials used to construct cables.

Power cables, data cables, coaxial cables, and Ethernet cables are just a few examples. Data cables are used to transport digital data over shorter distances, whereas power cables are used to transmit electrical power. Coaxial cables are used for high-frequency broadcasts like cable TV, the internet, and other similar applications, whereas Ethernet cables are used for local area network (LAN) connections.

Fibre optic cables are a modern form of cable that utilises transparent strands of glass or plastic to rapidly carry data across great distances. Since these cables can transfer a lot of data swiftly and efficiently, they are gaining popularity in the telecommunications and internet infrastructure industries.

Cables are essential to the operation of nearly every aspect of our modern technological and physical infrastructure. They make possible the vast majority of modern conveniences we use on a daily basis. Mainly there are three types of cables:

a. Coaxial cable

In electrical wiring, a coaxial cable (or coax cable) has three parts: an inner conductor, an outside conductor, and an insulating layer. The signal is sent down the copper inner conductor, while the outside conductor acts as a shield to block out unwanted signals. Radio frequency signals, including those used for cable TV, internet connections, and other communications applications, are typically transmitted over a coaxial cable. Due to their superior bandwidth, minimal signal loss, and noise tolerance, these cables are frequently used in place of others.

b. Twisted pair cable

Twisted pair cable is a type of insulated copper wiring commonly used in telecommunications. Since EMI and crosstalk tend to worsen the quality of data transmissions at greater distances, the twisted design helps to mitigate these issues.

Telephones, Ethernet networks, and Internet connections are just a few examples of the widespread use of twisted pair cables for speech and data transmission. Cat5, Cat6, and Cat7 are only few of the categories available; each has its own unique set of requirements in terms of bandwidth, maximum transmission distance, and other features.

Twisted pair cables are widely used in the communication industry because they are inexpensive and simple to set up. They deliver consistent performance and are applicable in a variety of settings, from home offices to enterprise-wide rollouts.

c. Fibre optic cable

Thin strands of glass or plastic are used in fibre optic cables to swiftly carry data over great distances. Multiple optical fibres are enclosed in a protective jacket and form the cable. Each fibre is around the thickness of a human hair and can transmit data over several channels.

Compared to copper cables, fibre optic cables have many advantages, including greater bandwidth, greater transmission distances, and resistance to electromagnetic interference (EMI). They find widespread use in high-speed data transmission settings including telecommunications networks and internet backbones.

In terms of speed and reliability, fibre optic technology has completely changed the way we share and access information. Despite the fact that fibre optic cable installation is more expensive than copper or coaxial cable installation in the short term, the long-term benefits and savings more than make up for the original outlay.

3. THE USE OF A COMPUTER NETWORK IN APPLICATIONS

3.1 Resource share

Allow for the sharing of files, data, and various other types of information in a network context, and grant authorised users access to the files, data, and information that is kept on other computers that are part of the network.

3.2 Interpersonal communications

E-mail, instant messaging, chat rooms, the telephone, video telephone conversations, and video conferencing are just few of the ways that individuals are able to contact with one another in an efficient and uncomplicated manner thanks to the use of a network.

3.3 Server-Client model

The server-client concept is commonly used in the field of computer networking. A server is a central computer that is used to store information and is maintained by the system administrator in this way. The server is accessed by other computers. Computers acting as clients establish connections with the server. Clients are the computers that are employed in order to gain access to the data that is stored on the server via the use of a remote connection.

3.4 E-commerce

In businesses, a computer network is another component that is of the utmost importance. You should carry out your commercial operations online. Websites like Amazon.com, which do all of their business on the internet and serve as a model for e-commerce, are the greatest examples of what e-commerce may look like.

3.5 Communication medium

The overall number of users is still unknown. Computer networks demonstrate the qualities of a communication medium in that they have these features. For example, a corporation is considered to have an email system if it has more than one computer and its employees use email as their primary method of day-to-day communication.

4. THE BENEFITS OF WORKING WITH A COMPUTER NETWORK

Using a computer network has many useful applications. Some of the main benefits are as follows:

A. **Sharing resources:** Connecting many computers together in a network allows them to share peripherals like scanners, printers, and hard drives. Employees' access to resources is facilitated and expedited as a result.

B. **Improved communication:** Networks facilitate worker interaction by use of electronic mail, IM, and other means of group communication. As a result, productivity increases and collaborative efforts become less of a hassle.

C. **Increased security:** Firewalls, passwords, and other network security measures can keep prying eyes out of computers and off of private information.

D. **Remote access:** With a network in place, employees are able to connect with one another and share information from any location in the world. Businesses that employ freelancers or individuals who frequently travel to different locations may benefit greatly from this.

E. **Cost savings:** By sharing resources and using central servers, companies can save money on hardware and software expenses. Additionally, networks can help reduce downtime and increase efficiency, which can lead to cost savings over time.

5. DISADVANTAGES OF COMPUTER NETWORK

While computer networks have many advantages, there are also some disadvantages to be aware of, including:

a) Threats to network security Computer networks present new entry points for hackers and other crooks. Inadequate network security might result in the disclosure or alteration of sensitive data.

b) Computer networks can be difficult to implement and manage, eating up a lot of time and money. This might be difficult for startups with little resources and knowledge.

c) In the event of a network outage or other technical difficulties, businesses that rely largely on computers may endure disruptions in service. Productivity and income may suffer as a result of this.

d) Setting up and maintaining a computer network can be costly, despite the fact that they help businesses save money by standardising procedures and increasing productivity. All the resources (computers, programmes, and people) required to keep the network running smoothly go under this category.

e) Connectivity issues, incompatibilities, and hardware failures are just a few examples of the technical problems that can arise in computer networks. Fixing these problems, especially if you need to bring in outside technical expertise, may be expensive and time-consuming.

6. TOPOLOGY IN COMPUTER NETWORK

The term "topology" may be broken down into its most elementary components, which are the organization of a network and the method in which the various components of the network are connected to one another. Both the logical and the physical may be thought of as topologies in their own right. Neither one is more important than the other. The basic goal of physical topology is to offer a geometric representation of all of a network's nodes, and one of the purposes of physical topology is to try to provide this representation.

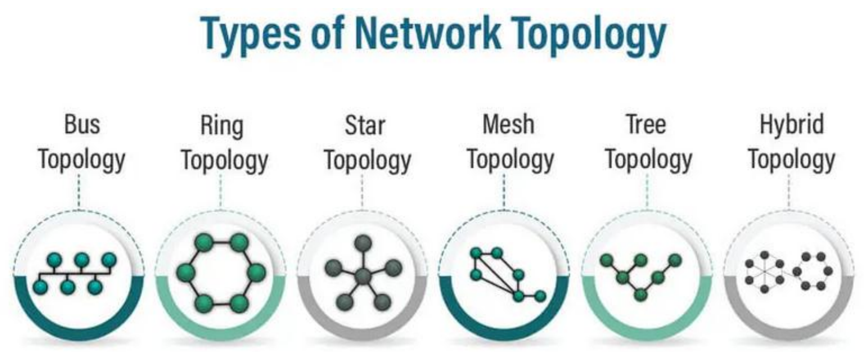

Fig. 2: Types of Network Topology

6.1 Bus Topology

a) The bus topology that is utilized often is also referred to by the phrase "backbone cable." A bus topology is characterized by the use of a single cable to link each node to the other nodes in the network.

b) There are two ways that each node can connect to the backbone cable: either directly or indirectly through a drop cable.

c) Whenever a node or system wishes to send a message to another node or system using a network, it will first upload the message to the network. The message is transmitted to each and every node in the network, regardless of whether or not that node has an address associated with it.

d) The bus topology is the most frequent structure used for network topologies that adhere to the 802.3 (Ethernet) and 802.4 standards.

e) The configuration of a bus topology is noticeably simpler in comparison to the design of other topologies.

f) The "single lane" that allows for the transmission of messages to all of the nodes is what is meant when the word "backbone" is used.

6.2 Ring Topology

a) The only difference between this topology and the bus topology is that the nodes are connected with one another using a point-to-point connection.

b) Due to the fact that it is unidirectional, data transfer may only occur in one way at a time.

c) There is no one point at which the connections between the various nodes in this structure come to a stop, as all of the nodes are connected to one another.

d) This structure is referred to as having ring topology due to the ring-like structure that it possesses.

e) When a ring topology is utilized, the flow of data occurs in a clockwise manner.

6.3 Star Topology

a) A star topology is a sort of network design in which every device on the network is linked to a central hub or switch. This style of architecture is also known as a star configuration. The centralised hub serves as an intermediary, controlling and directing the flow of data between all of the devices that are linked to it.

b) Every node on the network has a direct link to the central hub when the network is set up in a star topology, which enables devices to communicate with one another in a timely and effective manner. Because of this architecture, even if one of the devices on the network stops working, it will not have an effect on the other devices on the network because each device has its own independent connection to the hub.

c) The simplicity of installation and upkeep is one of the most significant advantages offered by a star topology. In order to add or remove devices, one need just connect or unplug them from the central hub. This will not affect the functionality of the remaining devices on the network. In addition, because each device has its own dedicated connection, the performance of the network can be optimized and maintained with far less effort.

d) The fact that a star topology is dependent on a central hub is, unfortunately, one of its drawbacks. In the event that the hub fails, the functionality of the whole network will be disrupted until the hub is either fixed or replaced. In addition, the cost of the central hub might be a major investment, particularly for networks that are on a bigger scale.

e) Because of its straightforward design and user-friendliness, the star topology is frequently used in the construction of small to medium-sized networks. It ensures that devices are able to communicate with one another in a dependable and effective manner, but care must be taken to ensure that the central hub is properly maintained and safeguarded to avoid disruptions to the network.

6.4 Mesh Topology

a) A computer network with a mesh topology is an architecture in which the nodes are interconnected in a gridlike fashion. In this configuration, all nodes are linked to one another, allowing for different communication channels. This means that even if one link fails, data may still be sent via other channels, making mesh topology a highly redundant and fault-tolerant network design.

b) Wireless networks frequently employ a mesh architecture, especially for large-scale installations where redundancy and stability are paramount. Some wired networks utilise it as well, including those for HPC and server farms. When compared to other network topologies, the fundamental drawback of a mesh topology is the complexity and cost it entails due to the enormous number of physical connections it requires.

6.5 Tree Topology

a) When it comes to computer network design, "tree topology," also known as "hierarchical topology," refers to a configuration in which nodes are placed in a hierarchical structure. A hub or switch in the centre of this topology connects to other hubs or switches, forming a tree-like structure among the nodes. In conventional network architecture, nodes at the bottom of the hierarchy represent end users or devices, while nodes higher up represent routers and switches.

b) Enterprise networks often employ tree topology due to its scalability and management benefits, making it a popular choice for large-scale installations. It has certain benefits over bus topology, for example, since it gives redundancy in data transfer and may be expanded without requiring major changes to the underlying network architecture. However, if the hierarchy goes too deep, it can cause performance concerns and increased latency, making it more difficult to maintain than alternative topologies. A single point of failure can disrupt the whole network because of its dependence on a central hub or switch.

6.6 Hybrid Topology

a) The term "hybrid topology" refers to a specific category of computer network design in which two or more distinct topologies are combined into a single system. The star-bus topology, a combination of the star and bus topologies, is the most prevalent type of hybrid topology.

b) In this configuration, a central hub or switch is linked to several nodes in a star topology, and the nodes in the star topology are linked to each other in a bus topology. As subsets of devices may be added or withdrawn without impacting the whole network, and backup connections can be used in the event of a connection failure, this design produces a network architecture that is both scalable and fault-tolerant.

c) In big business networks, where various departments may need distinct network architectures to suit specific requirements or accommodate existing equipment, hybrid topologies are frequently utilised. A bus topology might be used to connect individual star topology LANs in different office buildings into a WAN that connects all of the offices in the firm.

7. CONCLUSION

Explain in this article the analytical study that was done on the many fundamental topologies so that we may have a rough idea of what each topology comprises and how they differ from one another. The features of topology are as follows: reliability, scalability, flexibility, and efficiency. If it mixes two or more distinct topologies, the design may become more difficult, and the infrastructure may become more expensive. This is the sole potential negative of the approach. The development of computer networks will fundamentally alter people's ways of life, such that it will never again be the same. Human activities like as working, playing, and talking will all make use of networks in the future. The proliferation of computer networks has had an effect on the progress that has been made throughout the world. The networks will give rise to new protocols and standards, new applications will be conceived up, and as a result of these changes, our lives will continue to be transformed and enhanced. A network is made up of two or more computers that are linked to one another by means of a telecommunications system in order to make it easier for users to share information and make use of common resources. If businesses were unable to connect to a network, it would be impossible for them to work together on projects or share resources with one another. The ability to forecast the characteristics of complex networks requires fundamental information, which is part of the primitive knowledge base. It would appear that electronic communication has the potential to evolve into a highly valuable tool for networking, particularly if a large number of individuals with similar interests had access to the technology. Specifically, this would be the case if large numbers of people with similar interests had access to the internet.

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