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Overview of Network Topology

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ABSTRACT

In recent days, the significance and popularity of distributed computer systems have increased, offering high-performance capabilities at a reduced cost. The arrangement of autonomous computers in a distributed computing environment is facilitated through a communication network, organized in a geometrical shape referred to as network topology. This paper presents a comprehensive examination and analysis of various network topologies. Definitions for both Physical and Logical Topologies are also included. An introduction to Computer Network Topology is presented in this paper, accompanied by the provision of definitions for Physical and Logical Topologies. Furthermore, common realizations of Physical Topologies in Computer Networks are reviewed. Subsequently, the relationship between Graph Theory and topological analysis is explored. Following this, examples of analysis are discussed, placing emphasis on message routing concerns, network sizing, and virus analysis. These examples are examined to highlight the significance of topological design in the construction of a new computer network or the expansion of an existing one.

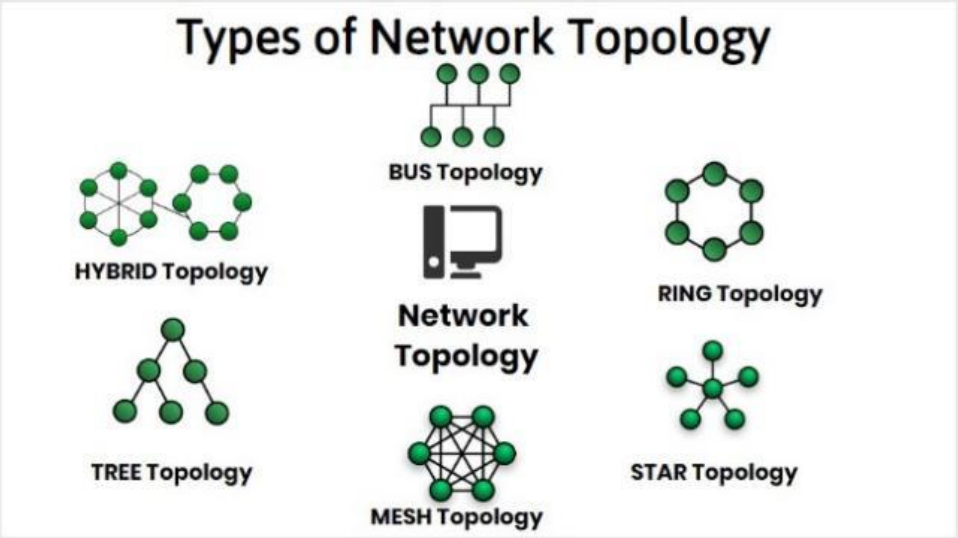
Keywords: Network topology, Physical Network Topology, Logical Network Topology

INTRODUCTION

The arrangement of elements in a communication network, known as network topology, can be used to describe various types of telecommunication networks such as command and control radio networks, industrial field busses, and computer networks. It represents the structural layout of a network and can be depicted either physically or logically. In this representation, devices are depicted as nodes, and the connections between them are shown as links or lines. Physical topology refers to the actual placement of network components, like the location of devices and installation of cables, while logical topology illustrates how data flows within the network. While different networks may have variations in distances between nodes, physical connections, transmission rates, or signal types, their logical topologies can be the same. The physical topology of a network is particularly addressed by the physical layer of the OSI model.

The arrangement in which computer systems or network devices are interconnected is defined by a Network Topology. Both the physical and logical aspects of the network may be outlined by topologies. In the same network, both logical and physical topologies can be the same or different.

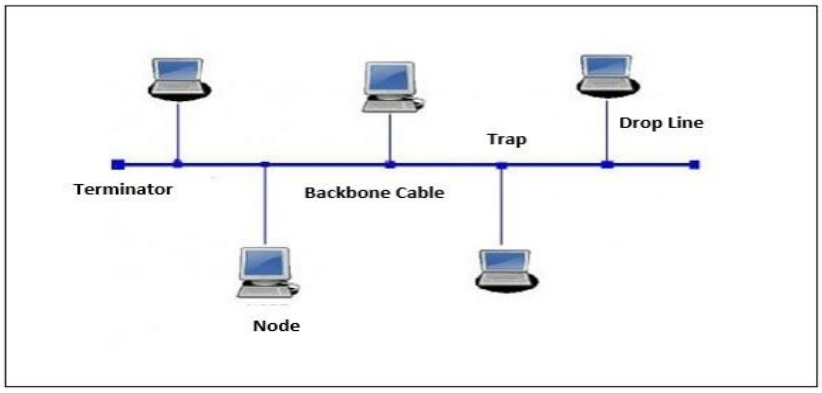
Some of the most common network topologies are:



[5] **Fig1: Types of Topology**

BUS TOPOLOGY

This configuration is widely used in local area networks (LANs). In this topology, a singular network cable spans the building or campus, connecting all nodes along this communication line. The nodes are linked to this common communication line at two endpoints known as the bus or backbone, as illustrated in the figure.



[6] **Fig2: BUS Topology**

In this topology, if a single node experiences a malfunction, it can potentially impact all other nodes because they all rely on the same cable for sending and receiving information. Despite this vulnerability, bus systems have the advantage of having the lowest cabling cost compared to various other topologies. To ensure proper functioning, each end of the cable is terminated using a specialized terminator.

ADVANTAGES:

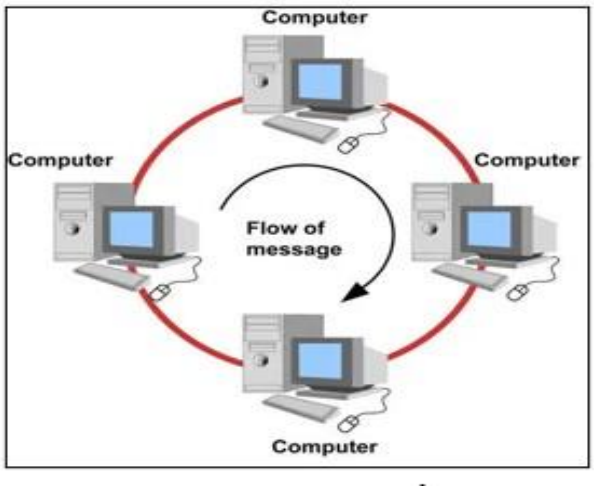
- This network topology is the simplest for linking computers or peripherals in a linear arrangement.
- It operates efficiently, especially in small network setups.
- The cable length needed is less compared to a star topology.
- Connecting or disconnecting devices in this network is straightforward and does not impact the functionality of other devices.

DISADVANTAGES:

- Large networks are not well-suited for bus topology.
- Difficulty arises in identifying problems when the entire network experiences downtime.
- Troubleshooting individual device issues becomes challenging.
- Terminators are necessary at both ends of the main cable.
- The network experiences slowdown with the addition of extra devices.

RING TOPOLOGY

Ring Topology is a network configuration where devices are interconnected to form a circular data path. Each device links precisely to its two neighboring devices, creating a ring-like structure, similar to points on a circle. In a Ring Topology with a significant number of nodes, repeaters are employed to facilitate data transmission and prevent data loss. The collective arrangement of devices in a ring topology is referred to as a ring network. In this topology, packets traverse from one device to the next until they reach their intended destination. The data travels unidirectionally, meaning it moves in only one direction. However, bidirectional communication can be achieved by establishing two connections between each network node, leading to what is known as Dual Ring Topology. This topology finds applications in both Local Area Networks (LANs) and Wide Area Networks (WANs), depending on the network card configuration in the computer.



[7] **Fig3: RING Topology**

ADVANTAGES:

- Ring networks provide excellent performance in scenarios with a limited number of workstations or in larger networks where each station shares a comparable workload.
- Ring networks can be easily expanded or extended.
- In a point-to-point line configuration, it is straightforward to identify and isolate faults.

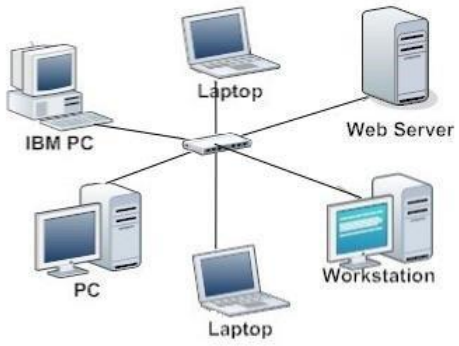
DISADVANTAGES:

- A single malfunctioning workstation has the potential to disrupt the entire network.
- It is comparatively costly and poses challenges during the installation.

STAR TOPOLOGY

The star topology is a widely used network configuration where every device or node links to a central hub. However, a significant drawback of this setup is that if the central hub experiences a failure, all computers connected to it would lose their connection. This topology's major disadvantage lies in its heavy reliance on the proper functioning of the central hub, as any failure in the hub would result in the entire network becoming inoperable.

A notable advantage of the Star Network Topology stems from its ability to localize cabling failures. In this configuration, a failure in the connection between the main hub and any subordinate node, or a failure in a subordinate node, does not disrupt the entire network. This advantage is particularly beneficial in Local Area Networks (LANs) that cover a larger geographic area compared to Bus or Ring Network Topologies. However, there are drawbacks to consider, such as the increased need for cabling. Additionally, the top-level node holds a potential disadvantage as any malfunction in this device can halt communication across the entire network. Another limitation of the Star Network Topology is the restricted number of connection points for top-level nodes.



[8] Fig4: STAR Topology

ADVANTAGES:

- It offers greater reliability, as the failure of one connection does not impact others in the network.
- In a star network, the central hub serves as a convenient location for diagnosing network faults. If a single computer within the network experiences a failure, the entire network remains undisturbed.
- Utilizing various cable types within the same network when connected to a hub.
- It has good performance.

DISADVANTAGES:

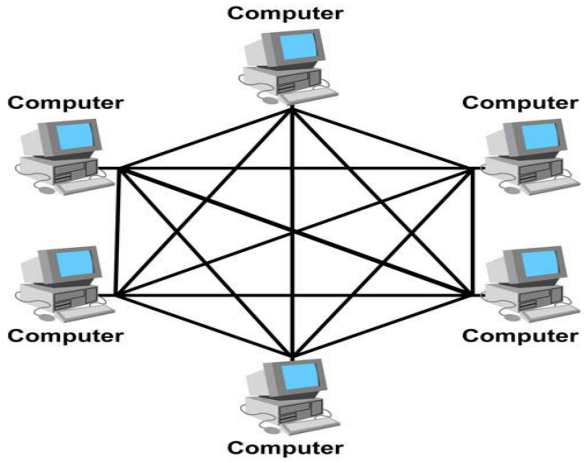
- The network's operation is contingent on the central hub, and if the hub experiences a failure, the entire network ceases to function.
- In numerous star networks, a device positioned at the central point is often necessary to retransmit or switch the network traffic.

MESH TOPOLOGY

Mesh topology is a network configuration where every computer and network device is directly linked to each other. This arrangement enables the distribution of most transmissions even in the event of a connection failure. It is a frequently employed topology, especially in the context of wireless networks.

Mesh topology involves random connections between devices, which can include computers, switches, hubs, or other devices. This setup allows for the distribution of nodes even if one connection fails.

In a mesh topology, every computer is not only responsible for transmitting its own signals but also acts as a relay for other nodes. This topology is commonly employed in wireless networks, where connections can be either wired or wireless. Each node in the mesh topology setup is directly connected to every other node through a point-to-point connection. The diagram below illustrates an example of a mesh topology network.



[9] Fig5: MESH Topology

ADVANTAGES:

- The use of point-to-point links simplifies the process of identifying and isolating faults.
- Privacy is upheld among computers as messages travel through dedicated paths.
- Network problems are easier to diagnose.

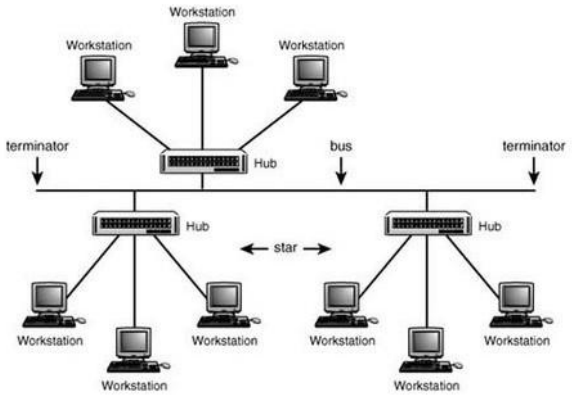
DISADVANTAGES:

- The amount of cabling required is high.
- There is a necessity for a substantial number of input/output (I/O) ports.

TREE TOPOLOGY

Tree Network Topology is formed by either creating a series of Star Network Topologies under the control of a central node or interconnecting several Star Network Topologies directly through a bus, thereby distributing the central node's functionality among multiple top-level nodes. In the second arrangement, the components linked via a bus are formed by the top-level nodes from each Star Network. In a straightforward Tree Network Topology, no subordinate nodes from the Star Network Topologies are connected to the bus. Messages within a Tree Network Topology can be broadcasted from the central node to all interconnected Star Networks or targeted to specific Star Networks.

In Tree topology, devices are arranged in a hierarchical manner, creating a structure that resembles a tree. The hierarchy in Tree topology includes a top-level root node, which is followed by child nodes. Each of these child nodes may, in turn, have their own child nodes. The nodes situated at the lowest level of the hierarchy are referred to as leaf nodes. As you descend in the Tree structure hierarchy, the number of nodes, clients, or devices tends to increase. In tree topology, a single line of connection between the connected devices is observed.



[10] **Fig6: TREE Topology**

ADVANTAGES:

- The installation and configuration of the network is easily accomplished.
- It is more cost-effective than mesh topology.
- Faults in the network can be identified through traces.

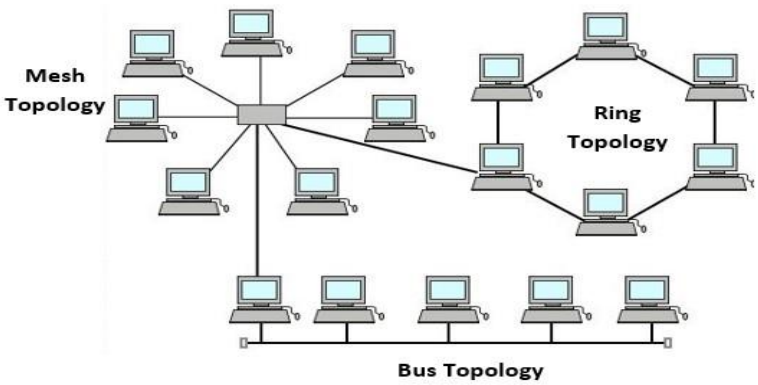
DISADVANTAGES:

- If the central hub experiences a failure, the entire network comes to a standstill.
- Additional cabling is necessary in comparison to bus topology, since every node is linked to the central hub.

HYBRID TOPOLOGY

Hybrid Topology is a combination of different links and nodes that communicate for data transfer. In this type of topology, we merge two or more distinct topologies to create a resultant topology that incorporates the strengths and weaknesses of all the basic constituent topologies, rather than having the characteristics of just one specific topology. This combination of topologies is established based on the organization's requirements.

Nevertheless, its physical implementation requires a range of technologies, resulting in a complex structure. Despite this complexity, it offers advantages such as increased flexibility, enhanced fault tolerance, and the ease of adding or removing basic topologies. Hybrid topology proves particularly valuable when aiming for diversity in a computer network. Within this topology, each network segment can adopt the configuration of different network topologies. For example, a hybrid network might consist of a Star Backbone and a Ring Network. Another option is the Star Mesh Hybrid Topology, where the failure of the main backbone leads to the collapse of the entire network.



[11] **Fig7: HYBRID Topology**

ADVANTAGES:

- This topology integrates the advantages of various types of topologies into a single configuration.
- It is extremely flexible.
- Scalability is effortless with Hybrid networks, as they are designed in a way that allows the seamless integration of new hardware components.
- The topology's speed increases significantly when two different topologies are combined.

DISADVANTAGES:

- It is a type of network expensive.
- A change in the hardware is made to connect one topology with another.
- The hubs utilized for connecting two distinct networks are expensive, and they differ from regular hubs as they need to possess the intelligence to function with various architectures.
- The installation process is a challenge.

LOGICAL TOPOLOGY

Logical topology is defined as the abstract representation of how data moves and is transmitted in a network, regardless of its physical arrangement. The structure that governs the path of data packets between network nodes is determined by the protocols and data handling techniques employed, including Token Ring, Ethernet, or wireless protocols. In contrast to physical topology, which concentrates on the physical links between network devices, logical topology directs attention to the route that data follows as it moves through the network.

There are two categories of logical topologies: Shared media topology and token-based topology.

SHARED MEDIA TOPOLOGY

In a shared media topology, systems have unrestricted access to the physical media, allowing any system in the network to access the physical layout whenever needed. Collision is the main disadvantage of this topology as more than one system send information out on the wire at the same time, the packets collide and as a result this collision kills the packets. Ethernet is an example of a shared media topology.

TOKEN-BASED TOPOLOGY

In token-based topology, a token circulates within the network to gain access to the physical media. When a node wishes to transmit a packet to another node, it must wait for the token to circulate within the network, either in a clockwise or anti-clockwise direction.

CONCLUSION

This paper examines and analyzes the performance of various topologies in computer networks. It includes a description of the inherent advantages and disadvantages of computer network topologies in the context of any system under study. The document offers insights into analysis approaches for addressing problems related to network topology and suggests that the techniques discussed can be applied to related computer network applications. Furthermore, the research work indicates potential extensions for further exploration. This will help us to know that which structure or topology is best for which organization or business. So finally, we can say that all topologies have some extra and different feature are available from other topology and that features are making it special from other topology. The paper presents various analysis approaches for addressing problems related to network topology, including routing analysis,

network sizing, and network corruption. The techniques discussed in this context can be applied to other computer network applications. Recognizing the fundamentals of Computer Network Topology is crucial for effective network analysis, preventing the allocation of effort towards less productive analysis approaches.

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