

NETWORK TOPOLOGIES

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Abstract

Network topology is the way various components of a network (like nodes, links, peripherals, etc) are arranged. Network topologies define the layout, virtual shape or structure of network, not only physically but also logically. The way in which different systems and nodes are connected and communicate with each other is determined by topology of the network. Topology can be physical or logical. Physical Topology is the physical layout of nodes, workstations and cables in the network; while logical topology is the way information flows between different components. Distances between nodes, physical interconnections, transmission rates, and/or signal types may differ between two networks, yet their topologies may be identical.

Keywords

Topology, P2P, Bus, Ring, Star, Mesh, Tree, , PON, Ethernet.

1 Topology - General

Network topology is usually a schematic description of the arrangement of a network, including its nodes and connecting lines. There are two ways of defining network geometry: the physical topology and the logical (or signal) topology. Physical topology describes where the network's various components like its devices and cables are placed and installed, while logical topology explains network's information (data) flow and transmission, apart from physical design. Distances between nodes, physical interconnections, transmission rates, and/or signal types may differ between two networks, yet their topologies may be identical.

FTTH example: Nodes in FTTH has one or more physical links to other devices in the network and drawing links, network designing, between these nodes in a map gives the physical topology for the network. Logical topology is designed by mapping and drawing how the data transmits through the network; line speeds, wavelengths, signaling etc.

Two basic categories of network topologies:

- Physical topology
- Logical topology

The physical topology and its capabilities is determined by network active devices and media like cable type(s), the level of control or fault tolerance desired, and the Capex/Opex costs related to its passive and active infrastructure.

The logical topology in contrast, is the way that the signals act on the network media, or the way that the data passes through the network from one device to the next without regard to the physical interconnection of the devices. A network's logical topology is not necessarily the same as its physical topology. For example, the original twisted pair Ethernet using repeated hubs was a logical bus topology with a physical star topology layout. Also Token Ring is a logical ring topology, but is wired as physical star topology from the Media Access Unit.

The logical classification of network topologies generally follows the same classifications as those in the physical classifications of network topologies but describes the path that the *data* takes between nodes being used as opposed to the actual *physical* connections between nodes. The logical topologies are generally determined by network protocols as opposed to being determined by the physical layout of cables, wires, and network devices or by the flow of the electrical or optical signals, although in many cases the paths that the signals take between nodes may closely match the logical flow of data, hence the convention of using the terms *logical topology* and *signal topology* interchangeably.

Logical topologies are able to be dynamically reconfigured by special types of equipment such as routers and switches.

The basic network topologies are:

- Point-to-point
- Bus
- Star
- Ring or circular
- Mesh
- Tree
- Hybrid

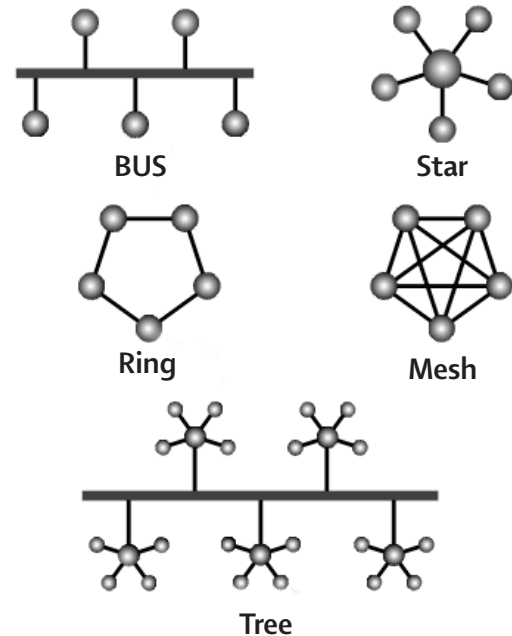


Diagram of different network topologies.

1.1 Point-to-point

The most basic and commonly in POTS (Plain Old Telephone Systems) systems used topology is a permanent link between two endpoints. Its switched point-to-point topology is the basic model of conventional telephony systems. Point-to-point network is designed to give direct and dedicated communications between the two endpoints.

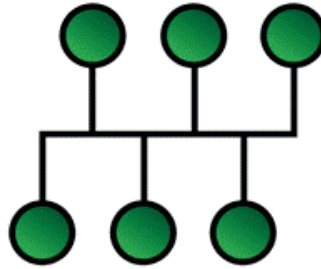
Permanent (dedicated)

Easiest to understand, of the variations of point-to-point topology, is a point-to-point Communications Channel that appears permanently between the two endpoints. Within many Switched telecommunications systems, it is possible to establish a permanent circuit. One example might be a telephone in the lobby of a public building, which is programmed to ring only the number of a telephone dispatcher.

Switched:

Using Circuit-switching or Packet-switching technologies, a point-to-point circuit can be set up dynamically, and dropped when no longer needed. This is the basic mode of conventional telephony.

1.2 Bus



Bus networks use a common backbone to connect all devices. A single cable, the backbone functions as a shared communication medium that devices attach or tap into with an interface connector. A device wanting to communicate with another device on the network sends a broadcast message onto the wire that all other devices see, but only the intended recipient actually accepts and processes the message. Since the bus topology consists of only one wire, it is rather inexpensive to implement when compared to other topologies. However, the low cost of implementing the technology is offset by the high cost of managing the network. Additionally, since only one cable is utilized, it can be the single point of failure. If the network cable is terminated on both ends and when without termination data transfer stop and when cable breaks, the entire network will be down.

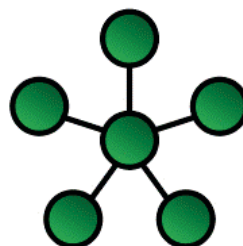
Linear bus

The type of network topology in which all of the nodes of the network are connected to a common transmission medium which has exactly two endpoints – all data that is transmitted between nodes in the network is transmitted over this common transmission medium and is able to be received by all nodes in the network simultaneously.

Distributed bus

The type of network topology in which all of the nodes of the network are connected to a common transmission medium which has more than two endpoints that are created by adding branches to the main section of the transmission medium – the physical distributed bus topology functions in exactly the same fashion as the physical linear bus topology (i.e., all nodes share a common transmission medium).

1.3 Star



In networks with a star topology, each host or client is connected to a central hub (switch, router, server) with a point-to-point connection. All traffic that traverses the network passes through the central hub. The hub acts as a signal router. The star topology is considered the easiest topology to design and implement. An advantage of the star topology is the simplicity of adding additional nodes. The primary disadvantage of the star topology is that the hub represents a single point of failure though this 'device' is commonly duplicated (redundancy).

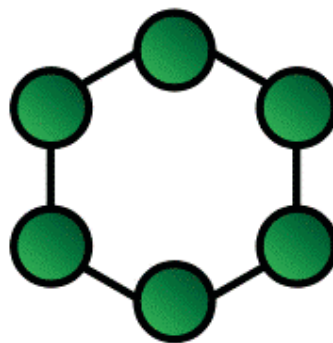
Extended star

A type of network topology in which a network that is based upon the physical star topology has one or more repeaters between the central node (the 'hub' of the star) and the peripheral or 'client' nodes. The repeaters are used to extend the maximum transmission distance of the point-to-point links between the central node and the peripheral nodes beyond that which is supported by the transmitter or the physical layer (cables, RF link).

Distributed Star

A type of network topology that is composed of individual networks that are based upon the physical star topology connected in a linear fashion – i.e., 'daisy-chained' – with no central or top level connection point (e.g., two or more 'stacked' hubs, along with their associated star connected nodes).

1.4 Ring

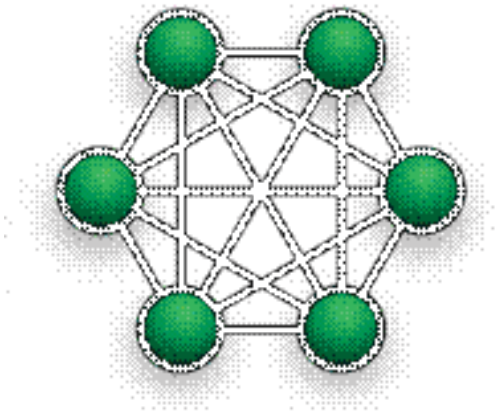


A network topology that is set up in a circular fashion in which data travels around the ring in one direction and each device on the ring acts as a repeater to keep the signal strong as it travels. Each device incorporates a receiver for the incoming signal and a transmitter to send the data on to the next device in the ring. When a device sends data, it must travel through each device on the ring until it reaches its destination. Every node is a critical link.

1.5 Mesh

The mesh network topology employs either of two schemes, called full mesh and partial mesh. In the full mesh topology, each workstation is connected directly to each of the others. In the partial mesh topology, some workstations are connected to all the others, and some are connected only to those other nodes with which they exchange the most data

Fully connected network

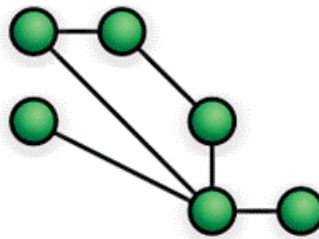


A fully connected network is a Communication network in which each of the nodes is connected to each other. A fully connected network doesn't need to use Switching nor Broadcasting. However, its major disadvantage is that the number of connections grows quadratically with the number of nodes, per the formula

$$C = \frac{n(n-1)}{2}$$

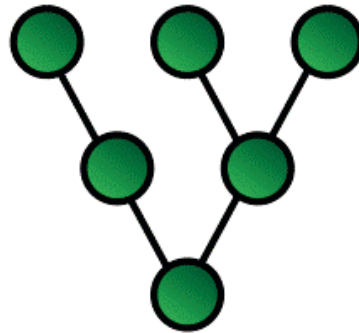
and so it is extremely impractical for large networks. A two-node network is technically a fully connected network.

Partially connected



The type of network topology in which some of the nodes of the network are connected to more than one other node in the network with a point-to-point link – this makes it possible to take advantage of some of the redundancy that is provided by a physical fully connected mesh topology without the expense and complexity required for a connection between every node in the network.

1.6 Tree



Tree topology is a combination of Bus and Star topology. This particular type of network topology is based on a hierarchy of nodes. The highest level of any tree network consists of a single, 'hub' node, this node connected to multiple nodes in the level below by (a point-to-point link(s)). These lower level nodes are also connected to a single or multiple nodes in the next level down. Tree networks are not constrained to any number of levels, but as tree networks are a variant of the bus network topology, they are prone to network failures when connections in a higher level of nodes fail/suffer damage. Each node in the network has a specific, fixed number of nodes connected to it at the next lower level in the hierarchy, this number referred to as the 'branching factor' of the tree.

1.7 Hybrid

Hybrid networks use a combination of any two or more topologies, in such a way that the resulting network does not exhibit one of the standard topologies (e.g., bus, star, ring, etc.). A hybrid topology is always produced when two different basic network topologies are connected. Two common examples for Hybrid network are: star ring network and star bus network

- A Star ring network consists of two or more star topologies connected using a centralized hub.
- A Star Bus network consists of two or more star topologies connected using a bus trunk (the bus trunk serves as the network's backbone).

2 Centralization

The **star topology** reduces the probability of a network failure by connecting all of the peripheral nodes (computers, etc.) to a central node. When the physical star topology is applied to a logical bus network such as Ethernet, this central node broadcasts all transmissions received from any peripheral node to all peripheral nodes on the network. All peripheral nodes may thus communicate with all others by transmitting to, and receiving from, the central node only. The failure in a transmission line linking any peripheral node to the central node will result in the isolation of that peripheral node from all others, but the remaining peripheral nodes will be unaffected. However, the disadvantage is that the failure of the central node will cause the failure of all of the peripheral nodes also (risk can be reduced by duplicating the central node, 'redundancy').



zCentral node can be *passive*, when the originating node must be able to tolerate the reception of an echo of its own transmission, and *active* where star network has an active central node that usually has the means to prevent echo-related problems.

A **tree topology** can be viewed as a collection of star networks arranged in a hierarchy. It has individual peripheral nodes which are required to transmit to and receive from one other node only and are not required to act as repeaters or regenerators. Unlike the star network, the functionality of the central node may be distributed.

Note: To alleviate the amount of network traffic that comes from broadcasting all signals to all nodes, more advanced central nodes were developed that are able to keep track of the identities of the nodes that are connected to the network. These network switches will "learn" the layout of the network by "listening" on each port during normal data transmission, examining the data packets and recording the address/identifier of each connected node and which port it is connected to in a lookup table held in memory. This lookup table then allows future transmissions to be forwarded to the intended destination only.

3 Decentralization

In a **mesh topology**, there are at least two nodes with two or more paths between them to provide redundant paths to be used in case the link providing one of the paths fails. This decentralization is often used to compensate for the single-point-failure disadvantage that is present when using a single device as a central node (e.g., in star and tree networks).

A **fully connected network**, or **full mesh topology** is a network topology in which there is a direct link between all pairs of nodes. In a fully connected network with n nodes, there are $n(n-1)/2$ direct links. Networks designed with this topology are usually very expensive to set up, but provide a high degree of reliability due to the multiple paths for data that are provided by the large number of redundant links between nodes. This topology is mostly seen in military / tactical and other critical applications.

Additional information

If there are additional questions on this topic or other fiber optic issues, please contact Sterlite Technologies at:

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