LAN NETWORK TOPOLOGIES

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Abstract: **This paper reviews the topologies that are used in designing of network and covers the technologies and the design approaches used when designing the local-area network (LAN). This paper also describes about the LAN topologies.**

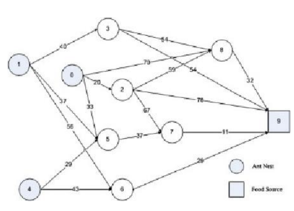
I. INTRODUCTION

For a restricted area like a single building or a small cluster of buildings, high data transmission will be available at a low cost of obtaining the comparable long-haul service from a tariffed common carrier. Local area networks can use the low cost, high speed transmission capability as the basis for a general purpose data transfer network. A local area network generally provides high-bandwidth communication over inexpensive transmission media. A local area network is composed of three basic hardware elements: a transmission medium, often twisted pair, coaxial cable, or fiber optics; a mechanism for control of transmission over the medium; and an interface to the network for the host computers or other devices-the nodes of the network-that are connected to the network.

II. TOPOLOGIES AND CONTROL STRUCTURES FOR LOCAL AREA NETWORKS

We discussed in introduction that we have three hardware components of local area networks here in this section we discuss the first two of those which provide the lowest functionality of the network.

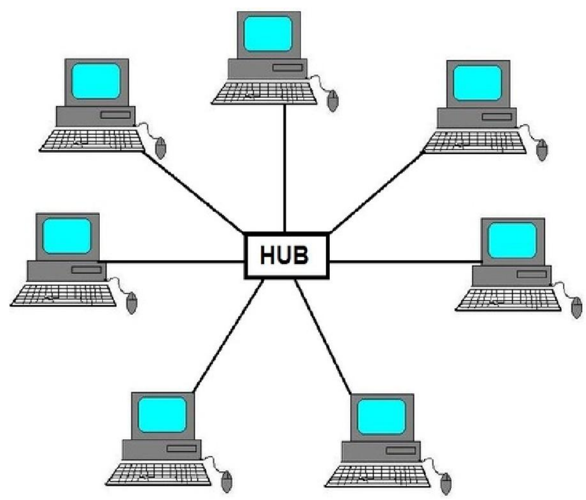
a) Network topology: Network topology is the pattern of interconnection used among the various nodes of the network. The most general topology is an unconstrained graph structure, with nodes connected together in an arbitrary pattern diagram.



Unconstrained topology

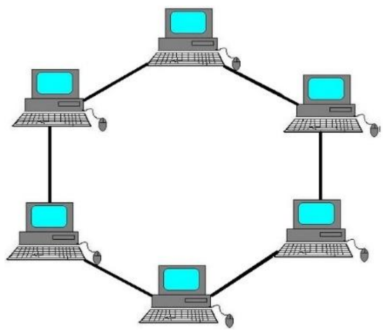
This general structure is the one normally associated with a packet-switched network; its advantage is that the arrangement of the communication links can be based on the network traffic. Local area network designers have identified a variety of constrained topologies with attributes particularly suited to local area networks. We shall consider three such topologies: the star, the ring, and the bus.

i) The Star Network: A star network eliminates the need for each network node to make routing decisions by localizing all message routing in one central node. This leads to a particularly simple structure for each of the other network nodes. This topology is an obvious choice if the normal pattern of communication in the network conforms to its physical topology, with a number of secondary nodes communicating with one primary node.

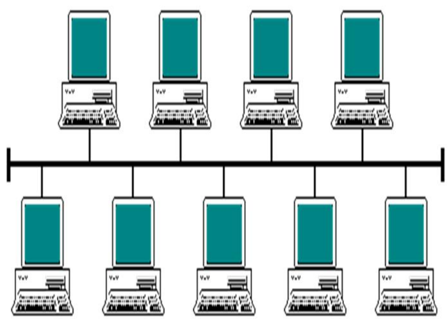


Star topology

ii) Ring and Bus Networks: The ring and bus topologies attempt to eliminate the central node on the network, without sacrificing the simplicity of the other nodes. While the elimination of the central node does imply a certain complexity at the other nodes of the net, a decentralized network can be constructed with a surprisingly simple structure of the nodes. In the ring topology a message is passed from node to node along unidirectional links. There are no routing decisions to be made in this topology; the sending node simply transmits its message to the next node in the ring, and the message passes around the ring, one node at a time, until it reaches the node for which it is intended. Similarly, in the bus structure there are no routing decisions required by any of the nodes. A message flows away from the originating node in both directions to the ends of the bus.



Ring topology



Bus topology

b) Network Control Structures: Both the ring network and the bus network introduce a problem, not immediately apparent in the star net, of determining which node may transmit at any given time. The mechanism for control, the second component of the network as listed in the introduction, performs this determination. This is not difficult in the star network; either the central node has sufficient capacity to handle a message for every node simultaneously, or it may poll each of the other nodes in turn to determine if that node wishes to transmit. Both the ring and the bus topology, lacking any central node, must use some distributed mechanism to determine which node may use the transmission medium at any given moment.

i) Daisy Chain, Control Token, and Message Slots: There are many control strategies that are suitable for the ring topology, based on the basic idea that permission to use the net is passed sequentially around the ring from node to node. In what is often called a daisy chain network, dedicated wires are used to transfer the information from one node to the next. The network for the Distributed Computing System uses an 8-bit control token that is passed sequentially around the ring. Any node, upon receiving the control token, may remove the token from the ring, send a message, and then pass on the control token. A third strategy for ring control is to continually transmit around the network a series of message slots, sequences of bits sufficient to hold a full message. A slot may be empty or full, and any node, on noticing an empty slot passing by, may mark the slot as full and place a message in it.

ii) Register Insertion: Another control strategy particularly suited for the ring topology is called register insertion. In this technique, a message to be transmitted is first loaded into a shift register. The network loop is then broken and this shift register inserted in the net, either when the net is idle or at the point between two adjacent messages. The message to be sent is then shifted out onto the net while any message arriving during this period is shifted into the register behind the message being sent.

iii) Contention Control: A bus topology also requires a decentralized control strategy. One very simple control strategy that has been used for bus networks is contention. In a contention net, any node wishing to transmit simply does so. Since there is no control or priority, nothing prevents two nodes from attempting to transmit simultaneously, in which case a collision occurs, and both messages are garbled and presumably lost.

c) Combinations of Topology and Control Structure: We have identified three network topologies the star, the ring, and the bus topology, and three control strategies: ring control, contention control, and centralized control. It is important to note that any control strategy can be used with any topology. Several interesting combinations are described in the following paragraphs. A bus topology using a daisy chain ring control strategy is a common means of implementing a computer bus. An example is the UNIBUS architecture of the Digital Equipment Corporation PDP-1.

III. PROTOCOLS FOR LOCAL AREA NETWORKS

As in long-haul networks, local area network protocols can be divided into two basic levels-low-level protocols and high-level protocols. At each level, the characteristics of local networks impact effects on protocol design and functionality.

a) Low-Level Protocols: The term low-level protocol identifies the basic protocols used to transport groups of bits through the network with appropriate timeliness and reliability. The low-level protocols are not aware of the meaning of the bits being transported, as distinct from higher level application protocols that use the bits to communicate about remote actions. Two aspects of local area networks have a very strong impact upon the design of low-level protocols. First, the high performance achievable purely through hardware technology enables the simplification of protocols. Second, low-level protocols must be designed to take advantage of and preserve the special capabilities of local networks, so that these capabilities can be .utilized, in turn, by higher level application protocols.

We will explore these two issues in this section.

i) Simplicity: Local area networks must support a wide variety of hosts, from dedicated microprocessors to large time-sharing systems. Two factors lead to the simplicity of low-level local area network protocols.

a) *Unrestricted use of overhead bits:* Bandwidth is inexpensive in a local area network; there is little motivation to be concerned with protocol features designed to reduce the size of the header or overhead bits sent with each message. This is in contrast to protocols developed for networks making the more conventional assumption that bandwidth is expensive For example, the ARPANET NCP host-to-host protocol initiates a connection using a 56-bit (net, host, socket) identifier for the destination, but then goes through a negotiation so that instead of sending this 56-bit value on subsequent messages, a 32-bit (net, host, link) value can be sent instead. It is not clear whether this conservation of bits is appropriate even in a long-haul network; in a local area network, where bandwidth is inexpensive, it is clearly irrelevant. Other examples of ways in which extra header space can be used to simplify processing include:
   1) Having a single standard header format with fields in fixed locations, rather than having optional fields or multiple packet types; field extraction at the host can be optimized, reducing processing time;
   2) Using addresses that directly translate into addresses of queues, buffers, ports, or processes at the receiver without table lookup.

b) *Simplified flow control:* The low transmission delay inherent in local area networks, as well as their high data rate, can eliminate the need for complex buffer management, flow control, and network congestion control mechanisms.

ii) Special Capabilities: The other aspect of low-level protocols for local area networks to be discussed is the manner in which protocols must be structured to take advantage of, and provide to higher levels, the unique capabilities of local networks. Conventional low-level protocols have provided a function best characterized as a bidirectional stream of bits between two communicating entities-a virtual circuit

iii) Protocol Structure: Based on the previous observations, a two-layer structure is a very natural one for low-level protocols in a local area network. The bottom layer should provide the basic function of delivering an addressed message to its (one or many) destinations.

a) Higher Level Protocols: In the previous section we considered low-level protocols for a local area network. These protocols exist, of course, to support higher level protocols, which, in turn, support user applications. In this section we will consider a number of applications for which local area networks are suited.

i) Access to Common Resources: The model of computing most common over the last few years is that of a large centralized computer, with the only remote components being terminals and, perhaps, a few other 1/0 devices. Line control protocols such as SDLC were created to serve this sort of arrangement. A simple but very important application of a local area network is to generalize this picture very slightly to include more than one central computer. As the total workload grows to exceed the capacity of a single machine, a common solution is to procure a second machine, and to divide the applications and workload between the two. The communication problem to be solved in this arrangement is simple but critical- to allow an individual terminal to have access to both of the central machines. A local area network can solve this problem, and provide some additional capabilities as well.

ii) Decentralized Computing: A wide variety of new uses for a local area network arises if the computing power available is not strongly centralized. Let us consider the alternative of a computing environment consisting of a large number of relatively small machines, each dedicated to a small number of users or a small number of tasks. In the extreme, we can look to the future and imagine the day when each user has a computer on his desk instead of a terminal. Such a completely distributed computing environment by no means eliminates the need for an interconnecting network, for users will still need to exchange information. Data files containing the results of one person's computation will need to be shipped through the local area network to be used as input to other tasks. Users will wish to communicate with each other by exchanging computer mail, as is now done over the ARPANET. Users will still want access to specialized resources which cannot be provided to each user, resources such as large archival storage systems, specialized output devices such as photo typesetters, or connection points to long-haul networks. All of these features can be made available through the local area network.

iii) Protocol and Operating System Support: The applications outlined in the previous paragraph can be supported by high-level protocols very similar to the ones already in existence in the ARPANET: TELNET for logging into a remote system through the network, and File Transfer Protocol for exchanging data between machines.

IV. LAN TOPOLOGIES

LANs can be organized into various different structures. The key thing is that there are physical and logical topologies. The physical topology is how wires are organized. The logical topology is how the network behaves logically.

a) Addressing: To support several transfer modes, there are several different addressing schemes.

• Unicast: Addressing is one-to-one, where one computer sends a frame to another computer. Even though many stations can receive the same data, they should ignore it since it is not addressed to them.

• Multicast: Addressing is one-to-many, where one computer is sending a frame to many other computers. This can be done via a list of addresses, or some masking scheme that selects a subset of addresses.

• Broadcasting: Addressing is one-to-all, where one computer sends data to all computers connected to the LAN.

b) Broadband vs. Baseband: Transmission on LANs can use either the whole bandwidth capacity of the medium, or split it into channels. Baseband is when the whole capacity of the medium is used, while Broadband is when the medium capacity is split into channels. Baseband is generally used for digital transmissions, while Broadband is generally used for analog transmissions.

c) Physical Topologies: There are three primary physical topologies: Bus, Ring, and Star.

i) Bus: The bus topology is basically a wire that all devices connect to using a passive interface **(**they listen, but don't amplify/repeat). There are terminators on both ends of the wire to remove the frame. Since all computers are connected to the medium, they all get all the frames sent. The terminators are responsible for the removal of the frame. In baseband setup, each computer sends frames in all (both, as there are 2) directions. In broadband setup, the transmission is unidirectional (but then it can use a separate channel for transmissions in the opposite direction). The bus topology generally uses coaxial cable.

Characteristics of Bus topology:

• Failure of the medium disrupts communication.

• Failure of devices doesn't effect the communication (passive interface).

• There is a limit on the length of the network (devices don't amplify/repeat the signal).

• The propagation delay isn't effected by the number of devices.

ii) Ring: Ring topology is somewhat different from the bus topology. The major differences are:

• There is no need for terminators (the receiving or sending stations remove the frame).

• All transmissions are baseband, and go in a single direction.

The connected devices can be in several modes, the bypass mode, and operational mode. In bypass mode, the device is not connected to the medium. In operational mode, the device can be either listening or transmitting.

a) Removing Frames:

The major issue in ring topology is who gets to remove the frame. If the frame is removed by the destination, then we can only have unicast transmissions (one-to-one). If the source removes the frame (after the frame has gone around the ring), then we can have unicast, multicast, and broadcasting capability.

Characteristics of Ring topology:

• Failure of the medium seriously disrupts communication.

• Malfunctioning of the interface can seriously effect communication (devices are active).

• There is no limitation on the length of the network (devices repeat/retransmit the frame).

• Propagation speed is effected by the number of stations (because each station reads and retransmits the frame).

• The network can use any medium, like twisted pair, coax, or fiber.

iii) Star: In a stat topology, each station is connected to a central node, or hub (or switch). Each station only talks to the central node. Each station generally has two connections to the hub; one to send data to the hub, and another to get data from the hub. Thus, each connection is unidirectional. The Star topology can use either broadband or baseband transmissions. Baseband is used for guided media (like wire), while broadband is used for unguided (wireless). The central hub can be either active or passive. A passive hub just links all workstations together (without retransmitting). An active hub reads and then retransmits the frame to all workstations. Normally, the hub retransmits data to all the connected stations. If a switch is used, it can learn to only send data to the destination station. It does that by first operating like a regular hub, and then observing and recording which addresses appear on which interfaces. If the star uses a hub, then addressing works just like in the bus network. If the star uses a switch, then the destination is determined by the switch (as in, unicast works just as expected, while broadcasting and multicasting has to be supported by the switch).

Characteristics of Ring topology:

• Failure of the medium does not seriously disrupt communication.

• Malfunctioning of the station doesn't seriously effect the communication.

• The network can use guided or unguided media.

• Failure of the hub disrupts the communication.

V. CONCLUSION

Current trends in hardware costs encourage abandonment of a single large computer in favor of a number of smaller machines. This decentralization of computing power is, for many applications, a natural and obvious pattern. In many information processing applications, for example, the information itself is distributed in nature, and can most appropriately be managed by distributed machines. Distributed applications can only be constructed, however, if it is possible to link their machines together in an effective manner. Subject to their geographical limitations, local area networks offer a very effective and inexpensive way to provide this inter- connection. The greatest impact of local area networks will come with the development of operating systems that integrate the idea of distribution and communication at a fundamental level. The impact of local area networks on the decentralization of computing is sociological as well as technological. I Operational control of centralized computers has traditionally been vested in the staff of a computer center. The trend toward decentralized computing greatly increases the autonomy of individual managers in the operation of their machines, and appears to reduce the need for a centralized staff of computer managers. The communication capability made available by local area networks will serve to bind these decentralized machines together into a unified information processing resource. The effectiveness of this resource can be measured by the degree of coherence it achieves, which, in turn, depends upon the care and foresight put into the design of the local area network and the development of standards for communication at all levels. It is in the identification of areas in which standards are needed, and in their development, that the staff of the "computer center" of the future will find its work.

VI. FUTURE DEVELOPMENT

One possible avenue of future development in LAN topology is in the area of "cooperative diversity." Cooperative diversity can be viewed as somewhat of a cross between MIMO techniques and mesh networking. In a cooperative diversity scheme, redundancy in transmission is achieved in a manner analogous with diversity transmission in MIMO. However, the redundant transmission is realized via the cooperation of third party devices rather than solely from the originating device. In a cooperative diversity scheme, third parties which can successfully decode an on-going exchange will effectively regenerate and relay, with appropriate coding, the original transmission in order to improve the effective link quality between the intended parties.

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