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Wireless Communication

STUDY TOPIC:
A COMPREHENSIVE STUDY ON WIRED LOCAL AREA NETWORK LAN

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Introduction [9th April 2016]

A local Area network is a computer network within a small geographical area such as an office building, school, a home or a computer laboratory. It comprises of workstations and personal computers that are inter-connected and are capable of sharing data and accessing common resources such as printers, scanners and data storage devices within the network. Even though Local area networks are limited in geographical scope, they have a good reputation in terms of their high-bandwidth communication and low-delay attributes over low-cost transmission media [1]. This study is a comprehensive study on Local Area Network LAN, it will review the concept of the local area networks, it will discuss the different protocols of LAN (and focus a little on Ethernet), will look at the different types of LAN topologies, will look at LAN media access methods, transmission methods, communication functions on the LAN and finally a little on addressing and LAN frame structure.

Components of LAN

A LAN is comprised of the following components.

Communication Media

Communication media is a means to transfer data from one network device to another network device on the network. Low-cost LANs are connected with twisted wire pair. Many LANs use coaxial or fiber-optic cables. These cables are usually quite expensive but offer faster transmission speeds compared to the former. Some LANs use wireless transmission media. Making use of infrared or radio waves to connect computers and network devices. Wireless networks are easy to setup and maintain. However, they have low transmission rates and limited distance between two communication devices [1].

NIC

NIC stands for network interface card. It is sometimes also known as a network adapter. This network interface card is a device that physically connects each network device to the network. It is responsible for controlling the flow of data between the network and the network device. On a personal computer, it

is a circuit board that is fitted into the expansion slot on the main motherboard. However some devices contain built-in network cards.

Bridge

Bridge is a device that connects two network segments. It is used for connecting a number of similar types of networks into one large network.

Router

A router is a device that is used to connect multiple networks using similar or different protocols. It manages the best route between two communication networks, it is more intelligent than the bridge because it uses protocols and reads addresses of network devices. Routers are used when several networks are connected together. They can connect networks of different countries and transfer data in very short time.

Gateway

Gateway is a device that connects two or more networks with different types of protocols. Two different types of networks require a gateway to communicate with each other. It receives data from one network and converts it according to the protocol of other network. For example, the computers on a LAN require gateway to access the internet [2].

Types of LAN protocols [10th April 2016]

There are many LAN protocols in use today. Some of the most common ones are Ethernet, Asynchronous Transfer Mode (ATM), Token Ring and Fiber Distributed Data Interface (FDDI). Ethernet is a very common LAN protocol that can be found in most organizations, school, office buildings etc. ATM is still gaining its popularity. The quality of service and class of service make ATM a very reliable LAN protocol that can handle both voice and video more efficiently than other protocols. Token Ring is a well-established protocol originally developed by IBM in the 1970's. FDDI is a high bandwidth protocol that utilizes fiber optic cable as its physical medium of transmission. FDDI is a less popular protocol due to its high cost of implementation.

Ethernet LAN

There are few types of Ethernet LAN networks based on the category of the cable used and its data rate.

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Fast Ethernet

Fast Ethernet is an Ethernet network that can transfer data at a rate of up to 100 Mbit/s. It can either be twisted pair or fiber optic cable based. There is the older 10 Mbit/s Ethernet which is still installed and used in some few places, but such networks do not provide enough bandwidth for some network video applications.

Most devices that are connected to a network, such as a personal computer, laptop or a printer, are equipped with a 100BASE-TX/10BASE-T Ethernet interface, most commonly known as a 10/100 interface. It supports both 10 Mbit/s and Fast Ethernet. The category of the twisted pair cable that supports Fast Ethernet is called a Cat-5 cable which just stands for category 5 cable, rated by the telecommunications industry Association TIA.

Gigabit Ethernet

Gigabit Ethernet, which can also be based on a twisted pair or fiber optic cable, provides a data rate of 1,000 Mbit/s (1 Gbit/s) and is becoming very popular and desirable. It is expected to soon replace Fast Ethernet as the de facto standard [1].

The type of twisted pair cable that supports Gigabit Ethernet is a Cat-5e cable (Enhanced), where all four pairs of twisted wires in the cable are used to achieve the high data rates. Cat-5e or higher cable categories are recommended for network video systems. Most interfaces are backwards compatible with 10 and 100 Mbit/s Ethernet and are commonly called 10/100/1000 interfaces.

For transmission over longer distances, fiber cables such as 1000BASE-SX (up to 550 m) and 1000BASE-LX (up to 550 m with multimode optical fibers and 5,000 m with single-mode fibers) can be used.

10 Gigabit Ethernet

10 Gigabit Ethernet is the newest generation and provides a data rate of 10 Gbit/s (10,000 Mbit/s), and also fiber optic or twisted pair cable can be used. 10GBASE-LX4, 10GBASE-ER and 10GBASE-SR based on an optical fiber cable can be used to bridge distances of up to 10,000 m. A very high quality cable (Cat-6a or Cat-7) is required for this network. 10 Gbit/s Ethernet is mainly used for backbones in high-end applications that require high data rates.

Switch

When only two devices need to communicate directly with one another through a twisted pair cable, a so-called crossover cable is used. The crossover cable basically crosses the transmission pair on one end of the cable with the receiving pair on the other end and vice versa.

To setup multiple devices in a LAN, however, network equipment such as a network switch is required. When using a network switch, a regular network cable is used instead of a crossover cable.

The main purpose of a network switch is to forward data from one device to another on the same network. It does it in an efficient fashion since data can be directed from one device to another without affecting other devices on the same network.

Operation

A switch registers the MAC (Media Access Control) addresses of all devices that are connected to it. Each device on the network has a unique MAC address, which is made up of a series of numbers and letters. The MAC address is set by the manufacturer of the device often found on the product label. When a switch receives data, it forwards it only to the port that is connected to a device with the appropriate destination MAC address.

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A switch normally supports different data rates simultaneously. The most common rates used to be 10/100, supporting 10 Mbit/s as well as Fast Ethernet. Nevertheless, 10/100/1000 are now taking over as the standard switch rates, therefore supporting 10 Mbit/s, Fast Ethernet and Gigabit Ethernet at the same time. The transfer rate and mode between a port on a switch and a connected device are normally determined through auto-negotiation, whereby the highest common data rate and best transfer mode are used. A switch also allows a connected device to function in full-duplex mode, i.e. send and receive data at the same time, resulting in increased performance.

Switches may bring with them different features or functions. Some switches include the function of a router. A switch may also support Power over Ethernet or Quality of Service, which controls how much bandwidth, is used by different applications [3].

LAN Topologies [14th April 2016]

LAN topology is simply the arrangement of network devices or nodes on the network. There are 4 most known topologies in Ethernet LAN networks.

Bus Network

In this type of network, a long, central cable, the 'bus' is used to connect all the network devices or nodes on the network together. Each network device is connected to a short cable linking it to the 'bus'.

Characteristics

- Is cheap to install. Requires just one long cable, the bus
- Can be quite slow since all network devices share the same cable when transmitting data
- Will stop working if there is a breakdown in the central bus cable.

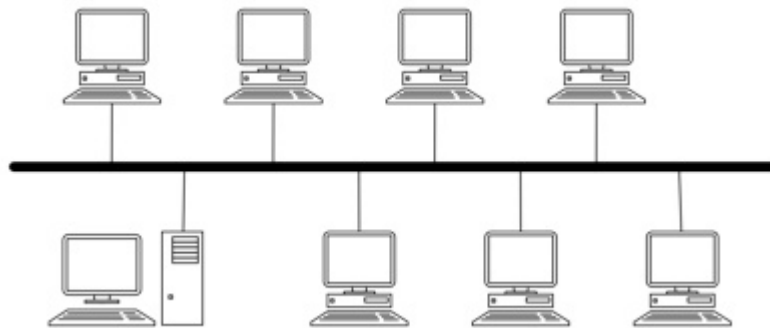


Figure 1 Bus topology

Ring Network

In the ring network each network device or node is connected to a single loop of cable, the 'ring'. Can be compared to the bus except it is connected from one end to the other to make a ring - If one took a bus network and connected the ends of the bus cable together, they would have made a ring network.

Characteristics

- Can survive a breakdown in the ring cable since all network devices are still joined together. Any discontinuity along the cable will just turn it into a bus network.

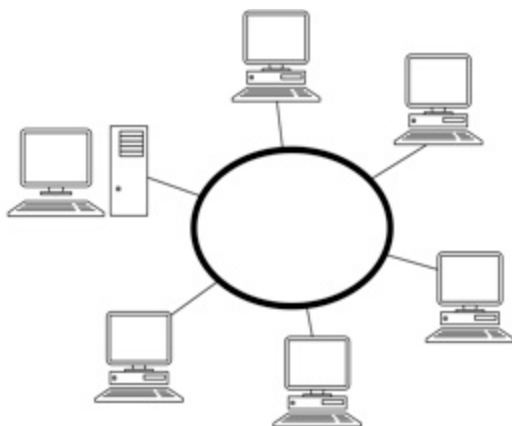


Figure 2 Ring Topology

Star Network

In this network topology every network device is connected to a central device. The device permits flow of data between network devices or nodes on the network.

A hub or a switch is usually used to interconnect the network devices in this topology. A hub is quite cheaper and offers slower data transmission speeds compared to a switch which is quite expensive but offers higher data transmission speeds.

Characteristics

- Expensive to install. Requires lots of cable plus the central device, switch/hub.
- very fast since each network device has its own cable for data transmission
- Can cope with a broken cable, only one network device will be affected
- Will not work if the switch or hub breaks
- Is the most common network topology

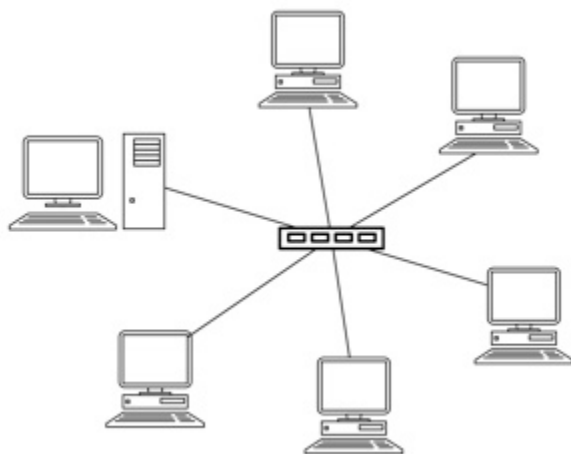


Figure 3 Star LAN topology

Hybrid Network

A hybrid network is merely one that comprises of a combination of two or more of the above basic topologies.

E.g. A network that has several star networks linked together is a hybrid network

Steve copley, IGCSE ICT, Computer Networks LAN topologies, 2009.www.igcseitc.info

LAN MEDIA ACCESS METHODS [27th April 2016]

Local area network (LAN) networks use baseband transmission technology. All stations or network devices on a baseband network share the same transmission medium, and they use the entire bandwidth of that medium for transmission. As a result, only one device on a baseband network can transmit at a given instant, resulting in the need for a media access control method to handle contention.

Media access methods are just means through which network devices use to access the medium consecutively. When two or more network devices have data to send at the same time they create a situation known as Media contention. Because multiple devices cannot talk on the network simultaneously, some type of method must be used to allow one device access to the network media at a time. This is done in two main ways: carrier sense multiple access collision detect (CSMA/CD) and token passing.

Carrier sense multiple access collision detect

In networks using CSMA/CD technology such as Ethernet, network devices compete for the network media. When a device has data to send, it first listens to check if any other device is currently using the network. If not, it starts sending its data. After finishing its transmission, it listens again to see if a collision occurred. A collision happens when two devices send data through the medium at the same time. When a collision happens, each device waits a random length of time before resending its data. In most cases, a collision will not occur again between the two devices. Because of this type of network contention, the busier a network becomes, the more collisions will occur. This explains the rapid degradation in performance of Ethernet as the number of devices on a single network increases.

Token-passing

In token-passing networks such as Token Ring and FDDI, a special network frame (signal) called a token is passed around the network from device to device. When a device has data to send, it must wait until it has received the token and then sends its data through the medium. When the data transmission is complete, the device releases the token so that other devices may receive it and use the network media.

The main advantage of token-passing networks is that they are deterministic. It is easy to calculate the maximum time that will pass before a device has the opportunity to transmit its data. This explains the popularity of token-passing networks in some real-time environments such as factories, where machinery must be capable of communicating at a determinable interval.

For CSMA/CD networks, switches divide the network into multiple collision domains. This reduces the number of devices per network segment that must contend for the media. By creating smaller collision domains in this way, the performance of a network can be increased significantly without requiring addressing changes.

Normally CSMA/CD networks are half-duplex, while a device sends information, it cannot receive at the same time. While that device is talking, it is incapable of also listening for other traffic. This is similar to a walkie-talkie system behavior. When one person wants to talk, he presses the transmit button and begins speaking. While he is talking, no one else on the same frequency can talk. When the sending person is finished, he releases the transmit button and the frequency is available to others.

However, when switches are introduced, full-duplex operation is possible in the network. Full-duplex works much like a telephone-you can listen as well as talk at the same time. When a network device is attached directly to the port of a network switch, the two devices may be capable of operating in full-duplex mode. In full-duplex mode, performance can be increased. A 100-Mbps Ethernet segment is capable of transmitting 200 Mbps of data, but only 100 Mbps can travel in one direction at a time. Because most data connections are usually asymmetric (with more data traveling in one direction than the other), the gain is not as great. However, full-duplex operation does increase the throughput of most applications because the network media is no longer shared. Two devices on a full-duplex connection can send data as soon as it is ready.

Token-passing networks such as Token Ring can also benefit from network switches. In large networks, the delay between turns to transmit may be significant because the token is passed around the network [4].

LAN TRANSMISSION METHOD

LAN data transmissions is classified into three categories namely; unicast, multicast, and broadcast. In each category of transmission, a single packet (unit data) is sent to one or more nodes.

Unicast

In a unicast transmission, a single packet is sent from the source to a destination on a network. First, the source node addresses the packet by using the address of the destination node. The package is then sent onto the network, and finally, the network passes the packet to its destination.

Multicast

A multicast transmission consists of a single data packet that is copied and sent to a specific subset of nodes on the network. First, the source node addresses the packet by using a multicast address. The packet is then sent into the network, which makes copies of the packet and sends a copy to each node that is part of the multicast address.

Broadcast

A broadcast transmission consists of a single data packet that is copied and sent to all nodes on the network. In these types of transmissions, the source node addresses the packet by using the broadcast address. The packet is then sent on to the network, which makes copies of the packet and sends a copy to every node on the network [4].

Communication Functions of LAN [28th April 2016]

A LAN network like most networks follows the open system interconnection OSI model. The communication functions are standardized and categorized according to the OSI model layers 1 through 7.

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Media Layers

Layer 1: The physical layer responsible for transmitting and receiving raw bit streams at the network card module of the network device on the network. Layer 2, data link layer, which is responsible for node to node data transfer, detection of errors and also defines the protocol for flow control of data. It's at this layer where media access control and are applied. Layer 3, the network layer where Structuring and managing a multi-node network is done, including addressing, routing and traffic control.

Host Layers

Layer 4, Transport layer where data is segmented, reliable transmission is insured (through acknowledgements) and multiplexing is done. Layer 5, Session layer where the communication sessions are managed, insuring continuous transmission of data between the network devices. Layer 6, the presentation layer basically for the translation of data between a networking service and an application; including functions such as data compression, character encoding and encryption/decryption. And finally Layer 7, the application layer where users can now interact directly with software. This layer interacts with software applications that implement a communicating component for the network device.

Network Addressing [29th April 2016]

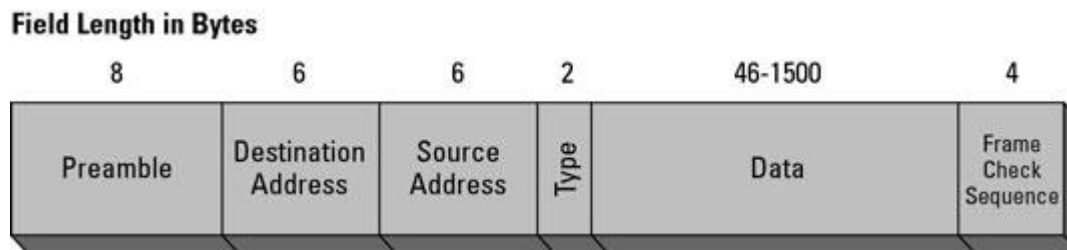
On a LAN network every device has a unique address known as the media access control address MAC. This address enables all the network devices on the network to identify each other during data transmission among the network devices.

Frame structure on LAN

Data at the data link layer across the LAN network is transmitted as a digital data transmission unit known as a frame. However this unit data in layer 3 (network) is referred to as a packet. A frame consists of information that determines how data receivers interpret a stream of data from a source and also contains its own control instructions.

Data travels over the physical media of the Ethernet network in small containers, or *frames*. There are different methods of framing data on LAN, but the two that are most likely are Ethernet II and IEEE 802.3. The structure of these frames is similar, and the following explains each:

- **Ethernet II:** It is the standard and most often seen framing type and is used to support required headers used by IP.
- **IEEE 802.3:** This frame type is an expanded frame type that is used to support Internetwork Packet Exchange/Sequenced Packet Exchange (IPX/SPX) protocol.



The Ethernet II frame structure. [2]

- **Preamble:** The *preamble* is a unique sequence of alternating zeros and ones followed by two ones that is eight bytes in length and sets the start of the Ethernet frame. This series of pulses is picked up by the network card in your computer and, by design, this sequence will never occur in the middle of the frame.
- **Ethernet header:** The Ethernet header is made up of the following pieces:
 - *Destination address:* Six bytes that contain the MAC address of the NIC that is the target for the network frame.
 - *Source address:* Six bytes that contain the MAC address of the NIC that sends the data on physical media.
 - *Type:* Two bytes that denote the frame type. The type field identifies the higher layer protocol, which typically is IP.

- **Data:** Between 46–1500 bytes of data. If the data is fewer than 46 bytes, padding is added to bring the frame to the minimum 64 byte frame size. There must be at least 64 bytes of data between preamble sequences.
- **Frame check sequence (FCS):** Four bytes of FCS data is stored at the end of the frame. Prior to sending the frame, the source computer generates a result from the data found in the frame and stores the result in the last four bytes of the frame.

To generate this FCS value, the entire frame is broken into blocks. All those blocks are then added together, and FCS is a sum of all these blocks of data. The receiving computer calculates its own result from the data in the frame and compares the number it calculates to the FCS data. If the results do not match, the frame is considered to be damaged or inaccurate so the frame is discarded.

Some people will also refer to this as cyclic redundancy check (CRC) data or a CRC sum. The purpose of the CRC and FCS is the same, which is to verify that the data that was received was not altered or damaged during transmission. [5]

Conclusion

LAN networks can be categorized in many ways. Designing a LAN or identifying one will require knowledge of cable type, topology, data rates and even geographical scope. From the study, the set of LAN cable can be one of the following, twisted pair, baseband coaxial cable, baseband coaxial cable or fiber optic cable. The topologies are usually the following if not a hybrid; Bus, star, ring and mesh topologies. In a LAN network data rates vary and this is also linked to the type of cable in use on the network, LAN data rates can vary between 4Mbps for twisted pair cable up to 40Gbps for fiber optic cable. LAN networks can also accommodate up as less as 255 network devices to several thousands of devices. LANs are great networks, they are low-cost networks, enable sharing of resources and they have high-bandwidth communication and low-delay attributes.

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