# Local Area Networks (Part 2)

**References**
**Study Guide 9**

## Lecture 9 Revision

- Question - How do the key requirements for computer room networks differ from those for personal computer local networks?

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- Question - How do the key requirements for computer room networks differ from those for personal computer local networks?
- Answer - Computer room networks require very high data rates and usually are concerned with transfer of large blocks of data.

## Lecture 9 Revision

- Question - Why are there multiple LAN standards?

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- Question - Why are there multiple LAN standards?
- Answer - No single technical approach will satisfy all requirements. Requirements with respect to cost, data rate, and range dictate a variety of technical alternatives.

## Lecture 9 Revision

- Question - List and briefly define the types of operation provided by the LLC protocol.

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- Question - List and briefly define the types of operation provided by the LLC protocol.
- Answer - Type 1 operation supports unacknowledged connectionless service. Type 2 operation supports connection-mode service, using mechanisms similar to HDLC. Type 3 operation supports acknowledged connectionless service. Each transmitted PDU is acknowledged using a stop-and-wait technique.

## Lecture 9 Revision

- Question - List some basic functions performed at the MAC layer.

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- Question - List some basic functions performed at the MAC layer.
- Answer - (1) On transmission, assemble data into a frame with address and error-detection fields. (2) On reception, disassemble frame, and perform address recognition and error detection. (3) Govern access to the LAN transmission medium.

## Lecture 9 Revision

- Question - What is CSMA/CD?

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- Question - What is CSMA/CD?
- Answer - Carrier sense multiple access control with collision detection (CSMA/CD) is a form of medium access control in which a station listens to the medium to try to see if another transmission is in progress. If the medium appears idle, the station transmits. If a collision occurs, the workstations wait a random amount of time before trying again.

## Lecture 9 Revision

- Question - What are the transmission medium options for Fast Ethernet?

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- Question - What are the transmission medium options for Fast Ethernet?
- Answer - Shielded twisted pair, high quality unshielded twisted pair (Category 5), relatively low quality unshielded twisted pair (Category 3) and optical fibre are transmission medium options for Fast Ethernet.

## Lecture 9 Revision

- Question - How does Fast Ethernet differ from 10Base-T, other than the data rate?

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- Question - How does Fast Ethernet differ from 10Base-T, other than the data rate?
- Answer - Fast Ethernet differs from 10Base-T in two important ways. Two physical links are used between nodes - one for transmitting, one for receiving (four links are used for Fast Ethernet using lower quality unshielded twisted pair (Category 3)). A different coding scheme 4B/5B-NRZI is used rather than Manchester Coding.

## Lecture 9 Revision

- Question - Under heavy loads, how do the behaviour of CSMA/CD and token ring differ?

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- Question - Under heavy loads, how do the behaviour of CSMA/CD and token ring differ?
- Answer - Under heavy loads, CSMA/CD's performance declines because of the number collisions. The token ring functions more efficiently under a heavy load.

## Learning Objectives

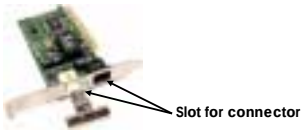
- **describe LAN Hardware**
- **describe LAN Software**
- **understand LAN Planning & Design**

## LAN Hardware

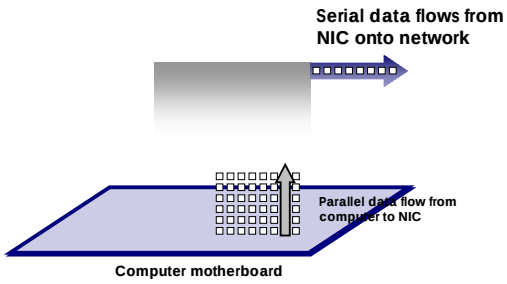
- Network Interface Card
- Connector
- Transmission Media
- Server( s)
- Internetworking devices/ Hubs/ Switches:
  - Repeater, router, bridge, gateway

## Network Interface Card

- Plug-in card that interface a computer to a given network or LAN. Provides physical connection to network cable
- Uniquely identified by manufacturing number and distinct number within the manufacture itself - MAC (Media Access Control) address
- The exposed side of NIC contains a slot for connector
- Exact function of the NIC depends on the type of networks (discussed in the next lecture)




## Network Interface Card




## Selection of NIC

- What type of network are you attaching to?
  - Ethernet, Token King, FDDI
- What type of media are you using?
  - Coax, UTP, optical fiber, wireless etc
- What type of bus your computer have
  - ISA, EISA, PCI etc.

## Connector

- The interface between a network node and the network wire
- Different transmission media require different connector type
  - RJ-45 connector for UTP, T-connector for coax
- For example, the picture below shows BNC T-type connectors that are used by the coaxial cables

## Transmission Media

- The most popular transmission medium for LAN is twisted pair cable, RJ45 UTP
- Most of the building has existing telephone networks that uses twisted pair
  - Cheapest option
  - Easy to install
- While most LANs use only one type of cable, it is possible to buy devices that permit different types of cables to be connected together

## Hubs

- Concentration points where network stations are connected. Provides an easy way to connect network cables
- Many hubs act as repeaters or amplifiers
- Physically the network is setup as a star network, logically can be a ring or bus network
- Reasonably easy to install

## Hub or Switch ?

- Both looks similar in appearance, but work differently
- **HUB**
  - all the devices connected will share the bandwidth
  - cheaper than switches
  - each station receives signal sent from all other stations
  - can be used to support a small number of stations
- **Switch**
  - each device is allocated a specific bandwidth
  - useful for supporting large number of connected stations
  - performs some network management & intelligent path selection

## Hubs

- Hubs can be connected to each other to extend a network but there is a limit to the numbers of interconnecting hubs
- If possible, it is better to connect each hub directly to a sever network card rather than to another hub
- The more hubs data pass through, the slower connection

## Servers

- Small organization can use a normal PC as a server
- Large organization usually use computer that is built as a server (very powerful and can be specialized)
- A LAN has one or more dedicated servers
- Server runs on network operating system
- Type of server:
  - Print
  - File
  - Database
  - Communication
  - Message
  - Web etc.

Server

## Servers

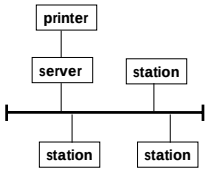
- Print Server
  - handle print requests on the LAN
  - can spool print jobs from several client computers at the same time while printing them one at a time
  - spooler on the server holds print jobs in its memory or in its hard drive while they are waiting
  - can specify priority of print jobs
- File Server
  - allow many users to share the same set of files on a common, shared disk drive
  - also supports
    - storage and data migration
    - update synchronization
    - archiving

## Servers

- Database servers
  - not only provides shared access to the files on the server, but also can perform database processing on those files associated with client-server computing
  - Provides complex service including
    - Security
    - Database optimization
    - Data distribution
      - maximizes network efficiency
- Communications servers
  - are dedicated to performing communications processing. There are three fundamental types:
  - Fax servers - manage fax
  - Modem servers - for dialing out of the network
  - Access servers - for dialing into the network

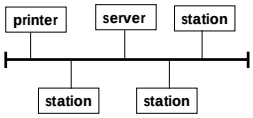
## Connecting Printer to a LAN

- Printer without NIC
  - Printer need to be connected to a server ( in server based connection) or to a station (in peer- to- peer connection) using parallel cable
  - Any station requires the service of the printer will generate request to the server/ station



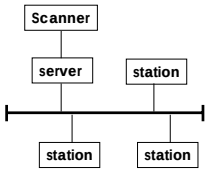

## Connecting Printer to a LAN

- Printer NIC
  - Can be attached directly to the network (become another node in the network)
  - A server/ station to handle spooling/ queue is still needed




## Connecting Input Device to a LAN

- Connecting scanner to a LAN
  - Scanner will be attached to a station or server
- It is not common to attach input device directly to a network




## Network Cable Plans

- In the early days of LANs, it was common practice to install network cable wherever it was convenient
- With today's explosion in LAN use, it is critical to plan for effective installation and use of LAN cabling
- Most buildings under construction have a separate LAN cable plan as they do for telephone cables and electrical cables

## Software

- LAN Operating Systems
  - Peer- to- peer connection
  - Server based connection
  - Example: Windows NT, Novell Netware, Unix etc.
- Network Application software – requires a network to operate
  - Email, FTP, Telnet etc.
  - Client server application, eg., database with Web interface
  - Groupware

## LAN Operating System

- Network Operating System (NOS) is the software that controls the network
- Consist of a number of protocols (related to OSI model or more popular TCP/ IP model) to govern communication of two parties in a LAN
- Supports administration of LAN
  - User management
  - Security
  - Performance monitor
  - Backup/ Recovery facilities
- Every NOS provides two sets of software:
  - one that runs the network server(s), and
  - one that runs on the network client(s)

## LAN Operating System

- NOS server software enables the file server, print server, or database server to operate. NOS server software typically replaced the normal operating system on the server
- NOS client software makes services that are available on the network appear to be local to the client
- Network profile specifies what resources on each server are available for network use by computers and which devices or people (user profile) are allowed what access to the network

## Network Interconnections

- Two LANs/LAN segments can be connected using:
  - Repeater
    - operates at physical layer
  - Bridge
    - operates at data link layer
  - Router
    - operates at network layer
  - Gateways
    - Operates at network layer

## Reasons for having multiple LANs

- Each part of the organization may need to implement different LANs
- The organization is geographically spread over several buildings separated by considerable distance
- Spread out the load of the network
- Increase reliability - breakdown of one LAN may not effect the whole organization's network.
- Increase security - isolate part of the network

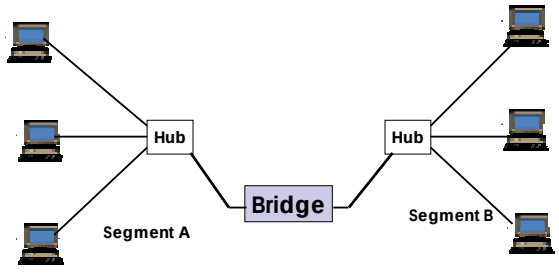
## Repeater

- Operates purely in the physical layer
- Signal are simply re-generated
- No error checking is performed
- Any type of LAN segment has a defined maximum limit to the physical length of the segment and the number of stations that may be attached to it
- Repeaters are used to connect segments of a LAN

## Bridge

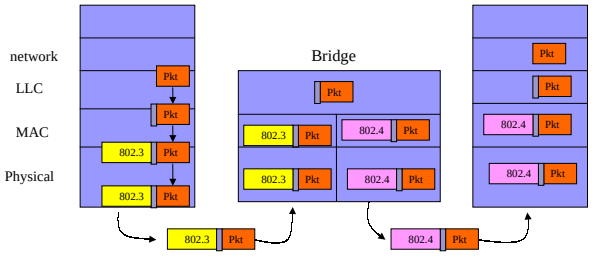
- Operates on the data link layer
- Used to connect LAN segments that use same media access control
- Combination of hardware & software
- May use the same or different types of cables
- Tasks/Functions performed by bridges:
  - receives and buffers all the frames from a segment
  - performs error checking
  - forwards frames that are error-free and designated to a different segment in the LAN

## Bridge



## Advantage of Bridges (compared to Repeater)

- The buffering of frames received on a segment before forwarding them to another segments allow different MAC protocols to be used in the segments




## Router

- Connect two LANs that do not share common media access control
- Operates at the network layer
- Combination of hardware & software
  - Hardware-can be network server/special device
  - Software-NOS and routing protocol
- Main function:
  - determine a route that a packet will take to reach to the designated station
  - chooses the best route between the networks when there are several possible routes

## Router

- A router will decide whether to forward a packet by looking at the protocol level addresses (for instance, TCP/IP addresses) rather than the MAC address
- Because routers work at layer 3 of the OSI stack, it is possible for them to transfer packets between different media types (i.e., leased lines, Ethernet, token ring, X.25,Frame Relay and FDDI).
- Many routers can also function as bridges

## Gateway

- Operates at both network and transport layer
- Connect two or more LANs that uses completely different protocols
- Interpret and translates one network protocol into another, translates data formats
- Can be comprised of software, dedicated hardware, or a combination of both
- Example: gateways are used to connect IBM mainframes that use SNA (System Network Architecture) to LANs that use TCP/IP and Ethernet

## LAN design & Planning

- The basic process involves four steps that are performed repeatedly:
  - Determining and quantifying current work load
  - Estimation and quantifying future load for LAN segments and interconnections
  - Design & planning new LAN-segment and interconnections; upgrade existing system
  - Installation of infrastructure and components
- New LAN design begins from step 2

## Step 1- Current Load Analysis

- Done by monitoring the existing system
- Goal is to determine resource demand by applications and users, and processing demand for all servers
- Review the list of applications that currently use the network
  - Graphics and CAD applications tend to place a heavier load on the network
  - Shared databases tend to put a low level of constant traffic on the network

## Step 1- current load analysis …

- In the past, applications system accounted for the majority of network traffic. Today, much network traffic is produced by the discretionary use of
  - e-mail
  - internet services
  - groupware
  - video-conferencing
- Assess the number and type of users that generate and receive network traffic
- Determine peak (busy) hour and traffic
- Network monitoring tools are useful
  - A number of tools are listed at **www.slac.stanford.edu/xorg/nmtf/nmtf-tools.html**

## Step 2- Estimation of future load

- Users identify the services they want want to implement during planning cycle
  - See Fig. 6.3 and Table 6-1 on page 134 of subject book for a comprehensive list
- Users identify volume ranges for the serves they are requesting
  - See Table 6-2 and Table 6-3 on page 135 of subject book
- Once the network requirements have been identified, they also should be organized into *mandatory requirements*, *desirable requirements*, and *wish list requirements*

## Step 2- Estimation of future load

- Assess the relative amount of traffic generated in each segment, based on some rough assessment of the relative magnitude of network needs
- An aggregate resource demand is calculated
- The aggregate results have to be extended by
  - Overhead
  - Contingency work load reserves

## Step 3- Design & planning of LAN components

- From the study of the previous steps, categorize the clients, servers and devices as *typical* or *high* volume
- *Typical* users are allocated the *base level* client computers, as are servers supporting typical applications. *High volume* users and servers are assigned some *advanced* computers
- In designing LANs practical capacity limits are considered
  - Ethernet with CSMA/CD - up to 40% use
  - Token Ring - up to 80% use
  - FDDI - up to 85% use

## Step 3- Design & planning of LAN components

- There are two interrelated decisions in designing network circuits and devices:
  - the fundamental technology and protocols
  - the capacity of each circuit
- Designing the circuit capacity means *capacity planning*, estimating the size and type of the *standard* and *advanced* network circuits for each type of network
- The assessment is based on the current and future *circuit loading*
- Although no organization wants to overbuild its network and pay for more capacity than it needs, in most cases, going back and upgrading a network significantly increases costs

## Step 3- Design & planning of LAN components

- The internetworking decision depends on
  - location of the LAN segments and processing entities
  - Level of distributed processing
  - Traffic concentration
- The LAN designer faces following alternatives
  - centralized processing and support of a few LAN sites
    - in most cases, private networks are used
  - distributed processing and support of a few LAN sites
    - local LANs are linked to a premise backbone and then to network backbones

## Step 3- Design & planning of LAN components

- The LAN designer faces following alternatives …
  - centralized processing and support of many smaller LAN sites
    - Usually overall topology is star
    - LANs are gatewayed to the central or remote concentrator
  - distributed processing and support of many smaller LAN sites
    - Each LAN segment works relatively independently
- Design includes the wiring concentrators and wiring connections to NIC in server and client stations
- First a logical network design is done, then it is mapped into a physical network design

## Step 3- Design & planning of LAN components

- Network modeling and design tools can perform a number of functions to help design process
  - Using tool, once the network map is complete, the next step is to add information about the expected network traffic and see if the network can support the level of traffic that is expected. This may be accomplished through simulation models
  - Once simulation is complete, the user can examine the results to see the estimated response times and throughput
- Use of design tools can also help revising the network design

## Step 3- Design & planning of LAN components

- The purpose of cost assessment is to assess the costs of various network alternatives produced from the previous step
- Some of the costs to consider are:
  - Circuit costs
  - Internetworking devices
  - Hardware costs
  - Software costs
  - Network management costs
  - Test and maintenance costs

## Step 4 - Implementation

- Implementation is the planning and executive of all activities related to upgrade or new installation
- The following activities are involved in this case
  - RFP (Request for proposal)
    - although some network components can be purchased *off-the-shelf*, most organizations develop an RFP before making large network purchases
    - once the vendors have submitted their proposals, the organization evaluates them against specific criteria, and selects the winner(s)
    - one of the key decisions in the RFP process is the scope (one vendor or multi-?)
  - Conversion plan
    - old network should be operational until the new one has been thoroughly tested and proven

## Step 4 - Implementation

- The following activities are involved in this case …
  - Contingency plan
    - preconceived action plans for restoring services are essential in case of adverse circumstances
    - a contingency plan is required to deal with ways for temporarily reconfiguring the network to overcome individually failing LAN components and allow for continued operation during the time taken to resolve the problem
  - Recovery plan
    - a recovery plan defines methods available to restore either a single component of the network or the entire network to operational status
    - Should take into account that system failure may result from device malfunction, natural disaster, fire, sabotage etc.

## Reading

- Study Guide 9