Lecture 3

LAN Design

What is LAN Design

- Network or LAN design can be defined as a complete communication system level design defining user access, the transportation medium and data transport elements, and all internal and external factors, which affect, manage, or interact with the communications medium.
- LAN design encompasses the following:
  - LAN infrastructure
  - Making the business case
  - Compiling the requirements
  - Choosing the technology
  - Planning for capacity
  - Completing the vendors selection
  - Other issues

Learning Objectives

- Upon completing this course, you should be able to:
  - Describe the LAN infrastructure
  - Describe network design and components
  - Describe network design methodology
  - Understand layer 1, 2 and 3 design

LAN Infrastructure

LAN Infrastructure

- What is Network Infrastructure?
  - The term network infrastructure refers to the shared set of **physical** and **logical** components that provide the basis for connectivity, security, routing, management, access, and other features integral to a network.

LAN Infrastructure (cont'd)

- **Physical Infrastructure**
  - Topology
  - Hardware components
    - Cabling
    - Routers
    - Switches
    - Bridges
    - Hubs
    - Repeaters
    - Client and Server computers
    - NIC
  - May aslo refer to technologies such as Ethernet , 802.11a/b/g, the Public Switch Telephone Network (PTSN), T-Service, which all depends on specific hardware and other physical requirement

LAN Infrastructure (cont'd)

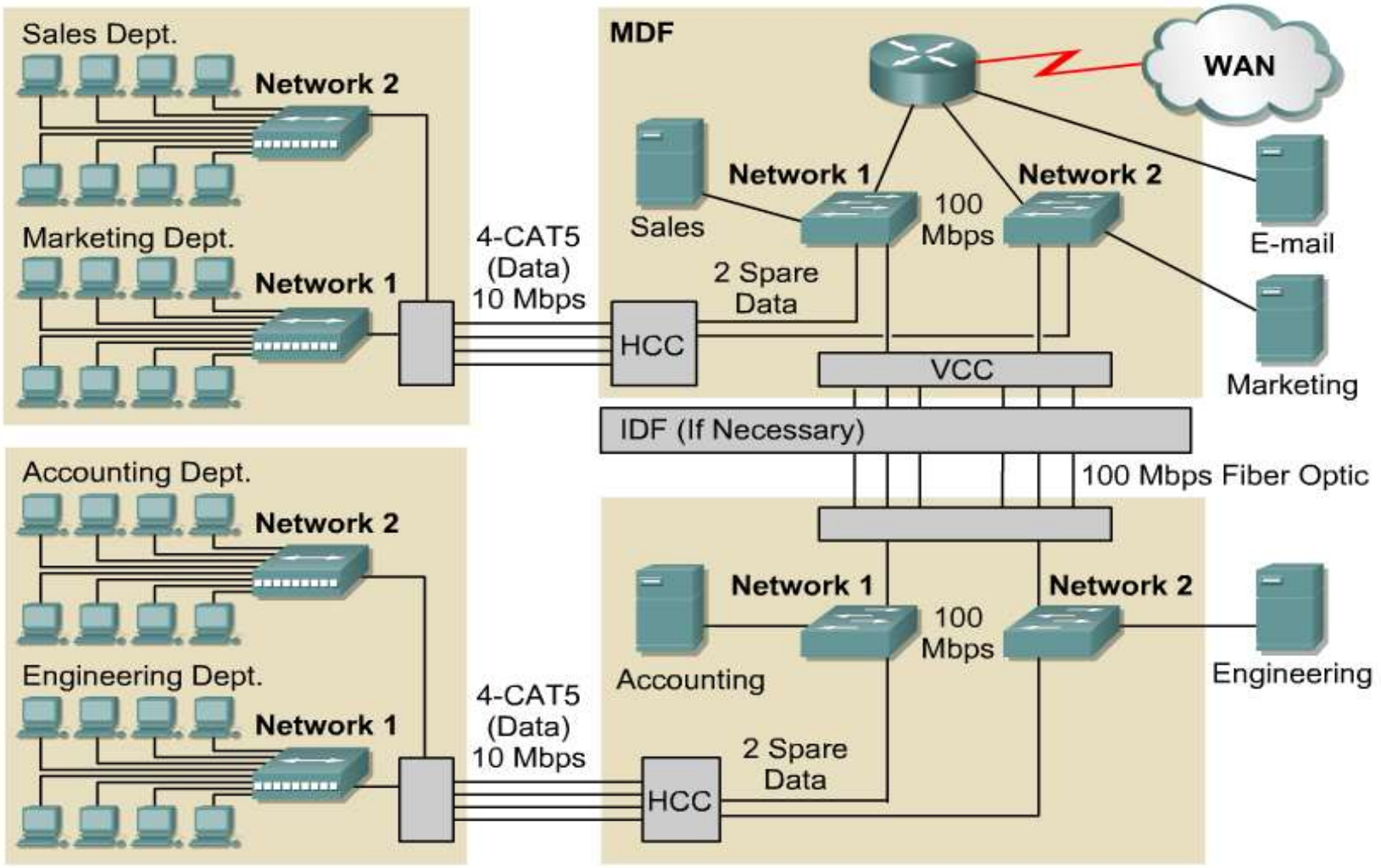


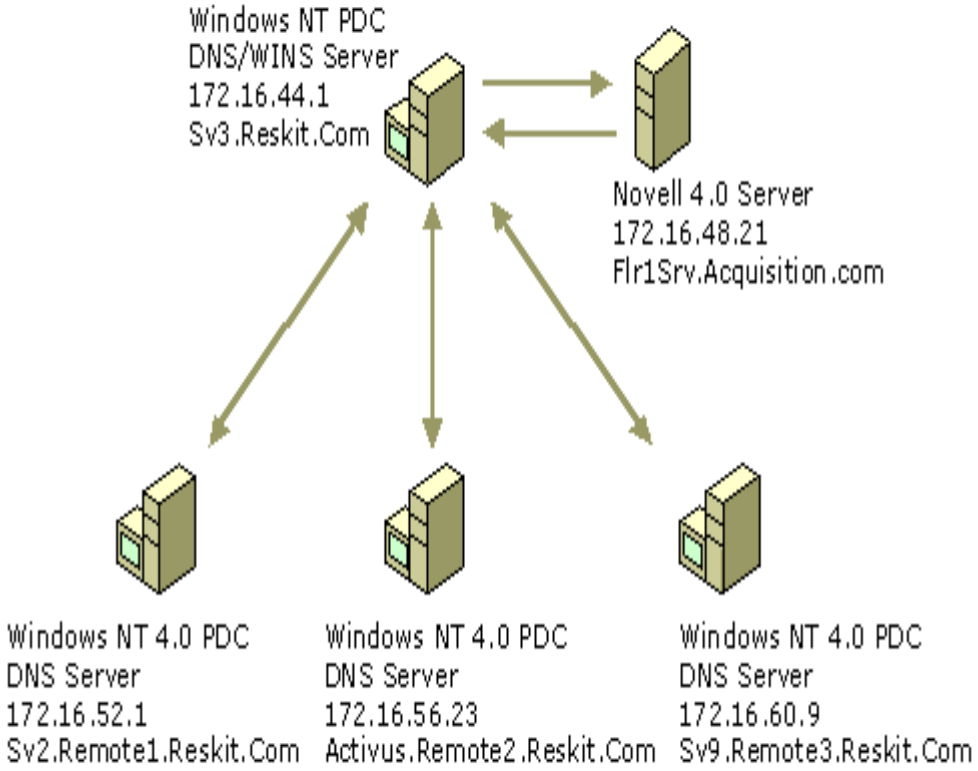
Fig1: Physical Infrastructure of network

LAN Infrastructure (cont'd)

- **Logical Infrastructure**
  - Refers to the shared software elements that allow computers to communicate over the network 's physical topology
  - Elements of logical infrastructure include:
    - Shared network protocols
    - An addessing scheme
    - Name resolution systems
    - Sever roles (Web server or Certificate server)
    - Network operating systems (microsoft Windows 2000 server, Unix, or Novell NetWare

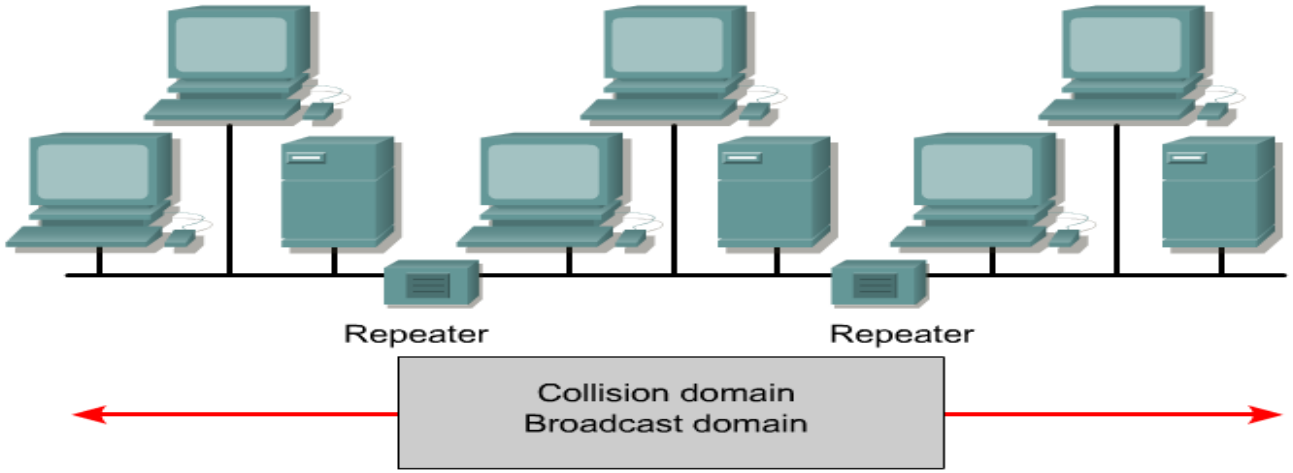
LAN Infrastructure (cont'd)

Logical Infrastructure (cont'd)



Hardware Components

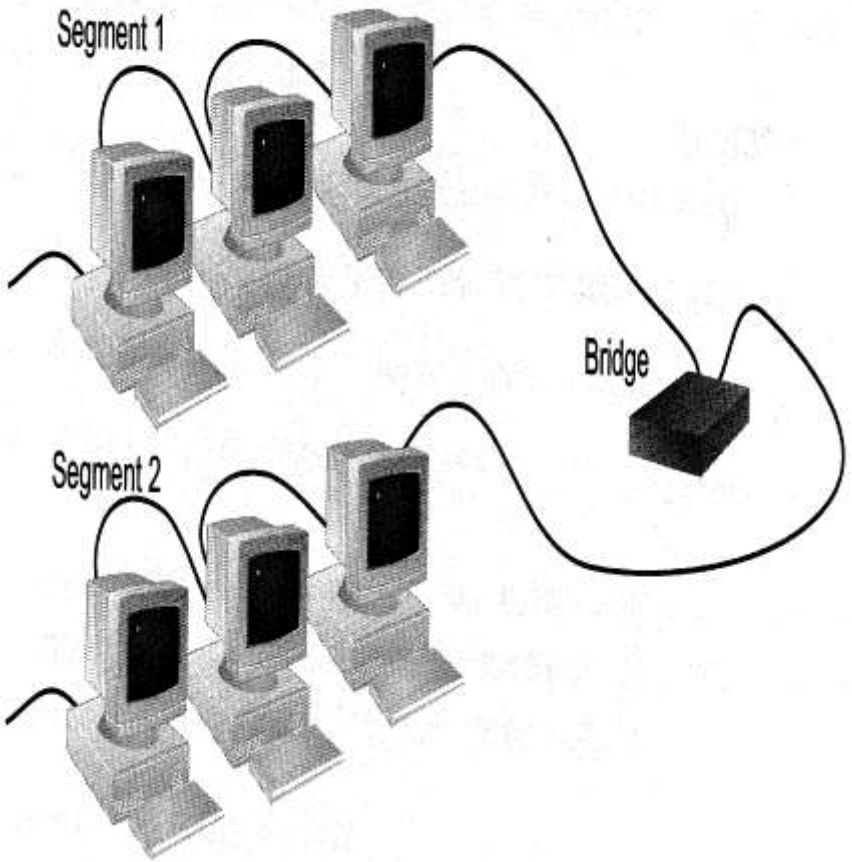
- **Repeaters**
  - Repeaters work at the OSI physical layer or layer 1 to regenerate or boost the network's signal and resend them to other segments



- Repeaters are Layer 1 devices that regenerate the signal, and pass it on
- Repeaters allow a longer end-to-end distance
- Repeaters increase the collision domain size
- Repeaters increase the broadcast domain size

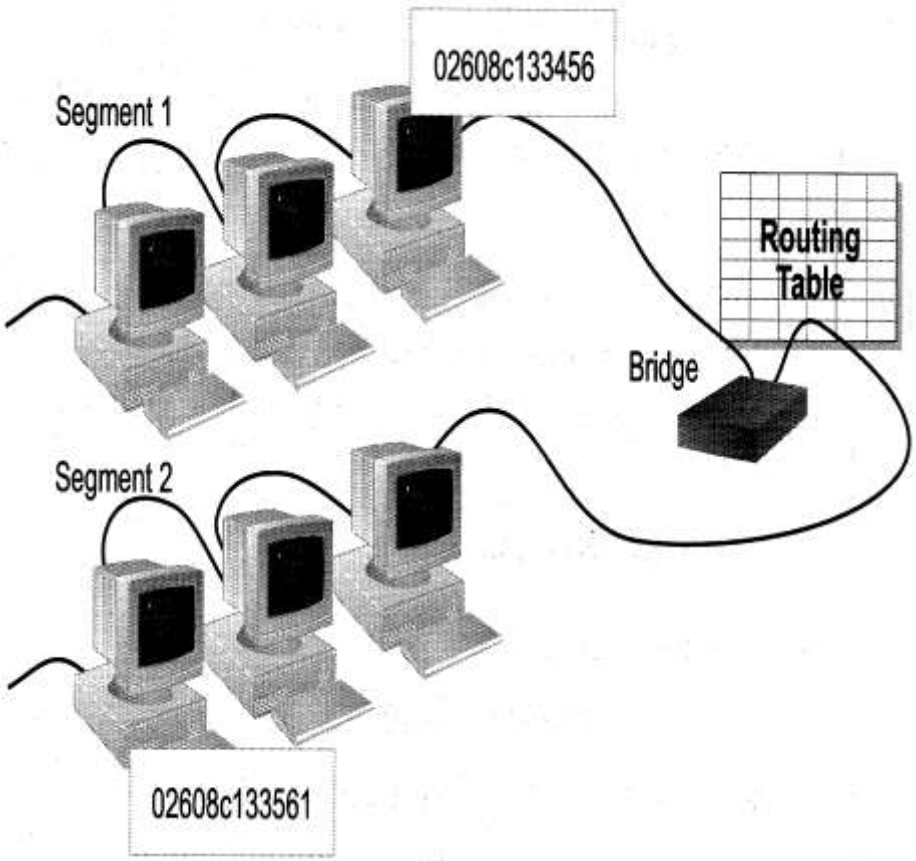
Hardware Components (cont'd)

- **Bridges**
  - A bridge is a Layer 2 device used to divide, or segment, a network.
  - Used to isolate network traffic and computers
  - Has the intelligent to examine incoming packet source and destination addresses.
  - But cannot interpret higher-level information
  - Hence cannot filter packet according to its protocol



Hardware Components (cont'd)

- **How bridges work?**
  - Bridges work at the Media Access Control Sub-layer of the OSI model
  - Routing table is built to record the segment no. of address
  - If destination address is in the same segment as the source address, stop transmit
  - Otherwise, forward to the other segment

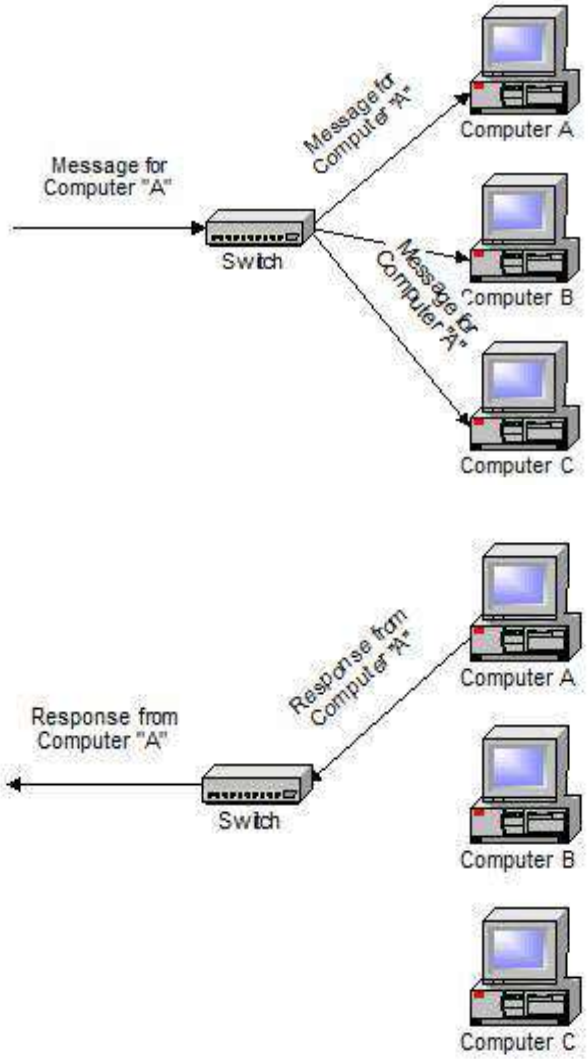


Hardware Components (cont'd)

- **Switches**
  - Switches operate at the Data Link layer (layer 2) of the OSI model
  - Can interpret address information
  - Switches resemble bridges and can be considered as multiport bridges
  - By having multiports, can better use limited bandwidth and prove more cost-effective than bridge
  - Switches divide a network into several isolated channels
    - Reduce the possibility of collision

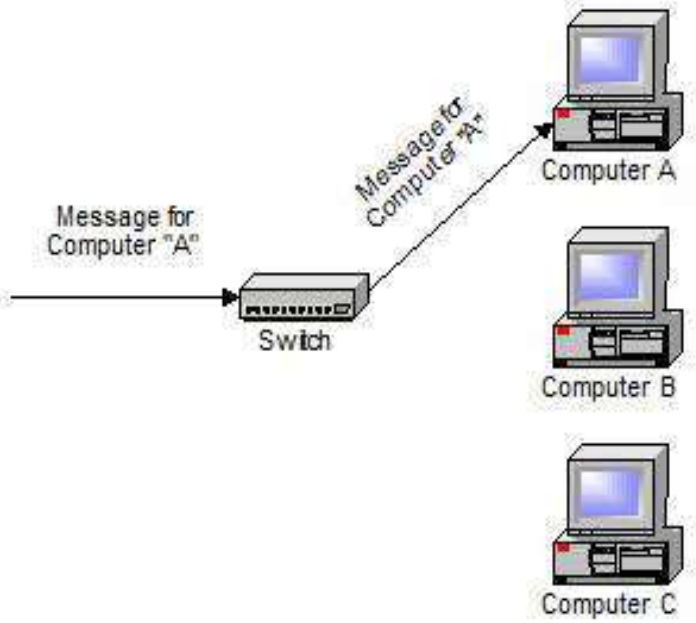
Hardware Components (cont'd)

- **How switches operate**
  - Initially, a switch knows nothing and simply sends on incoming messages to all ports
  - When the switch accepts the first message, it learns the connection the sender of the message is located
  - Thus, when machine "A" responds to the message, the switches only need to send that message out to the one connection
  - In addition to sending the response through to the originator, the switch has now learned the connection machine "A" is located.



Hardware Components (cont'd)

- **How switches operate (cont'd)**
  - That means that subsequent messages destined for machine "A" need only be sent to that one port:



Hardware Components (cont'd)

- A hub
  - In data communications, a **hub** is a place of convergence where data arrives from one or more directions and is forwarded out in one or more other directions
  - Star networks are based on hubs
  - Broadly speaking, there are two hub varieties
    - Passive
    - Active

See USB 7-Port Hub
To connect several
USB devices

Hardware Components (cont'd)

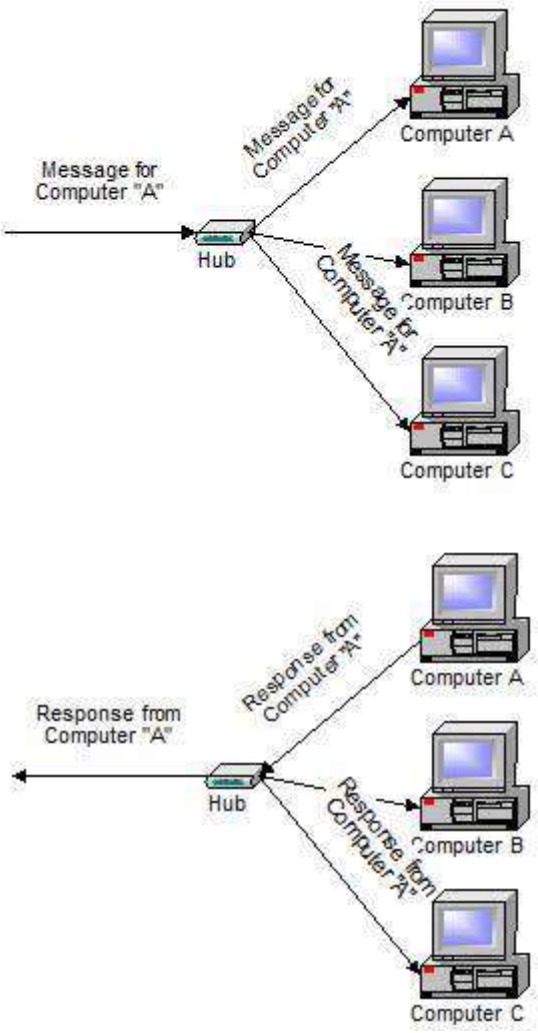
- Passive Hub
  - Passive hubs do not incorporate any power electronic components
    - As a result, the only function of a passive hub is to provide a central point for connecting cables
  - Passive hubs cannot provide network management or improve the quality of network signals
  - The IBM model 8228, a relay based hub that was developed by IBM's Token-Ring network is an example of passive hub

Hardware Components (cont'd)

- Active Hub
  - Active hubs have electronic components that can process signals
  - They include several interesting capabilities:
    - Amplification of weakened signals
    - Reshaping and rerieving of distorted waveforms
    - Detection of network problems
    - Sending perfomance and error reports to management
    - Remote management, enabling network administrators to control hubs that are located a considerable distance away

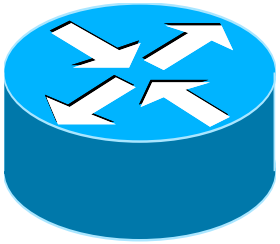
Hardware Components (cont'd)

- How hubs operate:
  - Anything that comes in one port is sent out to the others.
  - If a message comes in for computer "A", that message is sent out all the other ports, regardless of which one computer "A" is on
  - And when computer "A" responds, its response also goes out to every other port on the hub
  - Every computer connected to the hub "sees" everything that every other computer on the hub sees.
  - The computers themselves decide if they are the targeted recipient of the message and when a message should be paid attention to or not.



Hardware Components (cont'd)

- **Routers**
  - A router is a Layer 3 device.
  - Used to "route" traffic between two or more Layer 3 networks.
  - They use the "logical address" of packets and routing tables to determine the best path for data delivery



Hardware Components (cont'd)

- Network interface card (NIC) or Network adapter
  - It is the jack on the back or side of a computer where you will plug in the cables or exchange wireless signals
- There are three kinds of network adapters
  - **Peripheral component interconnect (or PCI) card**
    - This plugs into a slot inside the PC and provides one ethernet jack for connecting a network cable
  - **USB adapter**
    - This plugs into the USB port on any kind of computer and parks itself on the outside of the PC
  - **PC card**
    - Plugs into a special slot on laptops

Design Goals and Components

LAN Design Goals

- **Functionality**
  - The network must work.
  - The network must allow users to meet their job requirements.
  - The network must provide user-to-user and user-to-application connectivity with reasonable speed and reliability.
- **Scalability**
  - The network must be able to grow.
  - The initial design should grow without any major changes to the overall design.
- **Adaptability**
  - The network must be designed with a vision toward future technologies.
  - The network should include no element that would limit implementation of new technologies as they become available.
- **Manageability**
  - The network should be designed to facilitate network monitoring and management to ensure ongoing stability of operation.

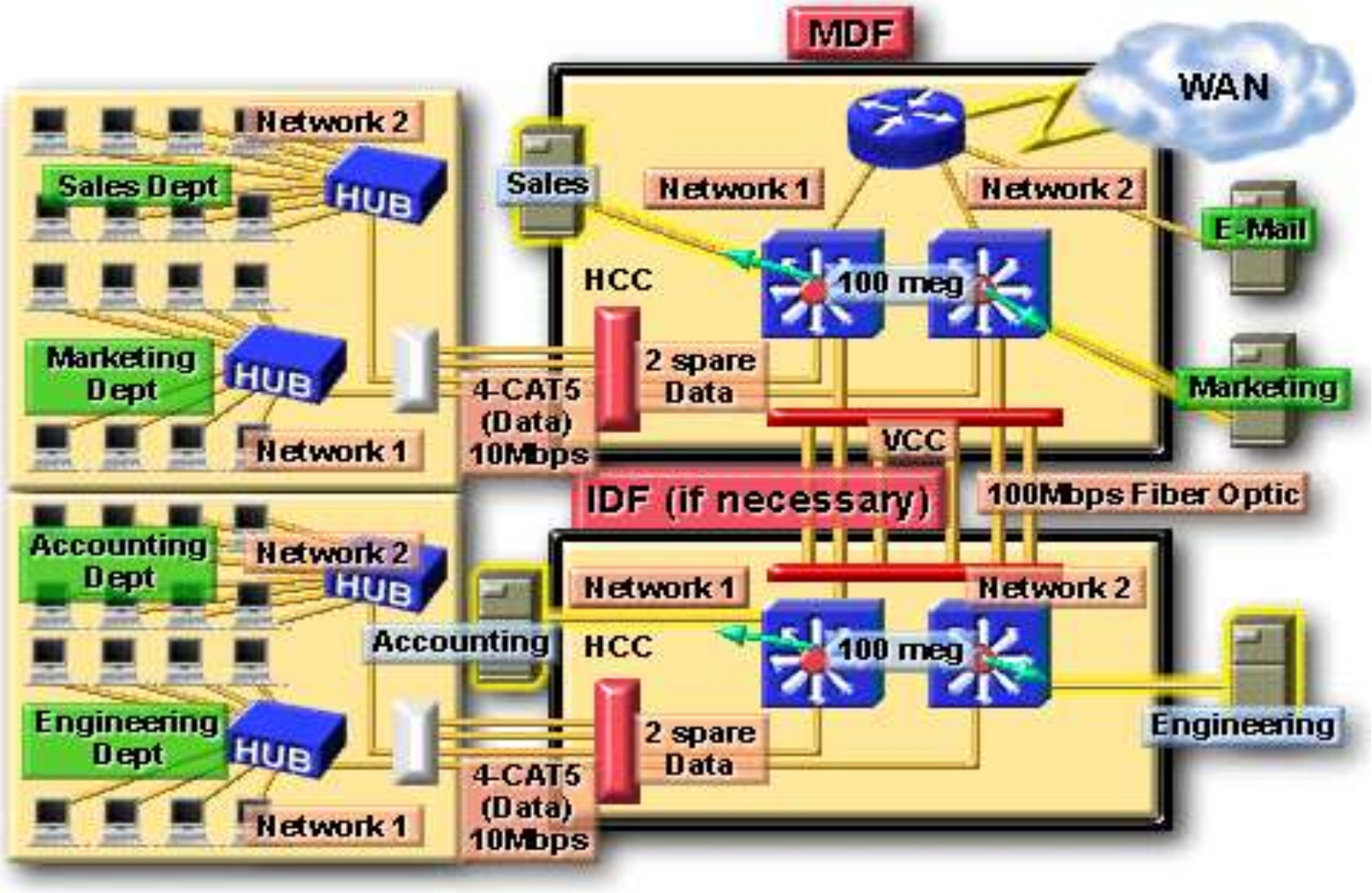
Critical Components of LAN Design

- With the emergence of high-speed technologies and complex LAN technologies, the following critical components need addressing in design
  - Function and placement of Servers
  - Contention
  - Segmentation
  - Bandwidth v. Broadcast domains
- Note: These are things an administrator has control over that will affect how efficiently network resources are to be used

Function and Placement of Servers

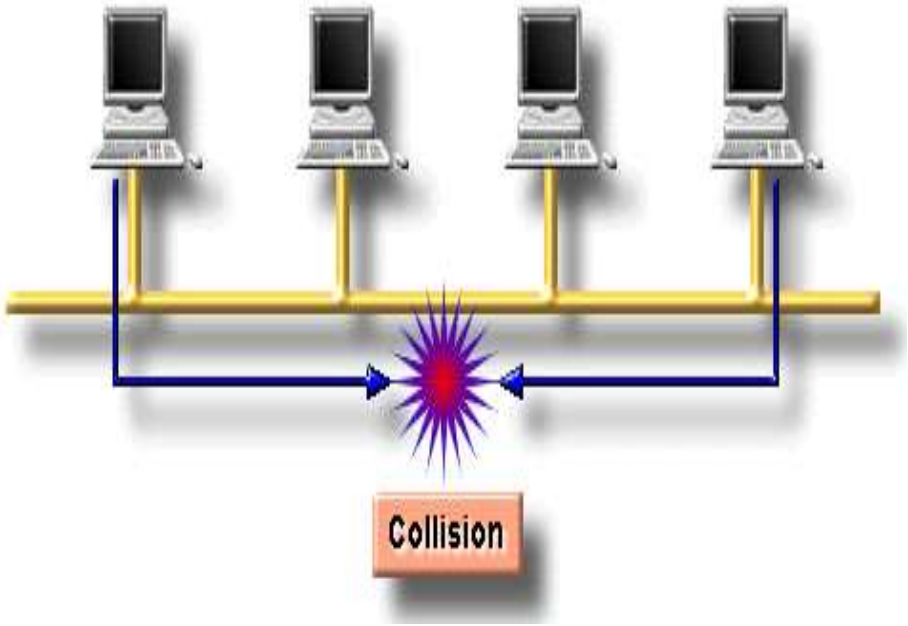
- Servers now perform special functions and can be categorized as either...
  - Enterprise Servers-:-supports all users on the network
    - DNS and mail servers
    - Should be placed in the MDF
  - Workgroup Servers-:-supports a specific set of users
    - File serving such as specialized databases
    - Should be place in the IDF closest to users

Placement of Servers (cont'd)

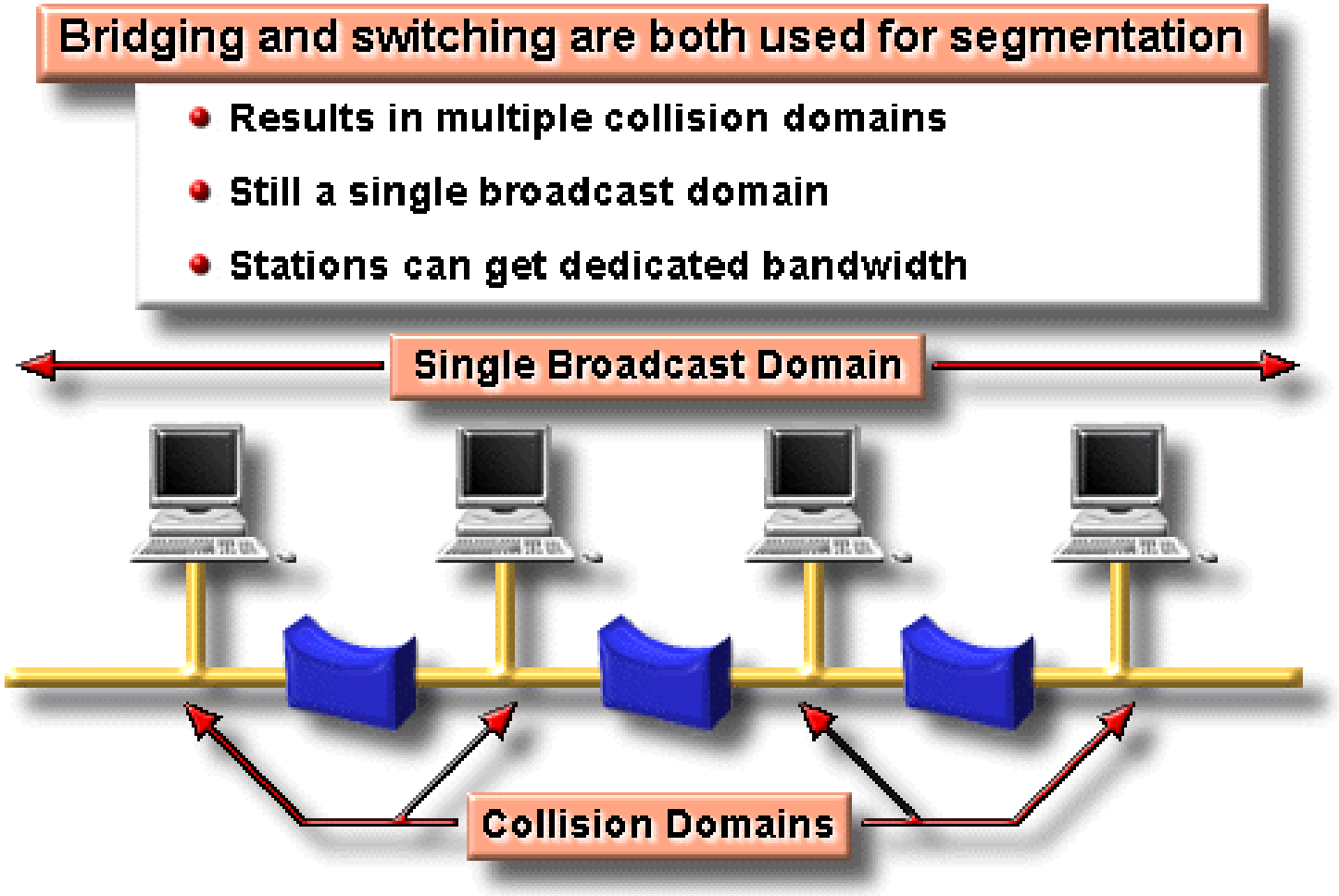


Contention on an Ethernet Network

- Contention refers to excessive collisions on Ethernet, caused by too many devices, each with a great demand, on a single network segment
- Collisions are overhead on Ethernet
  - more collisions means less data gets through
- Contention solved by segmentation

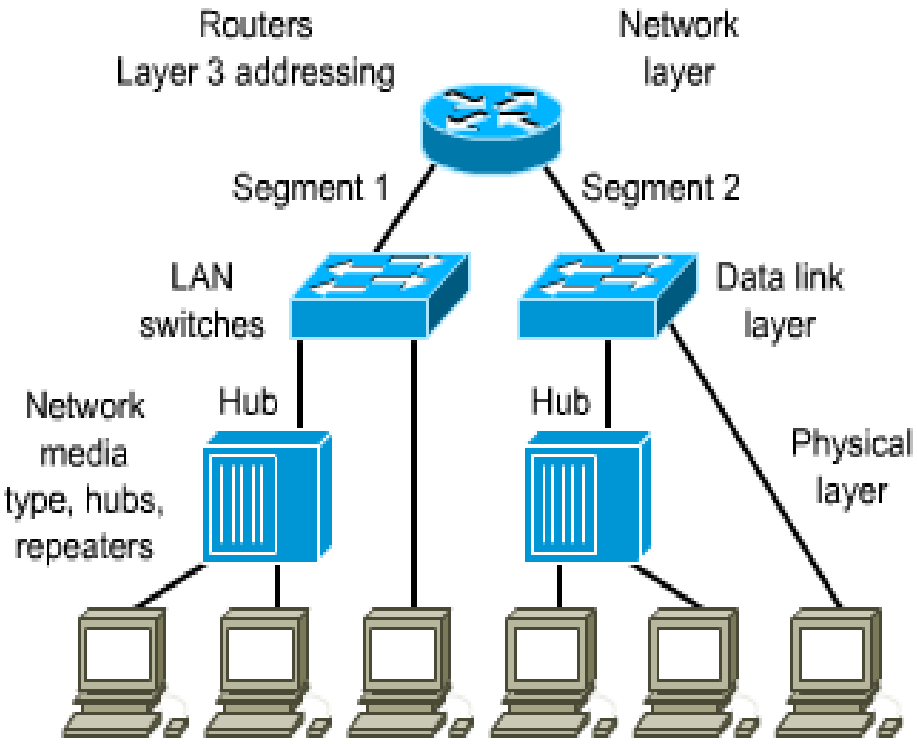


Broadcasts and Segmentation



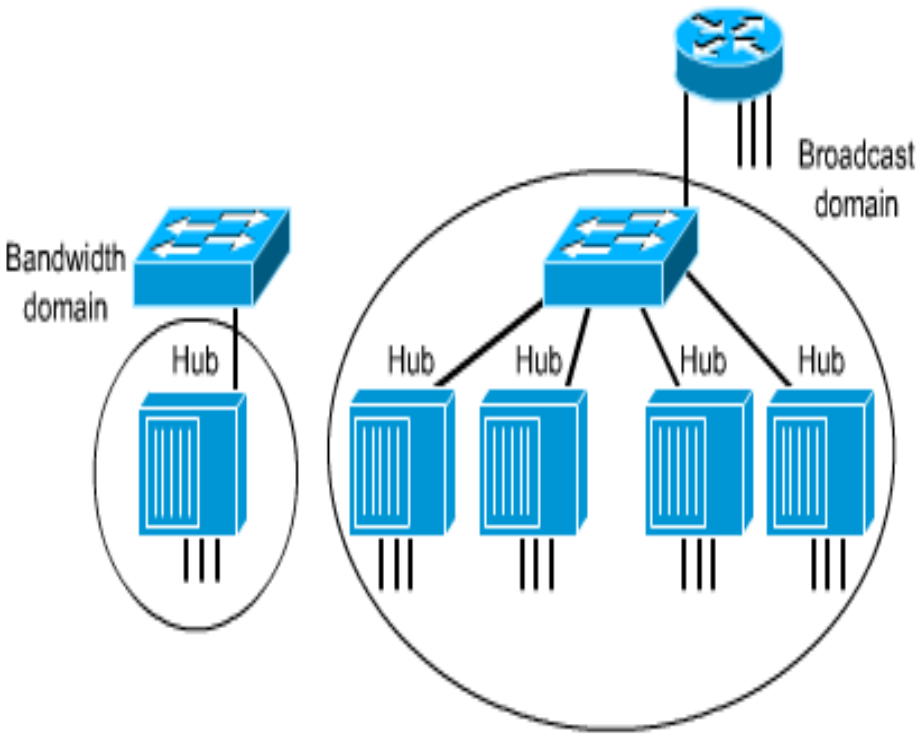
Broadcasts and Segmentation (cont'd)

- Layer 2 devices segment collision domains
- Layer 3 devices segment broadcast domains



Bandwidth Vs Broadcast Domains

- A bandwidth domain is shared by all devices on a single switched port.
  - Synonymous with collision domain
- A broadcast domain is shared by all devices on a single router interface.



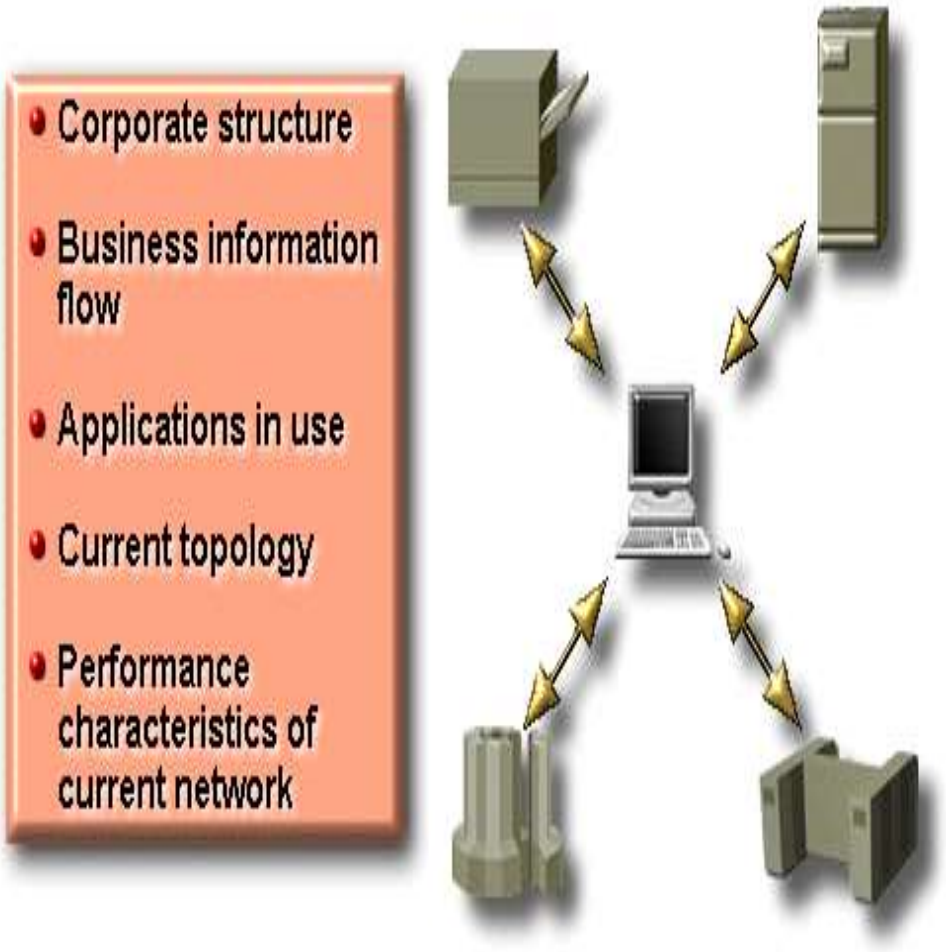
LAN Design Methodology

LAN design methodology

- Critical to design is insuring a fast and stable network that will scale well as the organization grows
- Design steps are
  - Gather and establish design goals based on user requirements
  - Determine data traffic patterns now and in the future
  - Define Layer 1, 2, and 3 devices and the LAN/WAN topologies
  - Document physical and logical network implementation

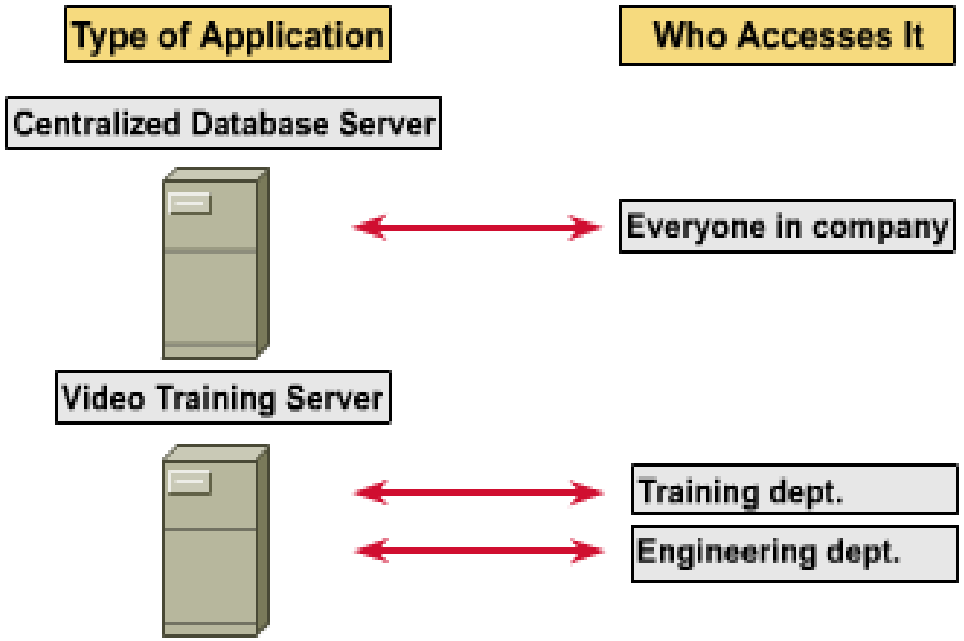
Gathering and Analyzing Requirements

•Gather and analyse info firstly on organisation structure (projected growth, operating policies / management procedures, staff skill levels)
e.g. mission critical data or operations? Restrictions on network protocols? What resources to support LAN? What hardware / software currently in use and projected for future?



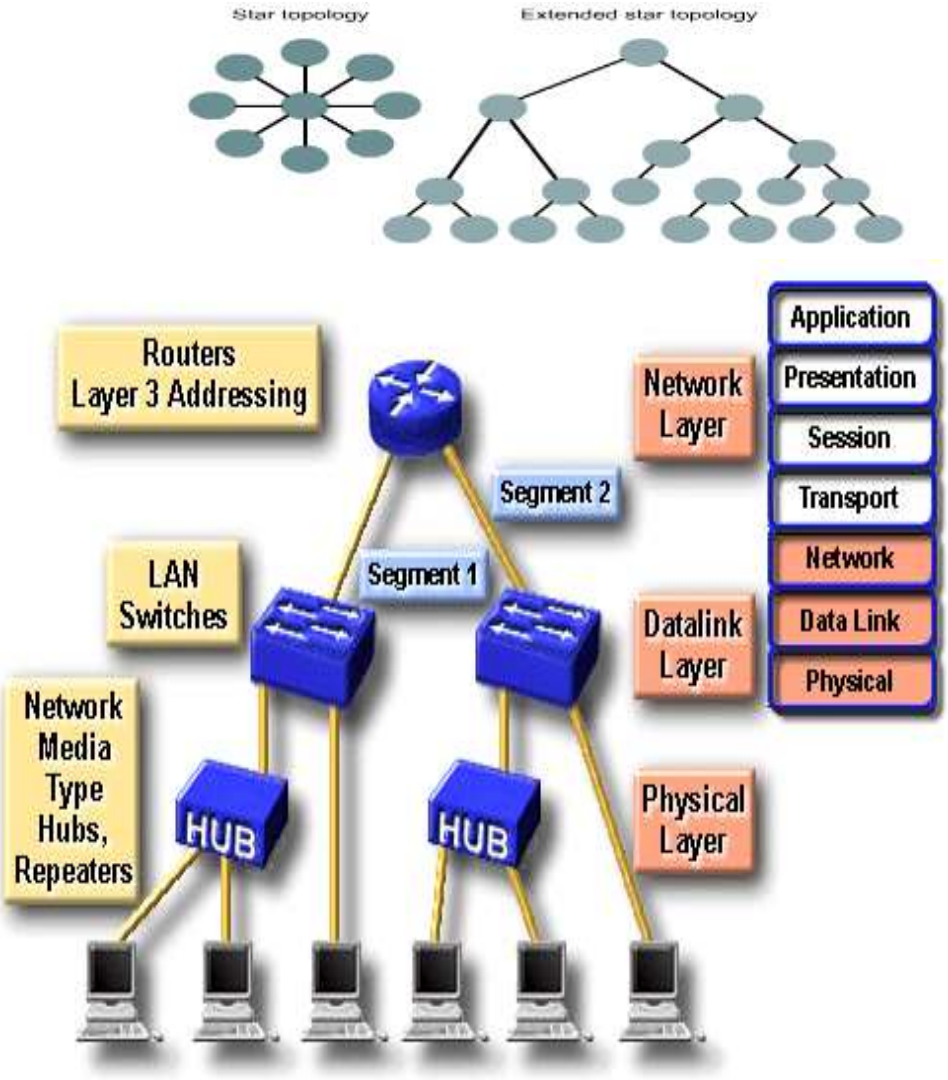
Network Availability

- Network design seeks to provide the greatest availability for the least cost.
- Factors that affect availability include...
  - Throughput
  - Response time
  - Access to resources
- In the graphic, what type of server is each and where should each be placed?



Developing a LAN Topology in 3 stages

- In the CCNA curriculum, we concentrate on the star/extended star physical topology which typically uses the Ethernet 802.3 standard.
- Why? Because it is the most popular topology used in LANs.
- Within the boundaries set by that topology, we then design the network by focusing on physical layer, data link layer and network layer in turn
  - i.e. using the OSI model to guide the design.



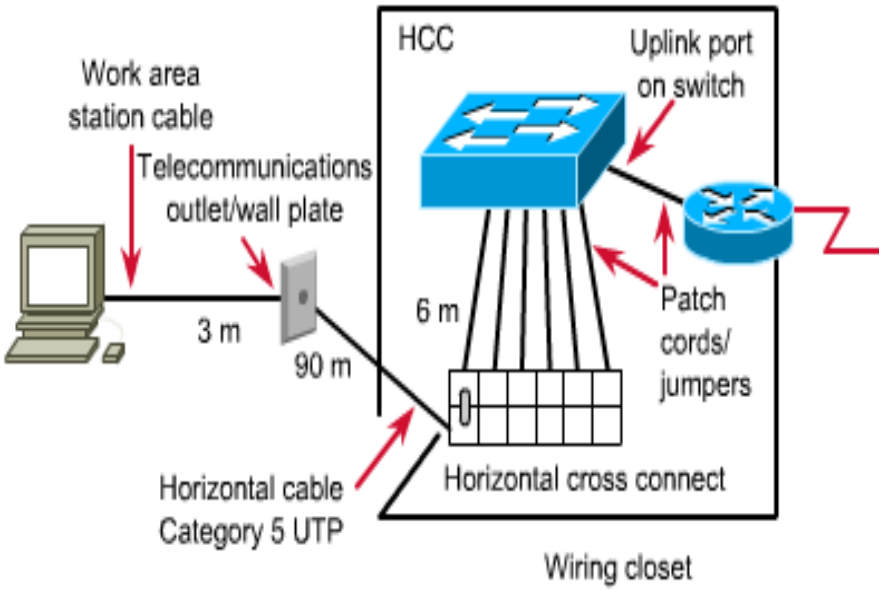
Layer 1 Design

Ethernet Cable Runs

- The physical cabling (also called the cable plant) is the most important Layer 1 issue to consider when designing a network.
- Design issues include...
  - Type of cable to use (twisted-pair, coax, fiber)
  - Where to use each type (e.g. fiber on the backbone)
  - How far each run must travel before being terminated (twisted-pair is limited to what distance?)
- In an existing LAN, a cable audit is performed to determine where upgrading and/or replacement of bad cables is needed.

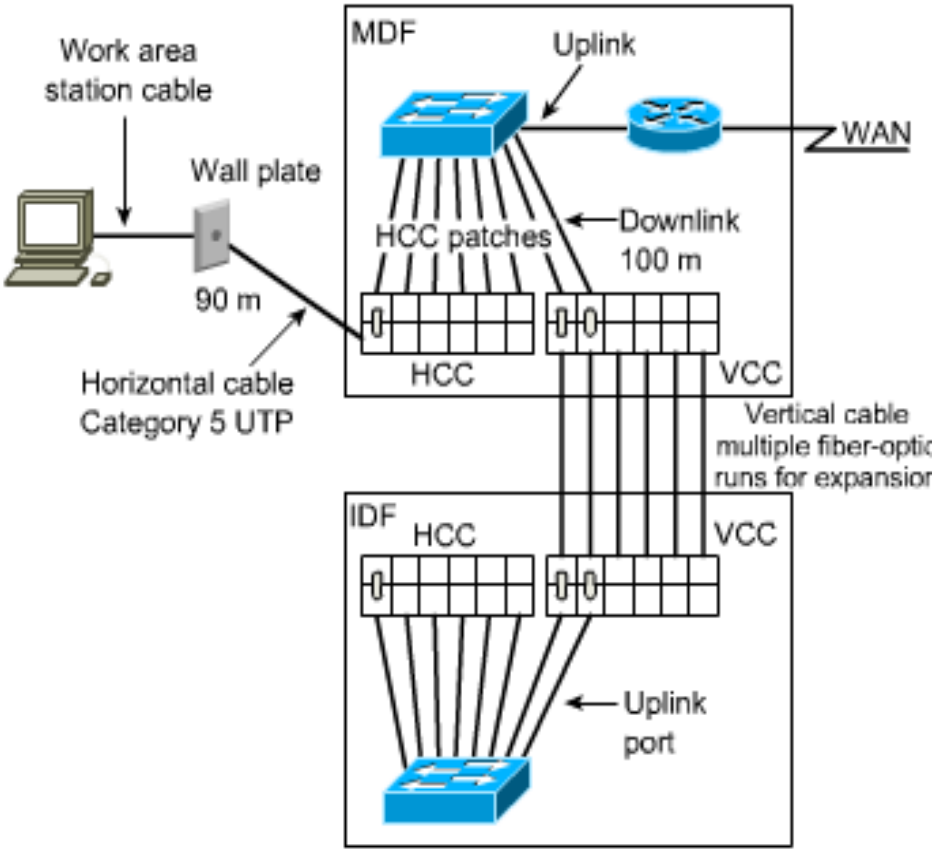
MDF and Other 568A Acronyms

- Whether the LAN is a star or extended star, the MDF is the center of the star.
  - From the workstation to the telecommunications outlet, the patch cable should be no more than 3m.
  - From there to the patch panel, called the HCC, no more than 90m.
  - From the patch panel (the HCC) to the switch, no more than 6m.



MDF & Other 568A Acronyms

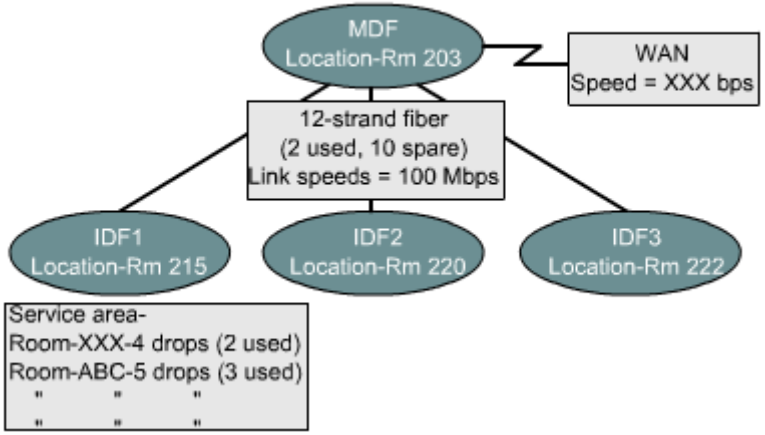
- When distances to the MDF are more than 100m, an IDF is normally added.
- The cable run from the IDF to the MDF is called the VCC and is usually fiber.
- VCC is just another name for the backbone.
- By adding more wiring closets (more IDFs), you create multiple catchment areas



Layer 1 Logical Documentation

- Layer 1 logical documentation is concerned with...
  - exact location of MDF/IDF
  - type & quantity of cabling
  - room locations & # of drops
  - port numbers
  - cable labels
- Notice Layer 1's logical documentation shows nothing about logical addressing
- The Logical Diagram and Cut Sheet are primary tools for design, but are crucial to the tech who is troubleshooting.

Logical Diagram



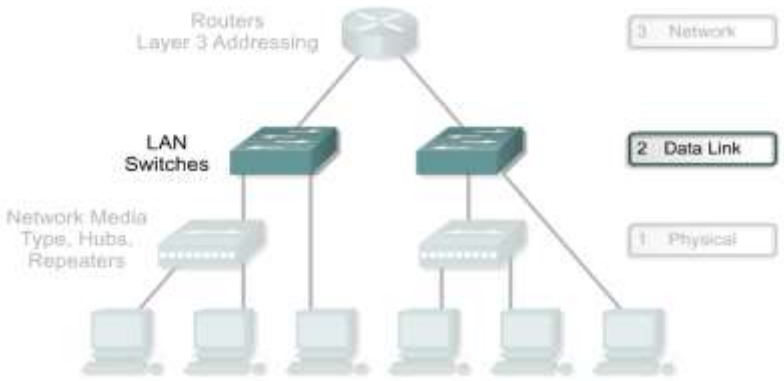
Cut Sheet

IDF1
Location-Rm XXX

Connection	Cable ID	Cross Connection Paired#/Port#	Type of Cable	Status
IDF1 to Rm 203	203-1	HCC1/Port 13	Category 5 UTP	Used
IDF1 to Rm 203	203-2	HCC1/Port 14	Category 5 UTP	Not used
IDF1 to Rm 203	203-3	HCC2/Port 3	Category 5 UTP	Not used
IDF1 to MDF	IDF1-1	VCC1/Port 1	Multimode fiber	Used
IDF1 to MDF	IDF1-2	VCC1/Port 2	Multimode fiber	Used

Layer 2 Design

Switches and Layer 2 Design



Hub A:
- Collision domain = 24 hosts
- Bandwidth average = 100 Mbps/24 hosts = 4.167 Mbps per host

Hub B:
- Collision domain = 24 hosts
- Bandwidth average = 10 Mbps/24 hosts = 0.4167 Mbps per host

Hub C:
- Collision domain = 8 hosts
- Bandwidth average = 100 Mbps/8 hosts = 12.5 Mbps per host

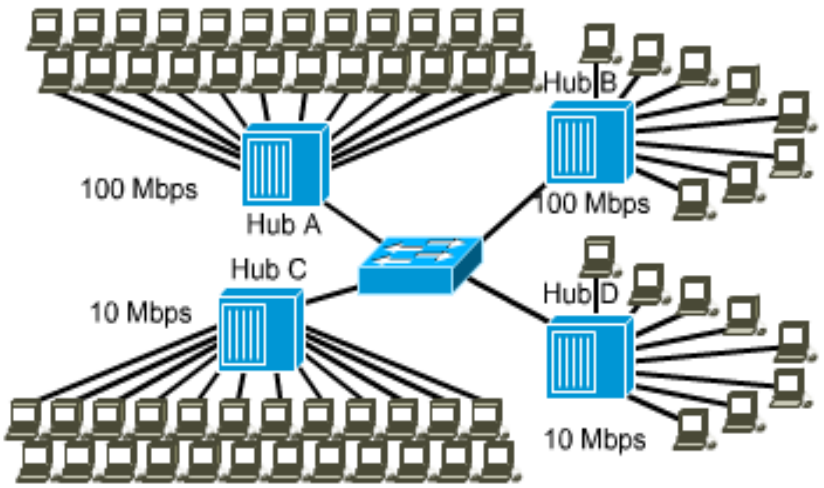
Hub D:
- Collision domain = 8 hosts
- Bandwidth average = 10 Mbps/8 hosts = 1.25 Mbps per host

- Collisions and collision domain size are two factors that negatively affect the performance of a network.
- Microsegmentation of the network reduces the size of collision domains and reduces collisions.
- Microsegmentation is implemented through the use of bridges and switches.
- The goal is to boost performance for a workgroup or a backbone.
- Switches can be used with hubs to provide the appropriate level of performance for different users and servers.

Sizing Collision Domains

- In a switched LAN environment using hubs, the bandwidth of each switched port is shared by all the devices. Therefore, they also share the same collision domain.
- To determine the bandwidth per host, simply divide the port's bandwidth by the number of hosts (see graphic).
- In a pure switched LAN environment where each host has its own port, the size of the collision domain is 2. If running full-duplex, then the collision domain is eliminated. Why?

Collision Domain Size with Hubs



Hub A: Collision domain = 24 hosts
Bandwidth average = 100 Mbps/24 host = 4.167 Mbps per host

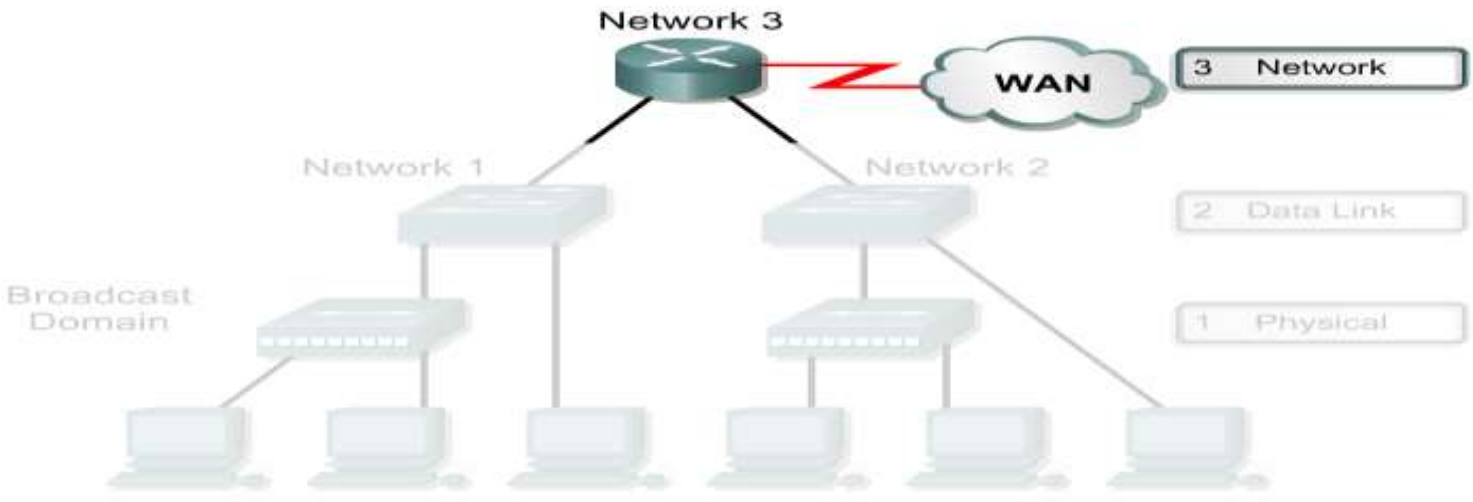
Hub B: Collision domain = 8 hosts
Bandwidth average = 100 Mbps/8 host = 12.5 Mbps per host

Hub C: Collision domain = 24 hosts
Bandwidth average = 10 Mbps/24 host = .4167 Mbps per host

Hub D: Collision domain = 8 hosts
Bandwidth average = 10 Mbps/8 host = 1.25 Mbps per host

Layer 3 Design

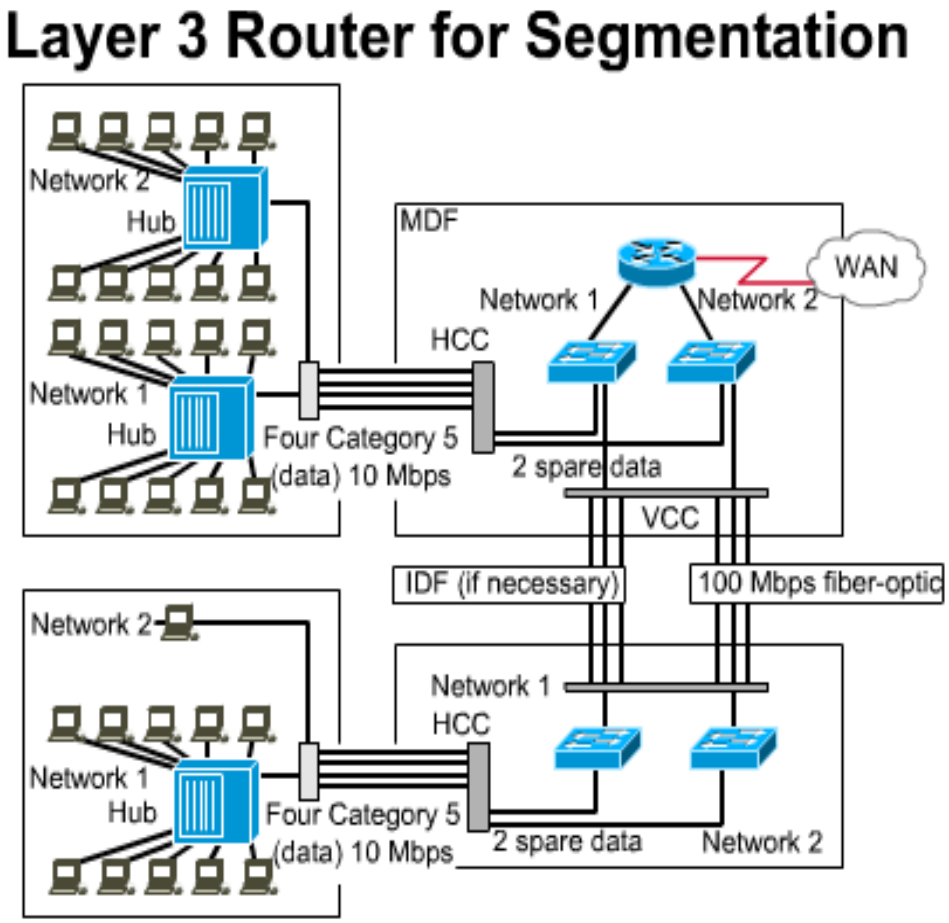
Routers and Layer 3 Design



- Routers can be used to create unique LAN segments and also allow for connectivity to wide-area networks (WANs), such as the Internet.
- Layer 3 routing determines traffic flow between unique physical network segments based on Layer 3 addressing.
- Routers provide scalability because they serve as firewalls for broadcasts.
- They can also provide scalability by dividing networks into subnetworks, or subnets, based on Layer 3 addresses.

Diagramming a LAN with Routers

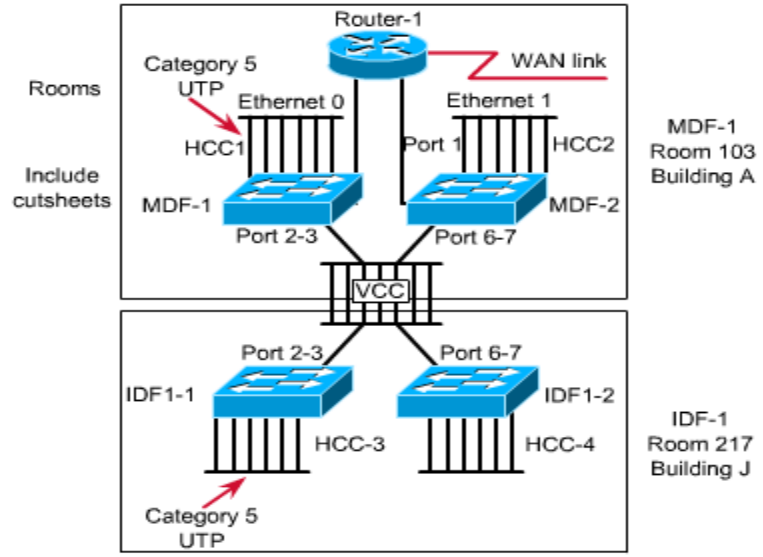
- Notice in the graphic that the two networks are kept separate by the router.
- Each switch serves a different network regardless of the physical location of the devices.
- To create another physical network in a structured Layer 1 wiring scheme, simply patch the HCC and VCC into the correct switch.



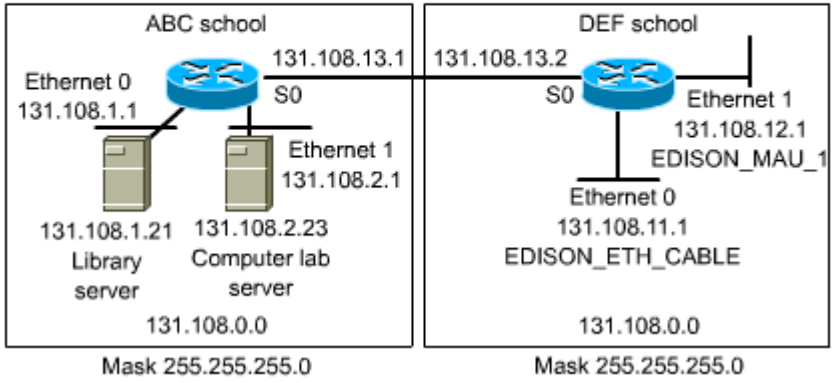
Logical & Physical Network Maps

- After determining your Layer 1, 2, and 3 design, you can create your addressing (logical) and physical maps. These are invaluable. They
  - Give a snapshot of the network
  - Show subnet mask info
  - Help in troubleshooting

Physical Network Maps



Addressing MAPs



End