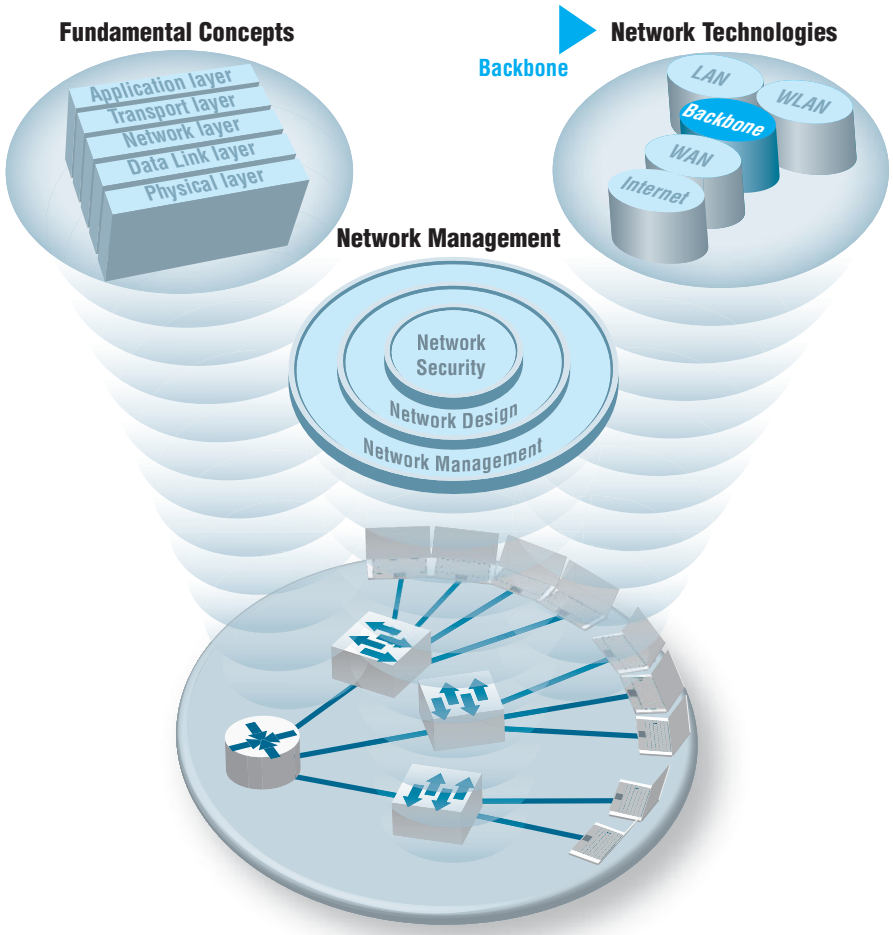
Chapter 7 (Backbone Networks , Fitzgerald)

BACKBONE



The Three Faces of Networking

Outline

7.1 Introduction

7.2 Components of Backbone networks

– Switches, Routers, Gateways

7.3 Backbone network architectures

7.4 Best practice backbone design

7.5 Improving backbone performance

7.6 Implications for Management

Backbone Networks

- **High speed networks linking an organization's LANs**
  - Making information transfer possible between departments
  - Use high speed circuits to connect LANs
  - Provide connections to other backbones, MANs, and WANs
- Sometimes referred to as
  - An **enterprise** network
  - A **campus-wide** network

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Backbone Network Components

- **Network cable**
  - Functions in the same way as in LANs
  - Optical fiber - more commonly chosen (provides higher data rates)
- **Hardware devices**
  - Computers or special purpose devices used for interconnecting networks
    1. Switches
    2. Routers
    3. Gateways

Backbone Network Devices

Device	Operates At	Packets	Physical Layer	Data Link Layer	Network Layer
Switch	Data link layer	Filtered using data link layer addresses	Same or different	Same	Same
Router	Network layer	Routed using network layer addresses	Same or different	Same or different	Same
Gateway	Network layer	Routed using network layer addresses	Same or different	Same or different	Same or different

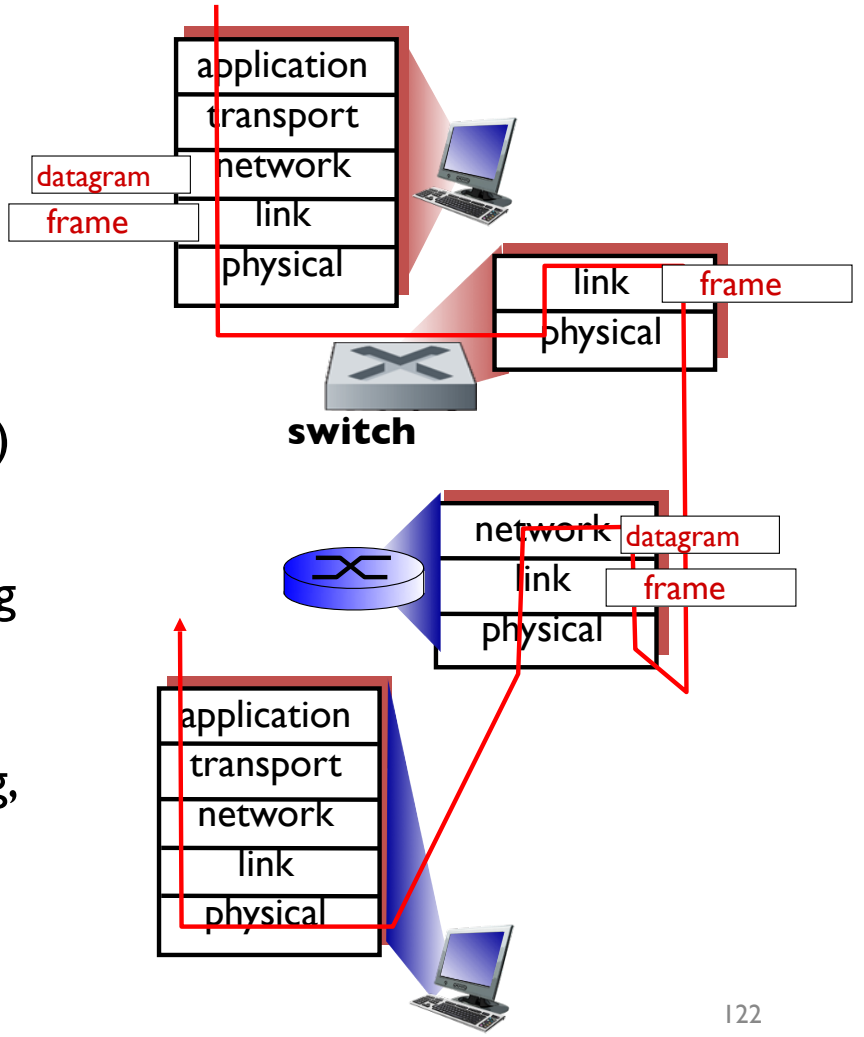
Switches vs. Routers

both are store-and-forward:

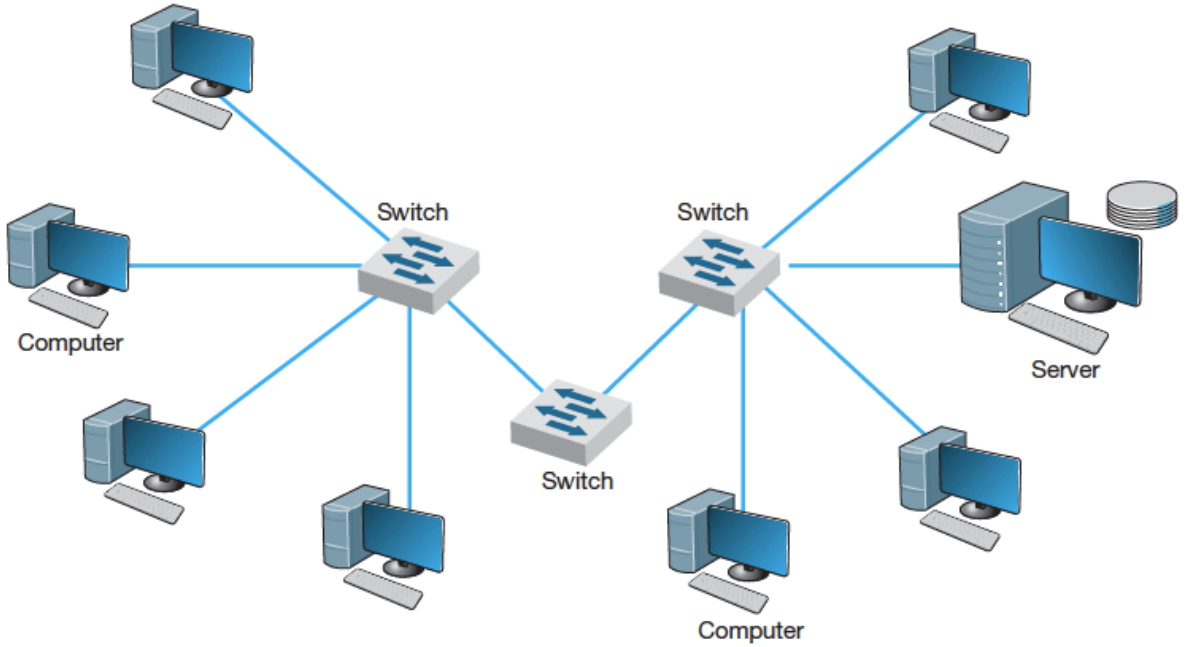
- *routers:* network-layer devices (examine network-layer headers)
- *switches:* link-layer devices (examine link-layer headers)

both have forwarding tables:

- *routers:* compute tables using routing algorithms, IP addresses
- *switches:* learn forwarding table using flooding, learning, MAC addresses



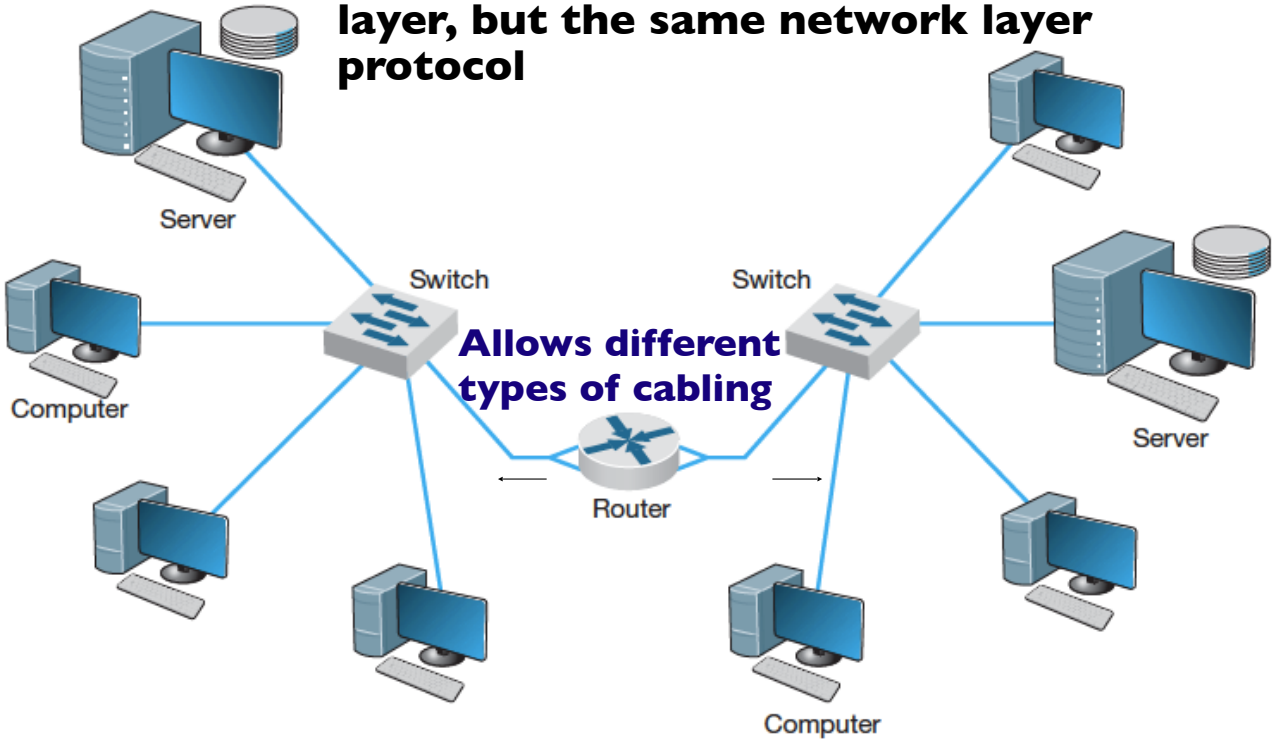
Switch



- Operate at the data link layer
- Connect two or more network segments that use the *same* data link and network protocol.
- Understand only data link layer protocols and addresses.
- They may connect the *same or different* types of cable.

Routers

- Operate at the network layer
- Connect LANS with different data link layer, but the same network layer protocol



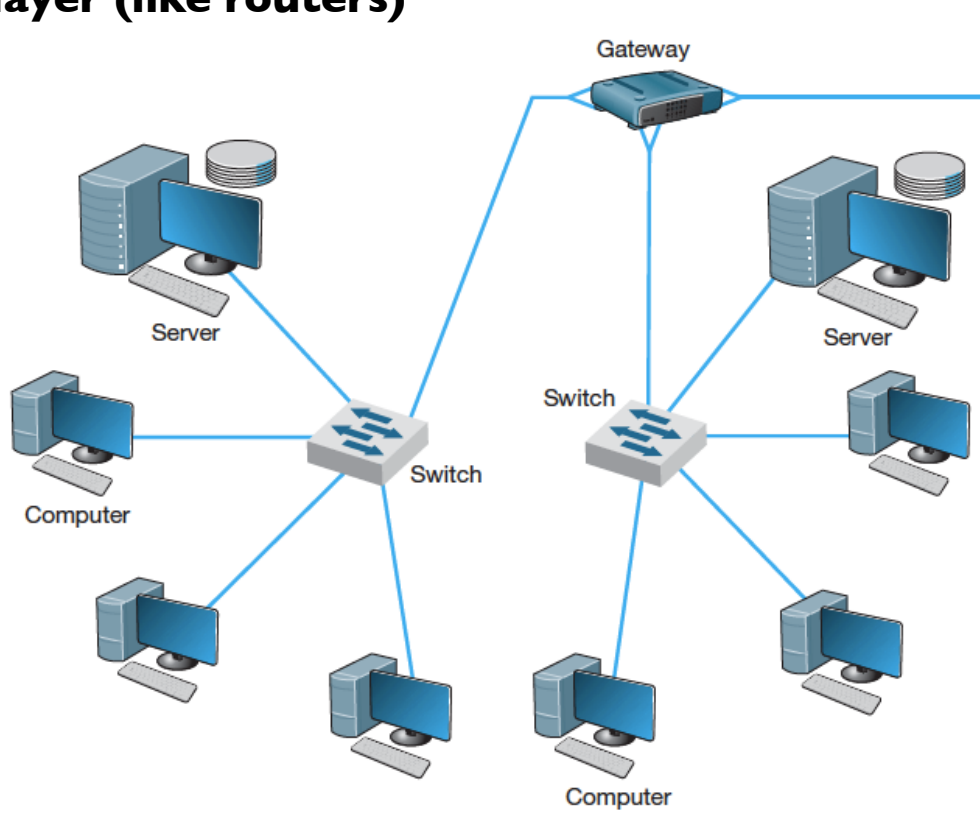
Perform more processing than bridges or layer 2 switches

Routers (Cont.)

- **Operations**
  - Strip off the header and trailer of the incoming L2 frame
  - Examine the destination address of the network layer
  - Build a new frame around the packet
  - Choose the "best" route for a packet (via routing tables)
  - Send it out onto another network segment

Gateways

Also operate at network layer (like routers)

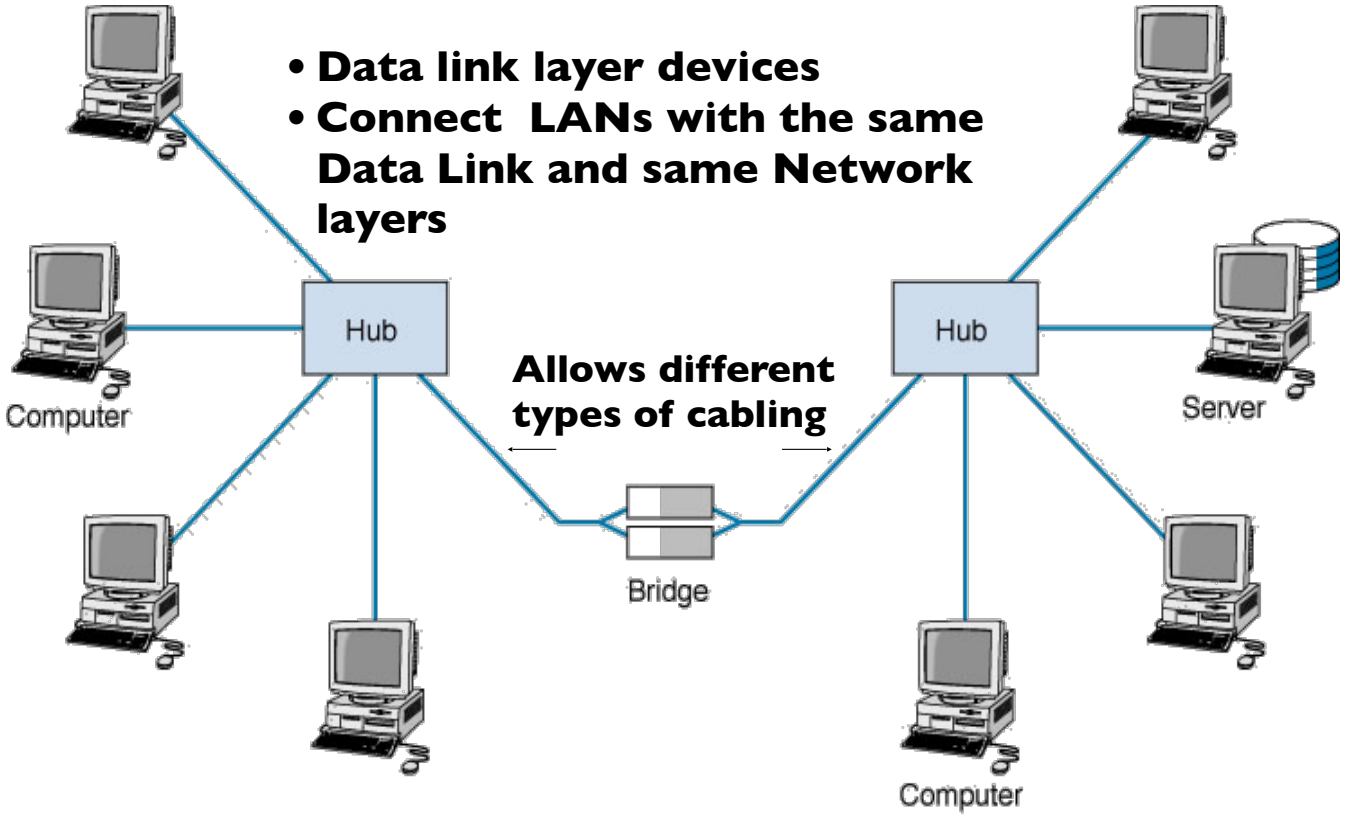


Connect LANS with different data link layer and different network layer protocols

Some operate at the application layer as well

Bridges

- **Data link layer devices**
- **Connect LANs with the same Data Link and same Network layers**



Operate in a similar way to layer 2 switches (learning bridges)

Learning Bridges

- Operate in a similar way to layer 2 switches:
  - Learn which computers are on each side of the bridge
    - By reading the source addresses on incoming frames and recording this information in forwarding tables
- Data link layer devices
  - Connecting similar type of networks
    - But they can connect different types of cable
- **Not popular anymore**
  - Losing market share to layer 2 switches as the latter become cheaper and more powerful

Other BB Network Devices

- **Multiprotocol routers**
  - Can handle several different protocols (no translation)
    - In and out protocols must be the same
- **Brouters**
  - Combine bridge and router functions
    - Examine L2 addresses of all messages
- **Layer-3 switches**
  - Similar to L2 switches, but switch messages based on L3 addresses
  - Can support many more simultaneous ports than routers

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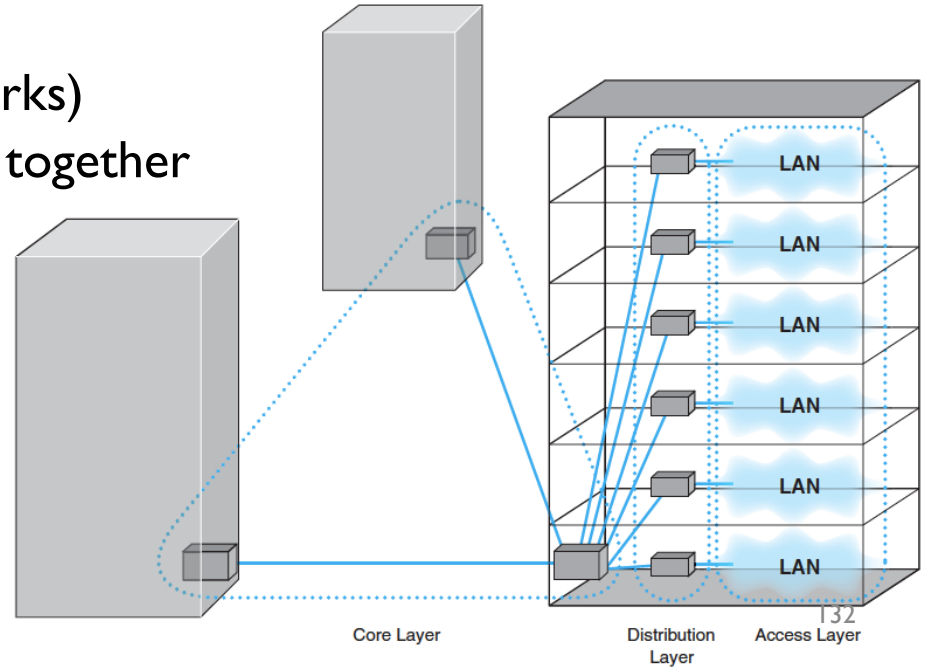
Backbone Network Architectures

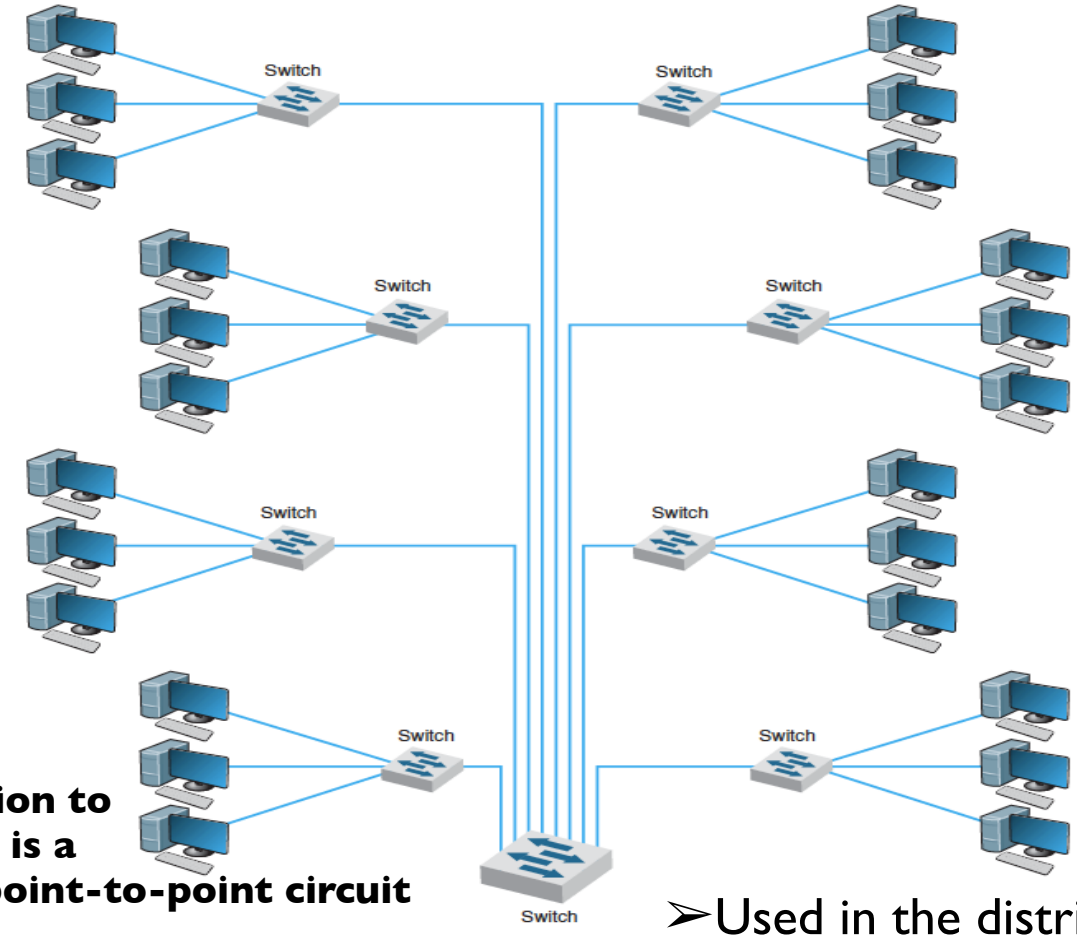
- **Identifies** the way backbone interconnects LANs
- **Defines** how it manages packets moving through BB
  - **Fundamental architectures**
    1. **Routed Backbones**
       - Routers that move packets on the basis of network layer addresses
    2. **Switched Backbones**
       - Switches that move packets based on data link layer addresses
    3. **Virtual LANs**
       - Switches that move packets through LANs that are built virtually, not using physical location

Backbone Architecture Layers

- **Access Layer (not part of BB)**
  - Closest to the users; e.g., 100Base-T and Wireless Ethernet
- **Backbone Design Layers**
  - **Distribution Layer**
    - Connects the LANs together (often in one building)
  - **Core Layer** (for large campus/enterprise networks)
    - Connects different BNs together (building to building)



Switched Backbone



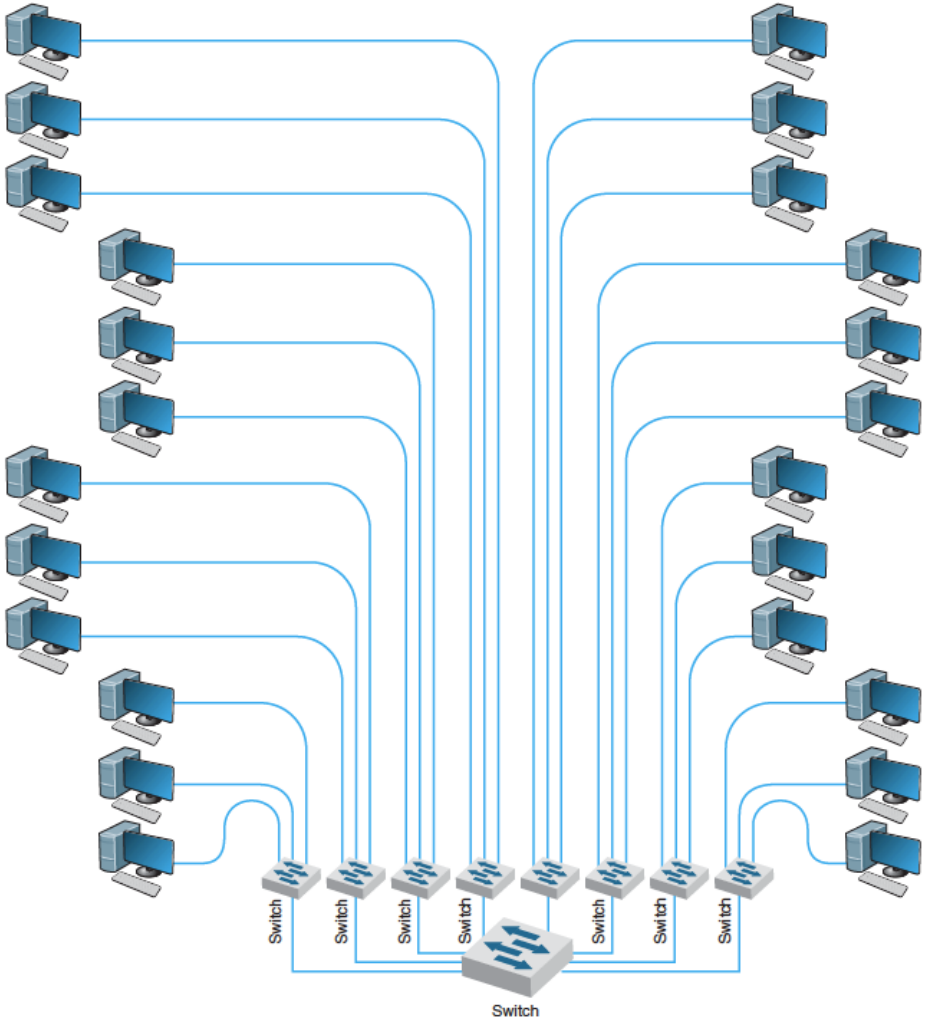
A connection to the switch is a separate point-to-point circuit

- Used in the distribution layer
- Star topology

Switched Backbone

- Replaces the many routers or bridges of the previous designs
  - Backbone has more cables, but fewer devices
  - No backbone cable used; switch is the backbone.
- **Advantages:**
  - Improved performance (200-600% higher)
    - Simultaneous access; "switched" operations
  - A simpler more easily managed network – less devices
- **Two minor disadvantages**
  - Use more and longer cables
  - Reliability:
    - If the central switch fails, the network goes down.

Rack-Mounted Switched Backbone



Rack-Mounted Switched Backbone

- Places all network equipment (hubs and switch) in one room (rack room)
  - Easy maintenance and upgrade
  - Requires more cable (but cables are cheap)
- **Main Distribution Facility (MDF)** or Central Distribution Facility
  - Another name for the rack room
  - Place where many cables come together
    - Patch cables used to connect devices on the rack
- Easier to move computers among LANs
  - Useful when a busy hub requires offloading

Chassis-Based Switch Backbones

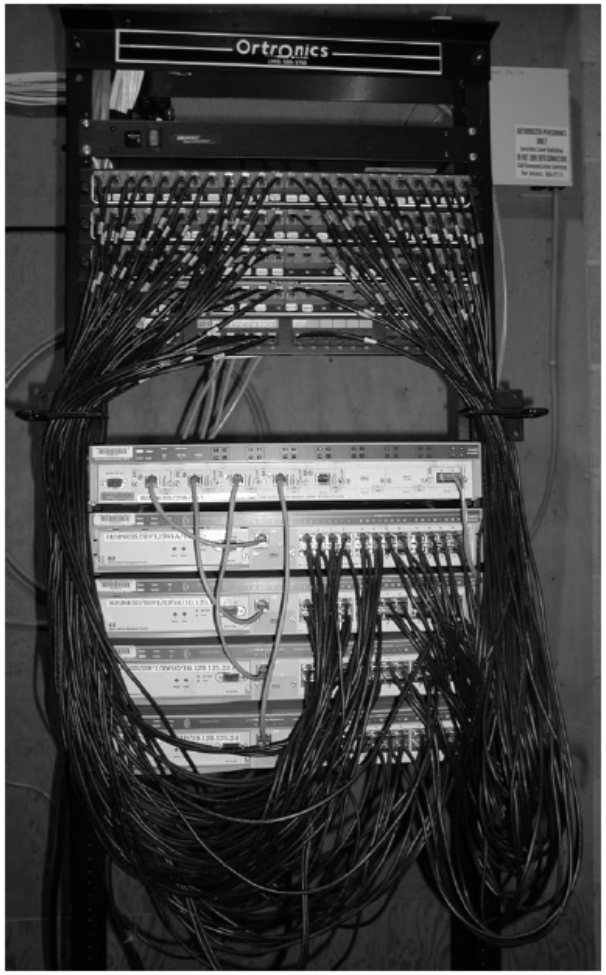
➢Use a **"chassis"** switch instead of a rack

- A collection of modules
  - Number of hubs with different speeds
  - L2 switches
  - Example of a chassis switch with 710 Mbps capacity
    - 5 10Base-T hubs, 2 10Base-T switches (8 ports each)
    - 1 100Base-T switch (4 ports), 100Base-T router

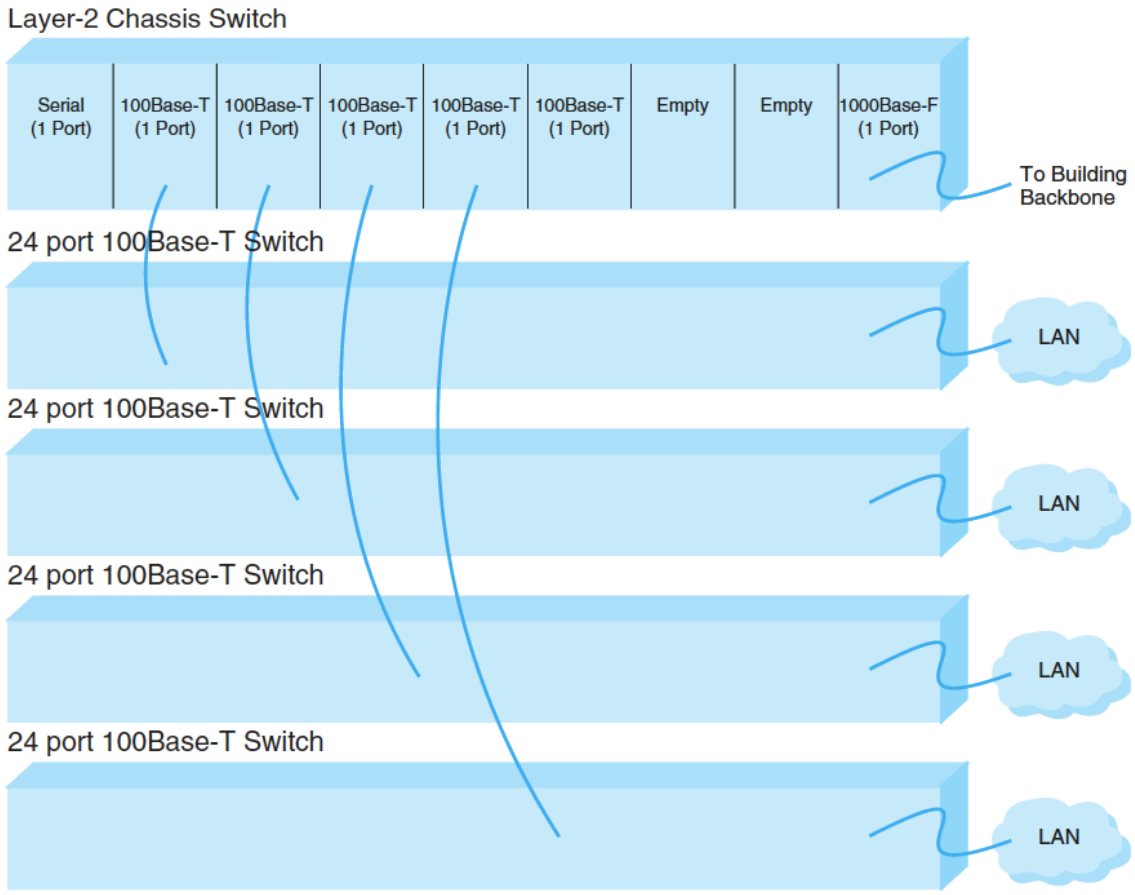
= (5 x 10) + (2 x 10 x 8) + (4 x 100) + 100 = 710 Mbps

- **Flexible**
  - Enables users to plug modules directly into the switch
  - Simple to add new modules

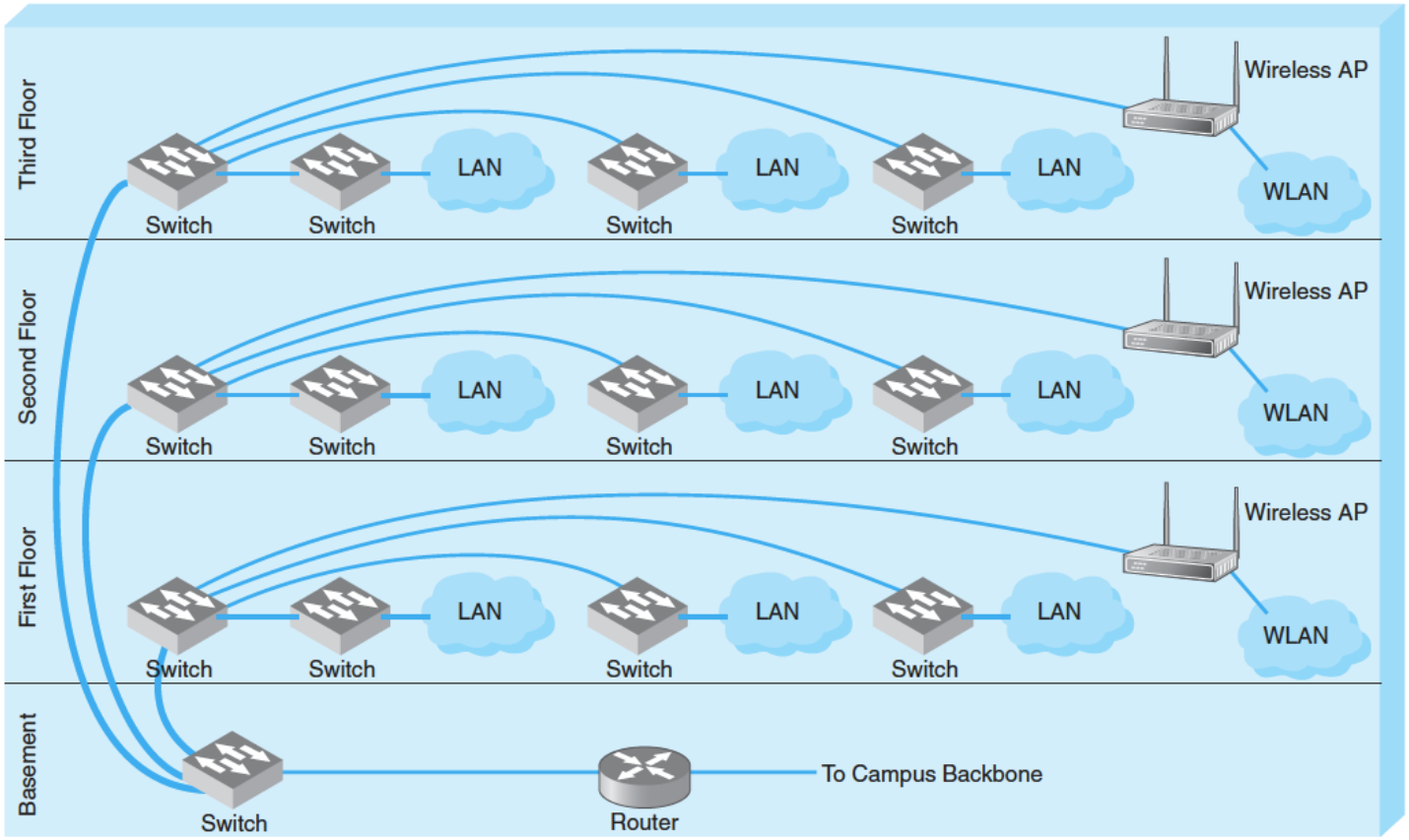
Main Distribution Facility (MDF)
Indiana University



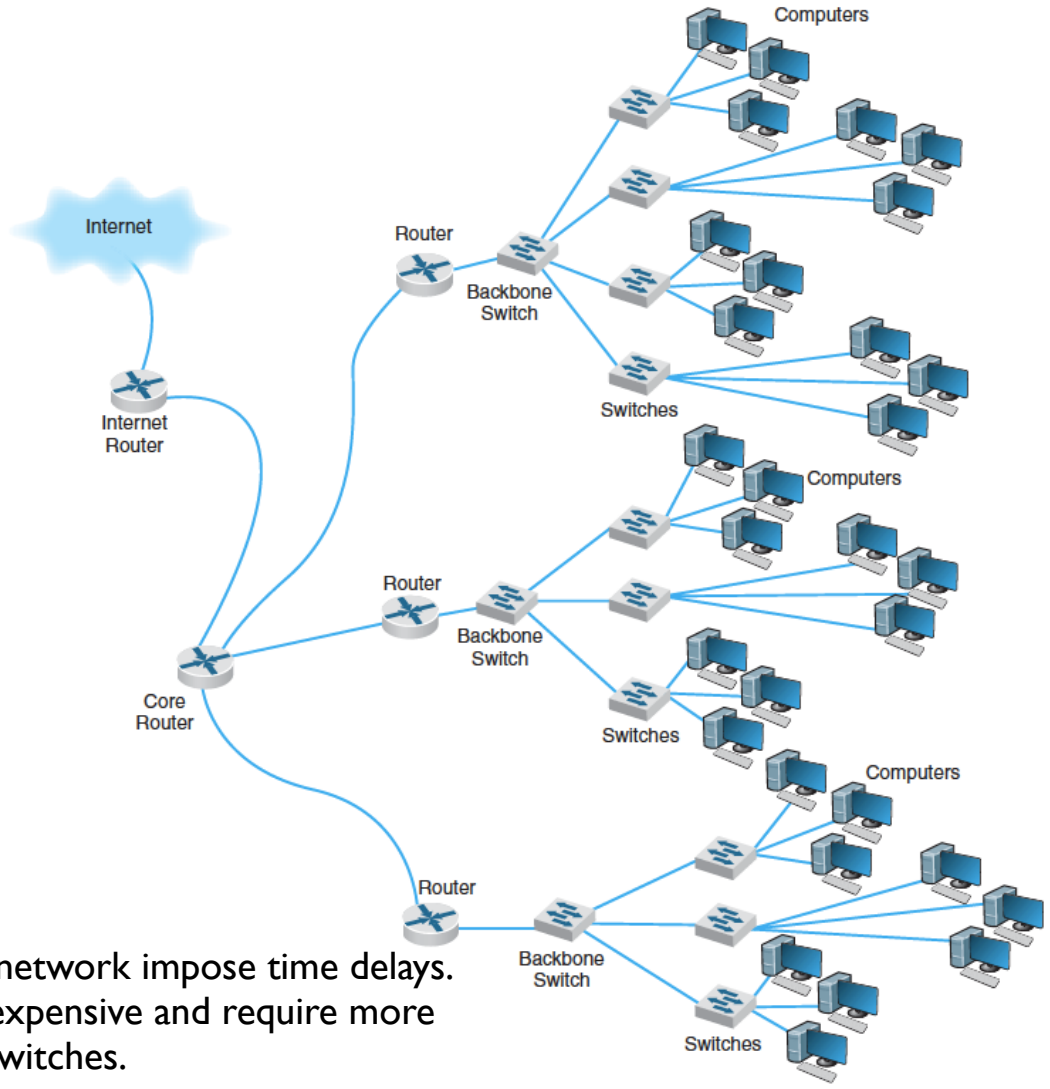
MDF Network Diagram



Switched BB at Indiana University



Routed Backbones

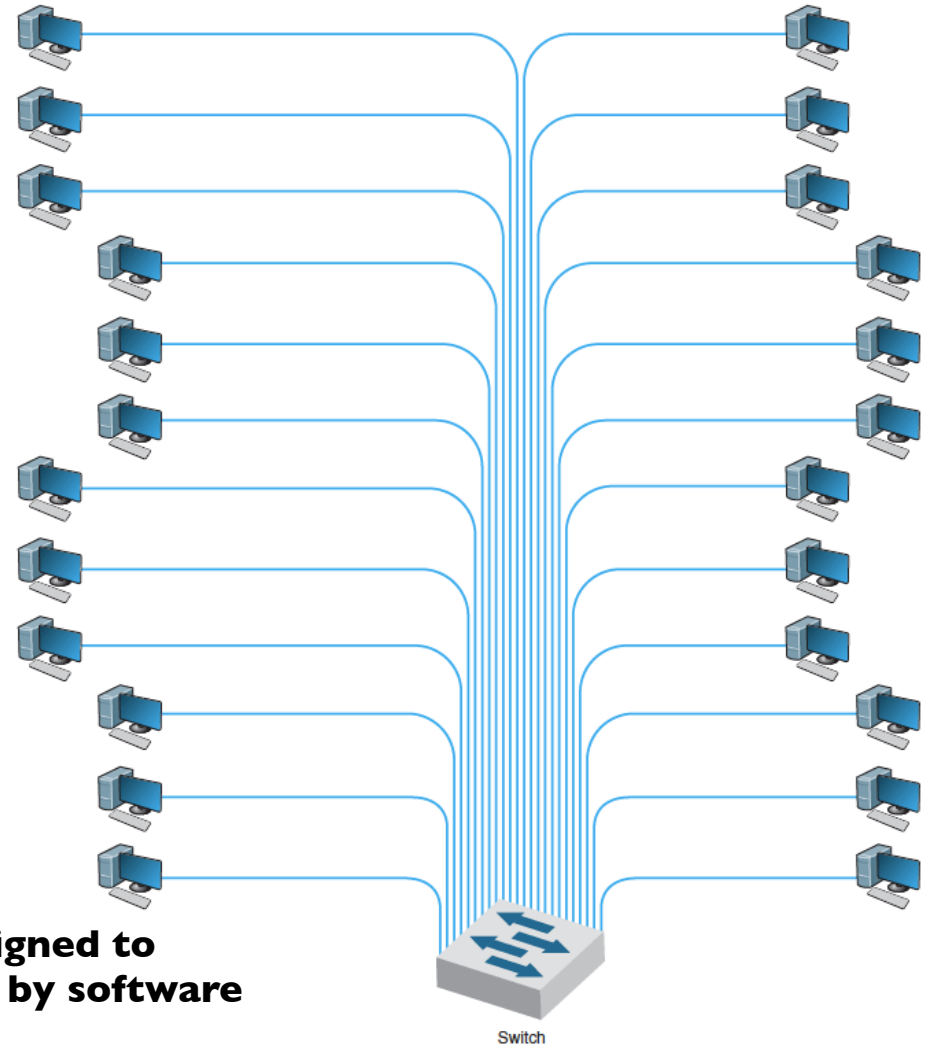


- The routers in the network impose time delays.
- Routers are more expensive and require more management than switches.

Virtual LANs (VLANs)

- **A new type of LAN-BN architecture**
  - Made possible by high-speed intelligent switches
  - Computers assigned to LAN segments by software
- Often faster and provide more flexible network management
  - Much easier to assign computers to different segments
- More complex and so far usually used for larger networks
- **Basic VLAN designs:**
  - Single switch VLANs
  - Multi-switch VLANs

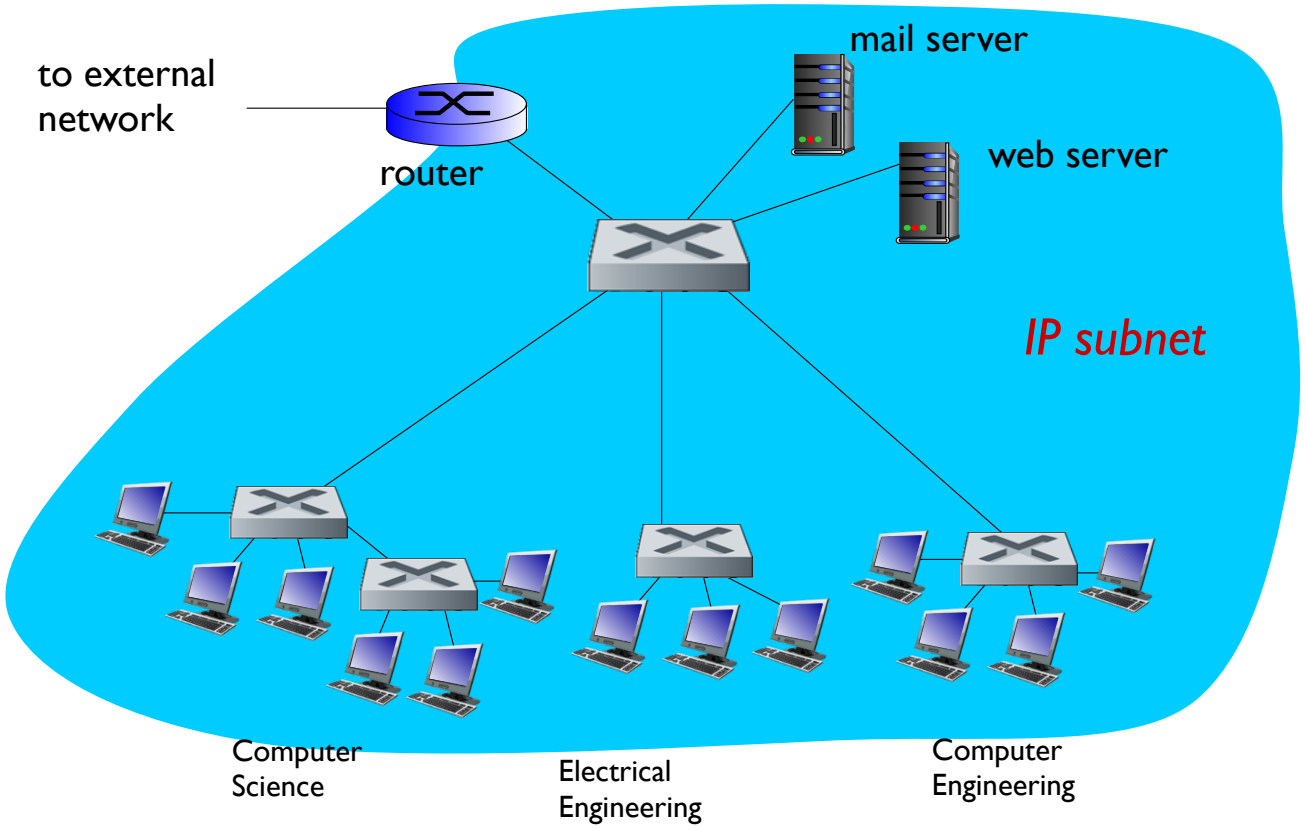
VLAN-based BB Network Design



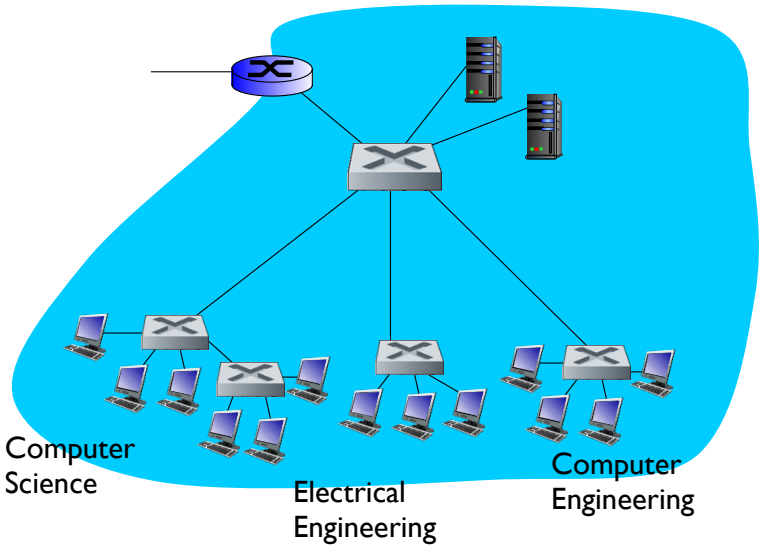
Acting as a large physical switch

Computers assigned to different LANs by software

Institutional Network



VLANs: motivation



consider:

- CS user moves office to EE, but wants connect to CS switch?
- single broadcast domain:
  - all layer-2 broadcast traffic (ARP, DHCP, unknown location of destination MAC address) must cross entire LAN
  - security/privacy, efficiency, and management issues

Types of Single Switch VLANs

1. **Port-based VLANs (Layer 1 VLANs)**
   - Use physical layer port numbers on the front of the VLAN switch to assign computers to VLAN segments
   - Use a special software to tell the switch about the computer-port number mapping
2. **MAC-based VLANs (Layer 2 VLANs)**
   - Use MAC addresses to form VLANs
   - Use a special software to tell the switch about the computer-MAC address mapping
     - Simpler to manage
       - Even if a computer is moved and connected to another port, its MAC address determines which LAN it is on

Types of Single Switch VLANs

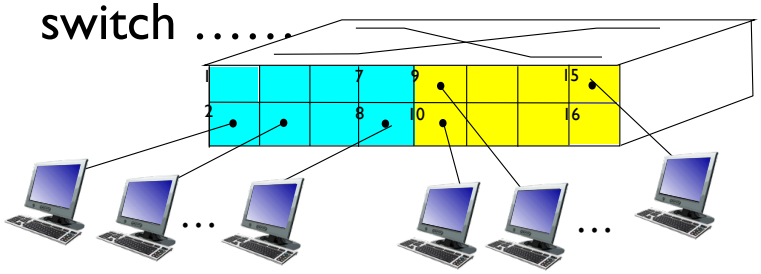
3. **IP-based VLANs (Layer 3 VLANs, protocol based VLANs)**
   - Use IP addresses of the computers to form VLANs
   - Similar to MAC based approach (use of IP instead of MAC address)
4. **Application-based VLANs (Layer 4 VLANs, policy-based VLANs)**
   - Use a combination of
     - The type of application (Indicated by the port number in TCP packet) and
     - The IP address to form VLANs
   - Complex process to make assignments
   - Allow precise allocation of network capacity

VLANs

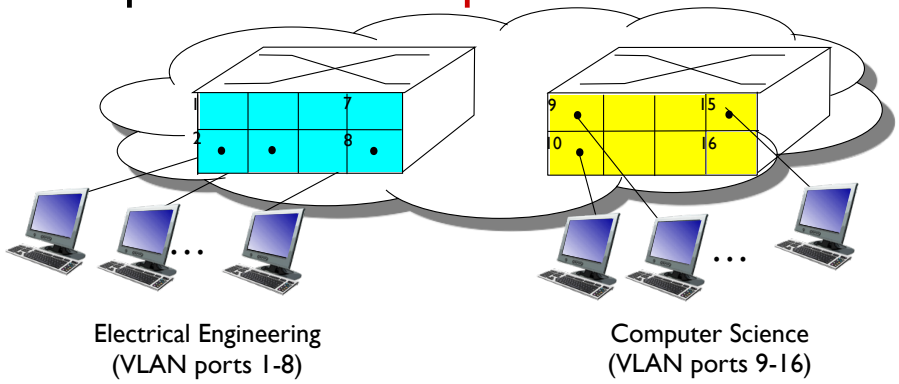
Virtual Local Area Network

Switch(es) supporting VLAN capabilities can be configured to define multiple ***virtual*** LANS over single physical LAN infrastructure.

port-based VLAN: switch ports grouped (by switch management software) so that *single* physical switch ……

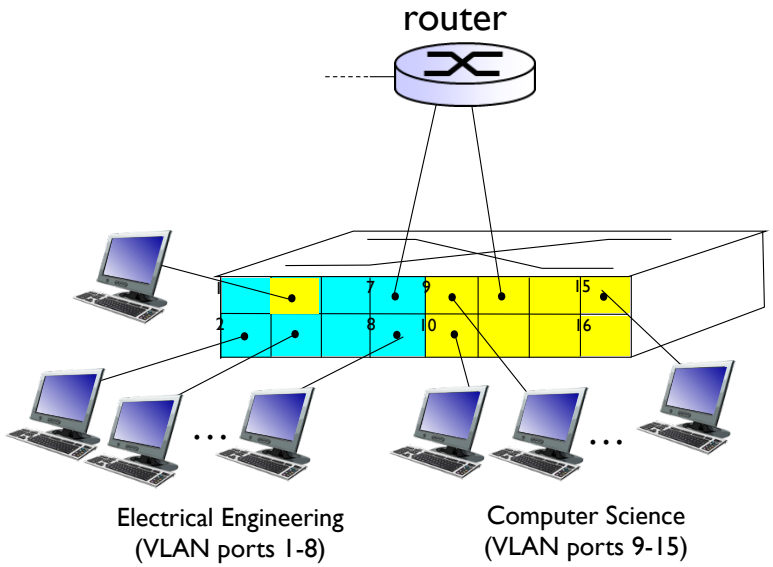


… operates as multiple virtual switches



Port-based VLAN

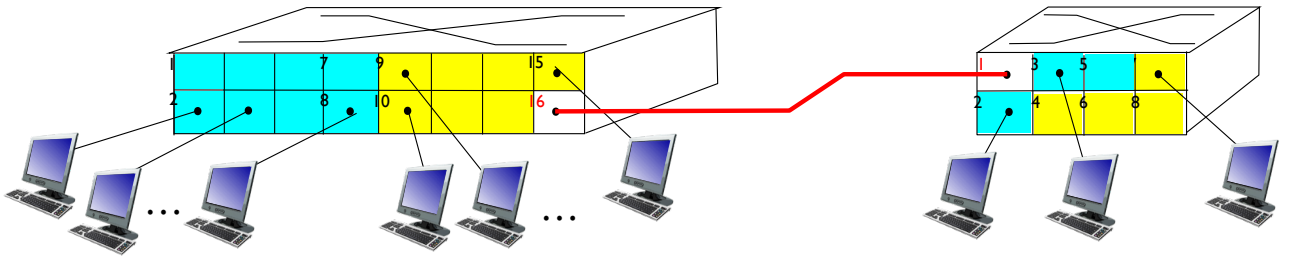
- *traffic isolation:* frames to/from ports 1-8 can *only* reach ports 1-8
  - can also define VLAN based on MAC addresses of endpoints, rather than switch port



- dynamic membership: ports can be dynamically assigned among VLANs

- forwarding between VLANS: done via routing (just as with separate switches)
  - in practice vendors sell combined switches plus routers

VLANS Spanning Multiple Switches



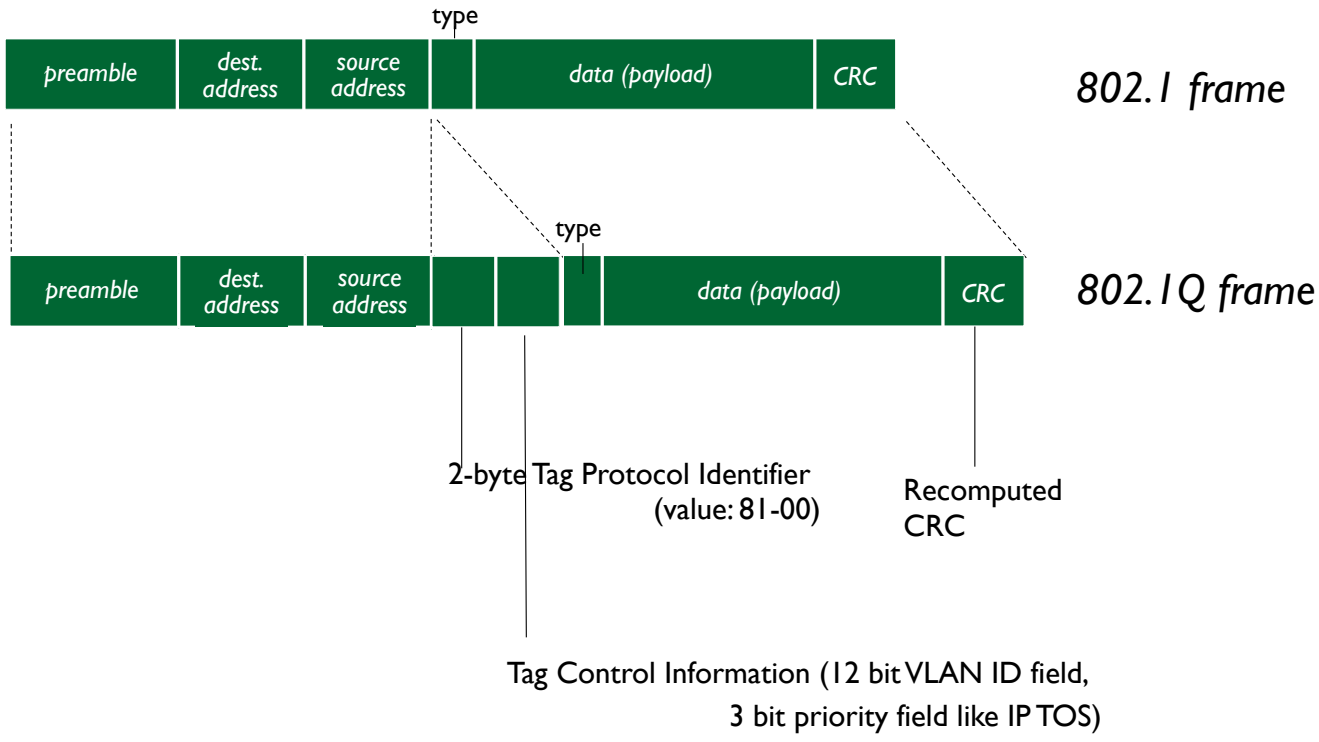
Electrical Engineering
(VLAN ports 1-8)

Computer Science
(VLAN ports 9-15)

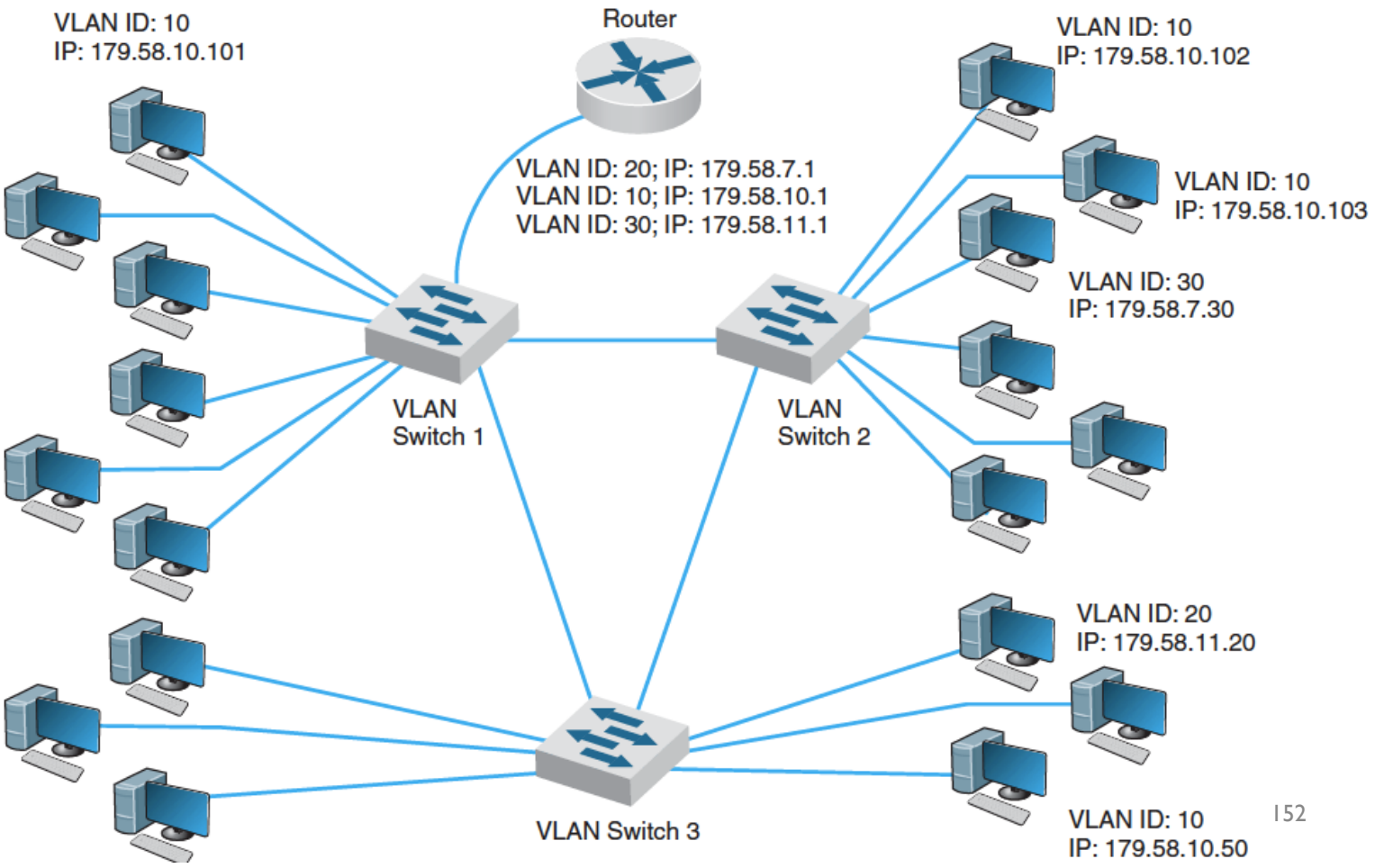
Ports 2,3,5 belong to EE VLAN
Ports 4,6,7,8 belong to CS VLAN

- *trunk port:* carries frames between VLANS defined over multiple physical switches
  - frames forwarded within VLAN between switches can't be vanilla 802.1 frames (must carry VLAN ID info)
  - 802.1q protocol adds/removed additional header fields for frames forwarded between trunk ports

802.1Q VLAN frame format



Multi-Switch VLAN-based Network Design



VLAN Operating Characteristics

- **Advantages of VLANs**
  - **Faster performance**
    - Precise management of traffic flow
    - Ability to allocate resources to different type of applications
  - **Traffic prioritization (via 802.1q VLAN tag)**
    - Include in the tag: a priority code based on 802.1q
    - Can have QoS capability at MAC level
      - Similar to RSVP and QoS capabilities at network and transport layers
- **Drawbacks**
  - Cost
  - Management complexity

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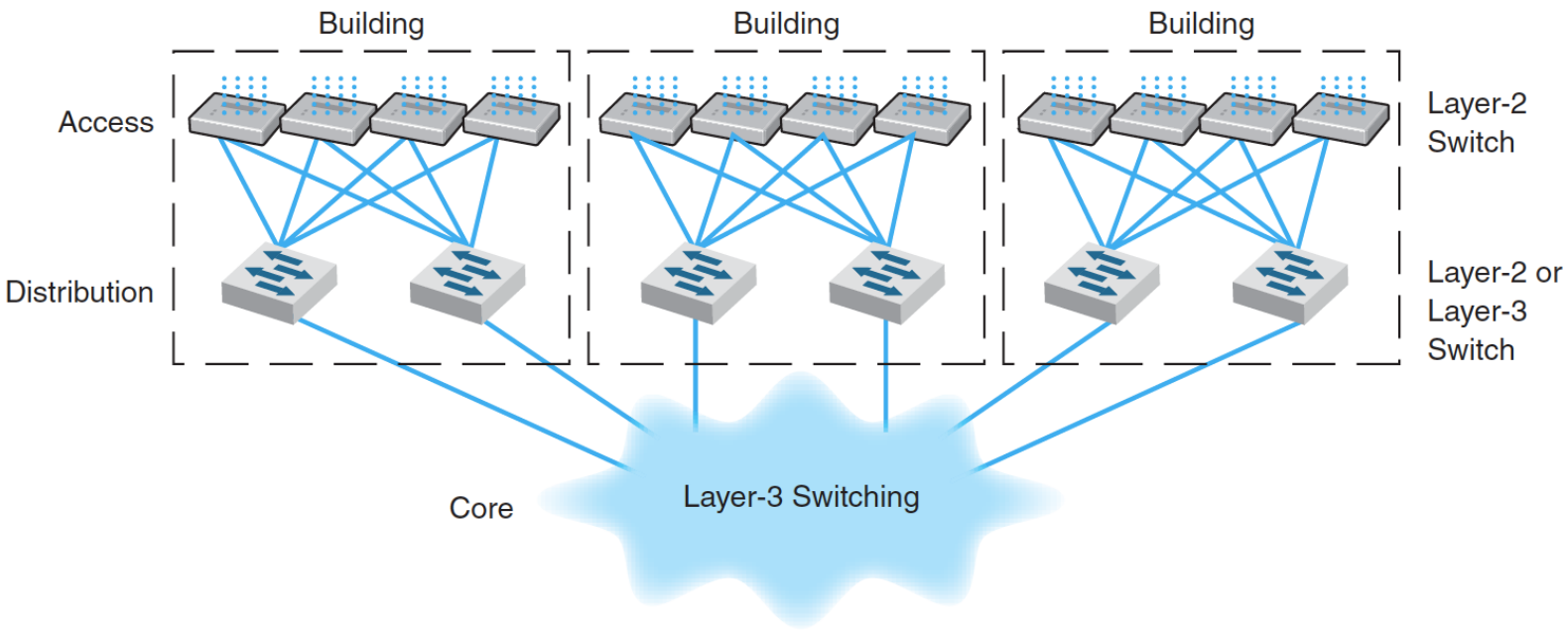
Recommendations for BB Design

- **Best architecture**
  - Collapsed backbone or VLAN
- **Best technology**
  - Gigabit Ethernet
- **Ideal design**
  - A mixture of layer-2 and layer-3 Ethernet switches
  - Access Layer
    - 10/100Base-T Later 2 switches with cat5e or cat6
  - Distribution Layer
    - 100base-T or 1000BaseT/F Layer 3 switches
  - Core Layer
    - Layer 3 switches running 10GbE or 40GBe

Best Practice BB Design



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Improving Backbone Performance

- **Improve computer and device performance**
  - Upgrade them to faster devices
  - Use faster routing protocols
    - Static routing is faster for small networks
  - Use gigabit Ethernet as BB (eliminate translations)
  - Increase memory in devices
- **Improve circuit capacity**
  - Upgrade to a faster circuit; Add additional circuits
  - Replace shared circuit BB with a switched BB
- **Reduce network demand**
  - Restrict applications that use a lot of network capacity
  - Reduce broadcast messages (placing filters at switches)

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Implications for Management

- **Increased traffic at backbone due to faster technologies**
  - May requires that BN be replaced

  => Design BN to be easily upgradeable
- **FDDI and ATM becoming as legacy technologies**
  - Vendors stopping the production of these

  => Begin to invest more funds to replace these
- **Ethernet moving into Backbone extensively**
  - One standard technology used for both LANs and BN

  => Cheaper equipment; Easier management