Business Data Communications and Networking

11th Edition

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Chapter 7

Backbone Networks

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Chapter 7: Outline

7.1 - Introduction

7.2 - Backbone Network Components

- **Switches, Routers, Gateways**

7.3 - Backbone Network Architectures

7.4 - The Best Practice Backbone Design

7.5 - Improving Backbone Performance

7.6 – Implications for Management

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7.1 Introduction

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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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7.2 Backbone Network Components

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

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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

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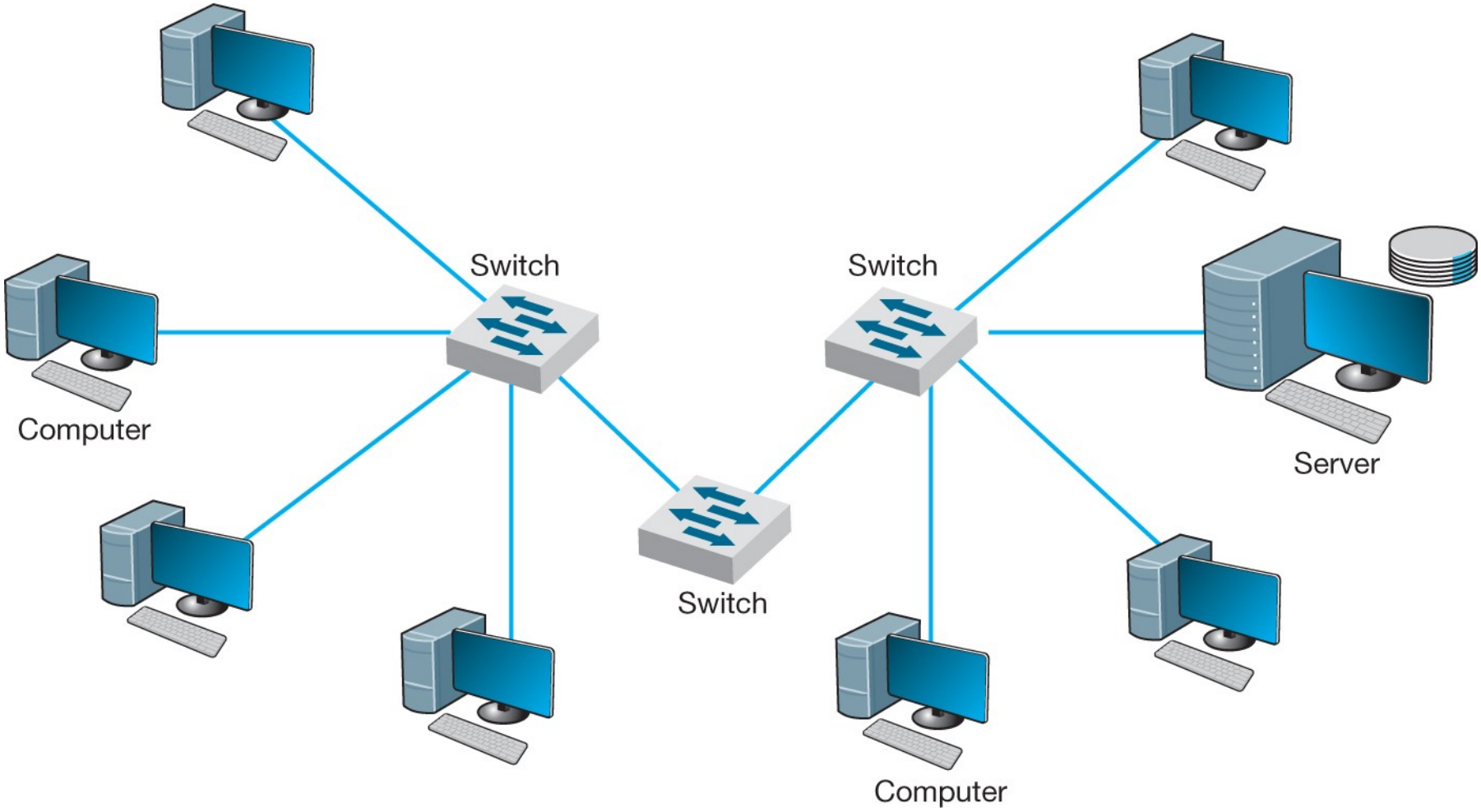
Switches



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Switches

- **Most switches operate at the data link layer**
- **They connect two or more network segments that use the same data link and network protocol**
- **They may connect the same or different types of cable**
- **These use the data link layer address to forward packets between network segments**

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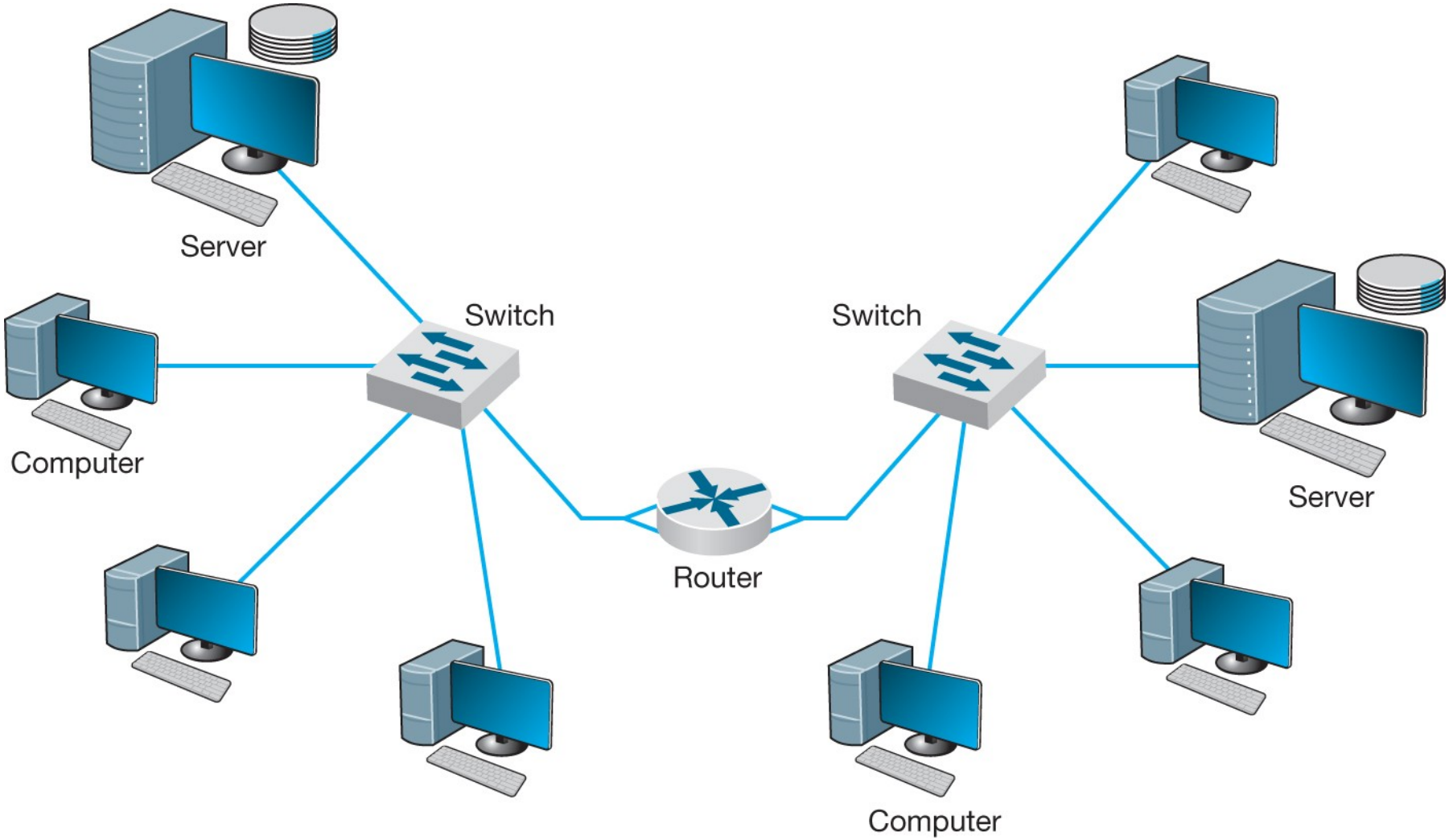
Routers



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Routers

- **Operations**
  - **Operates at the network layer**
  - **Examines the destination address of the network layer**
  - **Strips off the data link layer packet**
  - **Chooses the “best” route for a packet (via routing tables)**
  - **Forwards only those messages that need to go to other networks**
- **Compared to Switches**
  - **Performs more processing:**
  - **Recognizes that message is specifically addressed to it before message is passed to network layer for processing**
  - **Builds new data link layer packet for transmitted packets**
  - **Processes only messages specifically addressed to it**

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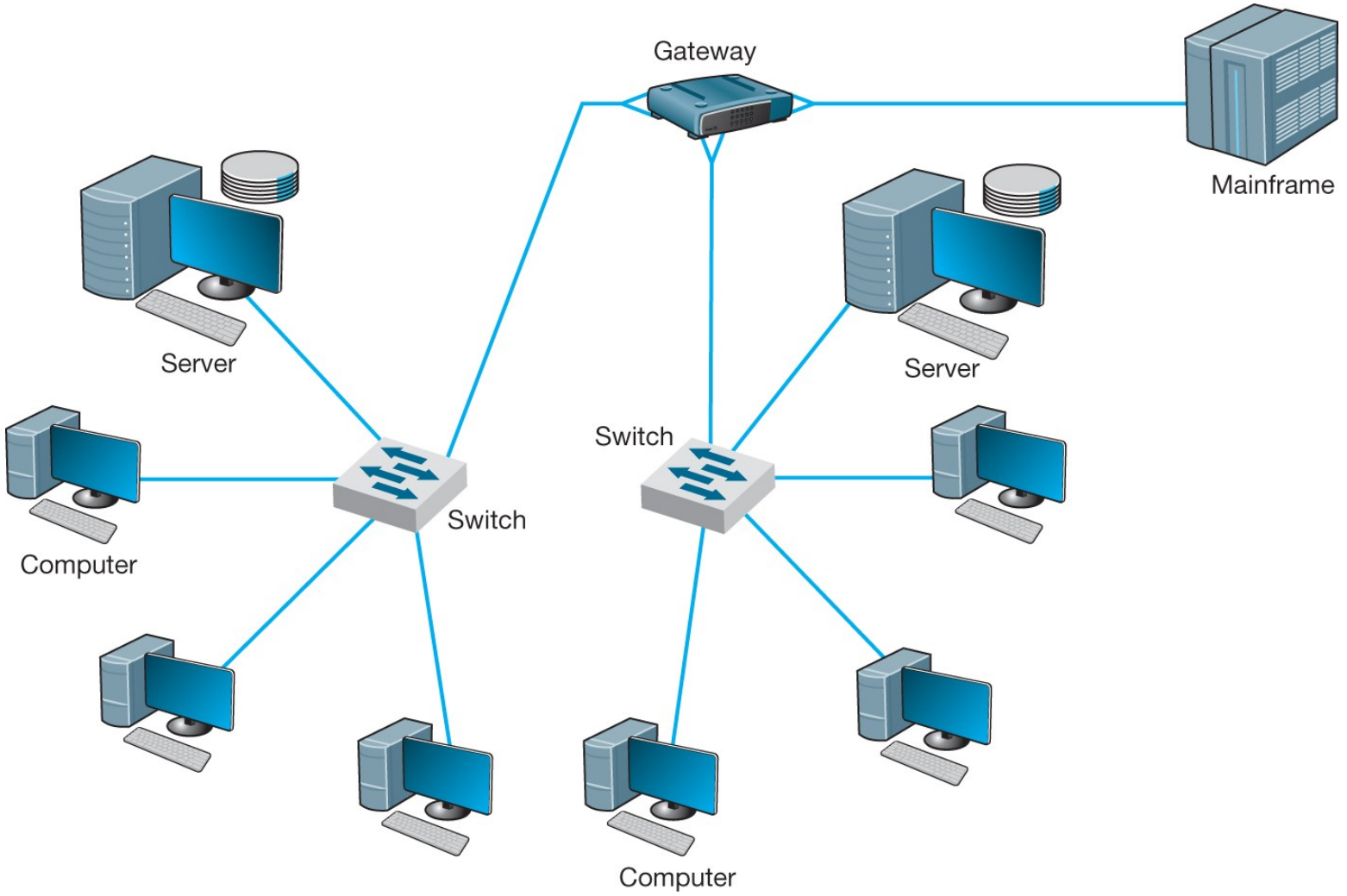
Gateways



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Gateways

- **Operate at network layer and use network layer addresses in processing**
- **More complex than switches or routers:**
- **Connect two or more networks that use the same or different data link and network protocols**
- **Some work at the application layer (using data link layer address) to route messages to other networks**
- **Process only those messages addressed to them**

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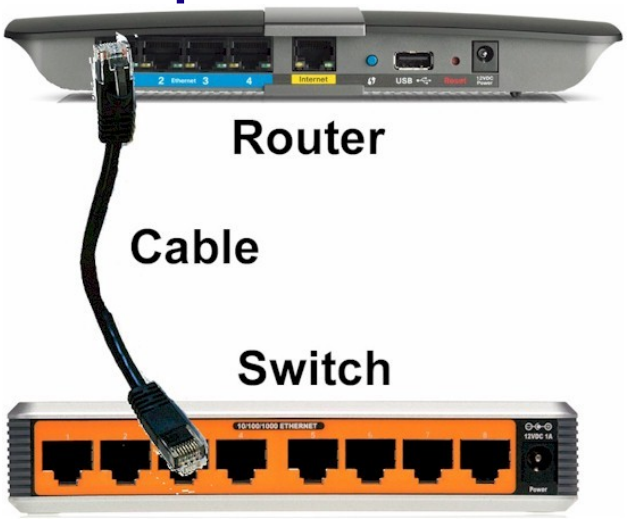
Other Backbone Network Devices

- **Terminology in marketplace is variable by vendor**

- **Layer-3 switches**
  - **Similar to L2 switches, but switch messages based on network layer addresses (usually IP address)**
  - **Have the best of both switches and routers**
  - **Can support more simultaneously active ports than routers**

For example: one way to increase port numbers to your home Network is to connect the router to a switch



7.3 Backbone Network Architectures

- **Identifies the way backbone interconnects LANs**
- **Manages way packets from one network move through the backbone to other networks**
- **Three layers:**
  1. ***Access layer:*** **used in LANs attached to BB**
  2. ***Distribution layer:*** **connects LANs together**
  3. ***Core layer:*** **connects different backbone networks together in enterprise network**

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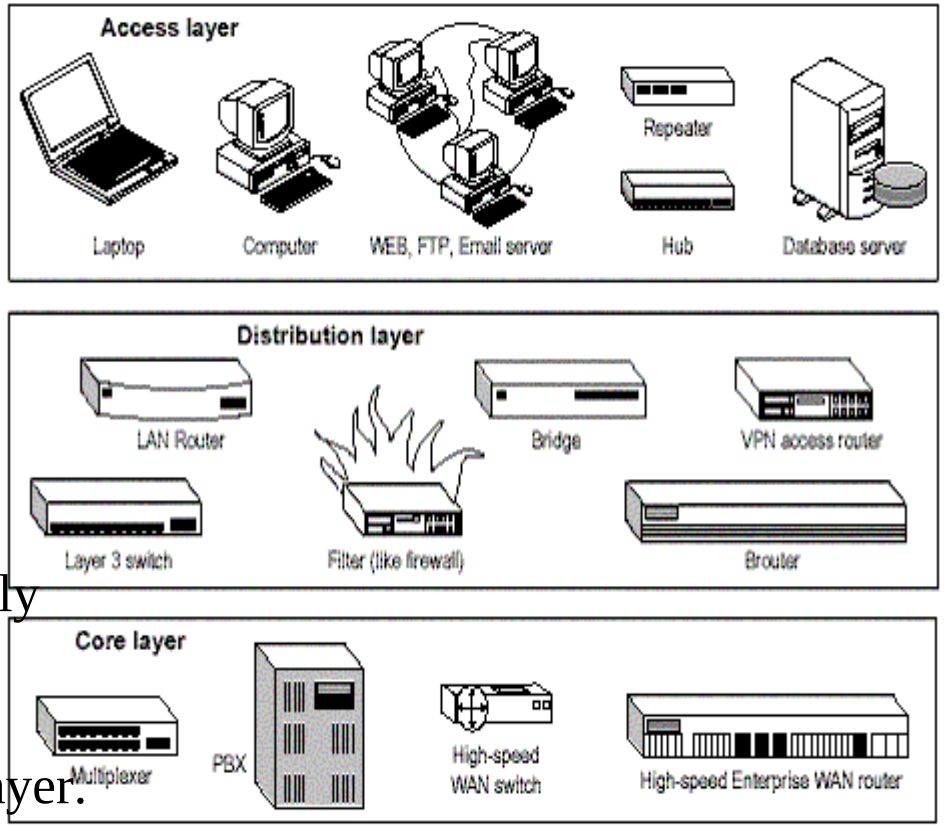
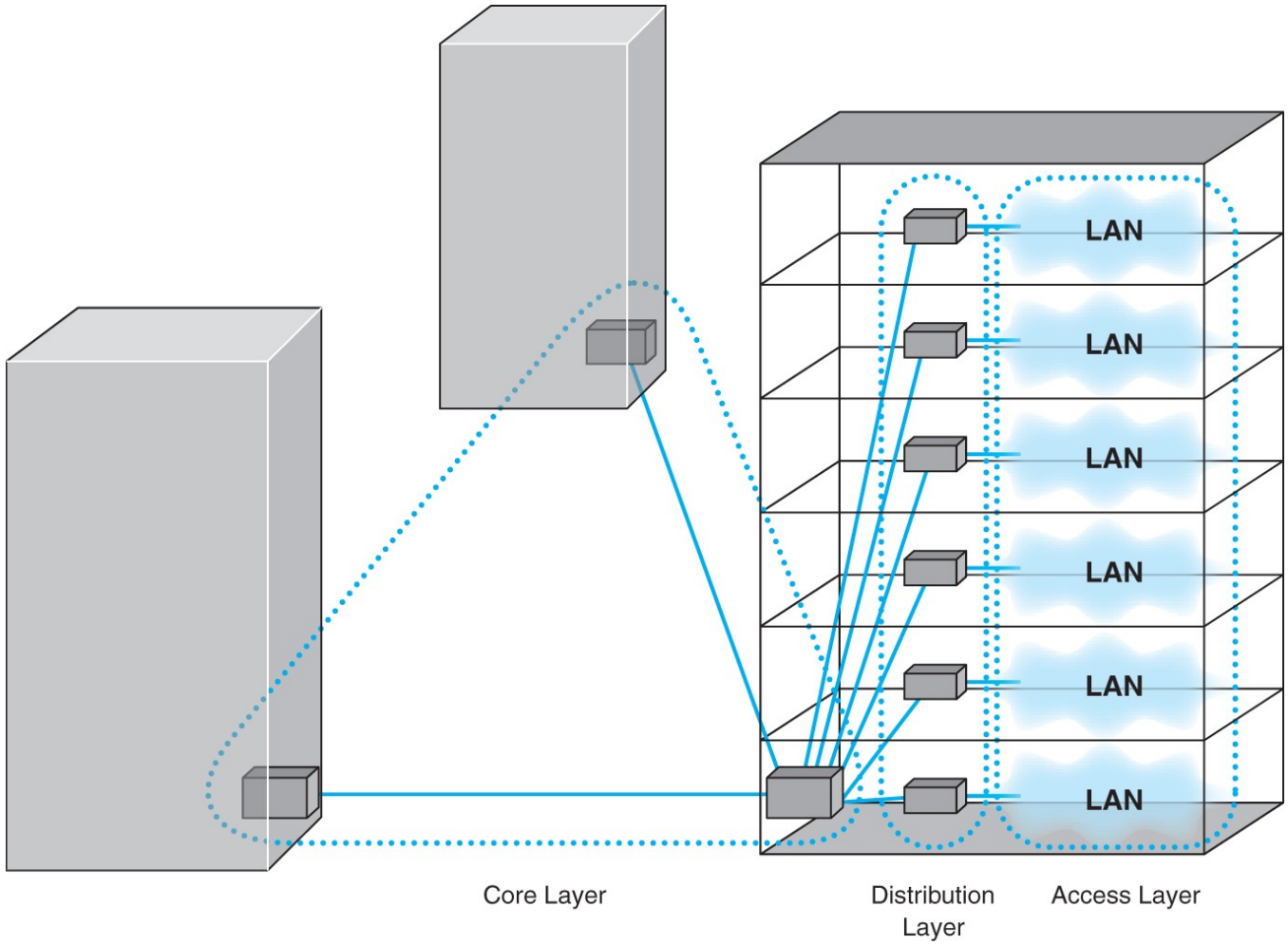
Core layer: This layer is considered the backbone of the network and includes the high-end switches and high-speed cables such as fiber cables.
This layer of the network does not route traffic at the LAN.
In addition, no packet manipulation is done by devices in this layer. Rather, this layer is concerned with speed and ensures reliable delivery of packets.



Distribution layer: This layer includes LAN-based routers and layer 3 switches. This layer ensures that packets are properly routed between subnets and VLANs in your enterprise.
This layer is also called the Workgroup layer.

Access layer: This layer includes hubs and switches. This layer is also called the desktop layer because it focuses on connecting client nodes, such as workstations to the network. This layer ensures that packets are delivered to end user computers.

Backbone Network Design Layers



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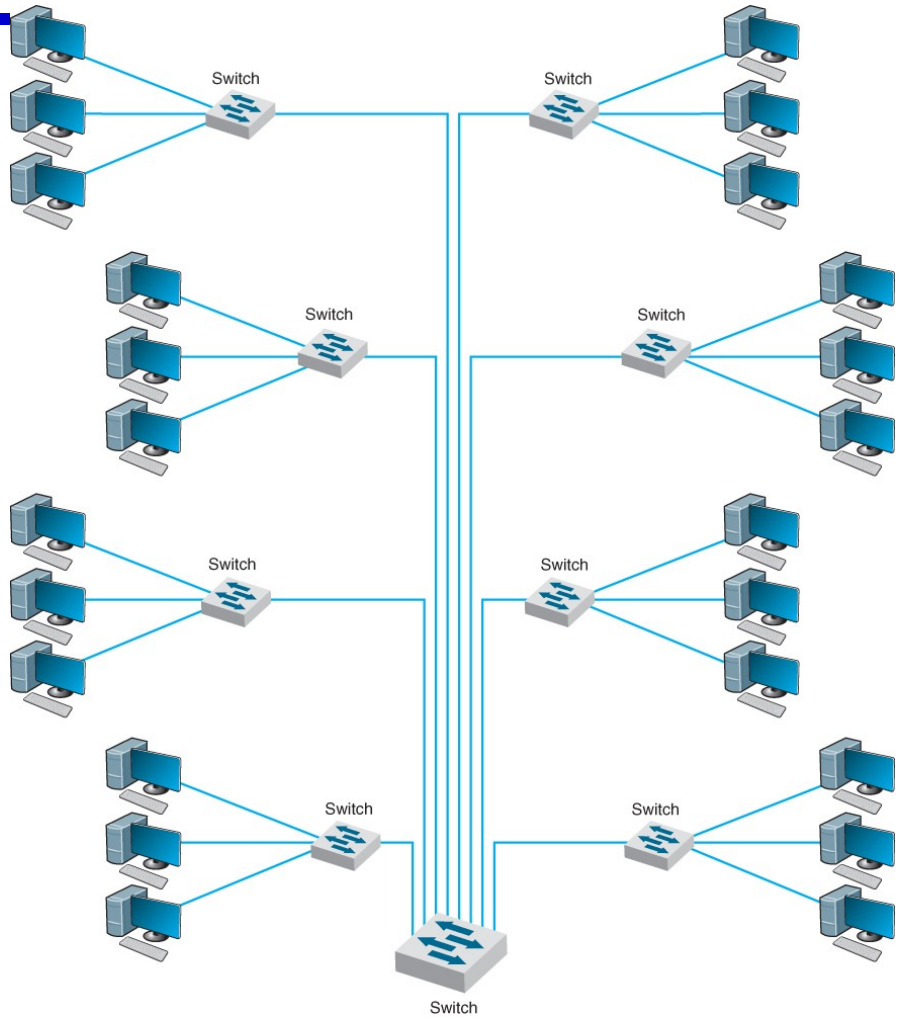
Fundamental Backbone Architectures

***Switched Backbones*:**

- **most common, used in distribution layer,**
- **used in new buildings,**
- **sometimes in core layer,**
- **can be rack or chassis based.**



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Switched Backbones

- **Replaces the many routers of other designs**
  - **Backbone has more cables, but fewer devices**
  - **No backbone cable used; switch is the backbone.**
- **Advantages:**
  - **Improved performance (200-600% higher) due to simultaneous access of switched operations**
  - **A simpler more easily managed network – less devices**

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- ***Routed Backbones*: move packets along backbone on basis of network layer address, typically using bus, Ethernet 100Base-T, sometimes called subnetted backbone**

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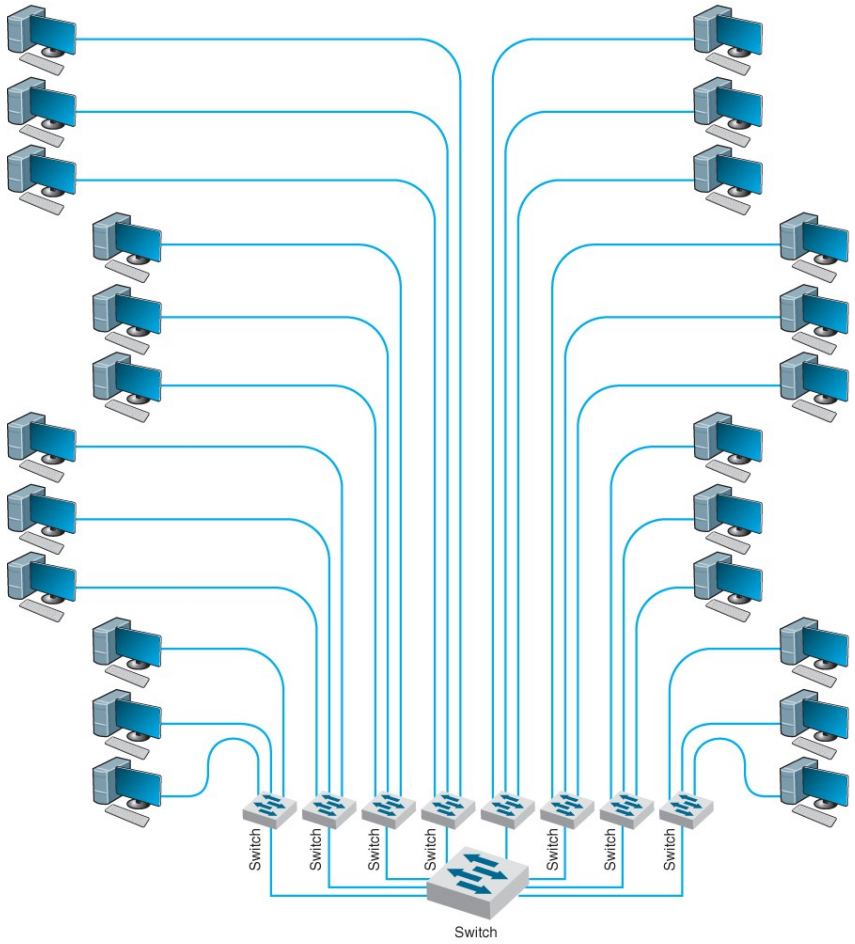
Rack-Mounted Switched Backbones



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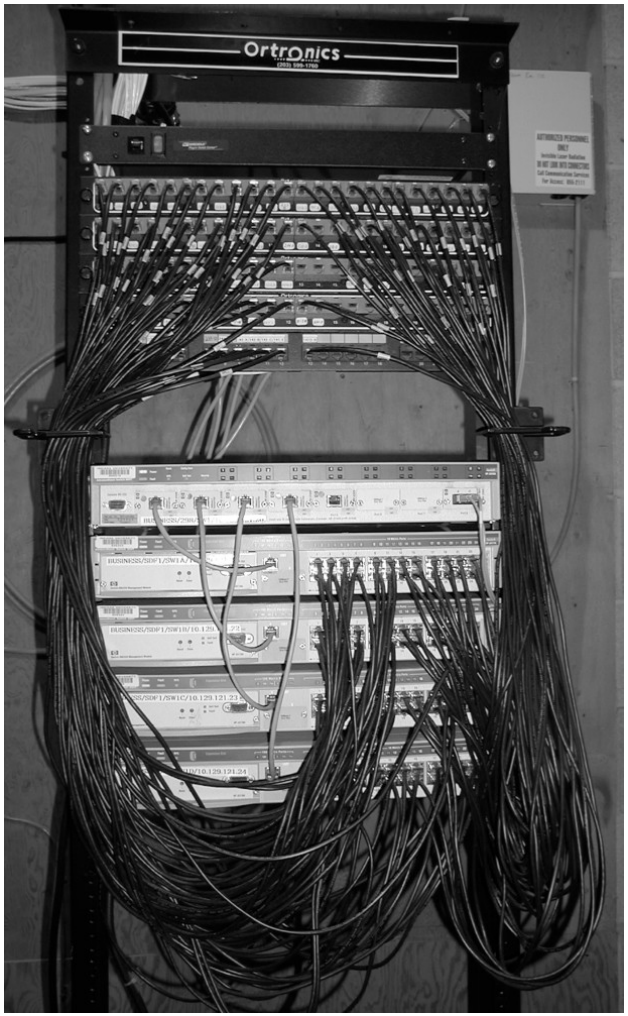
Rack-Mounted Switched Backbones



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Rack-Based Switched Backbones

- **Places all network switch equipment physically in one “rack” room**
  - **Easy maintenance and upgrade**
  - **Requires more cable, but usually small part of overall cost**
  - **Easier to move computers among LANs**

Aka Main Distribution Facility (MDF) or Central Distribution Facility (CDF)

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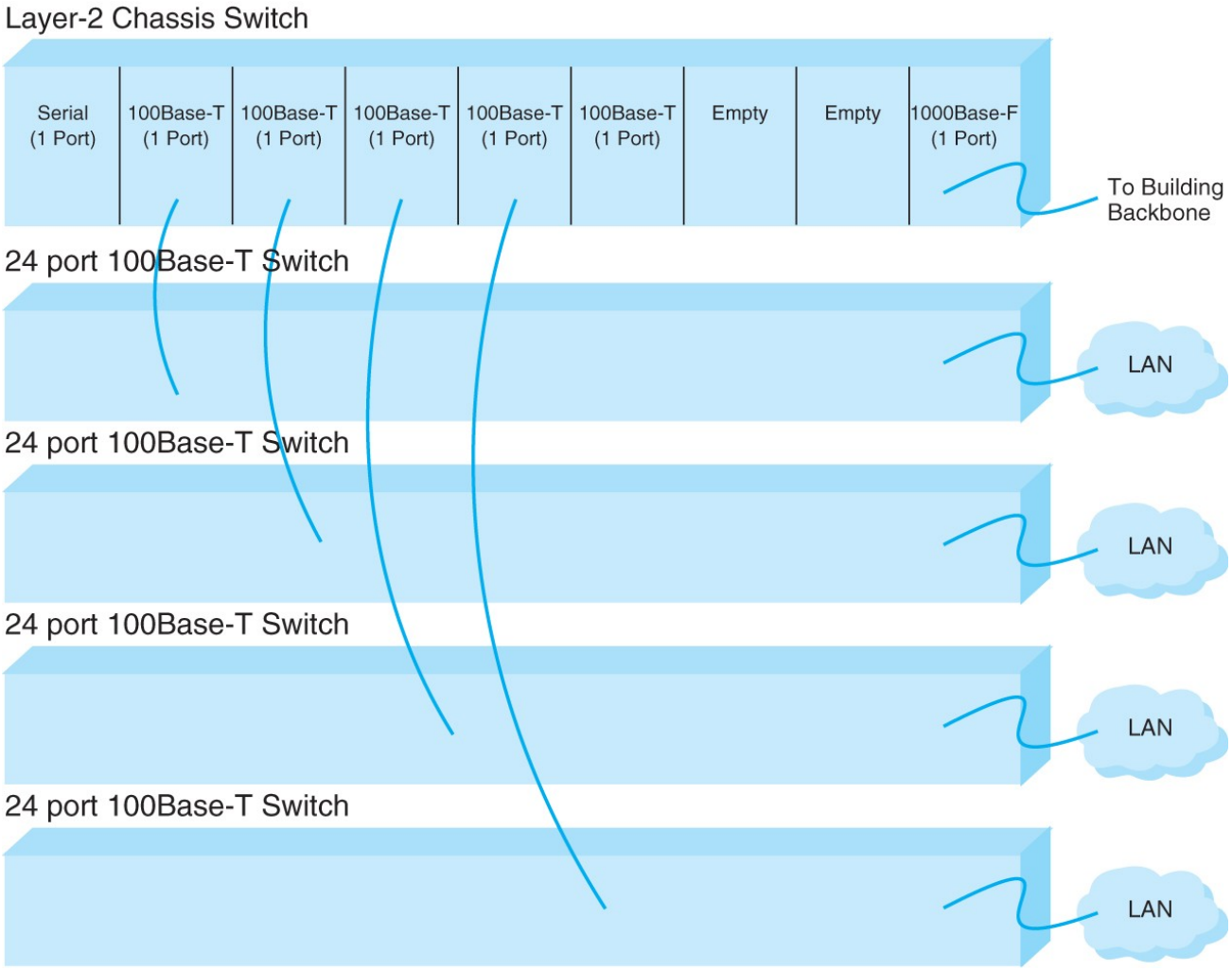
Main Distribution Facility (MDF)



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Chassis-Based Switched Backbones

- **Use a "chassis" switch instead of a rack**
  - **Enables administrators to plug modules into switch**
  - **Modules can vary in nature, router or 4-port 100Base T switch**
    - **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**
- **Advantage is flexibility**
  - **Enables users to plug modules directly into the switch**
  - **Simple to add new modules**

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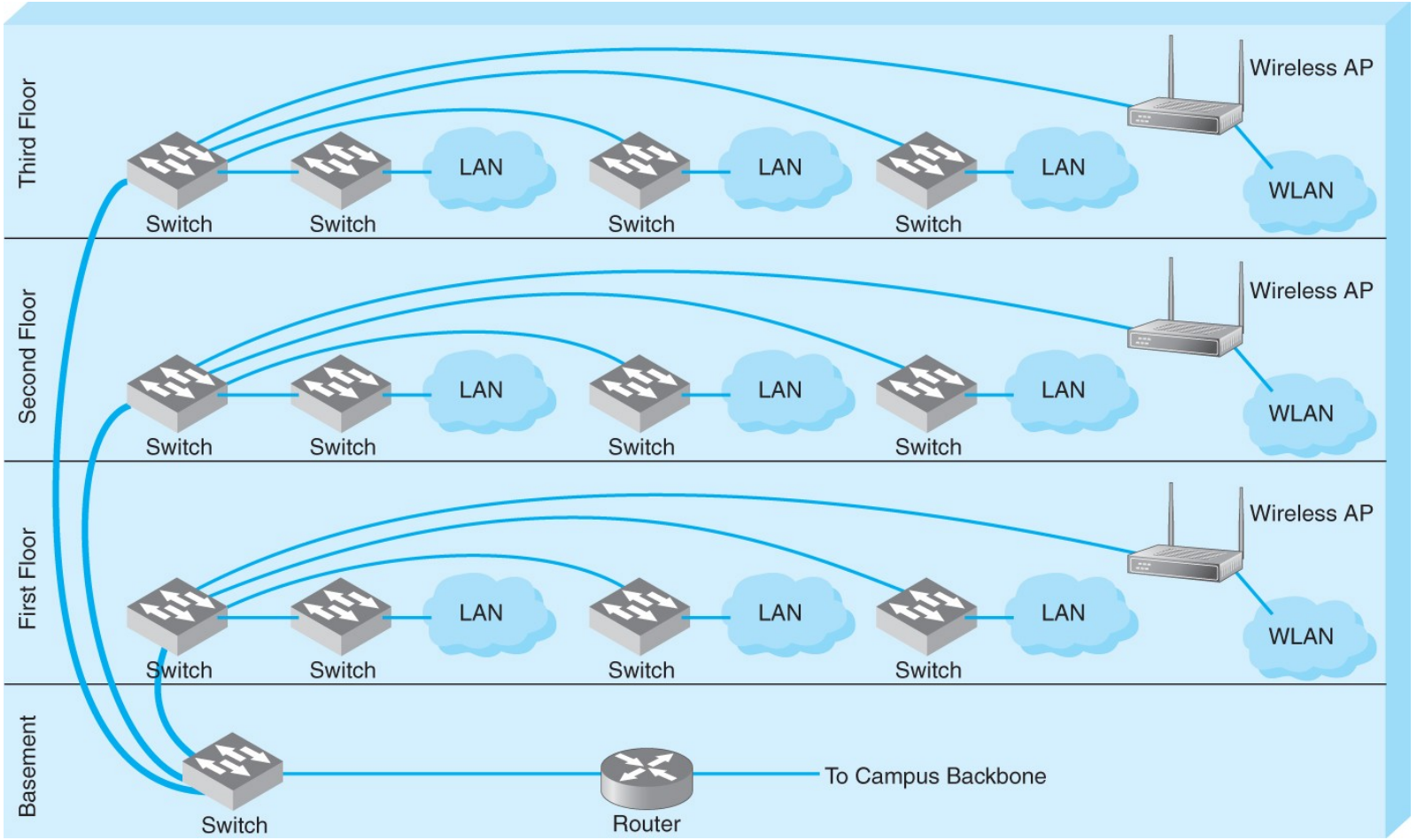
Switched Backbone at Indiana Univ.



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Routed Backbone

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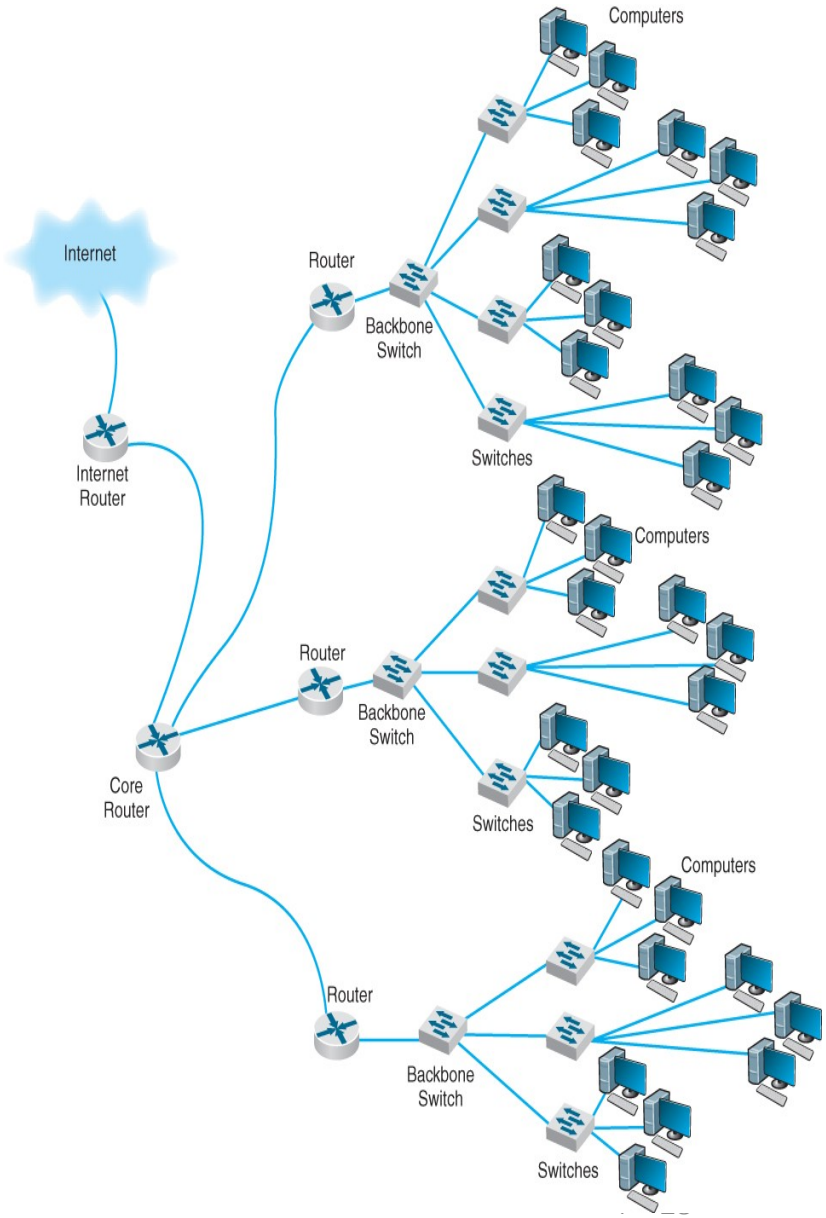
Routed Backbones

- Move packets using network layer addresses
- Commonly used at the core layer
  - Connecting LANs in different buildings in the campus
  - Can be used at the distribution layer as well
- LANs can use different data link layer protocols
- Main advantage: LAN segmentation
  - Each message stays in one LAN; unless addressed outside the LAN
  - Easier to manage, LANs are separate entities, segments
- Main disadvantages
  - Tend to impose time delays
  - Require more management than switches



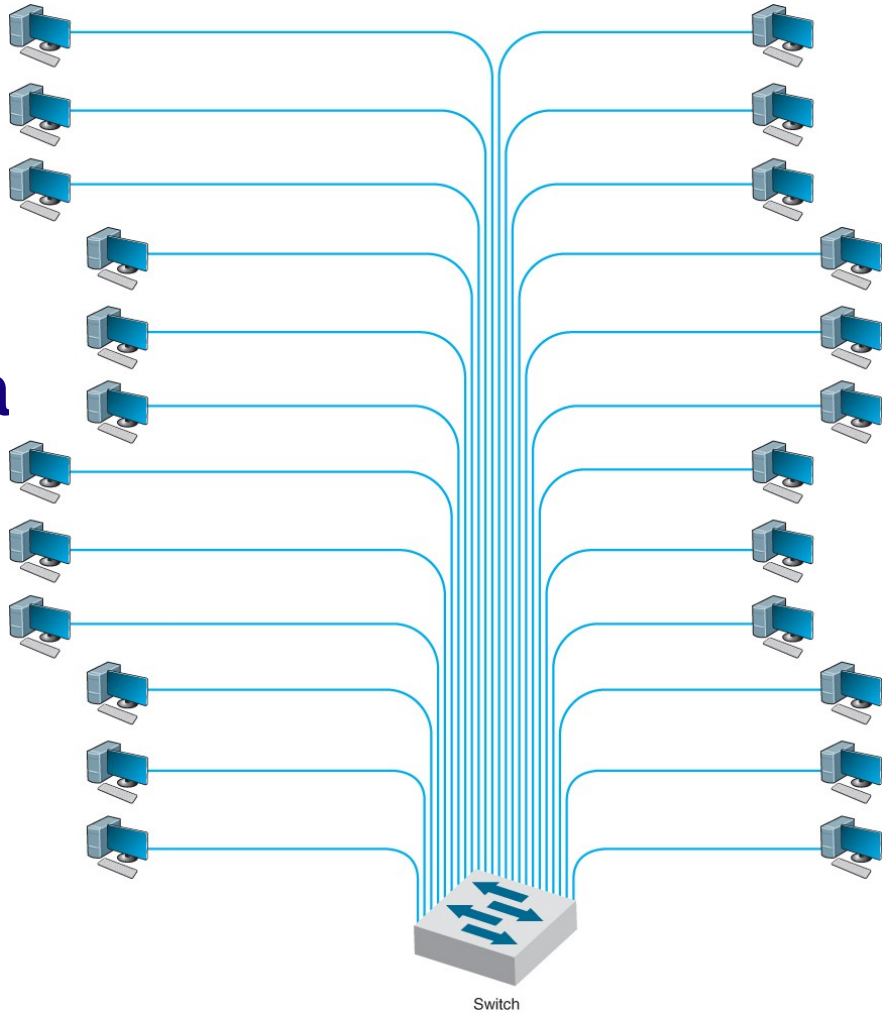
Virtual LANs (VLANs)

***Virtual LANs*:**

in this type of network computers are assigned into LAN segments by software rather than by hardware; (cisco offers a variety or setup a VPN using your OS on your PC)

can be single switch

or multiswitch VLANs.



Very popular technology.

Virtual LANs (VLANs)

- **Often faster , more complex infrastructure**
- **Usually used for larger networks**
- **Basic VLAN designs:**
  - **Single switch VLANs**
  - **Multi-switch VLANs**

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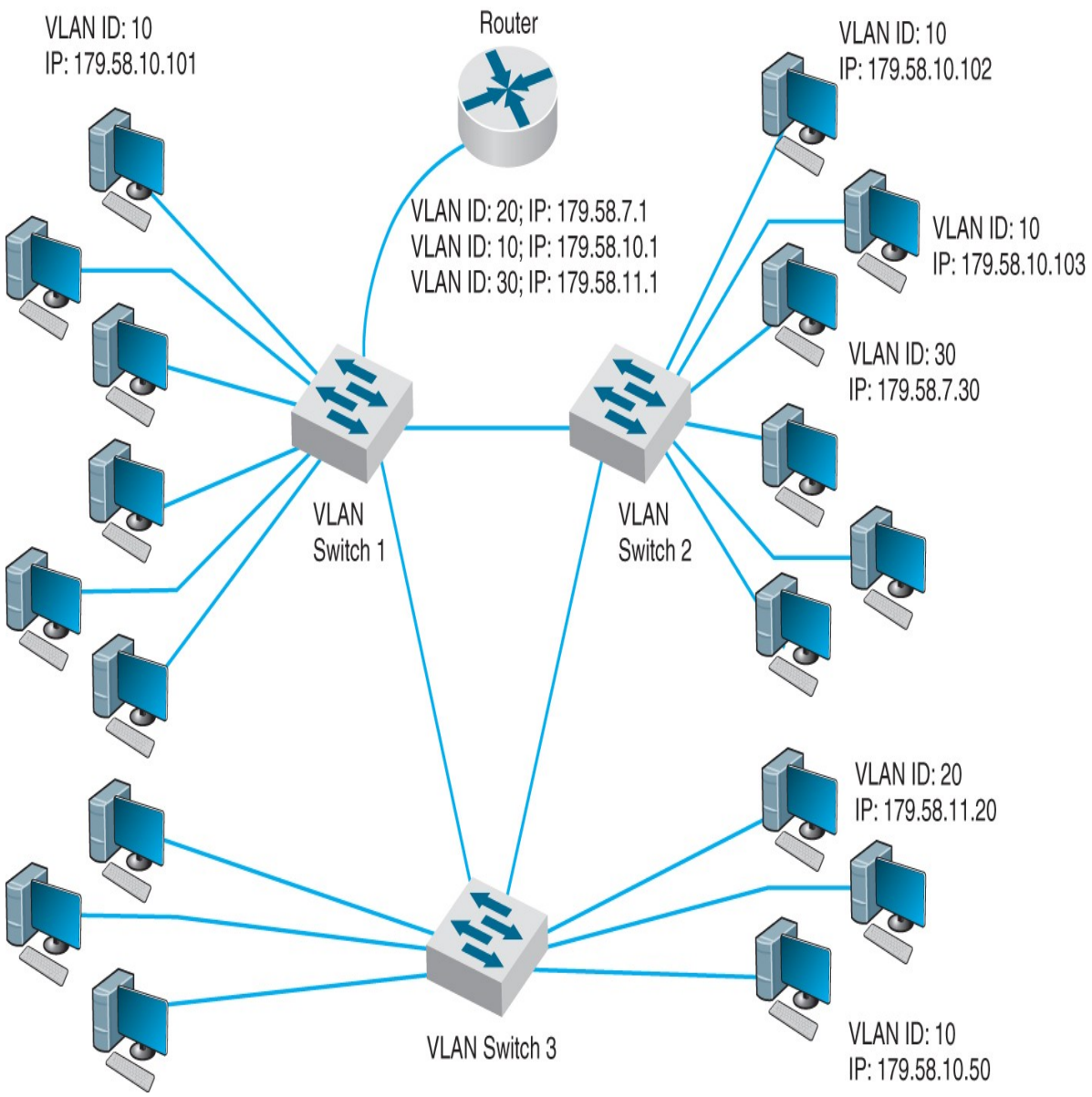
Multi-switch VLAN-Based Backbone



In single switch infrastructure:

Each computer is assigned into a VLAN that has a VLAN ID

Each VLAN ID is matched to a traditional IP subnet

Each computer gets an IP address from that switch (Similar to how DHCP operates)

Computers are assigned into the VLAN based on physical port they are plugged into

Multiswitch VLAN Operations

- **Same as single switch VLAN, except uses several switches, perhaps in core between buildings**
- **Inter-switch protocols**
  - **Must be able to identify the VLAN to which the packet belongs**
- **Use IEEE 802.1q (an emerging standard)**
  - **When a packet needs to go from one switch to another**
    - **16-byte VLAN tag inserted into the 802.3 packet by the sending switch**
  - **When the IEEE 802.1q packet reaches its destination switch**
    - **Its header (VLAN tag) stripped off and Ethernet packet inside is sent to its destination computer**

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VLAN Operating Characteristics

- **Advantages of VLANs**
  - **Faster performance: Allow precise management of traffic flow and 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**
  - **Some "bleeding edge" technology issues to consider**

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7.4 Best Practice Backbone Design

- **Architectures**
  - **At distribution layer → switched backbone because of performance and cost**
  - **At core layer → routed backbone**
  - **VLANs closer but more costly and complex**

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Recommendations for BB Design

- **Best architecture**
  - **Switched backbone or VLAN at distribution layer**
  - **Routed backbone at core layer**
- **Best technology - Gigabit Ethernet**
- **Ideal design**
  - **A mixture of layer-2 and layer-3 Ethernet switches**
  - **Access Layer**
    - **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 over fiber**

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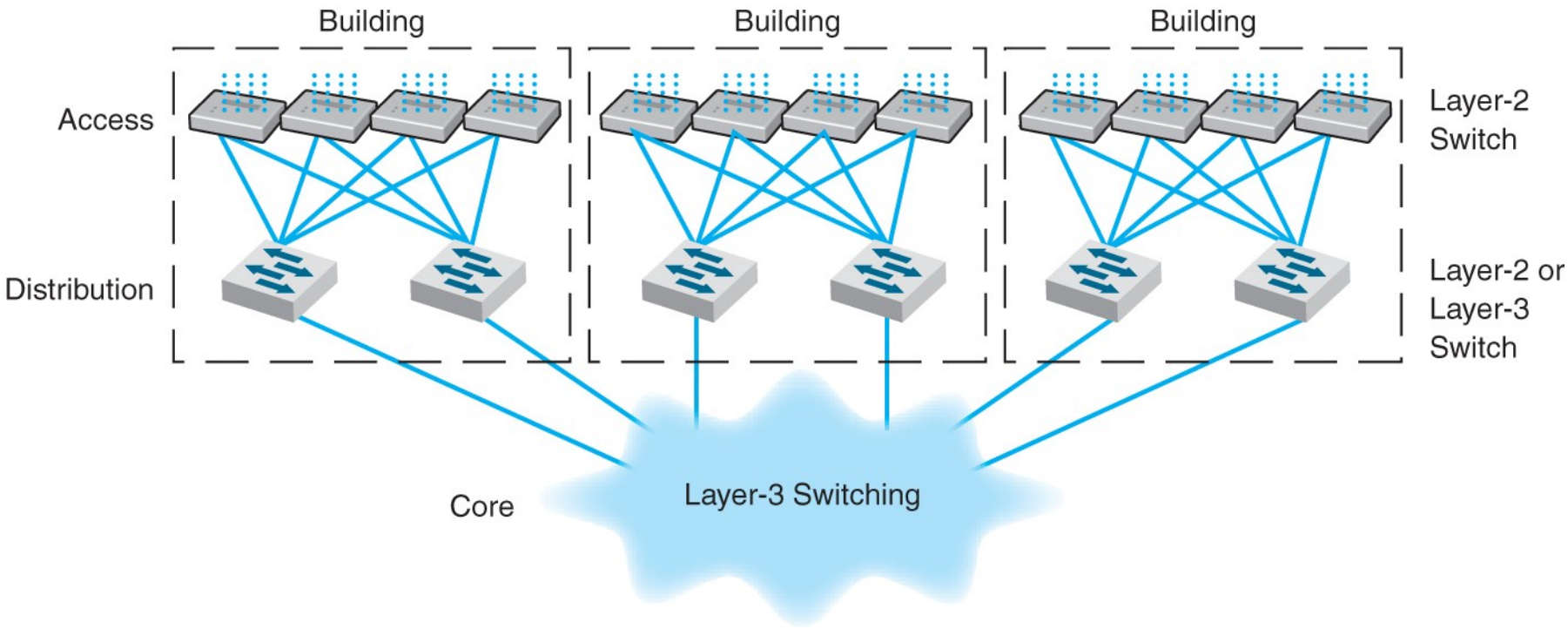
Best Practice Network Design



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7.5 Improving Backbone Performance

- **Improve computer and device performance**
  - **Upgrade them to faster devices**
  - **Change to a more appropriate routing protocol**
    - **Distance vector – typically used on BNs**
    - **Link state – typically used on WANs and MANs**
  - **Use gigabit Ethernet as BB (eliminate translations/conversion of cable to Ethernet and back)**
  - **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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7.6 Implications for Management

- **Amount of traffic backbone needs to support is increasing at faster rate**
  - **May require that BN be replaced**
  - **Design BN to be easily upgradeable**
- **ATM is legacy technology (replace with Ethernet)**
  - **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**
  - **Cost of equipment decreasing while management is becoming easier**
  - **Performance of Ethernet in backbone increasing quickly**

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