Business Data Communications & Networking:

12th Edition

Chapter 8: Backbone Networks

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Fall 2022

OBJECTIVES

- In this chapter we examine backbone networks (BNs) that are used in the **distribution layer** (within-building backbones) **and the core layer** (campus backbones).
- We discuss improving BN performance and the future of BNs.

- Objectives:
  a) Understand the Internetworking **devices** used in BNs
  b) Understand the **switched backbone architecture**
  c) Understand the **routed backbone architecture**
  d) Understand **Virtual LAN architecture**
  e) Understand the **best practice recommendations for backbone design**
  f) And learn about ways to improve **BN performance**

8.1 INTRODUCTION

- This chapter focuses on the next two major network architecture components:
  - The backbone networks that connect the access LANs with a building (called the distribution layer) and
  - The backbone networks that connect the different buildings on one enterprise campus (called the core layer).
- Backbones used to be built with special technologies, but today most BNs use **high-speed Ethernet**.
- There are two basic components to a BN:
  - **The network cable** (same as that used in LANs, except that it is often fiber optic to provide higher data rates. Fiber optic is also used when the distances between the buildings on an enterprise campus are >100 M) and
  - **The hardware devices that** connect other networks to the BN.

8.1 INTRODUCTION (contd)

- **Switches** operate at the data link layer. These are the same layer-2 switches that use the data link layer address to forward packets between network segments.
- **Routers** operate at the network layer.
  - **Routers are the "TCP/IP gateways" and they connect two different TCP/IP subnets.**
  - Routers may be special-purpose devices or special network modules in other devices (e.g., wireless access points for home use often include a built-in router).
  - They perform more processing on each message than switches and therefore operate more slowly.
- **VLAN switches** are a special combination of layer-2 switches and routers. They are complex devices intended for use in large networks that have special requirements.

8.2 SWITCHED BACKBONES

- Switched backbones are probably the most common type of BN used in the distribution layer (i.e., within a building);
- Switched backbone networks use a **star topology** with one switch at its center. Figure 8-1 shows a switched backbone connecting a series of LANs.
- **There is a switch serving each LAN (access layer)** that is connected to the backbone switch at the bottom of the figure (distribution layer).
- Most organizations now use switched backbones in which all network devices for one part of the building are **physically located in the same room**, often in a **rack** of equipment.
- This has the advantage of placing all network equipment in one place for **easy maintenance and upgrade**, but it does require more cable.
- In most cases, **the cost of the cable is only a small part of the overall cost** to install the network, so the cost is greatly outweighed by
  - **the simplicity of maintenance and**
  - **the flexibility it provides for future upgrades**

8.2 SWITCHED BACKBONES

- Figure 8-1 shows a switched backbone connecting a series of LANs.

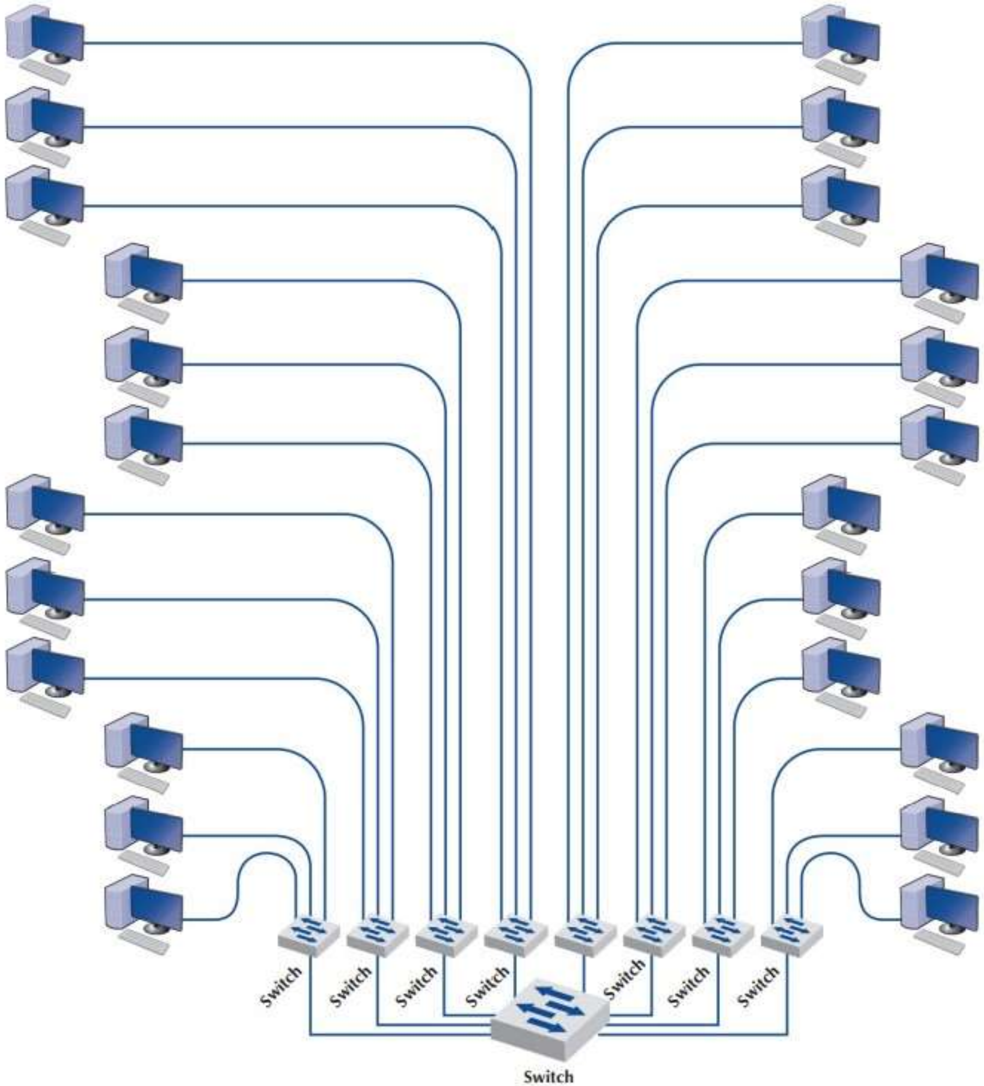


FIGURE 8-1 Rack-mounted switched backbone network architecture

8.2 SWITCHED BACKBONES (contd)

- The room containing the rack of equipment is sometimes called the **main distribution facility (MDF)** or **central distribution facility (CDF).**
- **The cables from all computers and devices in the area served by the MDF (often hundreds of cables) are run into the MDF room.** Once in the room, they are connected to various devices).
- The devices in the rack are connected among themselves using very short cables called **patch cables**.
- **With rack-mounted equipment, it becomes simple to move computers from one LAN to another.**
- **Usually, all the computers in the same general physical location are connected to the same switch and thus share the capacity of the switch.**
- With an MDF, all cables run into the MDF. **If one switch becomes overloaded, it is straightforward to unplug the cables from several high-demand computers** from the overloaded switch and plug them into one or more less-busy switches.
    - This effectively spreads the traffic around the network more efficiently and means that network capacity is no longer tied to the physical location.

8.2 CHASSIS SWITCH

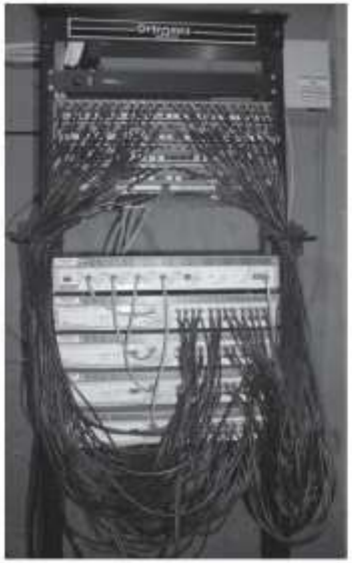


FIGURE 8-2
An MDF with rack-mounted equipment. A layer-2 chassis switch with five 100Base-T modules (center of photo) connects to four 24-port 100Base-T switches. The chassis switch is connected to the campus backbone using 1000Base-F over fiber-optic cable. The cables from each room are wired into the rear of the patch panel (shown at the top of the photo), with the ports on the front of the patch panel labeled to show which room is which. Patch cables connect the patch panel ports to the ports on the switches. *Source:* Photo courtesy of the author, Alan Dennis

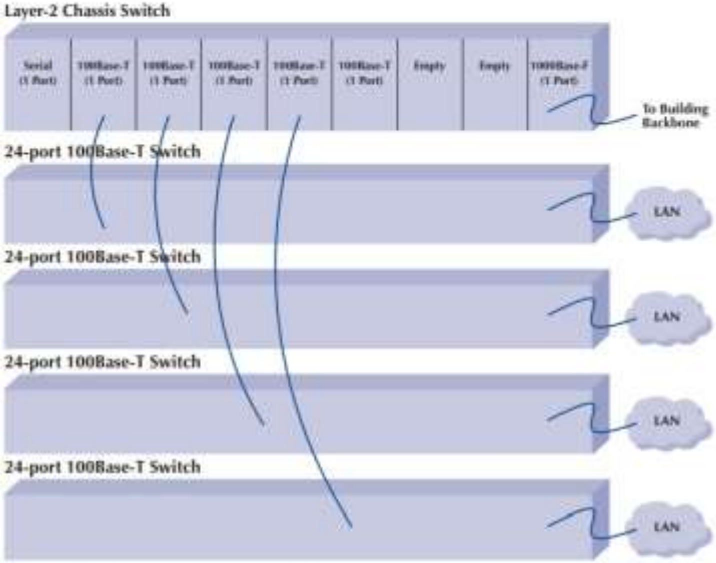
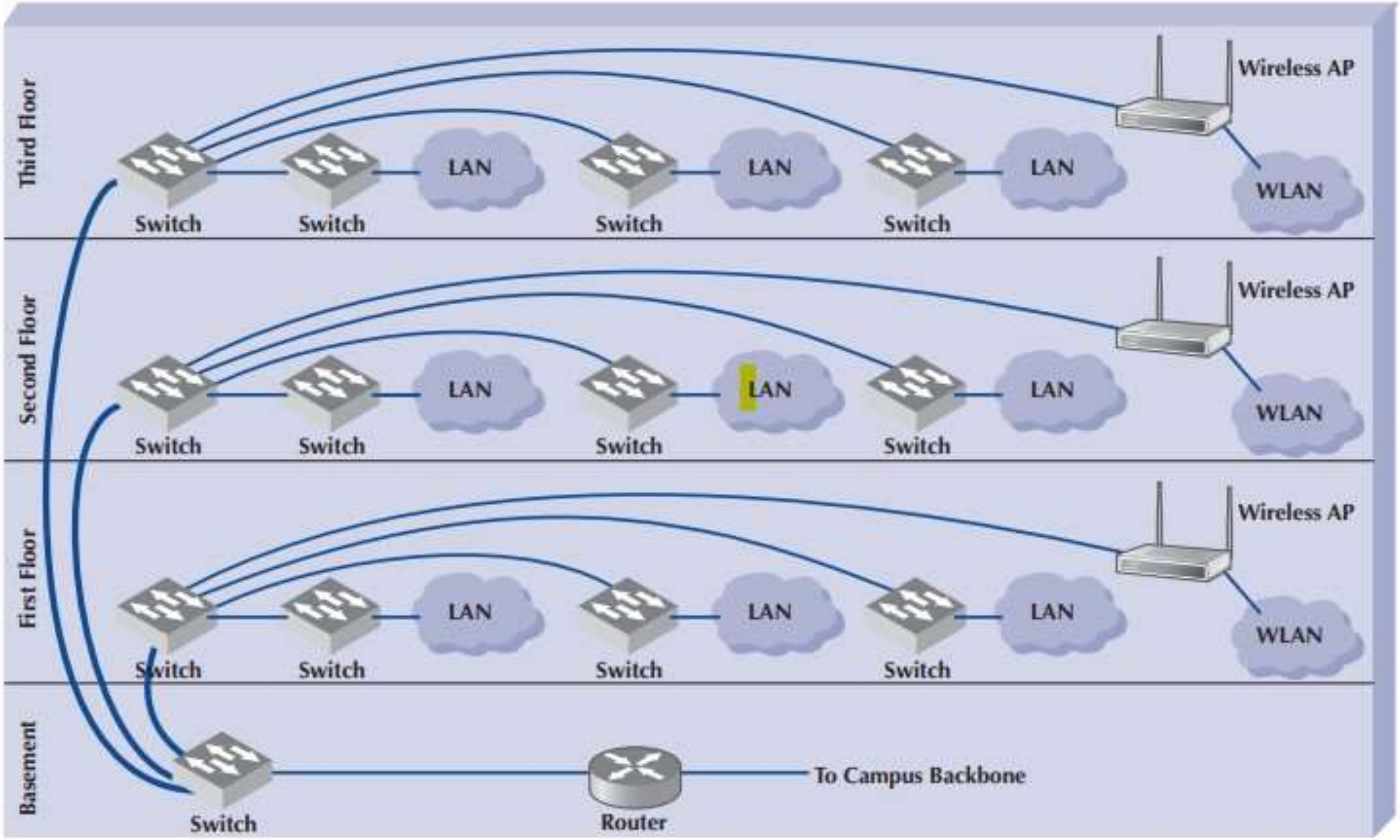


FIGURE 8-3 MDF network diagram

8.2 SWITCHED BACKBONE AT INDIANA UNIVERSITY



8.3 ROUTED BACKBONE

- **Routed backbones move packets** along the backbone on the basis of their network layer address (i.e., layer-3 address).
- Routed backbones are sometimes called **subnetted backbones** or **hierarchical backbones** and are most commonly used to connect different buildings on the same enterprise **campus backbone network (i.e., at the core layer).**
- Figure 8-5 illustrates a routed backbone used at the core layer.
- **A routed backbone is the basic backbone architecture we used to illustrate how TCP/IP works.**
- There are a series of LANs (access layer) connected to a switched backbone (distribution layer).
- Each backbone switch is connected to a router.
- Each router is connected to a core router (core layer). These routers break the network into separate subnets.
- The LANs in one building is a separate subnet from the LANs in a different building.
- There is no requirement that all LANs share the same technologies.
- Each set of LANs can contain its own server designed to support the users on that LAN, but users can still easily access servers on other LANs over the backbone, as needed.

8.3 ROUTED BACKBONES

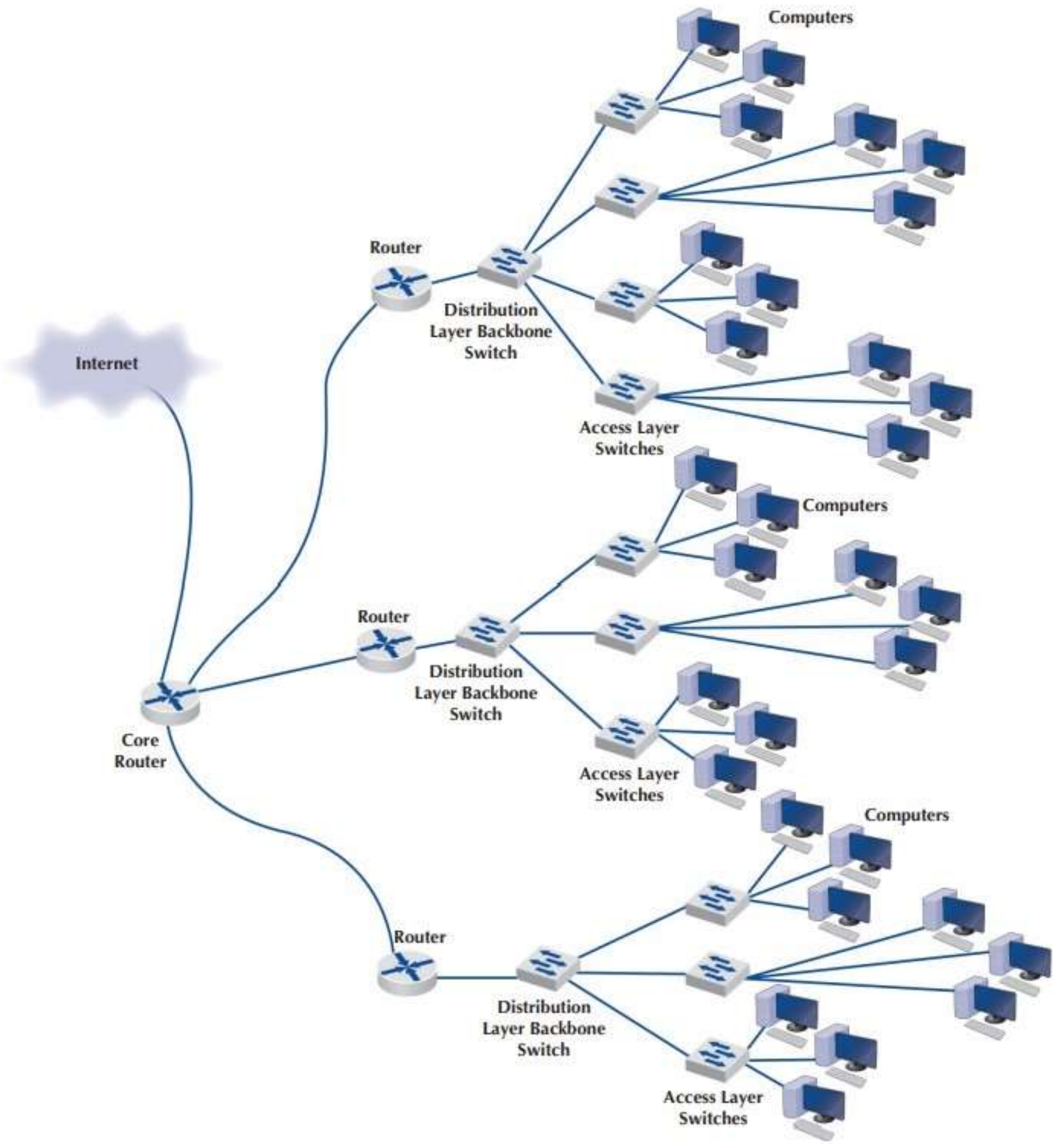


FIGURE 8-5 Routed backbone architecture

8.3 ROUTED BACKBONE: Advantages/Disadvantages

- One primary **advantage of the routed backbone is that it clearly segments** each part of the network connected to the backbone.
- **Each segment** (usually a set of LANs or switched backbone) has its own subnet addresses that **can be managed by a different network manager**.
- **Broadcast messages stay within each subnet** and do not move to other parts of the network.
- There are **two** primary **disadvantages** to routed backbones.
    - First, the **routers** in the network **impose** time **delays**.
        - Routing takes more time than switching, so routed networks can sometimes be slower.
    - Second, **routers are** more **expensive** and **require more management** than switches.

8.4 VIRTUAL LANs

- **A new type of LAN-BN** architecture made possible by **intelligent, high-speed switches**.
- Virtual LANs are networks in which **computers are assigned to LAN segments by software rather** than by hardware.
- **VLANs provide the capability via software** of moving computers from one hub to another. The network manager **does not have to unplug and replug** physical cables to move computers from one segment to another.
- VLANs are faster and provide **greater opportunities** to manage the flow of traffic on the LAN and BN than do the traditional LAN and routed BN architectures.
- However, **VLANs are significantly more complex**, so they **usually are used only for large network**

8.4 VIRTUAL LANs

- The simplest example is a **single-switch VLAN**, which means that the VLAN operates only inside one switch.
- The computers on the VLAN are connected into the one switch and assigned by software into different VLANs (Figure 8-6). The network manager uses special software to assign the dozens or even hundreds of computers attached to the switch to different VLAN segments.
- The VLAN segments function in the same way as physical LAN segments or subnets; the computers in the same VLAN act as though they are connected to the same physical switch or hub in a certain subnet.
- Because VLAN switches can create multiple subnets, they act like routers, except the subnets are inside the switch, not between switches.
- Therefore, broadcast messages sent by computers in one VLAN segment are sent only to the computers on the same VLAN.
- Virtual LANs can be designed so that they act as though computers are connected via hubs (i.e., several computers share a given capacity and must take turns using it) or via switches (i.e., all computers in the VLAN can transmit simultaneously).

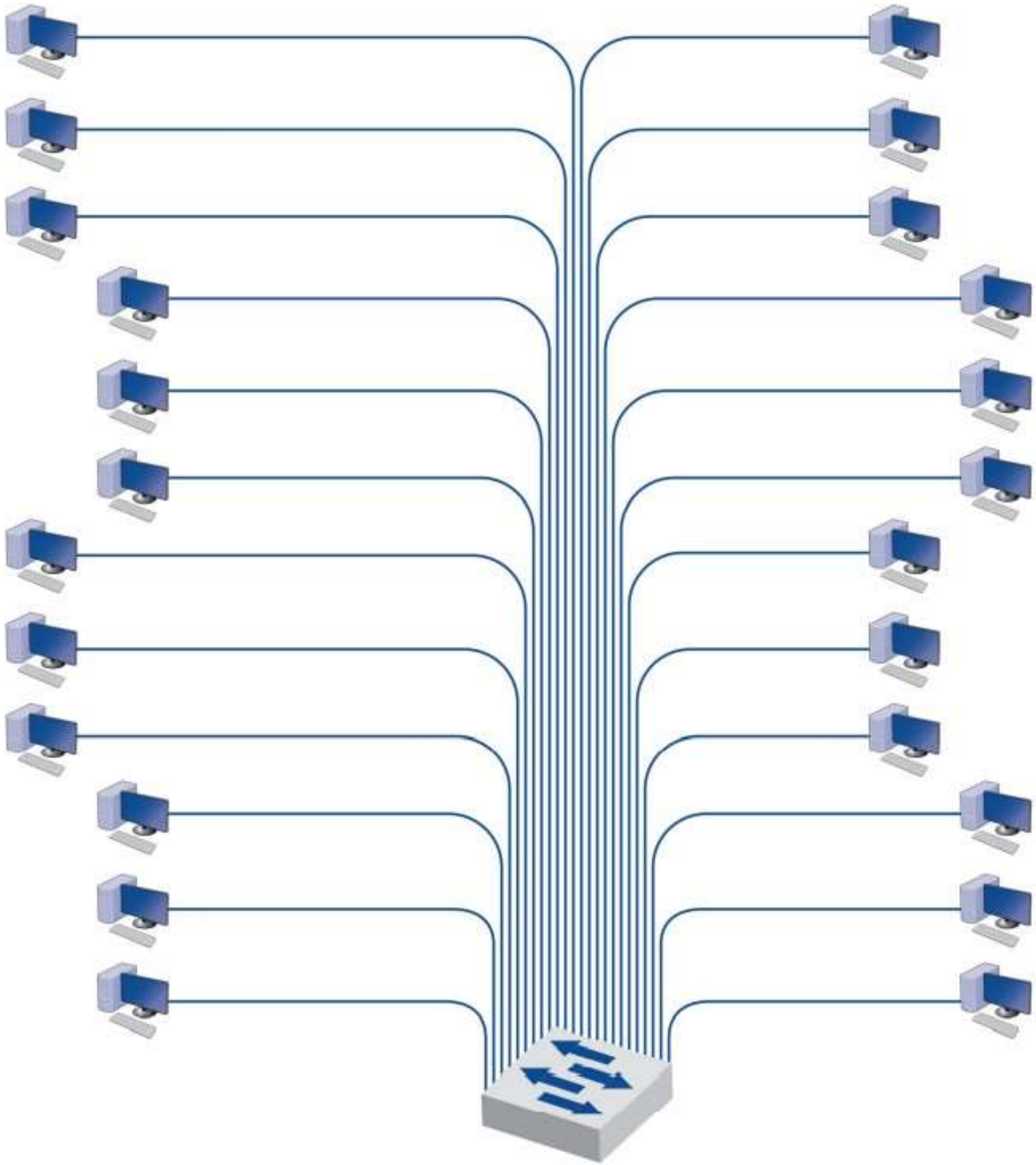


FIGURE 8-6 VLAN-based backbone network architecture

8.4 BENEFITS of VIRTUAL LANs:

- With VLANs, we can put computers in different geographic locations in the same subnet. For example, in Figure 8-6, a computer in the lower left could be put on the same subnet as one in the upper right—a separate subnet from all the other computers.
- A more common implementation is a **multiswitch VLAN**, in which several switches are used to build the VLANs (Figure 8-7).
- VLANs are most commonly found in **building backbone networks** (i.e., **access** and **distribution** layers) but are starting to move into the **core backbones between buildings.**
- In this case, we can now create subnets that span buildings (we have an accounting subnet and a marketing subnet (that is, based on who your are, not a Building A and a Building B subnet, that is where you are).
- Therefore, we now manage security and network capacity by who you are, not by where your computer is.
- Two more advantages:
  - VLANs make it much simpler to manage the broadcast traffic, so we can improve the performance.
  - The ability to prioritize traffic (based on priority code, RSVP QoS).
- The biggest drawback of VLANs are their cost and management complexity.

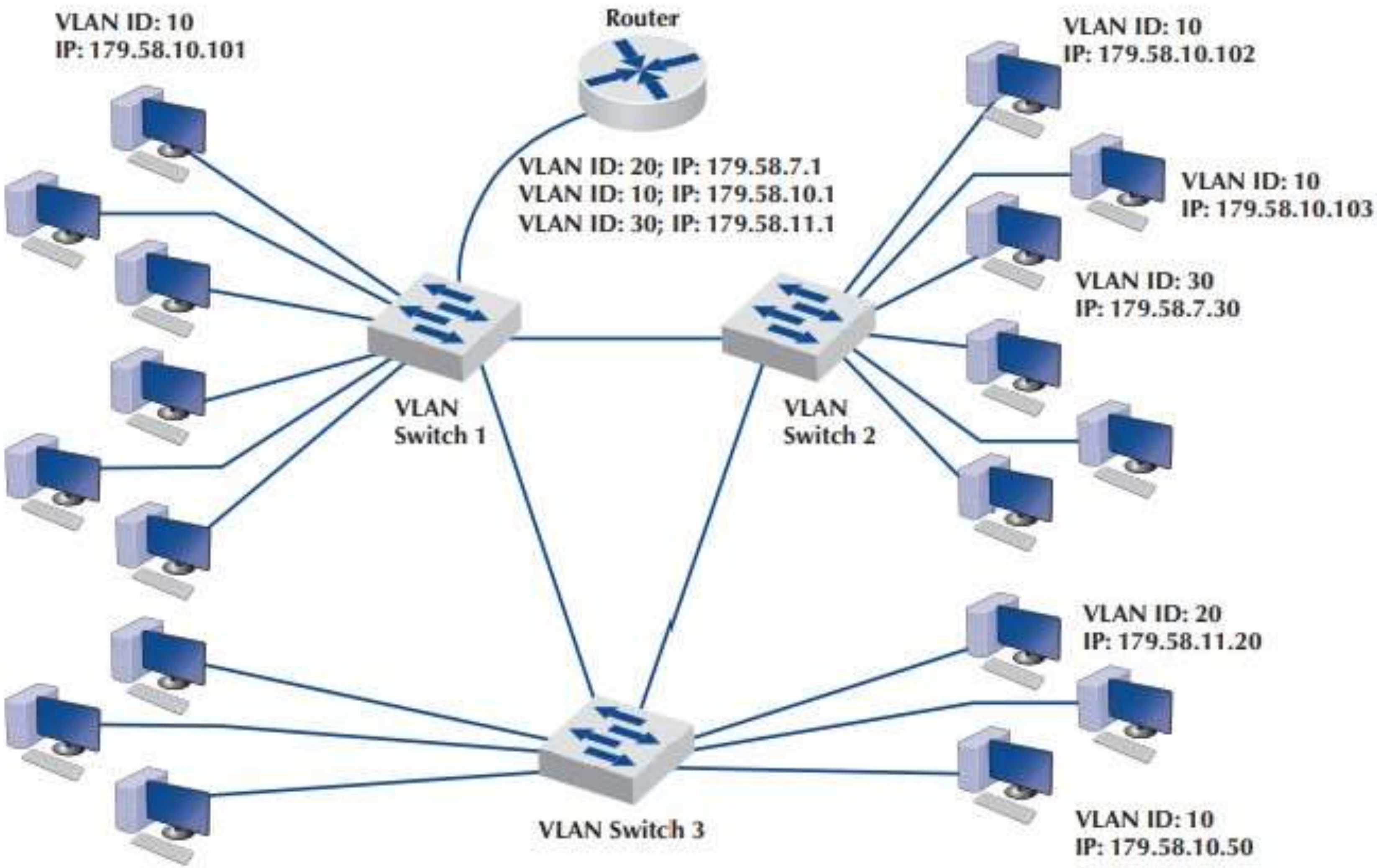


FIGURE 8-7 Multiswitch VLAN-based backbone network design

8.5 THE BEST PRACTICE BACKBONE DESIGN

- The past few years have seen radical changes in the backbone, both in terms of new technologies (e.g., gigabit Ethernet) and in architectures (e.g., VLANs).
  - Fifteen years ago, the most common backbone architecture was the routed backbone, connected to a series of shared 10Base-T hubs in the LAN.
  - Today, the most effective architecture for the distribution layer in terms of cost and performance is a **switched backbone (either rack-mounted or using a chassis switch) because it provides the best performance at the least cost.**
- For the **core layer**, most organizations use a **routed backbone**.
- Many large organizations are now implementing **VLANs**, especially those that have departments spread over multiple buildings, **but VLANs add considerable cost and complexity to the network**.

8.6 IMPROVING BACKBONE PERFORMANCE

- The method for improving the performance of **BNs is similar to that for improving LAN performance.**
- **First, find the bottleneck**, then remove it (or, more accurately, move the bottleneck somewhere else).
- You can improve the performance of the network by improving the performance of the devices in the network, by upgrading the circuits between them, and changing the demand placed on the network.

FIGURE 8-9
Facility map of the Western Trucking headquarters

Performance Checklist

Increase Device Performance
- Change to a more appropriate routing protocol (either distance vector or link state)
- Increase the devices' memory

Increase Circuit Capacity
- Upgrade to a faster circuit
- Add circuits

Reduce Network Demand
- Change user behavior
- Reduce broadcast messages

8.6 IMPROVING BACKBONE PERFORMANCE (contd)

- **8.6.1 Improving Device Performance:** If the devices and computers are the bottlenecks, routing can be improved with **faster devices** or a **faster routing protocol**. One simple way to improve performance is to ensure that the devices have sufficient **memory**. If they don't, the devices will lose packets, requiring them to be retransmitted.
- **8.6.2 Improving Circuit Capacity:** If network circuits are the bottlenecks, there are several options:
  - One is to **increase circuit capacity** (e.g., by going from 100Base-T Ethernet to gigabit Ethernet).
  - Another option is to **add additional circuits** alongside heavily used ones so that there are several circuits between some devices.
  - In many cases, the bottleneck on the circuit is only in one place—the circuit to the server.
  - **A switched network that provides 100 Mbps to the client computers but a faster circuit to the server (e.g., 1000Base-T) can improve performance at very little cost.**
- **8.6.3 Reducing Network Demand:** One way to reduce network demand is to **restrict** applications that use a lot of **network capacity**, such as **desktop videoconferencing**, **medical imaging**, or **multimedia**.