



Module 11: Network Design

Instructor Materials

Enterprise Networking, Security, and Automation v7.0
(ENSA)





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Module Objectives

Module Title: Network Design

Module Objective: Explain the characteristics of scalable network architectures.

Topic Title	Topic Objective
Hierarchical Networks	Explain how data, voice, and video are converged in a switched network.
Scalable Networks	Explain considerations for designing a scalable network.
Switch Hardware	Explain how switch hardware features support network requirements.
Router Hardware	Describe the types of routers available for small to-medium-sized business networks.

11.1 Hierarchical Networks

Video - Three-Layer Network Design

This video will demonstrate a three-layer model in network design.

The Need to Scale the Network

Organizations increasingly rely on their network infrastructure to provide mission-critical services.

Evolving organizations require networks that can scale and support:

- Converged network traffic
- Critical applications
- Diverse business needs
- Centralized administrative control

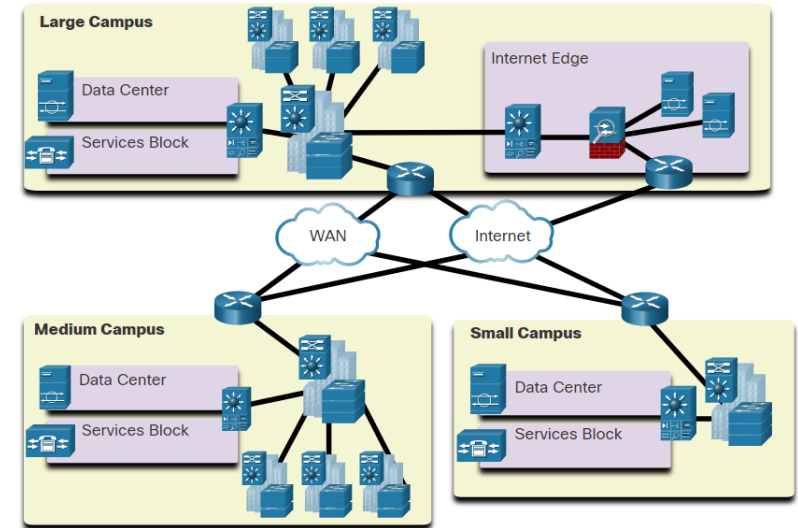
Campus network designs include small networks that use a single LAN switch, up to very large networks with thousands of connections.

Hierarchical Networks

Borderless Switched Networks

The Cisco **Borderless Network** is a network architecture that can connect **anyone**, **anywhere**, **anytime**, on **any device**; **securely**, **reliably**, and **seamlessly**.

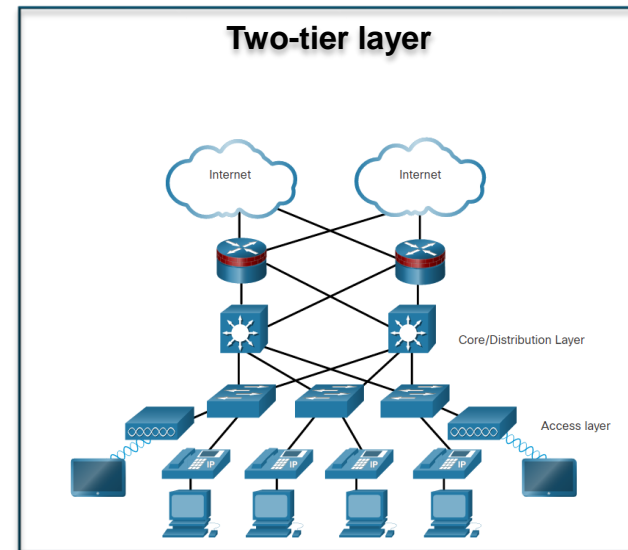
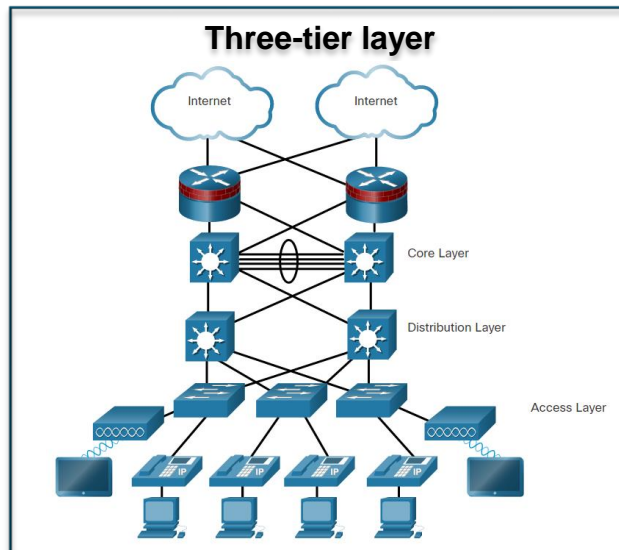
- It provides the **framework** to unify wired and wireless access, built on a hierarchical infrastructure of hardware that is **scalable** and **resilient**.
- Borderless switched networks are hierarchical, modular, resilient, and flexible.



Hierarchy in the Borderless Switched Network

Hierarchical networks use a **tiered design** of access, distribution, and core layers with each layer performing a well-defined role in the campus network.

There are two time-tested and proven hierarchical **design** frameworks for campus networks.



Access, Distribution, and Core Layer Functions

Access Layer

- The access layer provide network access to the user.
- Access layer switches connect to distribution layer switches.

Distribution Layer

- The distribution layer implements **routing**, **quality of service**, and **security**.
- It aggregates large-scale wiring closet networks and limits **Layer 2 broadcast** domains.
- Distribution layer switches connect to access layer and core layer switches.

Core Layer

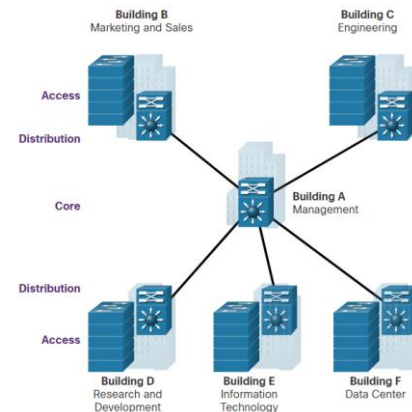
- The core layer is the network **backbone** and connects **several layers** of the network.
- The core layer provides fault isolation and **high-speed backbone** connectivity.

Hierarchical Networks

Three-Tier and Two-Tier Examples

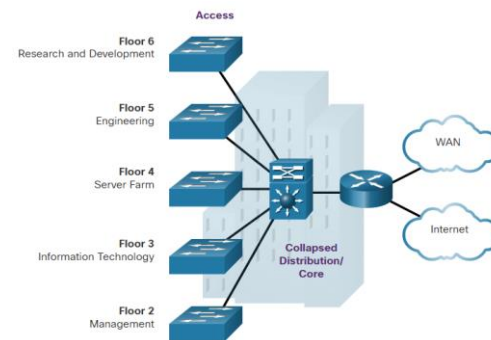
Three-tier Campus Network

- Used by organizations requiring **access**, **distribution**, and core layers.
- The recommendation is to build an **extended-star physical network topology** from a centralized building location to all other buildings on the same campus.



Two-tier Campus Network

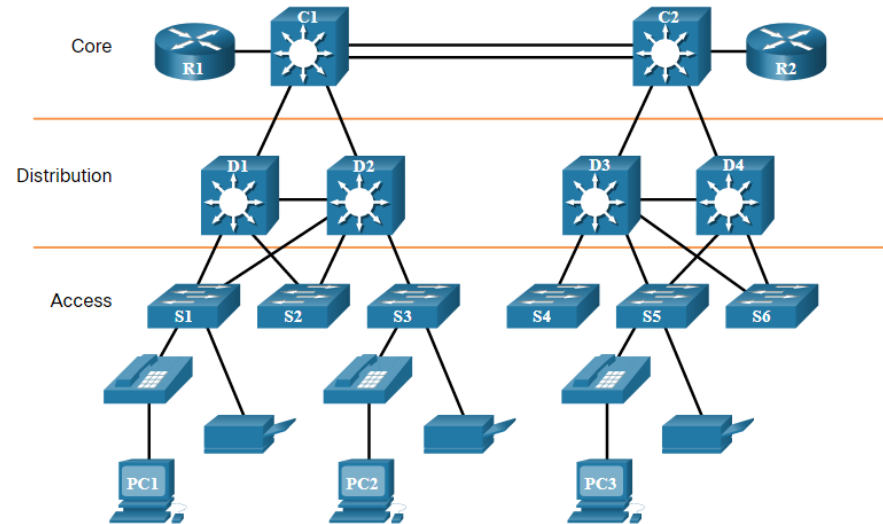
- Used when separate distribution and core layers is not required.
- Useful for smaller campus locations, or in campus sites consisting of a single building.
- Also known as the *collapsed core* network design.



Hierarchical Networks

Role of Switched Networks

- Networks have fundamentally changed from a flat network of hubs to switched LANs in a hierarchical network.
- A **switched LAN** allows additional flexibility, traffic management, quality of service, security.
- A switched LAN may also support wireless networking and other technologies such as IP telephone and mobility services.



11.2 Scalable Networks

Scalable Networks

Design for Scalability

Scalability is the term for a network that can **grow without losing availability and reliability**.

Network designers must develop **strategies** to **enable the network** to be available and to scale effectively and easily.

This is accomplished using:

- **Redundancy**
- **Multiple Links**
- **Scalable Routing protocol**
- **Wireless Connectivity**

Scalable Networks

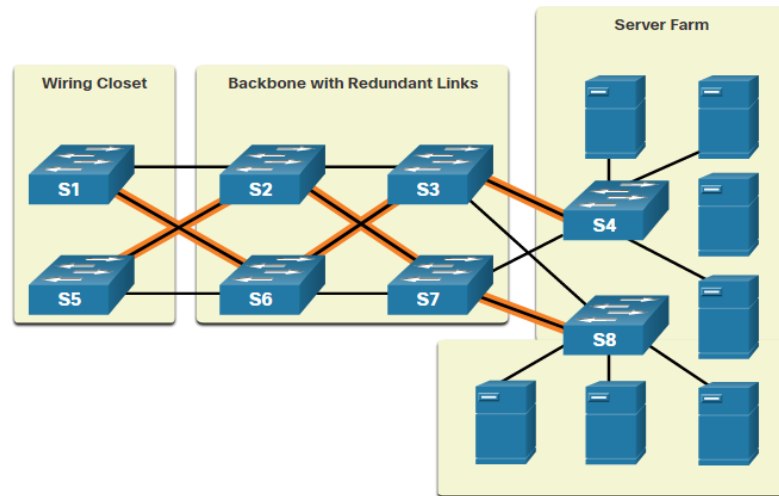
Plan for Redundancy

Redundancy can prevent disruption of network services by **minimizing** the possibility of a single **point of failure** by:

- Installing **duplicate equipment**
- Providing **failover services** for critical devices

Redundant paths offer alternate physical paths for data to traverse the network supporting high availability.

- However, redundant paths in an Ethernet network may cause logical Layer 2 loops.
- Therefore, Spanning Tree Protocol (STP) is required.



Reduce Failure Domain Size

A well-designed network controls traffic and limits the size of failure domains (i.e., the area of a network that is impacted when the network experiences problems).

- In the hierarchical design model, failure domains are terminated at the distribution layer.
- Every router functions as a gateway for a limited number of access layer users.

Routers, or multilayer switches, are usually deployed in pairs in a configuration referred to as a building, or departmental, switch block.

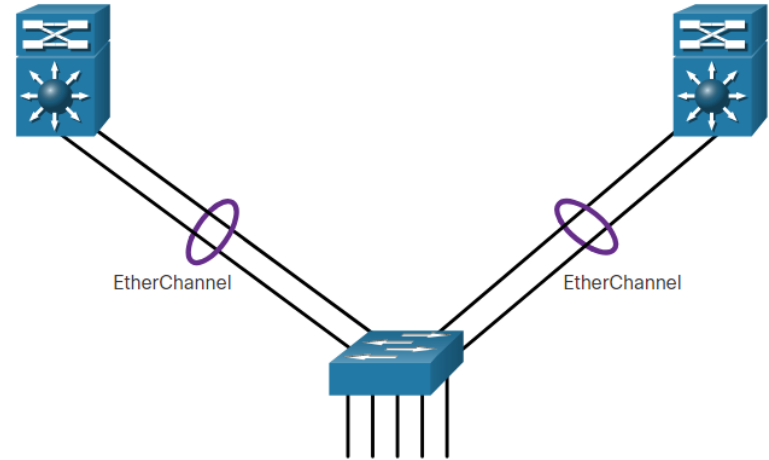
- Each switch block acts independently of the others.
- As a result, the failure of a single device does not cause the network to go down.

Scalable Networks

Increase Bandwidth

Link aggregation (e.g., EtherChannel) allows an administrator to increase the amount of bandwidth between devices by creating one logical link made up of several physical links.

- EtherChannel combines existing switch ports into one logical link using a Port Channel interface.
- Most configuration tasks are done on the Port Channel interface (instead of on each individual port) to ensure configuration consistency on the links.
- EtherChannel can load balance between links.



Scalable Networks

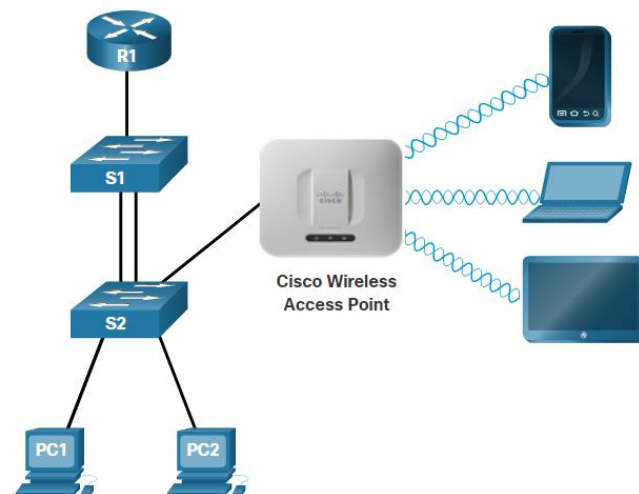
Expand the Access Layer

An increasingly popular option for extending access layer connectivity is through wireless.

- Wireless LANs (WLANs) provides increased flexibility, reduced costs, and the ability to grow and adapt to changing network and business requirements.
- To communicate wirelessly, end devices require a wireless NIC to connect to a wireless router or a wireless access point (AP).

Considerations when implementing a wireless network include:

- Types of wireless devices connecting to the WLAN
- Wireless coverage requirements
- Interference considerations
- Security considerations

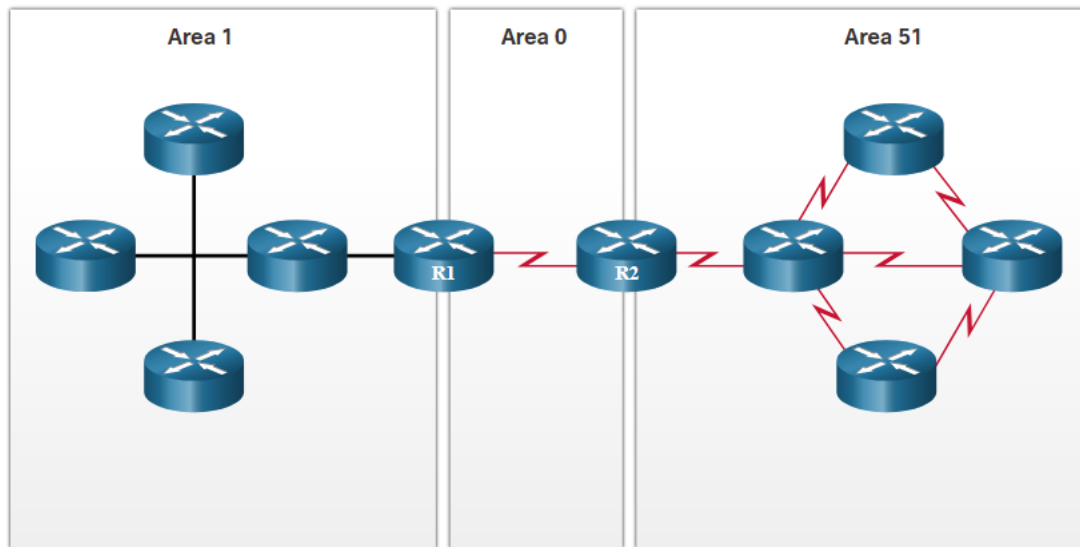


Scalable Networks

Tune Routing Protocols

Advanced routing protocols, such as **Open Shortest Path First (OSPF)** are used in large networks.

- OSPF is a link-state routing protocol that uses areas to support a hierarchical networks.
- OSPF routers establish and maintain neighbor adjacencies with other connected OSPF routers.
- OSPF routers synchronize their link-state database.
- When a network change occurs, link-state updates are sent, informing other OSPF routers of the change and establishing a new best path, if one is available.



11.3 Switch Hardware

Switch Hardware

Switch Platforms

There is a variety of switch platforms, form factors, and other features that must be considered before choosing a switch. When designing a network, it is important to select the proper hardware to meet current network requirements, as well as to allow for network growth. Within an **enterprise network**, both switches and routers play a critical role in network communication.

Campus LAN Switches, such as the Cisco 3850 series shown here, support high concentrations of user connections with speed and security appropriate for the enterprise network.



Switch Hardware

Switch Platforms (Cont.)

Cisco Meraki cloud-managed access switches enable virtual stacking of switches. They monitor and **configure thousands of switch ports over the web**, without the intervention of onsite IT staff.



The **Cisco Nexus** platform promotes infrastructure scalability, operational continuity, and transport flexibility in the data center.



Switch Hardware

Switch Platforms (Cont.)

Service provider Ethernet access switches feature **application intelligence**, **unified services**, **virtualization**, **integrated security**, and **simplified management**.



Cisco Nexus virtual networking switch platforms provide secure multi-tenant services by adding virtualization intelligence technology to the data center network.



Switch Hardware

Switch Form Factors

When selecting switches, network administrators must determine the switch **form factors**. This includes **fixed configuration**, **modular configuration**, **stackable**, or **non-stackable**.

Features and options on **fixed configuration switches** are limited to those that originally come with the switch.



The chassis on modular switches accept field-replaceable line cards.



Switch Hardware

Switch Form Factors (Cont.)

Special cables are used to connect **stackable** switches that allow them to effectively operate as one large switch.



The thickness of the switch, which is expressed in the number of rack units, is also important for switches that are mounted in a rack. For example, the fixed configuration switches shown in the figure are all one rack units (1U) or 1.75 inches (44.45 mm) in height.

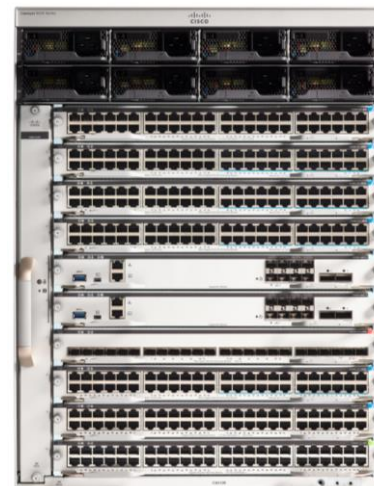
Switch Hardware

Port Density

The **port density** of a switch refers to the number of ports available on a single switch.



Fixed configuration switches support a variety of port density configurations. The Cisco Catalyst 3850 come in **12, 24, 48** port configurations.



Modular switches can support very high port densities through the addition of multiple switchport line cards. The modular Catalyst 9400 switch supports **384** switchport interfaces.

Switch Hardware

Forwarding Rates

Forwarding rates define the **processing capabilities** of a switch by rating how much data the switch can process per second.

- Switch product lines are **classified by forwarding rates**.
- Entry-level switches have lower forwarding rates than enterprise-level switches.

If switch forwarding rate is too low, it cannot accommodate full wire-speed communication across all of its switch ports.

- Wire speed is the data rate that each Ethernet port on the switch is capable of attaining.
- Data rates can be 100 Mbps, 1 Gbps, 10 Gbps, or 100 Gbps.
- Access layer switches typically do not need to operate at full wire speed, because they are physically limited by their uplinks to the distribution layer.

Switch Hardware

Power over Ethernet

Power over Ethernet (PoE) allows the switch to deliver power to a device (e.g., IP phone, AP, camera) over the existing Ethernet cabling.

A network administrator should ensure that the PoE features are actually required for a given installation, because switches that support PoE are expensive.

Switch Hardware

Multilayer Switching

Multilayer switches are typically deployed in the core and distribution layers of an organization's switched network.

- They support some routing protocols and forward IP packets at a rate close to that of Layer 2 forwarding.
- Multilayer switches often support specialized hardware, such as application-specific integrated circuits (ASICs).
- ASICs along with dedicated software data structures can streamline the forwarding of IP packets independent of the CPU.

Switch Hardware

Business Considerations for Switch Selection

Consideration	Description
Cost	The cost of a switch will depend on the number and speed of the interfaces, supported features, and expansion capability.
Port density	Network switches must support the appropriate number of devices on the network.
Power	It is now common to power access points, IP phones, and compact switches user Power over Ethernet (PoE). In addition to PoE considerations, some chassis-based switches support redundant power supplies.
Reliability	The switch should provide continuous access to the network.
Port speed	The speed of the network connection is of primary concern to end users.
Frame buffers	The ability of the switch to store frames is important in a network where there may be congested ports to servers or other areas of the network.
Scalability	The number of users on a network typically grows over time; therefore, the switch should provide the opportunity for growth.

11.4 Router Hardware

Router Hardware

Router Requirements

Routers use the network portion (prefix) of the destination IP address to route packets to the proper destination.

- They select an alternate path if a link goes down.
- All hosts on a network specify the IP address of the local router interface as their default gateway.

Routers also serve other beneficial functions as follows:

- They provide broadcast containment by limiting broadcasts to the local network.
- They interconnect geographically separated locations.
- They group users logically by application or department within a company, who have common needs or require access to the same resources.
- They provide enhanced security by filtering unwanted traffic through access control lists.

Router Hardware

Cisco Routers

Branch routers, shown in the figure, optimize branch services on a single platform while delivering an optimal application experience across branch and WAN infrastructures. Shown are the Cisco Integrated Services Router (ISR) 4000 Series Routers.



Router Hardware

Cisco Routers (Cont.)

Network edge routers, shown in the figure, enable the network edge to deliver high-performance, highly secure, and reliable services that unite campus, data center, and branch networks. Shown are the Cisco Aggregation Services Routers (ASR) 9000 Series Routers.



Router Hardware

Cisco Routers (Cont.)

Service provider routers, shown in the figure, deliver end-to-end scalable solutions and subscriber-aware services. Shown are the Cisco Network Convergence System (NCS) 6000 Series Routers.



Door Closed



Door Open

Router Hardware

Cisco Routers (Cont.)

Industrial routers, such as the ones shown in the figure, are designed to provide enterprise-class features in rugged and harsh environments. Shown are the Cisco 1100 Series Industrial Integrated Services Routers.



Router Hardware

Router Form Factors

Cisco 900 Series: This is a small branch office router. It combines WAN, switching, security, and advanced connectivity options in a compact, fanless platform for small and medium-sized businesses.



Router Hardware

Router Form Factors

Cisco ASR 9000 and 1000 Series Aggregation Services Routers: These routers provide density and resiliency with programmability, for a scalable network edge.

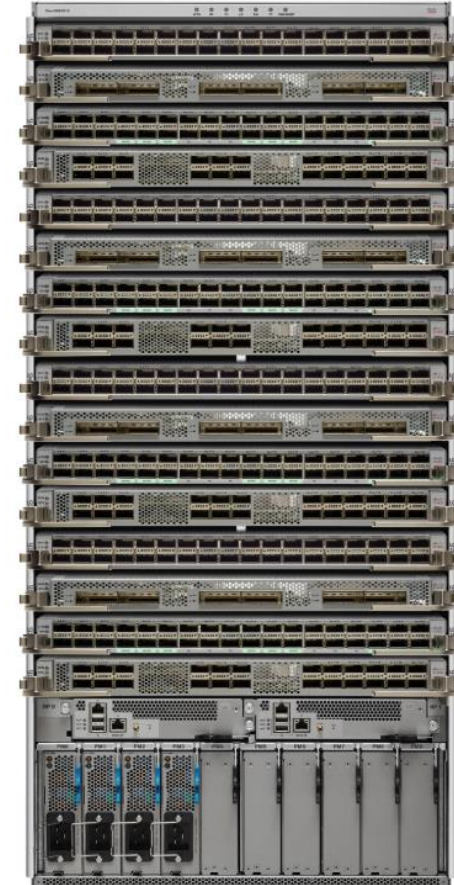


Router Hardware

Router Form Factors

Cisco Network Convergence System 5500

Series Routers: These routers are designed to efficiently scale between large data centers and large enterprise networks, web, and service provider WAN and aggregation networks.



Router Hardware

Router Form Factors

Cisco 800 Industrial Integrated Services Router: This router is compact and designed for harsh environments.



11.5 Module Practice and Quiz

Packet Tracer - Compare Layer 2 and Layer 3 Devices

In this Packet Tracer activity, you will use various commands to examine three different switching topologies and compare the similarities and differences between the 2960 and 3650 switches.

You will also compare the routing table of a 4321 router with that of a 3650 switch.

What did I learn in this module?

- The Cisco Borderless Network provides the framework to unify wired and wireless access, and is built on a hierarchical infrastructure of hardware that is scalable and resilient.
- Two proven hierarchical design frameworks for campus networks are the three-tier layer and the two-tier layer models.
- The three critical layers within these tiered designs are the access, distribution, and core layers.
- Implement redundant links between critical devices and between access layer and core layer devices.
- Implement multiple links between equipment, with either link aggregation (EtherChannel) or equal cost load balancing, to increase bandwidth.
- Use a scalable routing protocol and implementing features to minimize the routing table size.
- Implement wireless connectivity to allow for mobility and expansion.

What did I learn in this module? (Cont.)

- There are campus LAN, cloud-managed, data center, service provider, and virtual networking switches.
- Form factors for switches include fixed configuration, modular configuration, and stack
- Routers use the network portion (prefix) of the destination IP address to route packets to the proper destination.
- Routers select an alternate path if a link or path goes down.
- Cisco has several categories of routers including branch, network edge, service provider and industrial.

