Instructor Guide

Computer Networking Fundamentals

LESSON: Routing

Before you Begin

Just as with the previous module, focus on helping learners understand how data packets move through a network. Those students that were able to capture concepts from their lessons regarding IP addressing and subnetting will likely be able to better understand routing. You may need to provide a high level review of those concepts for the students. For this lesson and upcoming lessons, instructors are required to ensure the following activities are completed:

- Review the “Lesson Opener” and “Real World Scenario” with the learners prior to starting the module.
- Throughout the module, you will find “Consider the Real World Scenario” slides. Review the questions found on these slides, tie the concepts back to the scenario discussed at the start of the lesson as well as content you are presenting, and encourage the learners to share their thoughts.
- Ensure learners are given opportunities for breaks throughout the lesson. The pacing guide below provides recommended breaks. However, there are additional breaks added in the slide deck, please use them if needed.
- For each lesson, you will find a “Pulse Check” slide which is the opportunity for instructors to open a poll to gather feedback from the learners. Leave the poll open for about 1 minute and after you close the poll, share the results with the learners. Encourage the learners to share their thoughts. This information will help the instructors as well as the learners better understand where they are with regards to the lesson.
- Labs are to be demonstrated live for each module. The demonstration of labs is the top priority for the lead instructor. While demonstrating each lab, encourage students to participate and explore.
- At the end of each lesson, it is important to take a few minutes to review the key concepts for the lesson, provide guidance on what the learners can do to prepare for the next lesson, and wrap up with Q&A.

Summary

In this lesson, learners will be introduced to the fundamental concepts of router configuration and management. They will learn how to configure loopback interfaces, other router interfaces, and access the router's console and auxiliary ports. The lesson covers the importance of

configuring the default gateway and explores different routing protocols such as RIP and OSPF. Learners will understand the differences between static and dynamic routing, the use of metrics in routing protocols, and the advantages of using dynamic routing protocols in complex networks. They will also explore the features and characteristics of RIP, RIPv1, RIPv2, RIPng, and OSPF, including the algorithms and mechanisms used by OSPF for network topology monitoring and routing calculation. By the end of the lesson, learners will be equipped with the essential knowledge and skills to configure and manage routers effectively in diverse networking environments.

Objectives

- Identify the functions of a router in network topology.
- Explain the concept of routing and the purpose of a routing table in the routing process.
- Describe the associated codes for directly connected devices in a routing table.
- Explain the concept of software sniffing.
- Define remote networks.
- Compare and contrast Static Routing and Dynamic Routing.
- Explain when to use Static Routing.
- Define Dynamic routing.
- Summarize the routing source codes.
- Explain the key elements of dynamic routing.
- Identify the Administrative Distance (AD) Values.
- Explain the concept of Metrics and its routing protocol.
- Compare and contrast several protocol types, such as IGPS, EGP, Distance Vector, and Link State.
- Explain the Passive Interface feature and its benefits.
- Analyze the Classful & Classless Routing Protocols.
- Define Routing Information Protocol (RIP)
- Compare and contrast RIPv1, RIPv2 and RIPng.
- Explain the Auto-Summary feature.
- Illustrate the RIPv2 configuration.
- Define Gateway of Last Resort.
- Define OSPF and its main features.
- Explain the SPF Tree creation process.
- Describe the use of Wildcard Masks within the OSPF protocol.
- Illustrate the use of Router IDs.
- Define OSPFv2 Areas.

Lesson Activities and Teaching Strategies

Estimated Time	Lesson Portion	Directions
5 min	**Lesson Opener:** Routing	● Introduce learners to the importance of understanding routers as the basis for computer networking.
5 min	**Real World Scenario:** Routing	● Review the real world scenario challenge and inform learners that you will be constantly coming back to this scenario throughout the lesson to discover how to solve and apply concepts to this real situation.
20 min	**Cyber Uncovered:** Router Overview	● Explain the importance of routers in computer networks. ● Discuss their role in receiving, forwarding, and analyzing data packets. ● Highlight how routers facilitate inter-network communication and manage network traffic. ● Emphasize the role of the default gateway in directing network traffic to the appropriate destinations similar to how one may use a doorway to exit out of the existing room. ● Discuss the options for configuring the default gateway, including DHCP and manual configuration. ● Provide an overview of different types of router interfaces, such as Ethernet, serial, and logical ports. ● Discuss additional interfaces found on routers, such as the console port and auxiliary port and how they can be used to manage the router via remote connectivity. ● Explain the process of configuring interfaces on a router, including assigning IP addresses and enabling interfaces. ● Discuss the uses of loopback interfaces as a logical port used for testing, managing devices, and OSPF identification. ● Be prepared to discuss the implication of the real world scenario presented at the beginning of class to network types and devices. There are specific prompts that you should ask learners to reflect on to apply this concept to the real world scenario.
20 min	**Cyber Uncovered:** The Routing Process	● Explain the routing process in a network, involving the selection of paths for packet delivery across different networks via Layer 3 devices. ● Discuss the routing process in detail and how routers will decapsulate the packets to be able to examine layer 2 and layer 3 addressing and how routers make decisions with regards to the handling of these packets.

		● Explain how routers use static or dynamic routes to forward packets to the next hop based on the route. ● Introduce the concept of the "gateway of last resort" and explain its role in routing when no specific route is available. ● Discuss what happens if there is no default gateway and the router doesn't have a route for the destination packet. ● Present the associated codes in a routing table for directly connected devices and their meanings (C, S, L, D, O, B) and explain how these codes provide information about the routes connected to the router. ● Explain how administrators can use packet sniffers to monitor protocols, IP addresses, network troubleshooting and optimization. ● Be prepared to discuss the implication of the real world scenario presented at the beginning of class to network types and devices. There are specific prompts that you should ask learners to reflect on to apply this concept to the real world scenario.
20 min	**Lab:** Initial Routing Configuration	● Remind learners to use this lab to practice and apply the concepts they have learned throughout the day. ● Learners will receive direct feedback on their lab in order to properly assess their knowledge and determine where they might need additional assistance.
5 min	**Break**	● Share a timer on the screen so there is clarity as to when class will resume. Ensure cameras and microphones are disabled during the break.
15 min	**Cyber Uncovered:** Static Routing	● Explain the concept of a remote network, which refers to any network not directly connected to the router. ● Discuss how networks connected directly are automatically added to the routing table but that networks must be manually configured by the administrator. ● Discuss the differences between static and dynamic routing and each of their advantages and disadvantages. ● Present scenarios where static routing is an appropriate choice, such as in small networks or stub networks. ● Introduce the most common types of static routes: standard static routes and default static routes. ● Be prepared to discuss the implication of the real world scenario presented at the beginning of class to network types and devices. There are specific prompts that you should ask learners to reflect on to apply this concept to the real world scenario.
20 min	**Lab:**	● Remind learners to use this lab to practice and apply the concepts they have learned throughout the day.

	Static Routes on Cisco Routers	● Learners will receive direct feedback on their lab in order to properly assess their knowledge and determine where they might need additional assistance.
20 min	**Cyber Uncovered:** Dynamic Routing	● Explain the concept of dynamic routing, which automatically maps networks and updates routing tables with the shortest routes and highlights the use of algorithms and protocol packets to achieve automatic and independent routing updates. ● Show an example of a routing table with network information learned using the OSPF dynamic routing protocol and explain the meaning of different route codes, such as "S" for static, "O" for OSPF, and "R" for RIP. ● Discuss the advantages of dynamic routing, including its suitability for various network topologies. ● Define what a metric is in the context of routing protocols and its role in determining the best path to a remote network and explain how routing protocols use metrics to choose routes with the lowest metric value. ● Differentiate between Interior Gateway Protocols (IGPs) used within autonomous systems and Exterior Gateway Protocols (EGPs) for mapping routes between autonomous systems. ● Compare distance vector and link state routing protocols, focusing on how they discover network topology and share routing information. ● Provide an overview of BGP as a path vector protocol used for internet mapping. ● Explain the passive interface feature used in routing protocols to decrease resource usage and enhance security. ● Be prepared to discuss the implication of the real world scenario presented at the beginning of class to network types and devices. There are specific prompts that you should ask learners to reflect on to apply this concept to the real world scenario.
5 min	**Pulse Check**	● After the poll is concluded, review the results with the learners. Encourage those in the red zone to attend office hours and/or to reach out to the instructors for assistance.
5 min	**Break**	● Share a timer on the screen so there is clarity as to when class will resume. Ensure cameras and microphones are disabled during the break.
20 min	**Cyber Uncovered:** RIPv2	● Explain that RIP is a distance vector protocol with a hop count metric method.which was related in 1988. ● Describe RIP's default AD value of 120

		● Define RIP's metric as the number of hops (routers) to the target network and how RIP chooses the shortest route based on the least number of hops. ● Explain RIP's update timer, which is set to 30 seconds by default and how routers exchange updates with neighboring routers every 30 seconds. ● Discuss the invalid, flush, and hold-down timers and their roles in managing routing entries. ● Introduce the auto-summary feature, allowing automatic summarization of routes to their classful networks and how this feature simplifies the routing table by representing multiple networks with a single summary address. ● Describe the process of enabling RIP and entering RIP configuration mode and review relevant RIP configuration commands such as "version," "network," "no-summary," and "passive-interface." ● Explain the process of convergence, where routers share routing information and add remote networks to their tables. ● Describe the information included in the "show ip protocols" output, such as timer information, advertised networks, and passive interfaces. ● Define the static default route and its role in redirecting packets with unknown destinations to the Gateway of Last Resort and how each routing protocol shares its default routes with all routers on the network through protocol updates. ● Be prepared to discuss the implication of the real world scenario presented at the beginning of class to network types and devices. There are specific prompts that you should ask learners to reflect on to apply this concept to the real world scenario.
20 min	**Lab:** RIPv2 - Configure and Verify	● Remind learners to use this lab to practice and apply the concepts they have learned throughout the day. ● Learners will receive direct feedback on their lab in order to properly assess their knowledge and determine where they might need additional assistance.
5 min	**Break**	● Share a timer on the screen so there is clarity as to when class will resume. Ensure cameras and microphones are disabled during the break.
20 min	**Cyber Uncovered:** OSPFv2	● Introduce OSPF as a link state routing protocol with advanced features, designed as an alternative to RIP. ● Highlight its scalability and suitability for networks of any size.

		● Mention OSPFv2 as the version still in use today and OSPFv3 developed for IPv6. ● Describe the concept of "Hello" and "Dead" intervals to detect network status and failures. ● Discuss how OSPFv2 routers use LSAs to advertise routing topology to local routers in the same area. ● Discuss how OSPFv2 determines the best route based on the bandwidth of links along the path to the destination. ● Explain the concept of mask inversion and its usage in OSPFv2. ● Define the concept of areas in OSPF and their benefits in dividing the network topology. ● Compare single-area OSPF and multi-area OSPF, highlighting advantages and disadvantages. ● Be prepared to discuss the implication of the real world scenario presented at the beginning of class to network types and devices. There are specific prompts that you should ask learners to reflect on to apply this concept to the real world scenario.
5 min	**Lesson Closure**	● For this lesson, spend just a few minutes reminding the learners what the key ”take-aways'' were from the lesson and what they should do to prepare for the next module. Be cognizant that this module is very challenging for most learners. Focus on reviewing how routers make routing decisions based on the destination address found in each data packet. The destination address is compared to the entries in the router’s routing table which results in the router deciding on which the appropriate interface is to send the data packet out on to arrive at the next “hop” or final destination. ● You will be able to use the data collected in the pulse check to help with the lesson closure. Remind those learners that reported being in the “red zone” to take advantage of office-hours. ● Recommend that the learners ensure they submit all of the assignments on-time to ensure the appropriate credit is provided to them. ● Recommend that the students read-ahead and come prepared for the next lesson. ● Q&A
	Additional Time Filler (if needed)	● Kahoot ● Discuss interview prep and questioning ● Use breakout rooms for additional lab practice ● Continue Real World Scenario Conversation

Share Your Experience

Cybersecurity is a challenging field and learners need to stay motivated and engaged. To learners, you are not only a subject matter expert but also a role model and an inspiration. Consider sharing your personal experience in these areas:

- Describe a situation where you had to design or configure a routing network to optimize performance and security. What were the challenges you faced, and how did you address them? What lessons did you learn from that experience?
- Share an example of a complex routing issue you encountered in your career. How did you troubleshoot and diagnose the problem? What steps did you take to resolve it, and how did it impact the overall network's functionality and security?
- Describe a scenario where you had to mitigate a routing-related security threat or vulnerability. How did you identify the issue and implement countermeasures to protect the network? What were the key takeaways from this experience in terms of maintaining secure routing practices?