

# Instructor Guide

## Computer Networking Fundamentals

### LESSON: Subnetting

#### Before you Begin

As you may already know, subnetting may be one of the most challenging concepts and activities for our learners throughout the entire extended program. Many of them are not familiar with other numbering systems such as binary or hexadecimal. A review of the decimal system works may aid in explaining other numbering systems. While some instructors greatly appreciate this module, you may want to maintain a high-level overview as it will be easy for learners to find themselves in the “red zone” if you dive too deep at this point. It is crucial that learners understand the purpose of subnetting and understand the process. 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 explore the concepts of numbering systems in networking, including decimal, binary, and hexadecimal. They will understand the advantages and disadvantages of binary and hexadecimal systems in terms of compactness, hardware implementation, and error detection. The lesson will delve into subnetting, which involves dividing a large network into smaller subnetworks for efficient IP address management and faster packet delivery. Learners will grasp the importance of the octet boundary in subnetting and the limitations of using IPv4 address classes. The lesson will cover network configuration per user, including selecting appropriate subnet masks, determining network ranges and broadcast addresses, and optimizing network management through variable-length subnet masking (VLSM). Additionally, learners will explore address planning, documentation, and the use of DHCP for dynamic address assignment. The lesson will conclude with an understanding of the role of routers, switches, and gateways in network address assignment and packet forwarding.

## Objectives

- Define the differences between decimal, binary, and hexadecimal numbering systems and their usage in communication and networking.
- Apply binary and hexadecimal numbering systems to convert values between these systems and decimal.
- Evaluate the advantages and disadvantages of using binary and hexadecimal numbering systems in networking and communication.
- Explain the purpose of subnetting.
- Describe how IP addresses and subnet masks operate.
- Summarize how IP addresses and subnet masks work together.
- Define Classless Inter-Domain Routing (CIDR) notation.
- Apply the CIDR notation method to subnet a given IP address range.
- Illustrate how subnetting is crucial to creating effective address schemes that are perfectly tailored to the network topology.
- Explain the concept of Variable Length Subnet Masking (VLSM).
- Describe the network planning process and the considerations that must be made for an optimal design.

## Lesson Activities and Teaching Strategies

Estimated Time	Lesson Portion	Directions
2 min	<b>Career Outcomes</b>	<ul style="list-style-type: none"><li>● Remind learners about the Career Outcomes module to ensure that they know that the materials are available and to complete the assigned modules.</li></ul>

	<b>Content Reminder</b>	<ul style="list-style-type: none"> <li>• This module will help the learners do the following: <ul style="list-style-type: none"> <li>○ Provide foundation for a pathway to a career in the cyber field.</li> <li>○ Understand all of the support available from Career Outcomes.</li> <li>○ Explore positions in the cybersecurity field.</li> </ul> </li> <li>• The Career Outcomes module can be found in week 2 of Computer Networking Fundamentals.</li> <li>• Students can reach out to their SSM for questions and help if they need it.</li> </ul>
5 min	<b>Lesson Opener:</b> Subnetting	<ul style="list-style-type: none"> <li>• Introduce learners to the concept of subnetting networks.</li> </ul>
5 min	<b>Real World Scenario:</b> Subnetting	<ul style="list-style-type: none"> <li>• 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.</li> </ul>
25 min	<b>Cyber Uncovered:</b> Number Systems	<ul style="list-style-type: none"> <li>• Explain the concept of numbering systems and their role in representing IP addresses and that three different numbering systems can be used to represent IP addresses: decimal, binary, and hexadecimal.</li> <li>• Introduce the decimal system, based on the digits 0-9 and known as the base-10 numeral system.</li> <li>• Explain the binary system, consisting of only two numbers: 0 and 1. Emphasize its significance in computer communication and its base-2 numeral system.</li> <li>• Introduce the hexadecimal system, consisting of 16 characters (0-9 and A-F). Discuss its use as an alternative representation to binary and its base-16 numeral system.</li> <li>• Explain the positional notation method for number representation and demonstrate the function for calculating a number's value in any base using its digits and positions.</li> <li>• Explain the simplicity of converting from binary to hexadecimal due to the base comparison. Teach the three-step process: grouping binary digits, converting each group to hex, and merging the results.</li> <li>• Mention historical counting systems like base-6, base-8, and base-12, and their relevance in measurements.</li> </ul>
5 min	<b>Break</b>	<ul style="list-style-type: none"> <li>• 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.</li> </ul>
25 min	<b>Cyber Uncovered:</b>	<ul style="list-style-type: none"> <li>• Define subnetting as dividing a large network into smaller subnetworks for efficient IP address management and faster packet delivery and highlight the benefits of subnetting.</li> </ul>

	Subnetting Overview	<ul style="list-style-type: none"> <li>● Explain the challenges of large broadcast domains, leading to high network traffic and performance issues.</li> <li>● Discuss the significance of the octet boundary in subnetting, dividing the network address into subnets based on the number of bits used for the network and host portions.</li> <li>● Explore the practical benefits of subnetting, such as efficient IP address management, improved network efficiency, and effective traffic filtration.</li> <li>● 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.</li> </ul>
25 min	<b>Cyber Uncovered:</b> CIDR Notation	<ul style="list-style-type: none"> <li>● Highlight the issue of wasted addresses in organizations due to the incompatibility of IPv4 address classes with the number of hosts.</li> <li>● Illustrate how CIDR enables greater flexibility in IP address assignment and allocation.</li> <li>● Demonstrate a specific CIDR subnetting example, emphasizing the process of borrowing bits from the host portion to create smaller subnetworks.</li> <li>● Discuss the concept of subnetting classless networks and the impact of borrowing host bits on the number of subnetworks and hosts per subnet.</li> <li>● Encourage learners to consider the consequences of creating too many subnet masks by borrowing an excessive number of host bits.</li> <li>● 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.</li> </ul>
25 min	<b>Cyber Skills:</b> Subnetting Case Studies	<ul style="list-style-type: none"> <li>● There is no lab for this module so spend time demonstrating the process of subnetting using the case studies.</li> <li>● Demonstrate the first case study and walk learners through your problem solving skills.</li> <li>● For the other two case studies, spend more time on the demonstration encouraging student engagement. Ask if any learners are able to work through some of the steps in the process and share with the class.</li> </ul>
20 min	<b>Lab:</b>	<ul style="list-style-type: none"> <li>● Remind learners to use this lab to practice and apply the concepts they have learned throughout the day.</li> </ul>

	Understanding Subnetting and Subnet Masks	<ul style="list-style-type: none"> <li>• Learners will receive direct feedback on their lab in order to properly assess their knowledge and determine where they might need additional assistance.</li> </ul>
5 min	<b>Pulse Check</b>	<ul style="list-style-type: none"> <li>• 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.</li> </ul>
5 min	<b>Break</b>	<ul style="list-style-type: none"> <li>• 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.</li> </ul>
20 min	<b>Cyber Uncovered: VLSM</b>	<ul style="list-style-type: none"> <li>• Explain the concept of VLSM as a method for subnetting networks and further subnetting the subnets.</li> <li>• Illustrate the subsequent VLSM subnetting process applied to each network, creating additional subnets.</li> <li>• Highlight the benefits of VLSM when CIDR alone provides more unused addresses than necessary for a single network.</li> <li>• 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.</li> </ul>
15 min	<b>Cyber Uncovered: Network Address Scheme Design</b>	<ul style="list-style-type: none"> <li>• Explain the importance of a well-designed network and the need for proper address planning.</li> <li>• Discuss the configuration considerations for clients, servers, routers, switches, and gateways.</li> <li>• Explain the use of DHCP for dynamic address assignment to clients as well as the use of static addresses to servers, routers, switches, and gateways.</li> <li>• 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.</li> </ul>
15 min	<b>Real World Scenario Network Addressing Scheme</b>	<ul style="list-style-type: none"> <li>• There is no lab for this module so spend time demonstrating the process of subnetting using the case studies.</li> <li>• 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.</li> <li>• Work through with the class the process of subnetting the existing network</li> </ul>

		<ul style="list-style-type: none"> <li>• Diagram the results so the learners can visualize how the network will be designed post-subnetting.</li> </ul>
5 min	<b>Midpoint Course Survey</b>	<ul style="list-style-type: none"> <li>• This is the first time that a learner is asked to complete a midpoint survey. Future surveys will require less time for the learners to complete in class.</li> <li>• Encourage learners to provide honest and constructive feedback about their learning experience.</li> </ul>
3 min	<b>Discussion Board</b>	<ul style="list-style-type: none"> <li>• Allocate a few minutes on the Review Discussion Board Slides and how it impacts students' final grades.</li> </ul>
10 min	<b>Lesson Closure</b>	<ul style="list-style-type: none"> <li>• 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. Recommend practicing binary to decimal conversions to strengthen their understanding on how to subnet networks.</li> <li>• 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.</li> <li>• Recommend that the learners ensure they submit all of the assignments on-time to ensure the appropriate credit is provided to them.</li> <li>• Recommend that the students read-ahead and come prepared for the next lesson.</li> <li>• Q&amp;A</li> </ul>
	<b>Additional Time Filler (if needed)</b>	<ul style="list-style-type: none"> <li>• Kahoot</li> <li>• Discuss interview prep and questioning</li> <li>• Use breakout rooms for additional lab practice</li> <li>• Continue Real World Scenario Conversation</li> </ul>

## 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:

- Share your personal experience with subnetting and how it has impacted your career in computer networking. How has subnetting contributed to your understanding of network architecture and security?
- Reflect on a specific subnetting challenge or project you encountered in your career. How did you approach it, and what were the lessons learned from that experience? How did subnetting play a role in finding a solution?