

Module 5: Number Systems

Instructor Materials

Introduction to Networks v7.0
(ITN)



Instructor Materials – Module 5 Planning Guide

This PowerPoint deck is divided in two parts:

- Instructor Planning Guide
 - Information to help you become familiar with the module
 - Teaching aids
- Instructor Class Presentation
 - Optional slides that you can use in the classroom
 - Begins on slide # 8

Note: Remove the Planning Guide from this presentation before sharing with anyone.

For additional help and resources go to the Instructor Home Page and Course Resources for this course. You also can visit the professional development site on netacad.com, the official Cisco Networking Academy Facebook page, or Instructor Only FB group.

What to Expect in this Module

- To facilitate learning, the following features within the GUI may be included in this module:

Feature	Description
Animations	Expose learners to new skills and concepts.
Videos	Expose learners to new skills and concepts.
Check Your Understanding(CYU)	Per topic online quiz to help learners gauge content understanding.
Interactive Activities	A variety of formats to help learners gauge content understanding.
Syntax Checker	Small simulations that expose learners to Cisco command line to practice configuration skills.
PT Activity	Simulation and modeling activities designed to explore, acquire, reinforce, and expand skills.

What to Expect in this Module (Cont.)

- To facilitate learning, the following features may be included in this module:

Feature	Description
Hands-On Labs	Labs designed for working with physical equipment.
Class Activities	These are found on the Instructor Resources page. Class Activities are designed to facilitate learning, class discussion, and collaboration.
Module Quizzes	Self-assessments that integrate concepts and skills learned throughout the series of topics presented in the module.
Module Summary	Briefly recaps module content.

Check Your Understanding

- Check Your Understanding activities are designed to let students quickly determine if they understand the content and can proceed, or if they need to review.
- Check Your Understanding activities **do not** affect student grades.
- There are no separate slides for these activities in the PPT. They are listed in the notes area of the slide that appears before these activities.

Module 5: Activities

What activities are associated with this module?

Page #	Activity Type	Activity Name	Optional?
5.1.2	Video	Converting Between Binary and Decimal Numbering Systems	Recommended
5.1.4	Check Your Understanding	Binary Number System	Recommended
5.1.6	Activity	Binary to Decimal Conversions	Recommended
5.1.9	Activity	Decimal to Binary Conversions	Recommended
5.1.10	Activity	Binary Game	Recommended
5.2.2	Video	Converting Between Hexadecimal and Decimal Numbering Systems	Recommended
5.2.5	Check Your Understanding	Hexadecimal Numbering System	Recommended

Module 5: Best Practices

Prior to teaching Module 5, the instructor should:

- Review the activities and assessments for this module.
- Try to include as many questions as possible to keep students engaged during classroom presentation.

Topic 5.1

- Give your students plenty of practice and additional exercises until they have mastered the binary numbering system.
- Ask the students or have a class discussion
 - What kinds of tips or tricks have you learned to help remember the conversion process between binary and decimal?

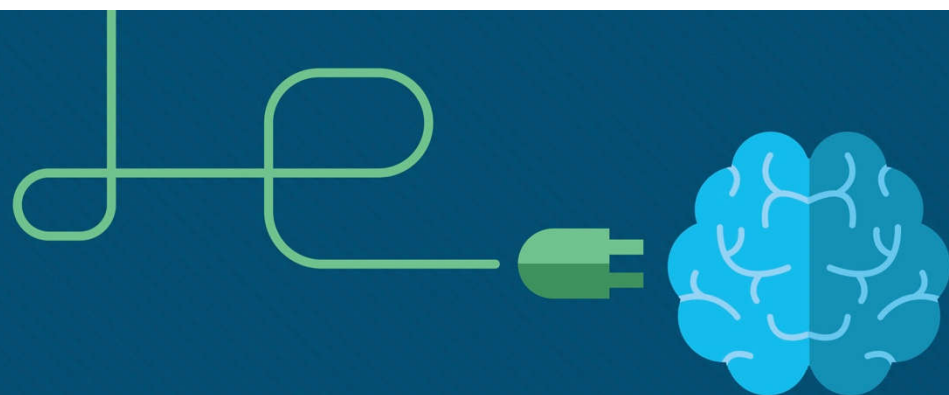
Topic 5.2

- Give your students plenty of practice and additional exercises until they have mastered the hexadecimal numbering system.
- Ask the students or have a class discussion
 - What kinds of tips or tricks have you learned to help remember the conversion process between hexadecimal and decimal?



Module 5: Number Systems

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Module Objectives

Module Title: Number Systems

Module Objective: Calculate numbers between decimal, binary, and hexadecimal systems.

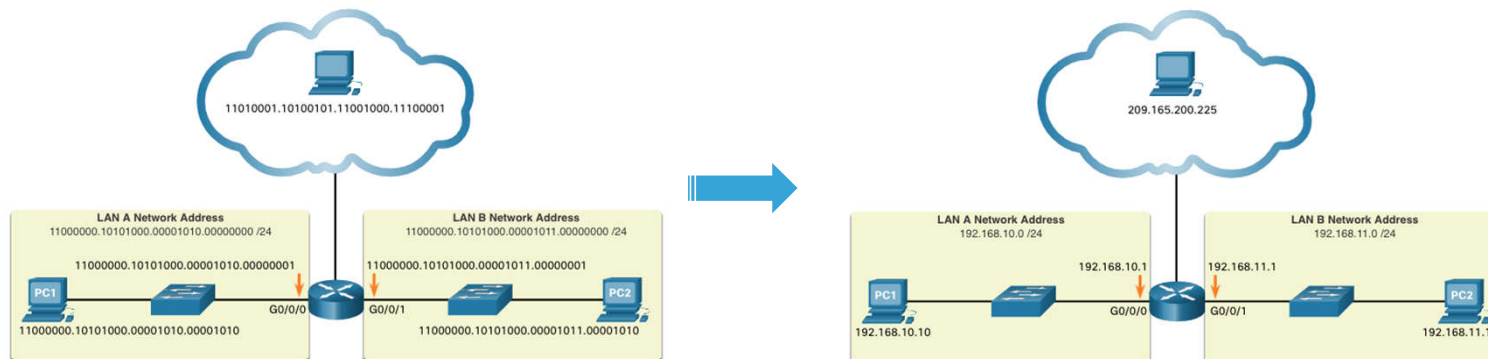
Topic Title	Topic Objective
Binary Number System	Calculate numbers between decimal and binary systems.
Hexadecimal Number System	Calculate numbers between decimal and hexadecimal systems.

5.1 Binary Number System

Binary Number System

Binary and IPv4 Addresses

- Binary numbering system consists of 1s and 0s, called bits
- Decimal numbering system consists of digits 0 through 9
- Hosts, servers, and network equipment using binary addressing to identify each other.
- Each address is made up of a string of 32 bits, divided into four sections called octets.
- Each octet contains 8 bits (or 1 byte) separated by a dot.
- For ease of use by people, this dotted notation is converted to dotted decimal.



Binary Number System

Video – Convert Between Binary and Decimal Numbering Systems

This video will cover the following:

- Positional notation review
- Powers of 10 review
- Decimal – base 10 numbering review
- Binary – base 2 numbering review
- Convert an IP address in binary to decimal numbering

Binary Number System

Binary Positional Notation

- Positional notation means that a digit represents different values depending on the “position” the digit occupies in the sequence of numbers.
- The decimal positional notation system operates as shown in the tables below.

Radix	10	10	10	10
Position in Number	3	2	1	0
Calculate	(10^3)	(10^2)	(10^1)	(10^0)
Position Value	1000	100	10	1



	Thousands	Hundreds	Tens	Ones
Positional Value	1000	100	10	1
Decimal Number (1234)	1	2	3	4
Calculate	1×1000	2×100	3×10	4×1
Add them up...	1000	+ 200	+ 30	+ 4
Result	1,234			

Binary Number System

Binary Positional Notation (Cont.)

The binary positional notation system operates as shown in the tables below.

Radix	2	2	2	2	2	2	2	2
Position in Number	7	6	5	4	3	2	1	0
Calculate	(2^7)	(2^6)	(2^5)	(2^4)	(2^3)	(2^2)	(2^1)	(2^0)
Position Value	128	64	32	16	8	4	2	1



Positional Value	128	64	32	16	8	4	2	1
Binary Number (11000000)	1	1	0	0	0	0	0	0
Calculate	1x128	1x64	0x32	0x16	0x8	0x4	0x2	0x1
Add Them Up...	128	+ 64	+ 0	+ 0	+ 0	+ 0	+ 0	+ 0
Result	192							

Binary Number System

Convert Binary to Decimal

Convert 11000000.10101000.00001011.00001010 to decimal.

Positional Value	128	64	32	16	8	4	2	1
Binary Number (11000000)	1	1	0	0	0	0	0	0
Calculate	1x128	1x64	0x32	0x16	0x8	0x4	0x2	0x1
Add Them Up...	128	+ 64	+ 0	+ 0	+ 0	+ 0	+ 0	+ 0
								➡ 192
Binary Number (10101000)	1	0	1	0	1	0	0	0
Calculate	1x128	0x64	1x32	0x16	1x8	0x4	0x2	0x1
Add Them Up...	128	+ 0	+ 32	+ 0	+ 8	+ 0	+ 0	+ 0
								➡ 168
Binary Number (00001011)	0	0	0	0	1	0	1	1
Calculate	0x128	0x64	0x32	0x16	1x8	0x4	1x2	1x1
Add Them Up...	0	+ 0	+ 0	+ 0	+ 8	+ 0	+ 2	+ 1
								➡ 11
Binary Number (00001010)	0	0	0	0	1	0	1	0
Calculate	0x128	0x64	0x32	0x16	1x8	0x4	1x2	0x1
Add Them Up...	0	+ 0	+ 0	+ 0	+ 8	+ 0	+ 2	+ 0
								➡ 10

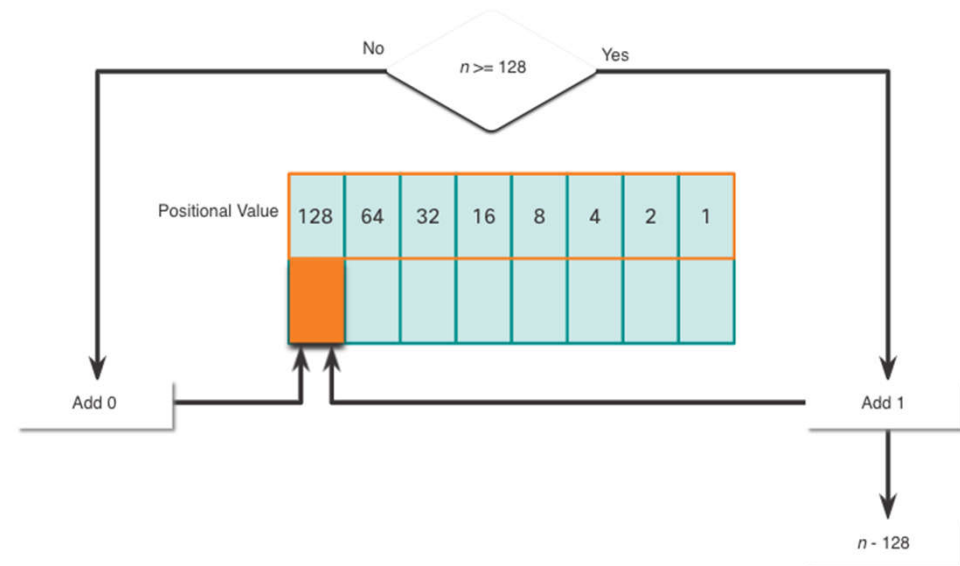
192.168.11.10

Binary Number System

Decimal to Binary Conversion

The binary positional value table is useful in converting a dotted decimal IPv4 address to binary.

- Start in the 128 position (the most significant bit). Is the decimal number of the octet (n) equal to or greater than 128?
- If no, record a binary 0 in the 128 positional value and move to the 64 positional value.
- If yes, record a binary 1 in the 128 positional value, subtract 128 from the decimal number, and move to the 64 positional value.
- Repeat these steps through the 1 positional value.



Binary Number System

Decimal to Binary Conversion Example

- Convert decimal 168 to binary

Is $168 > 128$?

- Yes, enter 1 in 128 position and subtract 128 ($168-128=40$)

Is $40 > 64$?

- No, enter 0 in 64 position and move on

Is $40 > 32$?

- Yes, enter 1 in 32 position and subtract 32 ($40-32=8$)

Is $8 > 16$?

- No, enter 0 in 16 position and move on

Is $8 > 8$?

- Equal. Enter 1 in 8 position and subtract 8 ($8-8=0$)

No values left. Enter 0 in remaining binary positions

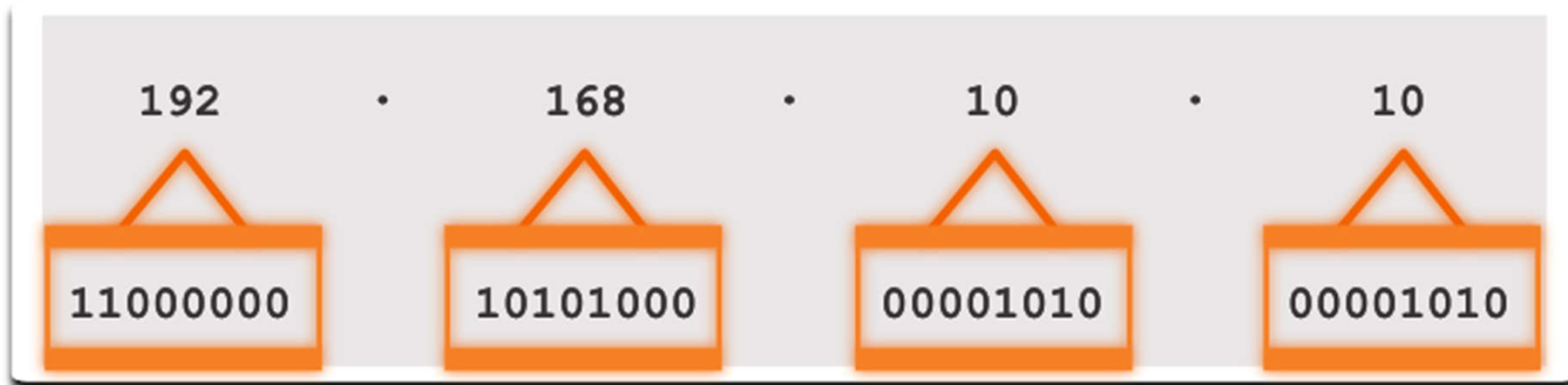
128	64	32	16	8	4	2	1
1	0	1	0	1	0	0	0

Decimal 168 is written as 10101000 in binary

Binary Number System

IPv4 Addresses

- Routers and computers only understand binary, while humans work in decimal. It is important for you to gain a thorough understanding of these two numbering systems and how they are used in networking.



5.2 Hexadecimal Number System

Hexadecimal Number System

Hexadecimal and IPv6 Addresses

- To understand IPv6 addresses, you must be able to convert hexadecimal to decimal and vice versa.
- Hexadecimal is a base sixteen numbering system, using the digits 0 through 9 and letters A to F.
- It is easier to express a value as a single hexadecimal digit than as four binary bit.
- Hexadecimal is used to represent IPv6 addresses and MAC addresses.

Decimal
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

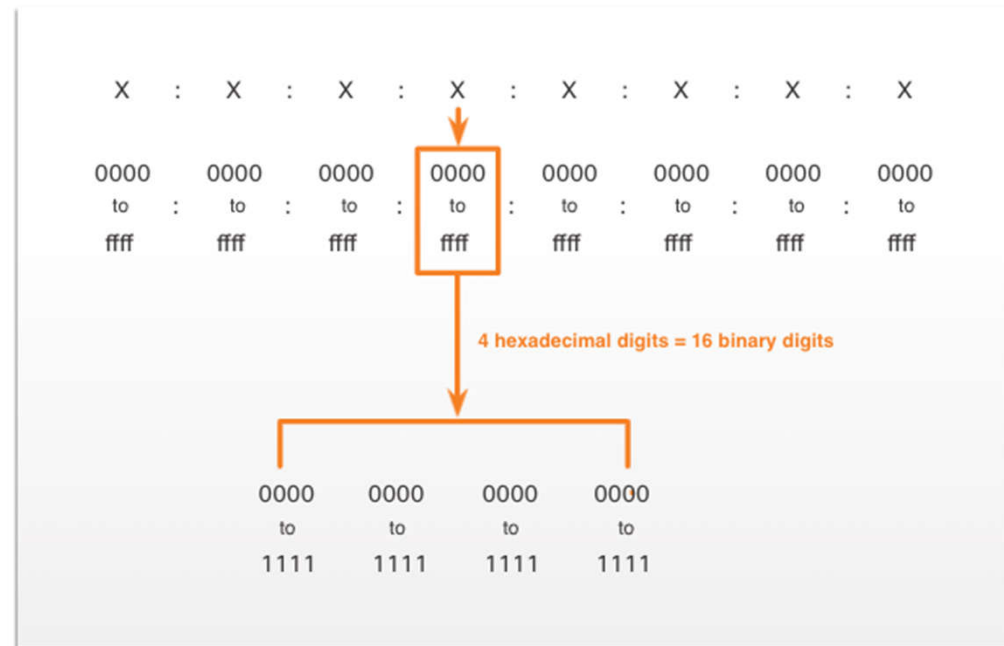
Binary
0000
0001
0010
0011
0100
0101
0110
0111
1000
1001
1010
1011
1100
1101
1110
1111

Hexadecimal
0
1
2
3
4
5
6
7
8
9
A
B
C
D
E
F

Hexadecimal Number System

Hexadecimal and IPv6 Addresses (Cont.)

- IPv6 addresses are 128 bits in length. Every 4 bits is represented by a single hexadecimal digit. That makes the IPv6 address a total of 32 hexadecimal values.
- The figure shows the preferred method of writing out an IPv6 address, with each X representing four hexadecimal values.
- Each four hexadecimal character group is referred to as a hextet.



Hexadecimal Number System

Video – Converting Between Hexadecimal and Decimal Numbering Systems

This video will cover the following:

- Characteristics of the Hexadecimal System
- Convert from Hexadecimal to Decimal
- Convert from Decimal to Hexadecimal

Hexadecimal Number System

Decimal to Hexadecimal Conversions

Follow the steps listed to convert decimal numbers to hexadecimal values:

- Convert the decimal number to 8-bit binary strings.
- Divide the binary strings in groups of four starting from the rightmost position.
- Convert each four binary numbers into their equivalent hexadecimal digit.

For example, 168 converted into hex using the three-step process.

- 168 in binary is 10101000.
- 10101000 in two groups of four binary digits is 1010 and 1000.
- 1010 is hex A and 1000 is hex 8, so 168 is A8 in hexadecimal.

Hexadecimal Number System

Hexadecimal to Decimal Conversions

Follow the steps listed to convert hexadecimal numbers to decimal values:

- Convert the hexadecimal number to 4-bit binary strings.
- Create 8-bit binary grouping starting from the rightmost position.
- Convert each 8-bit binary grouping into their equivalent decimal digit.

For example, D2 converted into decimal using the three-step process:

- D2 in 4-bit binary strings is 1101 and 0010.
- 1101 and 0010 is 11010010 in an 8-bit grouping.
- 11010010 in binary is equivalent to 210 in decimal, so D2 is 210 in decimal

5.3 Module Practice and Quiz

What did I learn in this module?

- Binary is a base two numbering system that consists of the numbers 0 and 1, called bits.
- Decimal is a base ten numbering system that consists of the numbers 0 through 9.
- Binary is what hosts, servers, and networking equipment uses to identify each other.
- Hexadecimal is a base sixteen numbering system that consists of the numbers 0 through 9 and the letters A to F.
- Hexadecimal is used to represent IPv6 addresses and MAC addresses.
- IPv6 addresses are 128 bits long, and every 4 bits is represented by a hexadecimal digit for a total of 32 hexadecimal digits.
- To convert hexadecimal to decimal, you must first convert the hexadecimal to binary, then convert the binary to decimal.
- To convert decimal to hexadecimal, you must first convert the decimal to binary and then the binary to hexadecimal.

Module 5: Number Systems

New Terms and Commands

- dotted decimal notation
- positional notation
- base 10
- base 16
- radix
- octet
- hextet

