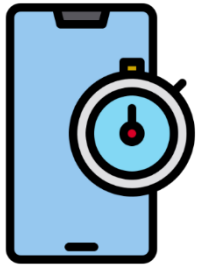
Number Systems

Dmytro Zubov, PhD
dmytro.zubov@ucentralasia.org

Naryn, 1:31pm, Sept 29, 2022

Lessons learnt last time



- Purpose of the Physical Layer: Describe the purpose and functions of the physical layer in the network
- Physical Layer Characteristics: Describe characteristics of the physical layer
- Copper Cabling: Identify the basic characteristics of copper cabling
- UTP Cabling: Explain how UTP cable is used in Ethernet networks
- Fiber-Optic Cabling: Describe fiber optic cabling and its main advantages over other media
- Wireless Media: Connect devices using wired and wireless media

What we gonna discuss today?

- Binary Number System: Calculate numbers between decimal and binary systems
- Hexadecimal Number System: Calculate numbers between decimal and hexadecimal systems

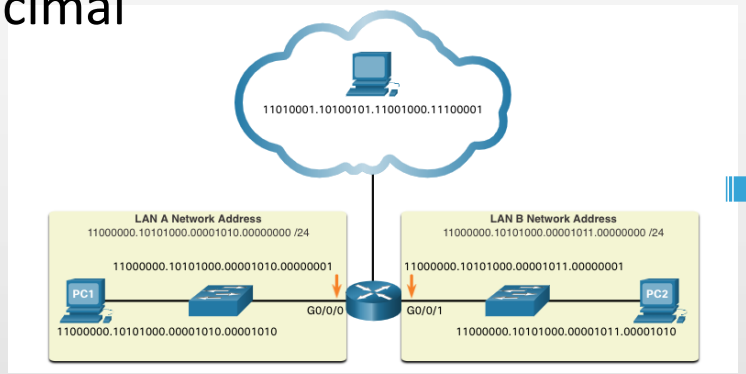
Binary Number System

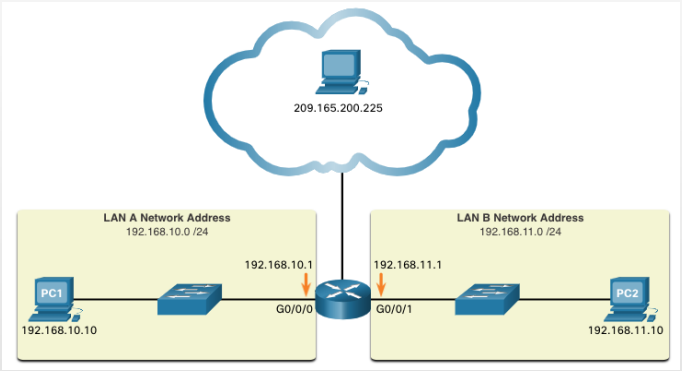
- Binary Number System

Binary Number System

192.168.1.35

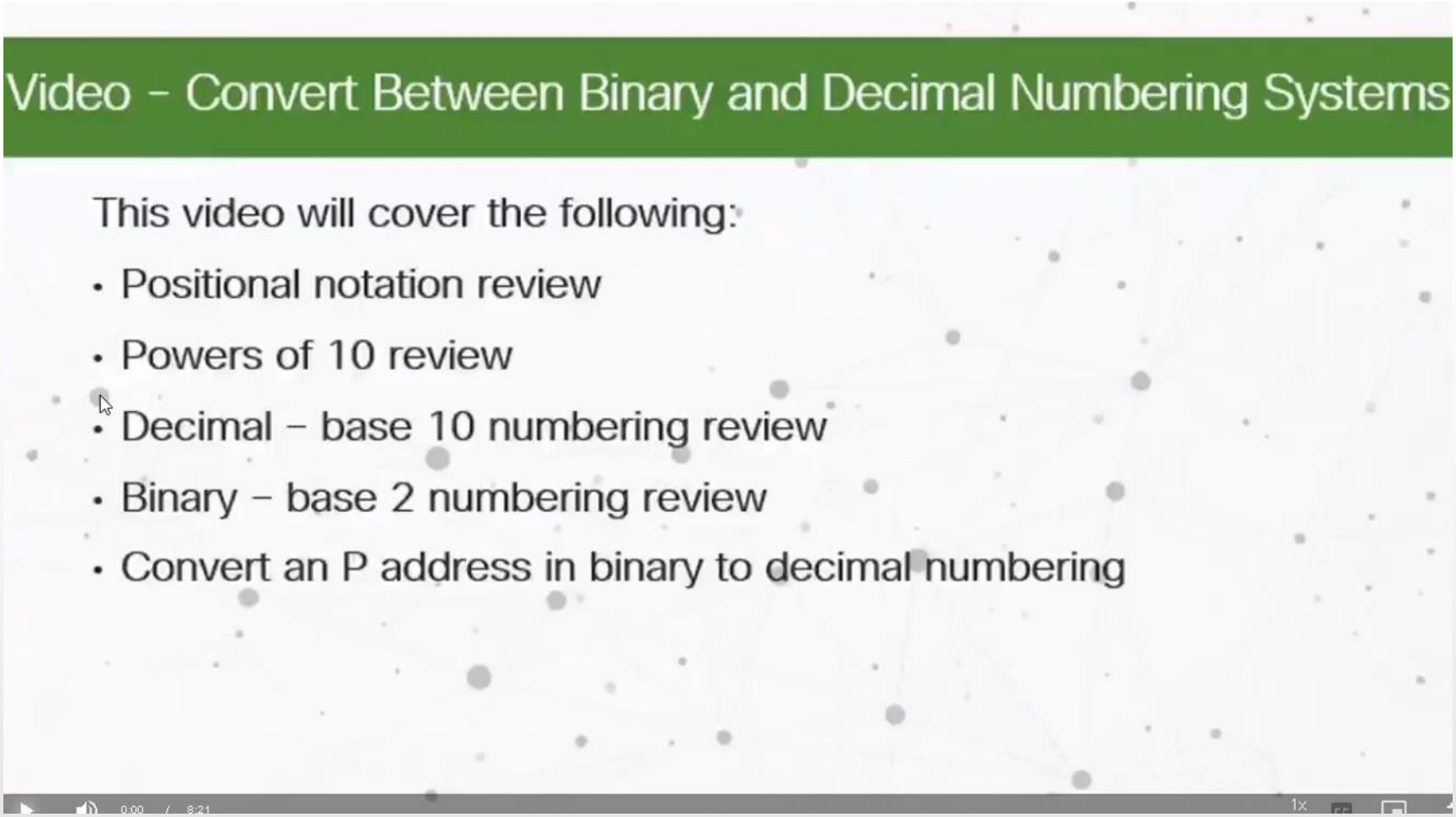
- Binary and IPv4 Addresses
  - Binary numbering system consists of 1s and 0s, called bits
  - Decimal numbering system consists of digits 0 through 9
  - Hosts, servers, and network equipment using binary addressing to identify each other
  - Each address is made up of a string of 32 bits, divided into 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

- Convert Between Binary and Decimal Numbering Systems



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 x 1000	2 x 100	3 x 10	4 x 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

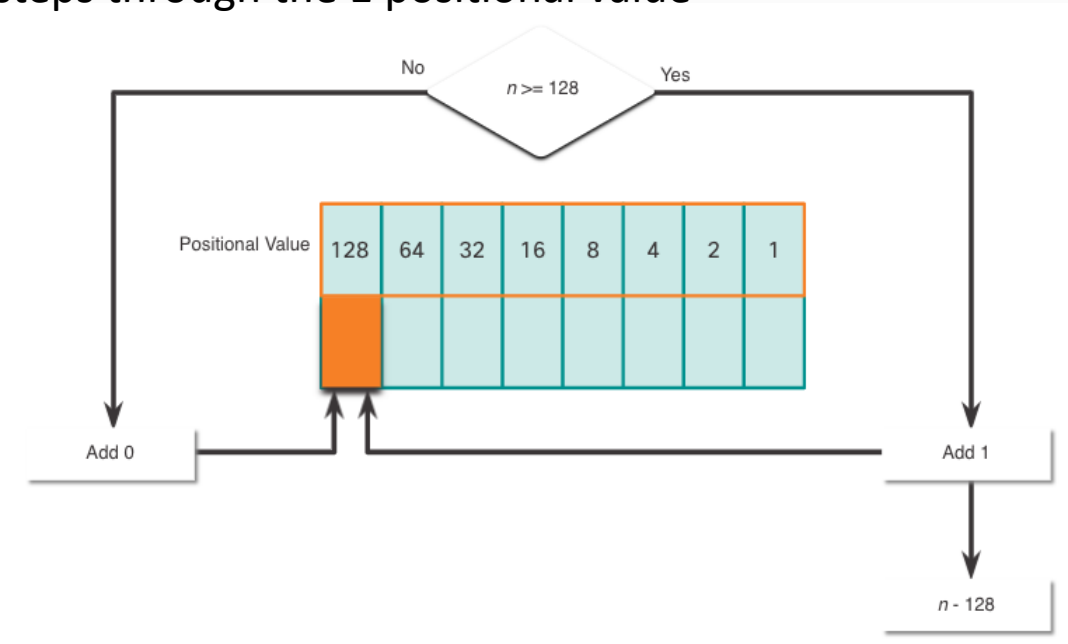
Positional Value	128	64	32	16	8	4	2	1	
Binary Number (11000000)	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	
Calculate	1x128	1x64	0x32	0x16	0x8	0x4	0x2	0x1	
Add Them Up…	128	+ 64	+ 0	+ 0	+ 0	+ 0	+ 0	+ 0	→ 192
Binary Number (10101000)	**1**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	
Calculate	1x128	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

  - 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: Convert decimal 168 to binary (168d=10101000b)

  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

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

Hexadecimal Number System

- Hexadecimal Number System

Hexadecimal Number System

- Hexadecimal and IPv6 Addresses

  - To understand IPv6 addresses, we 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

Hexadecimal Number System

- Hexadecimal and IPv6 Addresses (cont.)

Decimal	Binary	Hexadecimal
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

Hexadecimal Number System

- Hexadecimal and IPv6 Addresses (cont.)

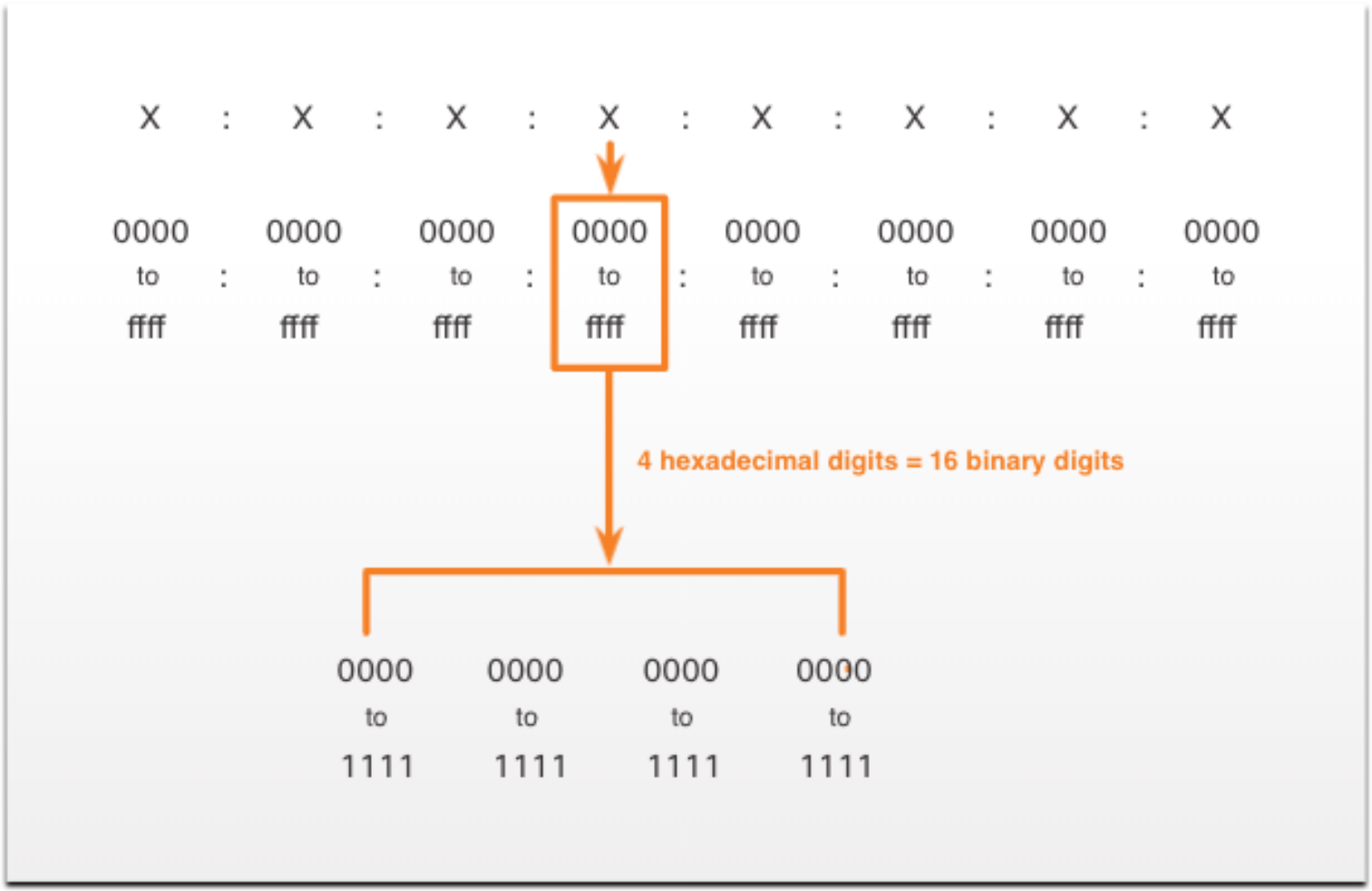
  - IPv6 addresses are 128 bits in length. Every 4 bits is represented by a single hexadecimal digit. That makes the IPv6 address a total of 32 hexadecimal values

  - 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

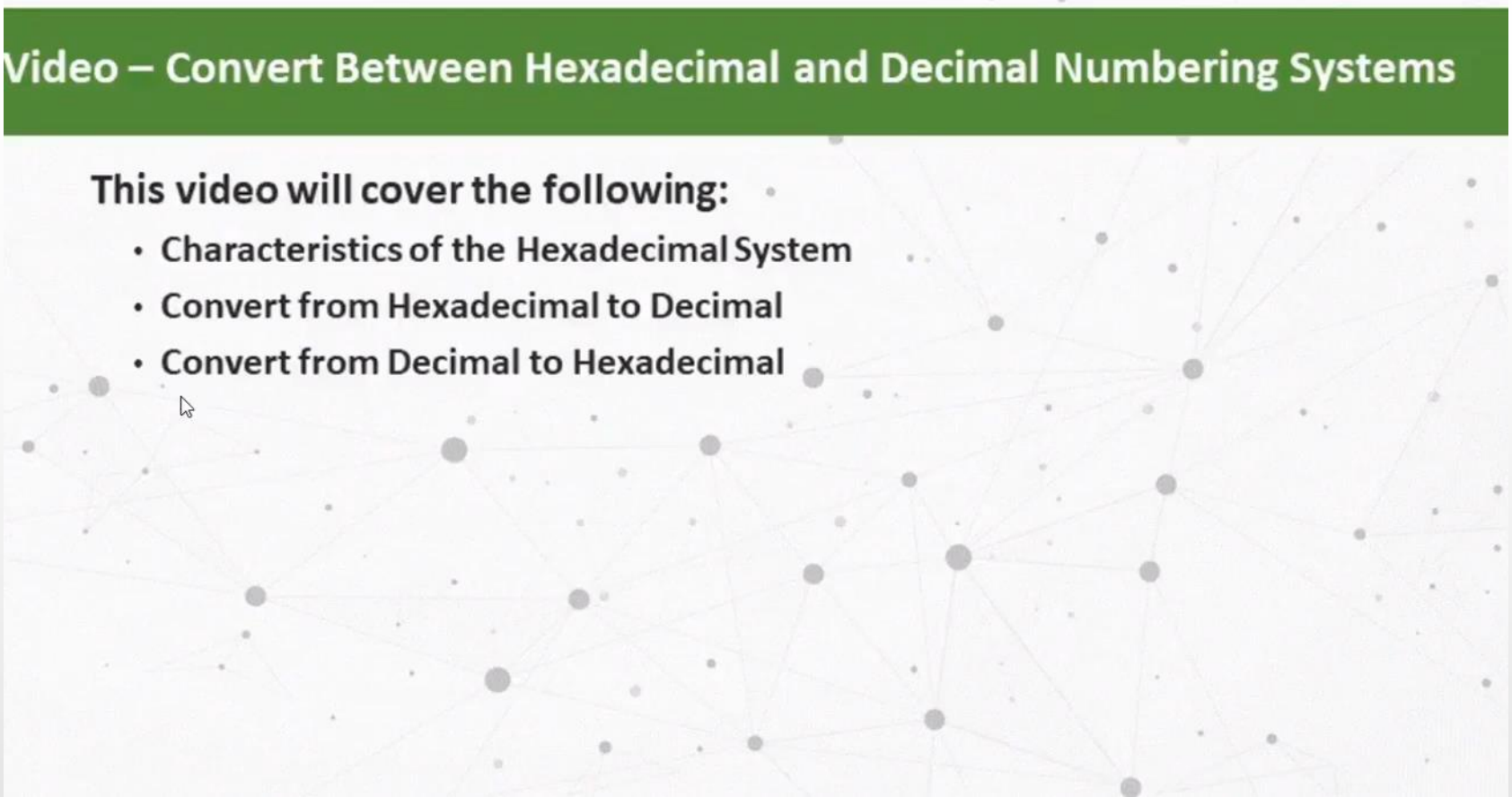
Hexadecimal Number System

- Hexadecimal and IPv6 Addresses (cont.)



Hexadecimal Number System

- Converting Between Hexadecimal and Decimal Numbering Systems



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 1110 and 0010
  - 1110 and 0010 is 11100010 in an 8-bit grouping
  - 11100010 in binary is equivalent to 210 in decimal, so **D2** is **210** is decimal

Do you have any questions or comments?

Thank you
for your attention !

In this presentation:

- Some icons were downloaded from flaticon.com and iconscout.com