

# Binary



# Binary

- Why do we care?
  - Subnetting
  - Access lists
  - Used in many other places

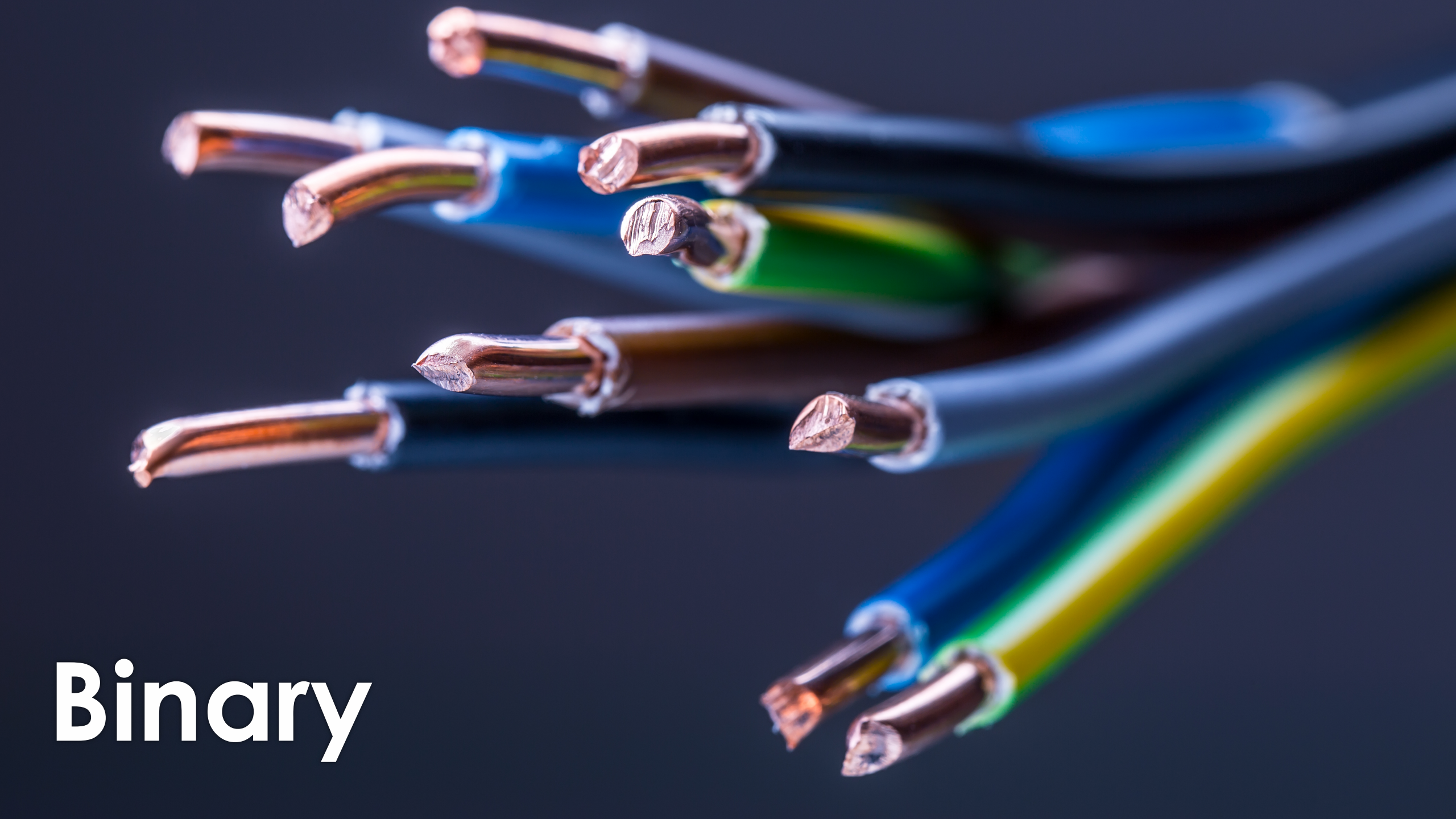


# Joke

- There are only 10 types of people in the world.
- Those that understand binary and those that don't.







**Binary**



# Binary

- All computers function by using a system of switches that can either be on or off
  - Off = 0
  - On = 1
- Binary values = 0 or 1



# Binary

- Cable
  - Either has current or doesn't
  - Binary values = 0 or 1





# Binary



0



# Binary



1







00



10



01



11

# Binary

- 2 states
- 2 cables
- $2 \times 2 = 4$
- Or  $2^2 = 4$





# Binary

- And so on: 4 cables gives 16 binary values:

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

- 2 states and 4 cables:  $2^4 = 16$



# Binary

- 2 states
- 4 cables
- $2 \times 4 = 16$
- Or  $2^4 = 16$





# Binary

- 2 to the power of 0 ( $2^0$ ) = 1
- 2 to the power of 1 ( $2^1$ )
  - which is 2 multiplied together 1 time ( $2 \times 1$ ) = 2
- 2 to the power of 2 ( $2^2$ )
  - which is 2 multiplied together 2 times ( $2 \times 2$ ) = 4
- 2 to the power of 3 ( $2^3$ )
  - which is 2 multiplied together 3 times ( $2 \times 2 \times 2$ ) = 8
- 2 to the power of 4 ( $2^4$ )
  - which is 2 multiplied together 4 times ( $2 \times 2 \times 2 \times 2$ ) = 16



# Binary

- 2 to the power of 5 ( $2^5$ )
  - which is 2 multiplied together 5 times ( $2 \times 2 \times 2 \times 2 \times 2$ ) = 32
- 2 to the power of 6 ( $2^6$ )
  - which is 2 multiplied together 6 times ( $2 \times 2 \times 2 \times 2 \times 2 \times 2$ ) = 64
- 2 to the power of 7 ( $2^7$ )
  - which is 2 multiplied together 7 times ( $2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2$ ) = 128
- 2 to the power of 8 ( $2^8$ )
  - which is 2 multiplied together 8 times ( $2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2$ ) = 256



# A table to remember

Base Exponent	$2^7$	$2^6$	$2^5$	$2^4$	$2^3$	$2^2$	$2^1$	$2^0$
Binary	1	1	1	1	1	1	1	1
Decimal	128	64	32	16	8	4	2	1





# Example 1

- If all binary bits are a one, the binary equivalent of 255 is:

Base Exponent	$2^7$	$2^6$	$2^5$	$2^4$	$2^3$	$2^2$	$2^1$	$2^0$
Binary	1	1	1	1	1	1	1	1
Decimal	128	64	32	16	8	4	2	1

- $128 + 64 + 32 + 16 + 8 + 4 + 2 + 1 = 255$
- Or written this way:
  - 11111111 in binary = 255 in decimal



# Example 2

- What is the binary equivalent of 1 in decimal?

Base Exponent	$2^7$	$2^6$	$2^5$	$2^4$	$2^3$	$2^2$	$2^1$	$2^0$
Binary	0	0	0	0	0	0	0	1
Decimal	<del>128</del>	<del>64</del>	<del>32</del>	<del>16</del>	<del>8</del>	<del>4</del>	<del>2</del>	1

- 1 in binary = 1 in decimal
- Or written this way:
  - 00000001 in binary = 1 in decimal

# Example 3 Question:

- What is the binary equivalent of 192 in decimal?

Base Exponent	$2^7$	$2^6$	$2^5$	$2^4$	$2^3$	$2^2$	$2^1$	$2^0$
Binary	0	0	0	0	0	0	0	0
Decimal	128	64	32	16	8	4	2	1



# Example 3: Answer

- What is the binary equivalent of 192 in decimal:

Base Exponent	$2^7$	$2^6$	$2^5$	$2^4$	$2^3$	$2^2$	$2^1$	$2^0$
Binary	1	1	0	0	0	0	0	0
Decimal	128	64	32	16	8	4	2	1

- $128 + 64 = 192$  in decimal
- Or written this way:
  - 11000000 in binary = 192 in decimal





# Example 4: Question

- What is the binary equivalent of 253 in decimal?

Base Exponent	$2^7$	$2^6$	$2^5$	$2^4$	$2^3$	$2^2$	$2^1$	$2^0$
Binary	0	0	0	0	0	0	0	0
Decimal	128	64	32	16	8	4	2	1



# Example 4: Answer

- What is the binary equivalent of 253 in decimal:

Base Exponent	$2^7$	$2^6$	$2^5$	$2^4$	$2^3$	$2^2$	$2^1$	$2^0$
Binary	1	1	1	1	1	1	0	1
Decimal	128	64	32	16	8	4	2	1

- $128 + 64 + 32 + 16 + 8 + 4 + 1 = 253$  in decimal
- Or written this way:
  - 11111101 in binary = 253 in decimal



# IP Address Example

- An IPv4 address is an address used to uniquely identify a device on an IP network
- 4 octets in length
- Value in each octet is 8 bits (8 cables) in the range 0 to 255

10. 129. 16. 123 (decimal)

00001010.10000001.00010000.01111011 (binary)



# IP Address Example

- IP address represented in both binary and decimal:

10. 129. 16. 123 (decimal)

00001010.10000001.00010000.01111011 (binary)





# IP Address Example

- IP address represented in both binary and decimal:

10. 129. 16. 123 (decimal)  
00001010.10000001.00010000.01111011 (binary)

Base Exponent	$2^7$	$2^6$	$2^5$	$2^4$	$2^3$	$2^2$	$2^1$	$2^0$
Binary	0	0	0	0	1	0	1	0
Decimal	128	64	32	16	8	4	2	1

- $8 + 2 = 10$ 
  - 00001010 in binary = 10 in decimal



# IP Address Example

- IP address represented in both binary and decimal:

10. 129. 16. 123 (decimal)  
00001010.10000001.00010000.01111011 (binary)

Base Exponent	$2^7$	$2^6$	$2^5$	$2^4$	$2^3$	$2^2$	$2^1$	$2^0$
Binary	1	0	0	0	0	0	0	1
Decimal	128	64	32	16	8	4	2	1

- $128 + 1 = 129$ 
  - 10000001 in binary = 129 in decimal



# IP Address Example

- IP address represented in both binary and decimal:

10. 129. 16. 123 (decimal)  
00001010.10000001.00010000.01111011 (binary)

Base Exponent	$2^7$	$2^6$	$2^5$	$2^4$	$2^3$	$2^2$	$2^1$	$2^0$
Binary	0	0	0	1	0	0	0	0
Decimal	128	64	32	16	8	4	2	1

- $16 = 16$ 
  - 00001000 in binary = 16 in decimal



# IP Address Example

- IP address represented in both binary and decimal:

10. 129. 16. 123 (decimal)  
00001010.10000001.00010000.01111011 (binary)

Base Exponent	$2^7$	$2^6$	$2^5$	$2^4$	$2^3$	$2^2$	$2^1$	$2^0$
Binary	0	1	1	1	1	0	1	1
Decimal	128	64	32	16	8	4	2	1

- $64 + 32 + 16 + 8 + 2 + 1 = 123$ 
  - 01111011 in binary = 123 in decimal





# Calculators

- Binary, Decimal and Hexadecimal Converter:
  - <https://davidbombal.com/binary-decimal-hexadecimal-converter/>
- Visual Binary to Binary:
  - <https://davidbombal.com/decimal-to-binary/>
- Subnet Calculator:
  - <https://davidbombal.com/subnetting-concepts-calculator/>



# Test yourself

- Unlimited tests:
  - <https://davidbombal.com/free-quiz/>
  - <https://davidbombal.com/binary-to-decimal-quiz/>
  - <https://davidbombal.com/decimal-to-binary-quiz/>



# Binary

