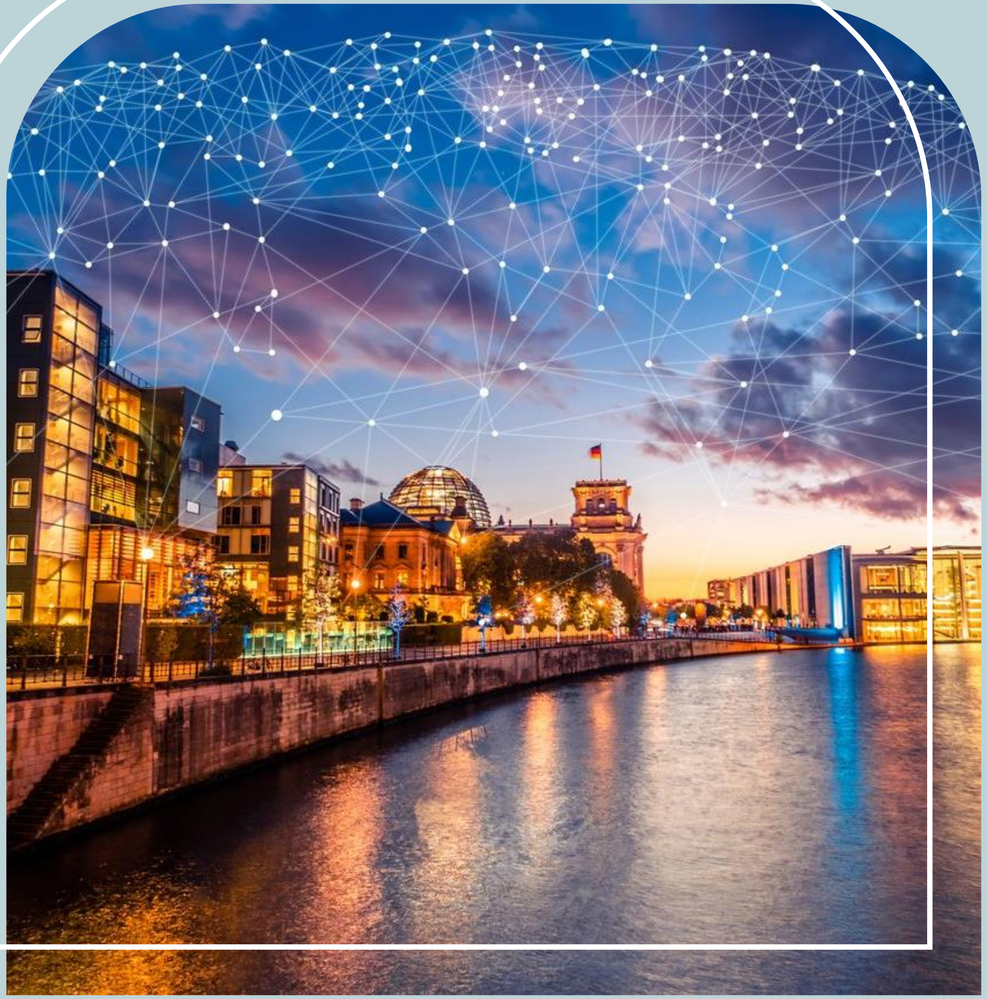
BLACK TOWER ACADEMY

Intro to Computer Networking



Objectives

01 What makes up a Computer Network?

02 Be able to identify a Private or Public Network.

03 The Purpose of Networks in our society.

04 Be able to configure a computer on a network manually.

05 Be able to identify and introduce Network Protocols.

06 Be able to summarize the OSI Model.

Value

01 Not everyone has the opportunity to be exposed to the fundamentals.

02 So much of our Modern life relies on Computer Networks. This Empowers you in life and business.

03 Computer Networking is EVERYWHERE.

04 Computer Networking is a NECESSITY.

05 Fills in gaps where books or YouTube videos don’t go.

06 Opportunity to ask questions.

What is a Computer Network?

Style based upon new and innovative technologies of construction, particularly the use of glass, steel, and reinforced concrete.

Computer Networking in Life

Style based upon new and innovative technologies of construction, particularly the use of glass, steel, and reinforced concrete.

Where can you find computer networks?

At home

We all use computer networking at home, from work, to music, to streaming TV, etc.

In business

We all use computer networking at work, to do our jobs

In Public

We use computer networking on the go, Waze, Google Maps, Fast-food orders, Uber, Lyft, and more.

How deep will we cover?

An Empty Cup

Industry Terms

Teh Maths

We are only going to outline what is necessary as fundamental understanding.

The math keeps going deeper, if you wish (as part of your studies) to keep going, it will be a good thing.

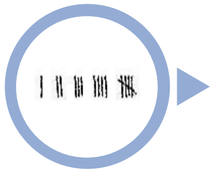
Math Quotes

“And, believe me, if I were again beginning my studies, I should follow the advice of Plato and start with mathematics.” ~ Galileo Galilei

“Without mathematics, there’s nothing you can do. Everything around you is mathematics. Everything around you is numbers.” ~ Shakuntala Devi

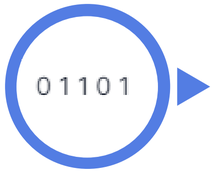
Base Numbering Systems

in Computer Networking



Tally Marks

Just 1 mark for each one



Binary

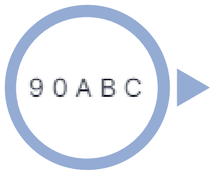
Base 2

Decimal

Base 10

Base 62

Alpha Numeric

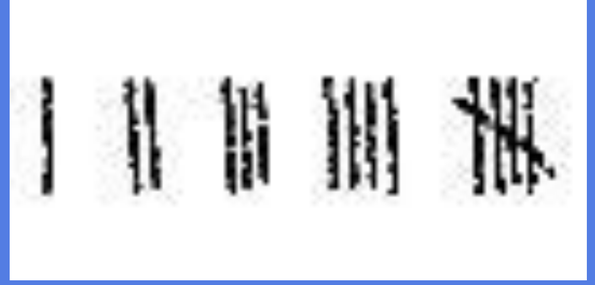


Hexadecimal

Base 16

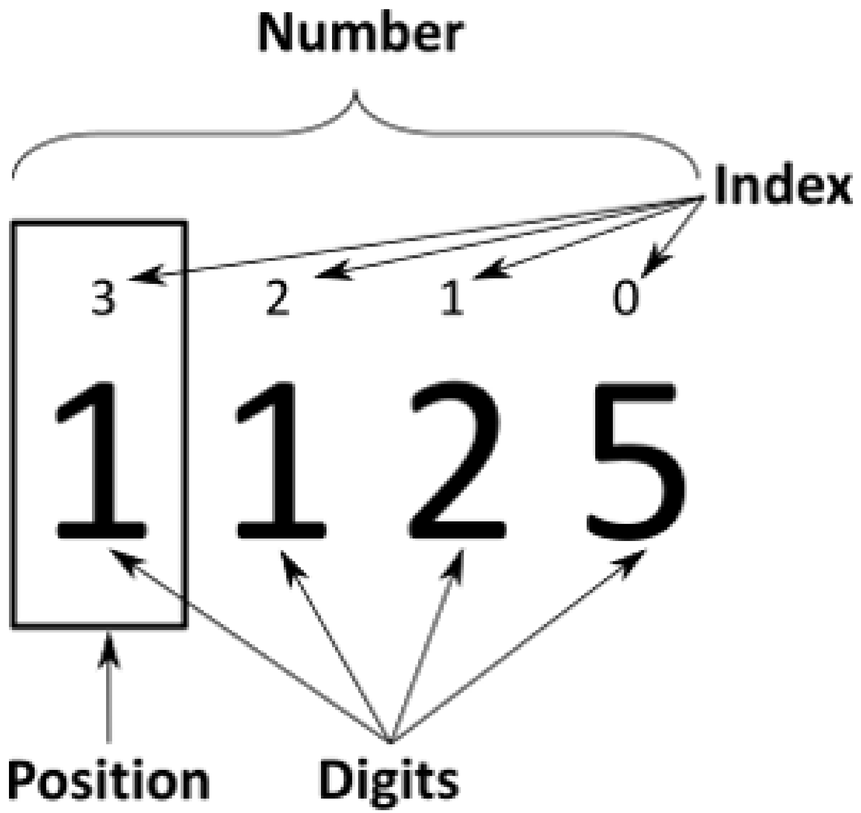
Base 64

Alpha Numeric + Special Characters



Tally Marks

Decimal – Base 10



Positional Notation

https://en.wikipedia.org/wiki/Positional_notation

0123456789abcdef

Hexadecimal – Base 16

Hex = 6

Decimal = 10

Hex + Decimal = 16

Hexadecimal = 16

Combining 0-9 with A-F you get the range of a Hexadecimal digit.

Binary – Base 2

Protip:

0

Computers start counting at zero.

Binary

Name		Character	Positions	Example
Bit	=	0 or 1	Single	1
Byte	=	0 or 1	8 positions	11111111

Binary Counting Orientation using bits

	Most Significant							Least Significant	Totals
Position	7	6	5	4	3	2	1	0	8 bits
Values	128	64	32	16	8	4	2	1	255
Binary	0	0	0	0	0	0	0	0	0
Binary	1	1	1	1	1	1	1	1	255

Binary Counting = 1

	Most Significant							Least Significant	Totals
Position	7	6	5	4	3	2	1	0	8 bits
Values	128	64	32	16	8	4	2	1	255
Binary	0	0	0	0	0	0	0	1	
									Sum
Decimal								1	1

0 + 0 + 0 + 0 + 0 + 0 + 0 + 1 = 1

Binary Counting = 2

	Most Significant							Least Significant	Totals
Position	7	6	5	4	3	2	1	0	8 bits
Values	128	64	32	16	8	4	2	1	255
Binary	0	0	0	0	0	0	1	0	
									Sum
Decimal							2		2

0 + 0 + 0 + 0 + 0 + 0 + 2 + 0 = 2

Binary Counting = 3

	Most Significant							Least Significant	Totals
Position	7	6	5	4	3	2	1	0	8 bits
Values	128	64	32	16	8	4	2	1	255
Binary	0	0	0	0	0	0	1	1	
									Sum
Decimal							2	1	3

0 + 0 + 0 + 0 + 0 + 0 + 2 + 1 = 3

Binary Counting = 4

	Most Significant							Least Significant	Totals
Position	7	6	5	4	3	2	1	0	8 bits
Values	128	64	32	16	8	4	2	1	255
Binary	0	0	0	0	0	1	0	0	
									Sum
Decimal						4	0	0	4

4 + 0 + 0 = 4

Binary Counting = 5

	Most Significant							Least Significant	Totals
Position	7	6	5	4	3	2	1	0	8 bits
Values	128	64	32	16	8	4	2	1	255
Binary	0	0	0	0	0	1	0	1	
									Sum
Decimal						4	0	1	5

4 + 0 + 1 = 5

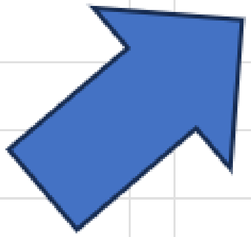
Binary Counting = 9

	Most Significant							Least Significant	Totals
Position	7	6	5	4	3	2	1	0	8 bits
Values	128	64	32	16	8	4	2	1	255
Binary	0	0	0	0	1	0	0	1	
									Sum
Decimal					8			1	9

8 + 0 + 0 + 1 = 9

Binary Counting = 20

	Most Significant							Least Significant	Totals
Position	7	6	5	4	3	2	1	0	8 bits
Values	128	64	32	16	8	4	2	1	255
Binary	0	0	0	1	0	1	0	0	
Decimal				16		4			20



16 + 0 + 4 + 0 + 0 = 20

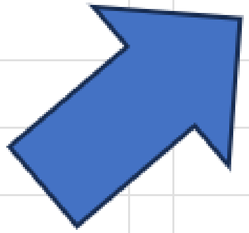
Binary Counting = 43

	Most Significant							Least Significant	Totals
Position	7	6	5	4	3	2	1	0	8 bits
Values	128	64	32	16	8	4	2	1	255
Binary	0	0	1	0	1	0	1	1	
Decimal			32		8		2	1	43

32 + 0 + 8 + 0 + 2 + 1 = 43

Binary Counting = 105

	Most Significant							Least Significant	Totals
Position	7	6	5	4	3	2	1	0	8 bits
Values	128	64	32	16	8	4	2	1	255
Binary	0	1	1	0	1	0	0	1	
Decimal		64	32		8			1	105



64 + 32 + 0 + 8 + 0 + 0 + 1 = 105

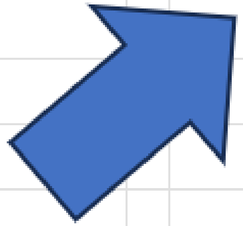
Binary Counting = 233

	Most Significant							Least Significant	Totals
Position	7	6	5	4	3	2	1	0	8 bits
Values	128	64	32	16	8	4	2	1	255
Binary	1	1	1	0	1	0	0	1	
Decimal	128	64	32		8			1	233

128 + 64 + 32 + 0 + 8 + 0 + 0 + 1 = 233

Binary Counting = 255

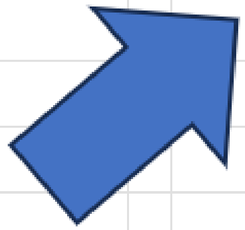
	Most Significant							Least Significant	Totals
Position	7	6	5	4	3	2	1	0	8 bits
Values	128	64	32	16	8	4	2	1	255
Binary	1	1	1	1	1	1	1	1	
Decimal	128	64	32	16	8	4	2	1	255



128 + 64 + 32 + 16 + 8 + 4 + 2 + 1 = 255

Binary Counting = 0

	Most Significant							Least Significant	Totals
Position	7	6	5	4	3	2	1	0	8 bits
Values	128	64	32	16	8	4	2	1	255
Binary	0	0	0	0	0	0	0	0	
Decimal									0



0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 = 0

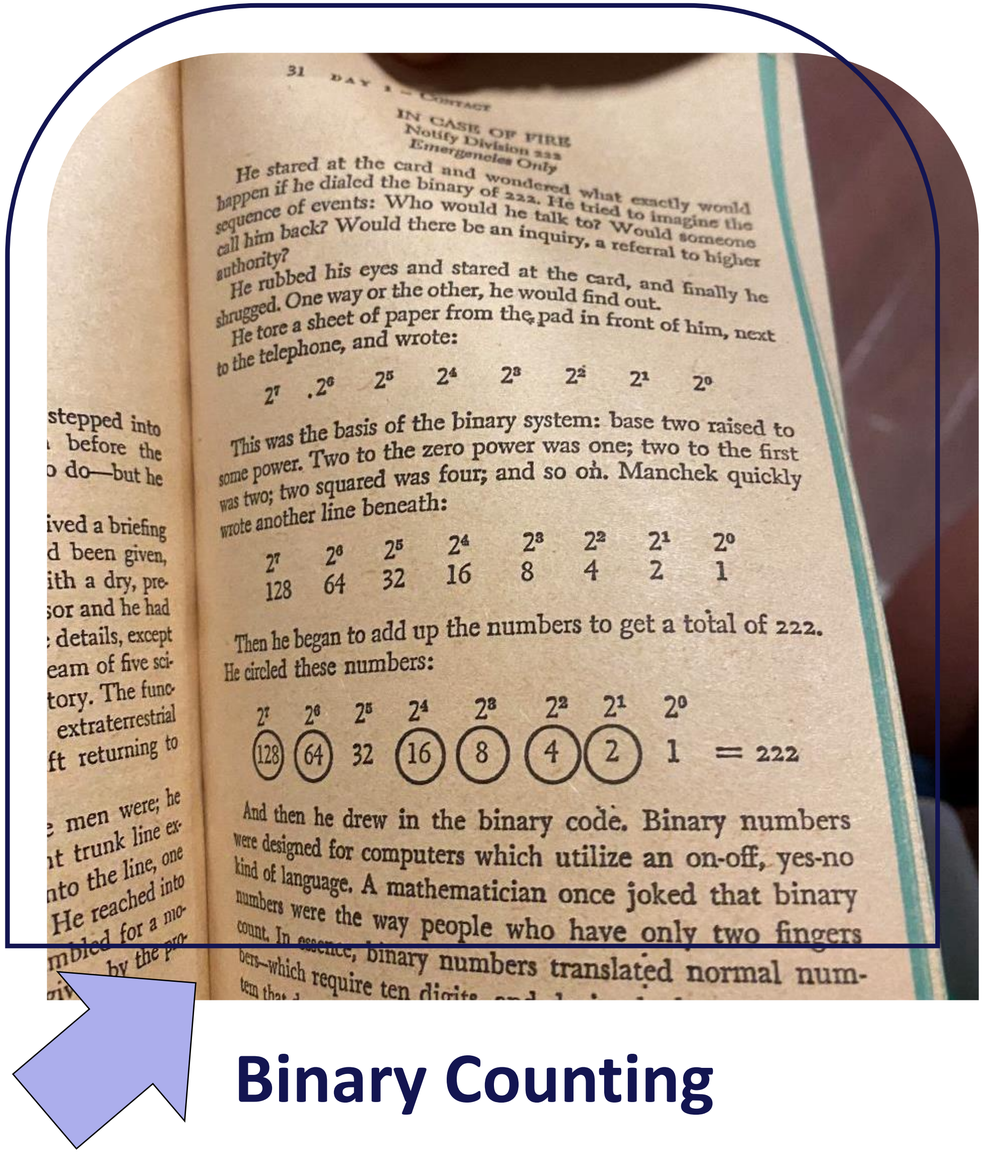
Bit to Byte

Bit	=	a 0 or a 1
8 bit	=	1 Byte

IMPORTANT

Range that 8 bits or 1 byte can represent:

0-255 = 256 in Total



31 DAY 1 — CONTACT

IN CASE OF FIRE
Notify Division 222
Emergencies Only

He stared at the card and wondered what exactly would happen if he dialed the binary of 222. He tried to imagine the sequence of events: Who would he talk to? Would someone call him back? Would there be an inquiry, a referral to higher authority?

He rubbed his eyes and stared at the card, and finally he shrugged. One way or the other, he would find out.

He tore a sheet of paper from the pad in front of him, next to the telephone, and wrote:

2^7 2^6 2^5 2^4 2^3 2^2 2^1 2^0

This was the basis of the binary system: base two raised to some power. Two to the zero power was one; two to the first was two; two squared was four; and so on. Manchek quickly wrote another line beneath:

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

Then he began to add up the numbers to get a total of 222. He circled these numbers:

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
(128)	(64)	32	(16)	(8)	(4)	(2)	1	= 222

And then he drew in the binary code. Binary numbers were designed for computers which utilize an on-off, yes-no kind of language. A mathematician once joked that binary numbers were the way people who have only two fingers count. In essence, binary numbers translated normal numbers—which require ten digits

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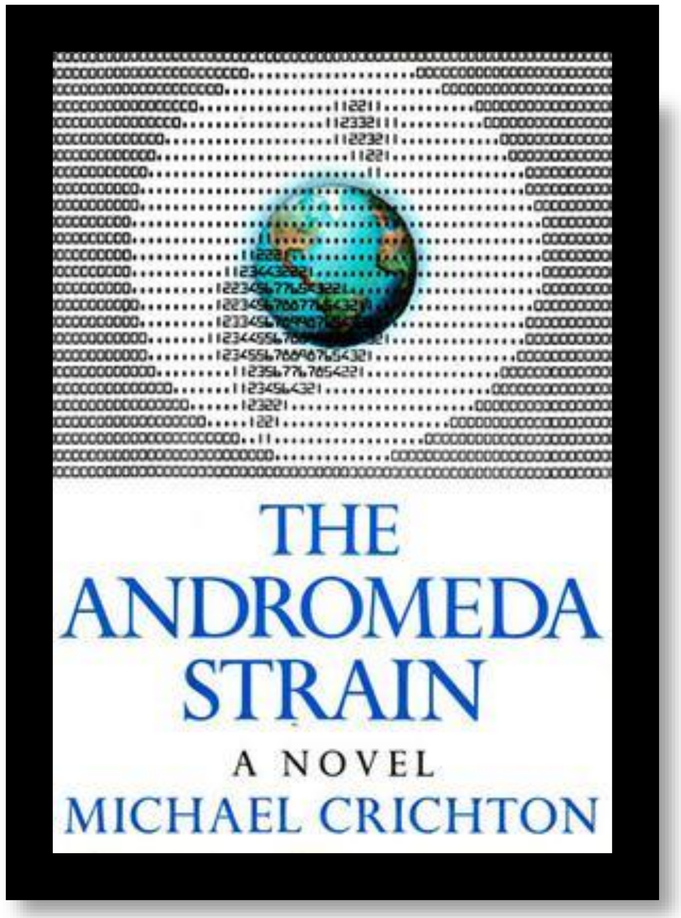
Binary Counting

Andromeda Strain

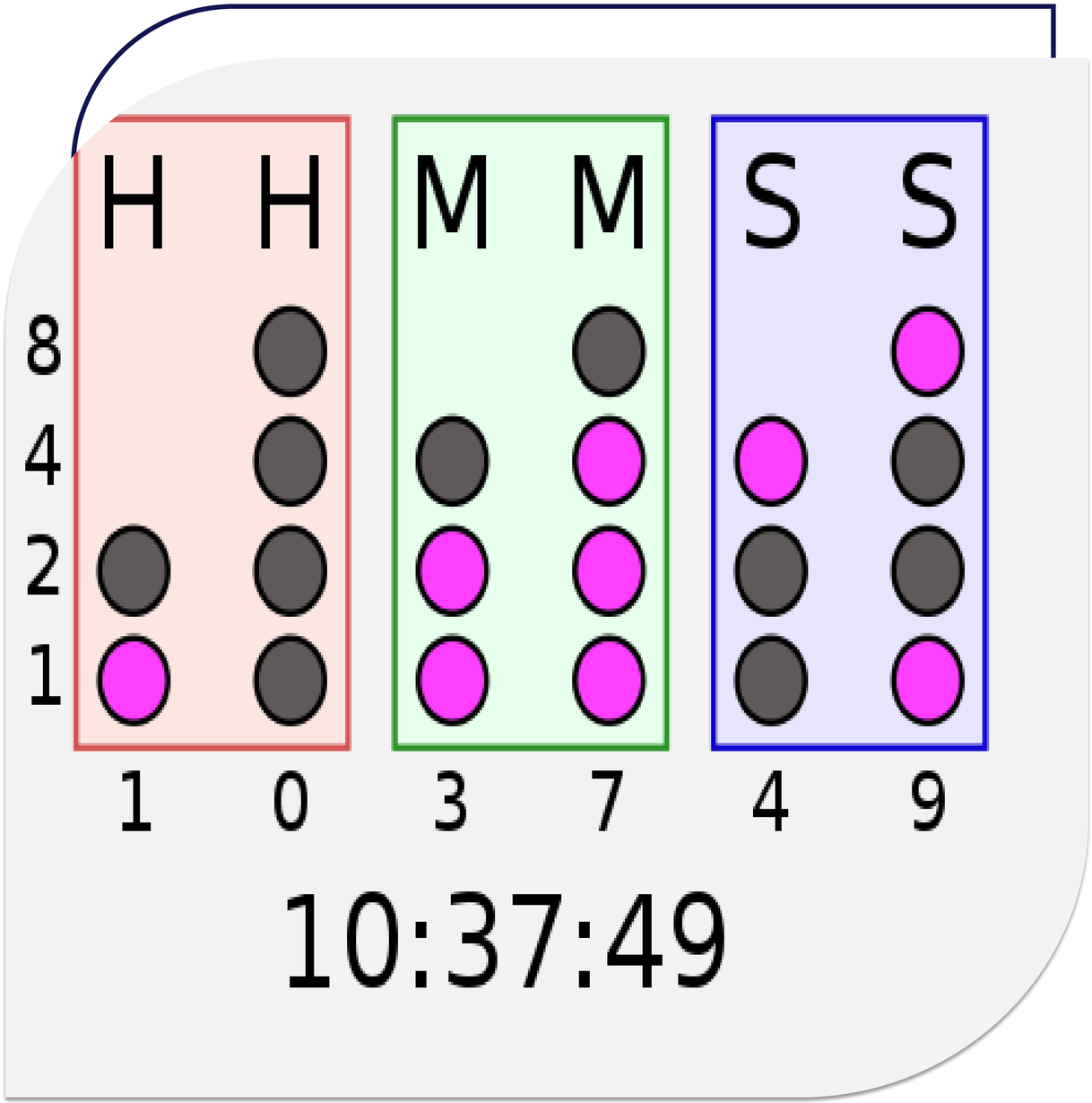


https://en.wikipedia.org/wiki/The_Andromeda_Strain

https://reactjsexample.com/content/images/2017/09/Binary-Clock.gif

Binary Clock Example

While not necessarily a advantage, it is geeky, it is cool, and it is a good way to practice your understanding of counting in binary.



https://en.wikipedia.org/wiki/Binary_clock

Binary Clock Example

Most common binary clocks use six columns of LEDs to represent zeros and ones. Each column represents a single decimal digit, a format known as binary-coded decimal (BCD). The bottom row in each column represents 1 (or 20), with each row above representing higher powers of two, up to 23 (or 8).

Binary Pattern

(Powers of 2)

<Memorize>

0	256
1	512
2	1024
4	2048
8	4096
16	8192
32	16384
64	32768
128	65535

Binary for Network Speeds

Bit	1	
Byte	8	
Kilobyte	1024	Bytes
Megabyte	1,048,576	Bytes
Gigabyte	1,073,741,824	Bytes
Terabyte	1,099,511,627,776	Bytes
Petabyte	1,125,899,906,842,620	Bytes
Exabyte	1,152,921,504,606,840,000	Bytes
Zettabyte	1,180,591,620,717,410,000,000	Bytes
Yottabyte	1,208,925,819,614,620,000,000,000	Bytes

https://en.wikipedia.org/wiki/Byte#History_of_the_conflicting_definitions

1000 or 1024?

Network Speeds and the Law

Decimal vs. Binary

~2.7%

0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ

abcdefghijkmnopqrstuvwxyz

Alpha Numeric – Base 62

URL Shorteners

URL Shorteners convert long URLs into shorter, more manageable ones, which are especially useful for platforms with character limits, like Twitter.

(Base 62 Encoding)

0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ

abcdefghijkmnopqrstuvwxyz

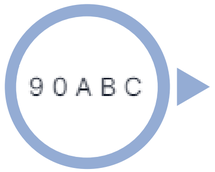
+ /

Alpha Numeric + more – Base 64

Base Numbering Systems in Networking

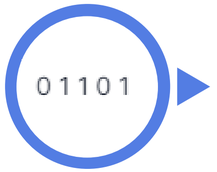
Decimal

Numbers and information presented to end users are presented this way.



Hexadecimal

Concise way of representing binary
Physical / MAC Addresses
Ethernet Frame Types
IPv6 Addresses
Website Certificates
File Signatures
PCAPs
Color Codes for Websites



Binary

IPv4 Addresses
Subnet Masking
Data Transmission
Bitwise Operations
Routing Tables
Much More*

Base 62

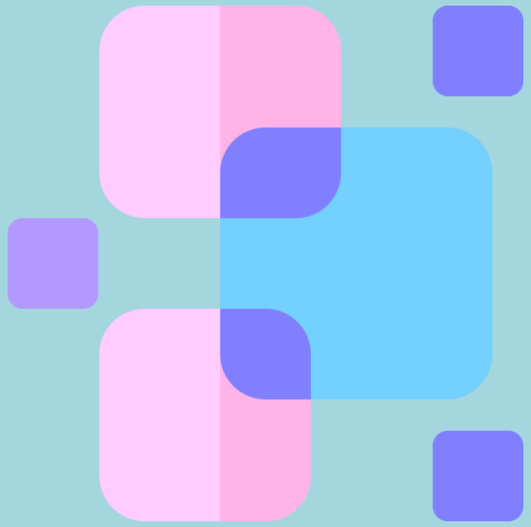
URL Shorteners

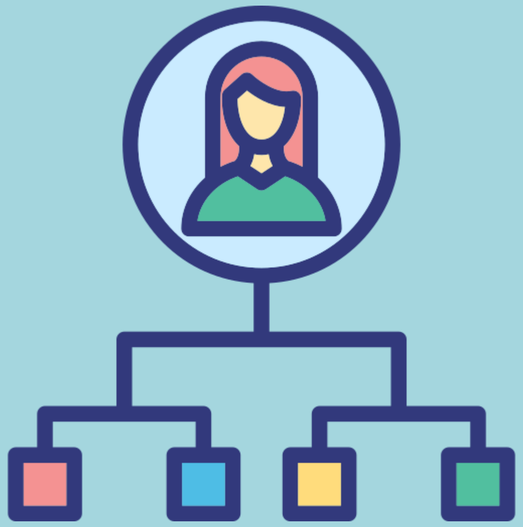
Base 64

QR Codes
Website Cookies
Website Certificates
Email Attachments
More

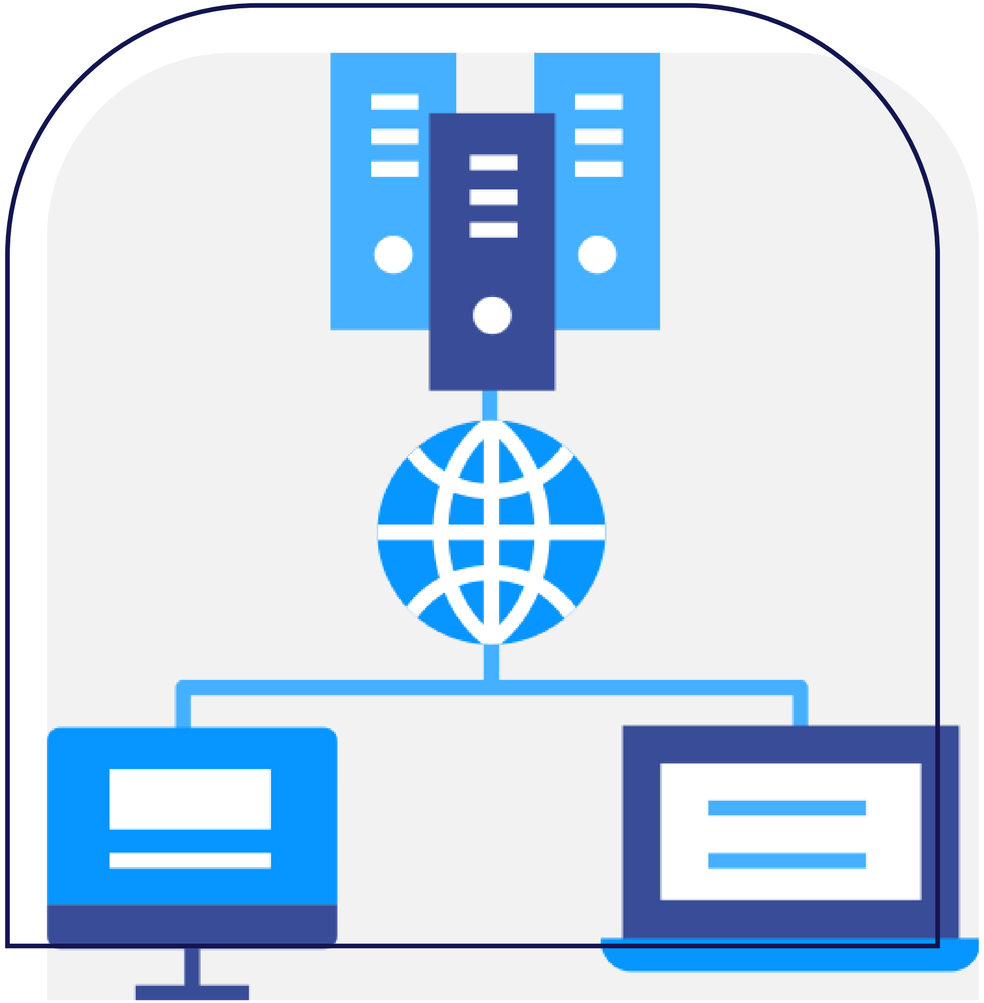
Abstractions

Simplification
Hierarchy/Relationships
Generalizations
Reduction of Overwhelming info





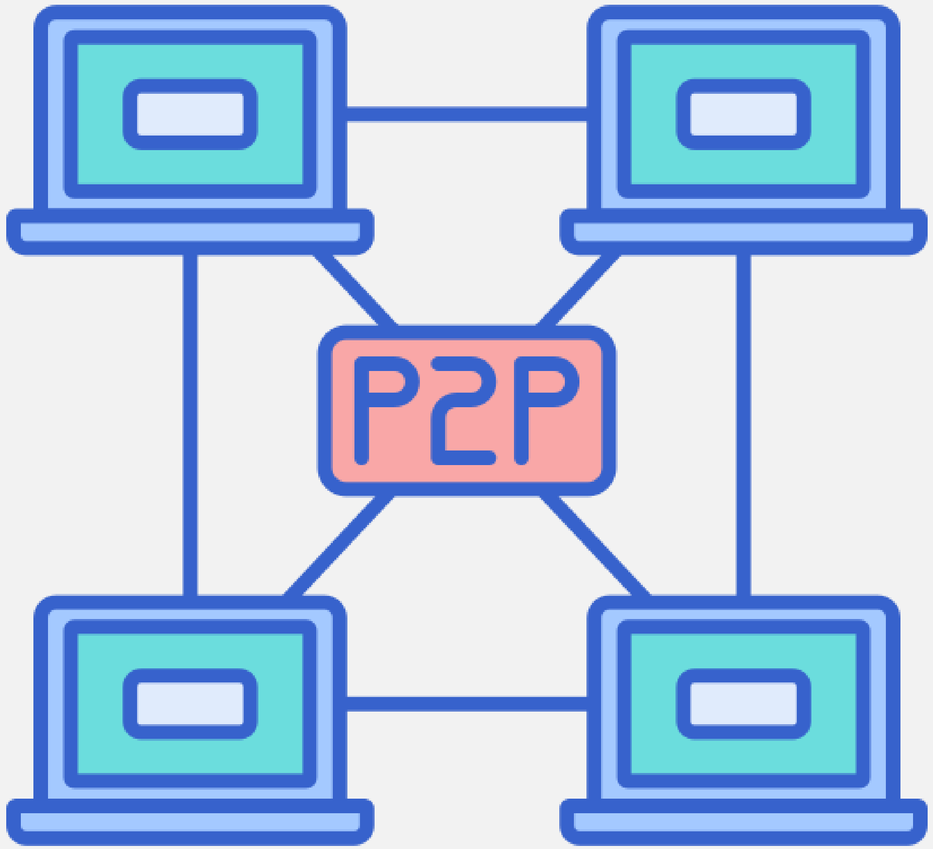
https://www.flaticon.com/free-icons/square
https://www.flaticon.com/free-icons/active-directory"



Client-Server

Network Architecture Model

https://www.flaticon.com/free-icons/client-server

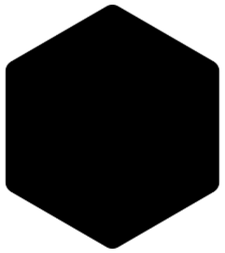


Peer to Peer

Network Architecture Model

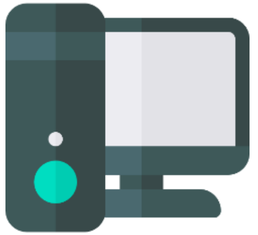
https://www.flaticon.com/free-icons/p2p

Network Terminology



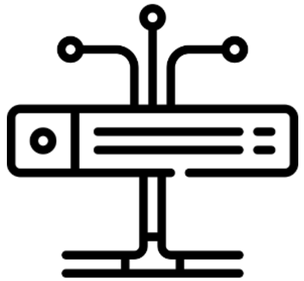
Nodes

A device connected to a network. Could be a Endpoint or a network redistribution point.



Endpoint

A device on a network that terminates communication, such as a Computer, or Server.



Gateway

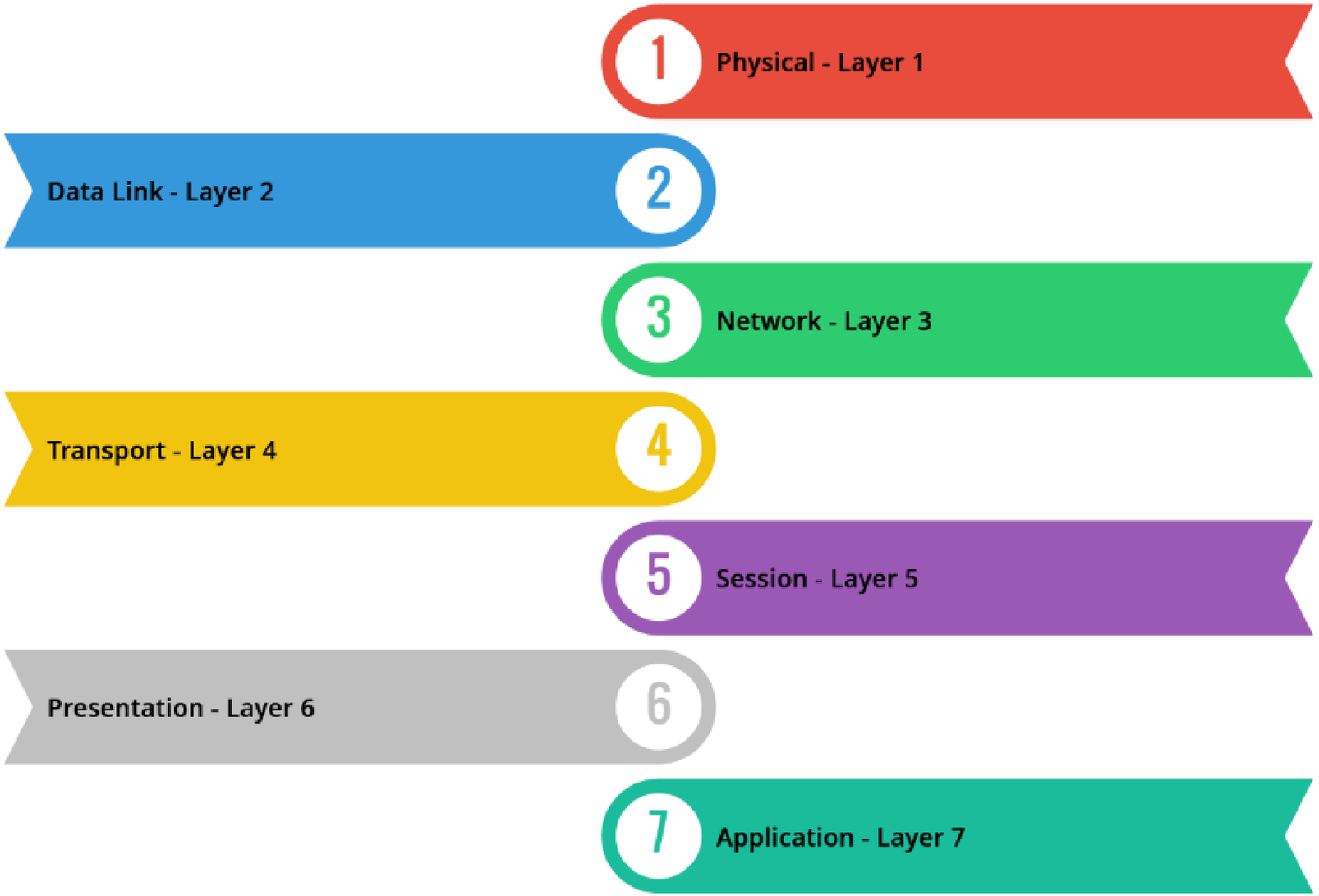
A node that acts as a interface between networks, this has a blended definition with the term Router.

Host

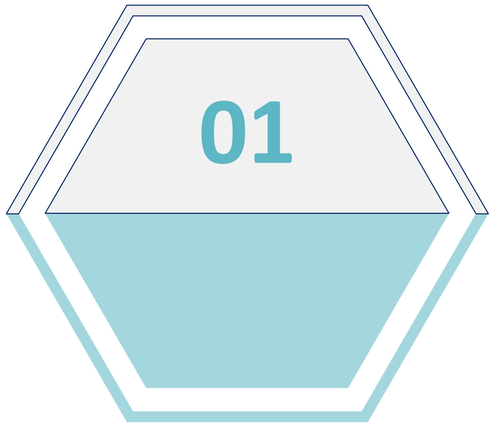
A node that is typically a device which runs applications, such as computers, smartphones, or server.

https://www.flaticon.com/free-icons/node-js
https://www.flaticon.com/free-icons/endpoint
https://www.flaticon.com/free-icons/gateway
https://www.flaticon.com/free-icons/workstation

OSI Model


1
Physical - Layer 1
Data Link - Layer 2
2
3
Network - Layer 3
Transport - Layer 4
4
5
Session - Layer 5
Presentation - Layer 6
6
7
Application - Layer 7

Physical Layer – Layer 1



Layer 1
Physical
Layer

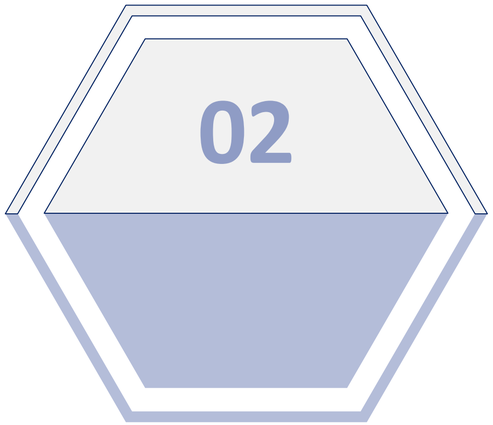
- Phone Cable
- Network Cable
- Fiber Optic Cable
- Coaxial Cable
- Wi-Fi Radio Frequencies
- Laser
- Microwave
- Bluetooth
- Zigbee
- USB
- HDMI
- Etc.

0s and 1s

- true/false
- yes/no
- +/–
- on/off

How does the
information get across?

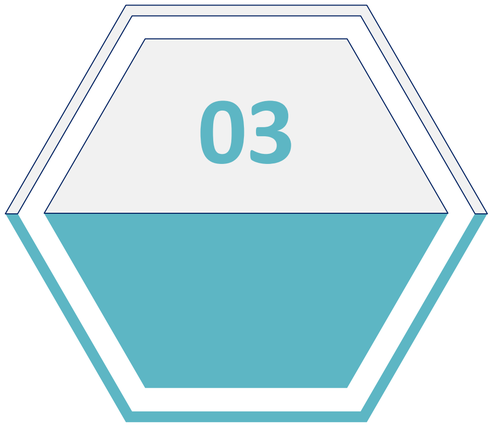
Data Link Layer – Layer 2



Layer 2
Data Link
Layer

- MAC Addresses
- Local Network Communication

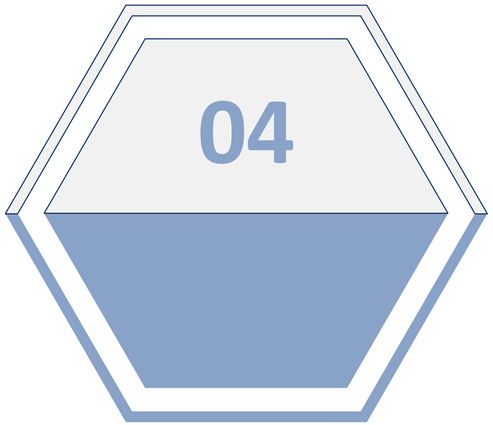
Network Layer – Layer 3



Layer 3
Networking
Layer

- MAC Addresses
- IPv4
- IPv6
- Network to Network Communication

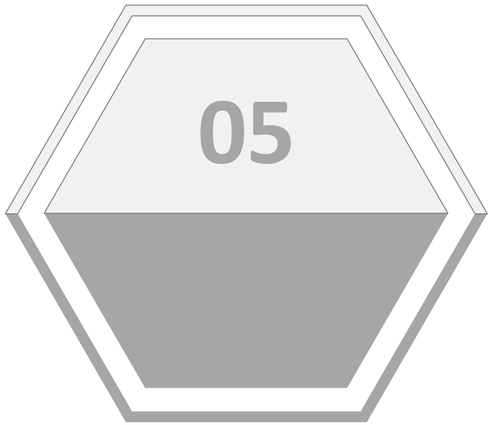
Transport Layer – Layer 4



Layer 4
Transport
Layer

- UDP – User Datagram Protocol
- TCP – Transmission Host Protocol

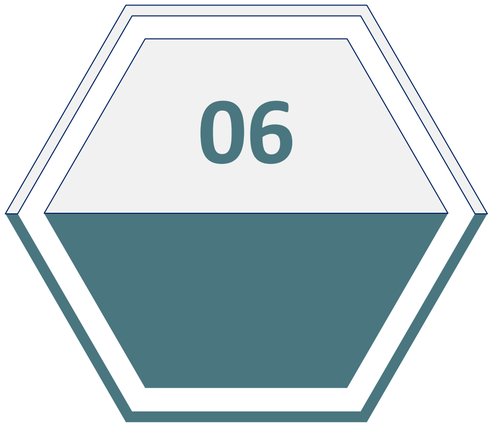
Session Layer – Layer 5



Layer 5
Session Layer

- Sessions

Presentation Layer – Layer 6



Layer 6
Presentation
Layer

- Translation
- Data Compression
- Data Encryption
- Graphics

Application Layer – Layer 7

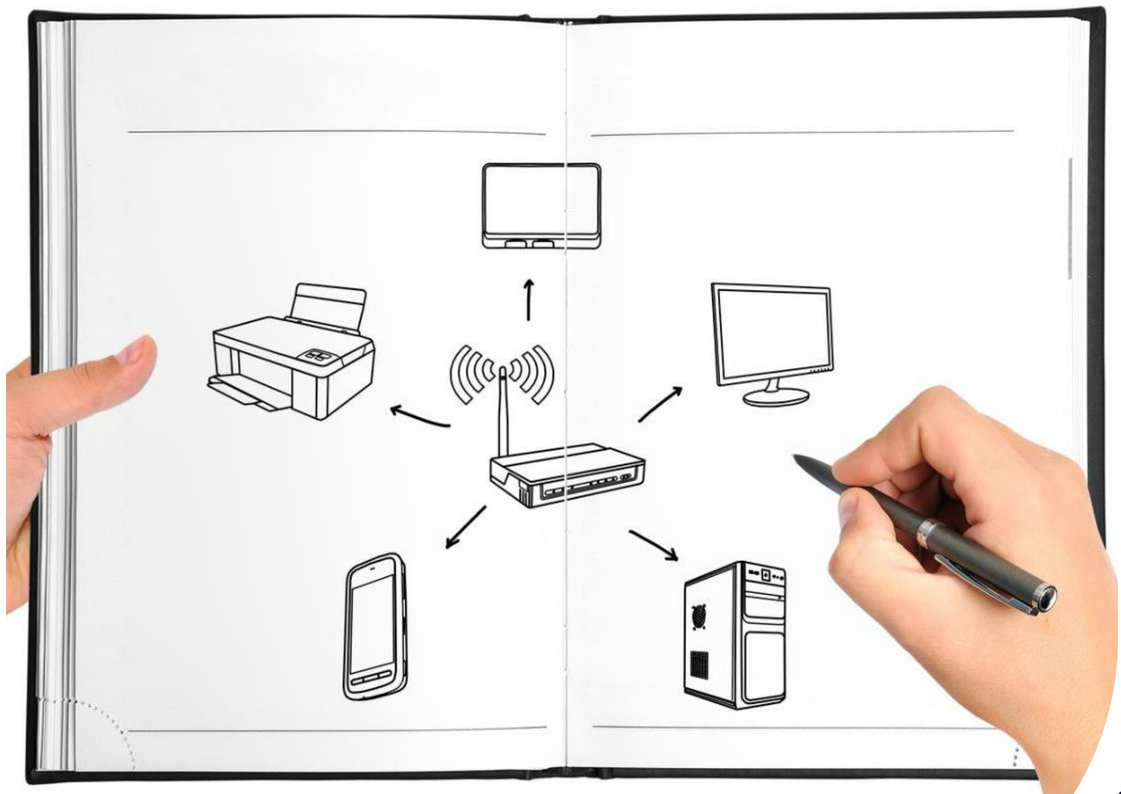
Layer 7
Application
Layer

- End User Interface
- Error-Handling & Recovery
- Protocols & Services
- Authentication and Authorization

Who decides how this stuff works?

-IETF

The Internet Engineering Task Force (IETF) is an open, international organization responsible for developing and promoting voluntary Internet standards.



IPv4

Internet Protocol

Version 4

https://datatracker.ietf.org/doc/html/rfc791

IPv4 Notation

#.#.#.#

- Each number here is in Computer Networking, referred to as an Octet. Octet = 8:

Octet.Octet.Octet.Octet

- Which means: (8+8+8+8= 32 bit Number or Address)

8-bitNumber. 8-bitNumber. 8-bitNumber. 8-bitNumber

IPv4 Notation

- The possible range of an 8-bit number (Octet) is from 0-255.
- (For a total of 256 numbers in the range)

- Examples of (0-255.0-255.0-255.0-255):

1.2.3.4

122.56.230.12

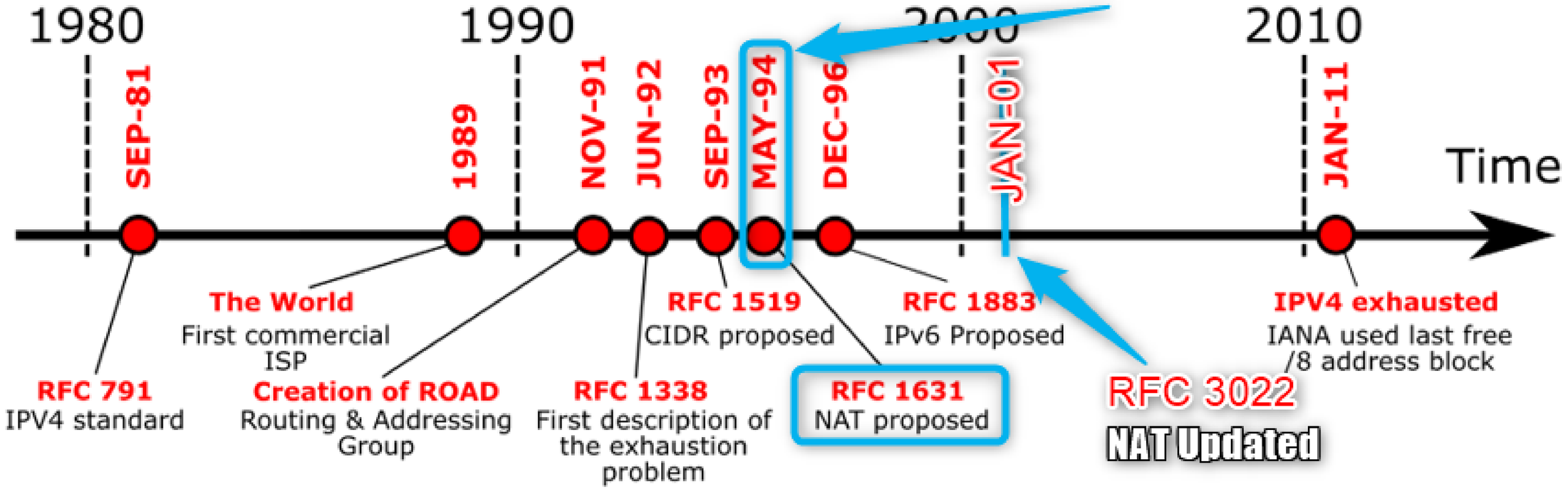
250.7.133.241

22.1.16.254

199.243.9.12

Range of all IPv4 Addresses: 0.0.0.0 – 255.255.255.255

BEST SELLERS MODERN DESIGNS



IPv4 Address Exhaustion

What happens when all the addresses run out?

No longer on the internet

Class A

- 10.0.0.0 – 10-.255.255.255

Class B

- 172.16.0.0 – 172.31.255.255

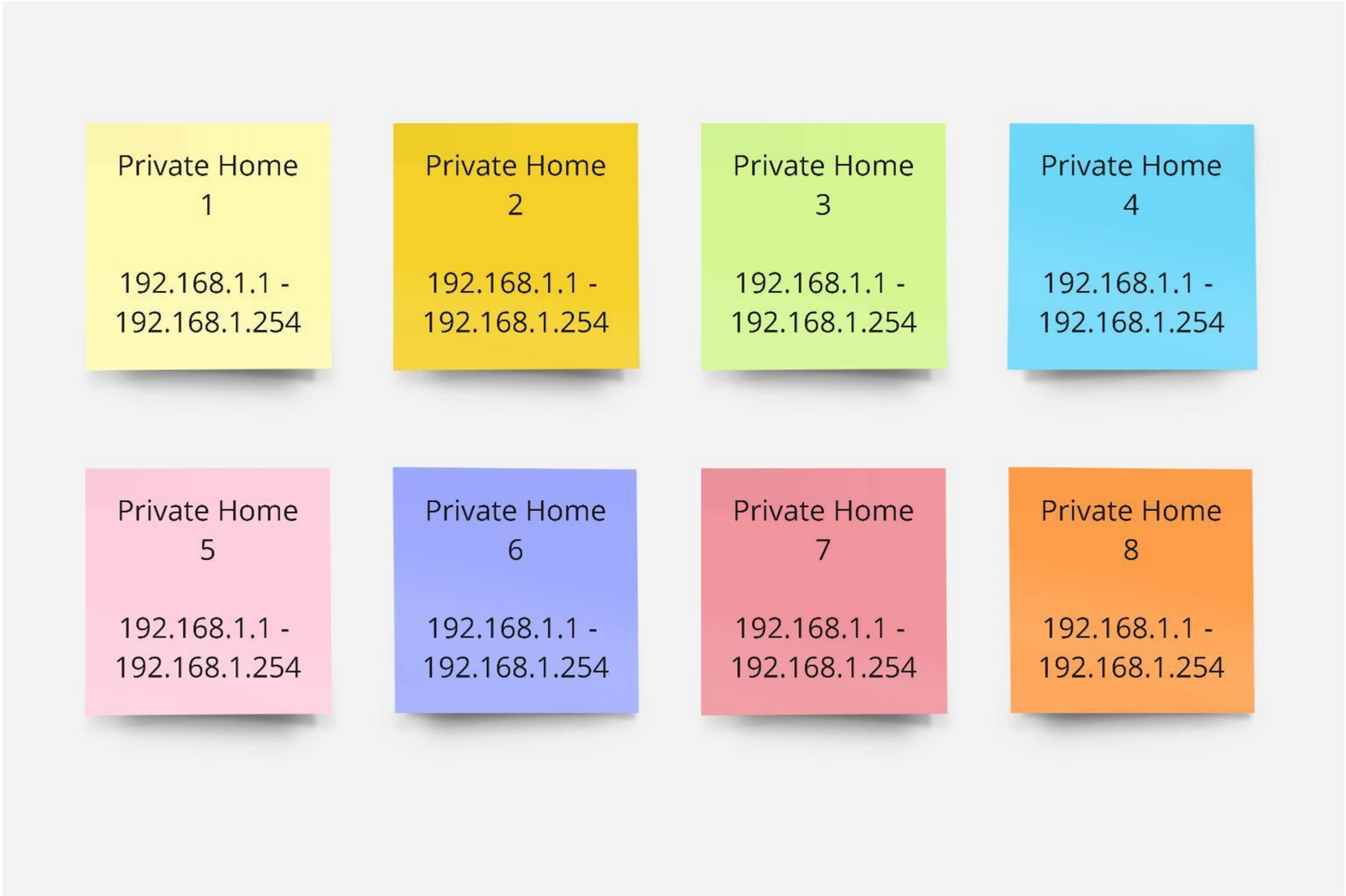
Class C

- 192.168.0.0 - 192.168.255.255

Public vs. Private IP Addresses

Private Addressing
https://datatracker.ietf.org/doc/html/rfc1918

Private Address Reuse

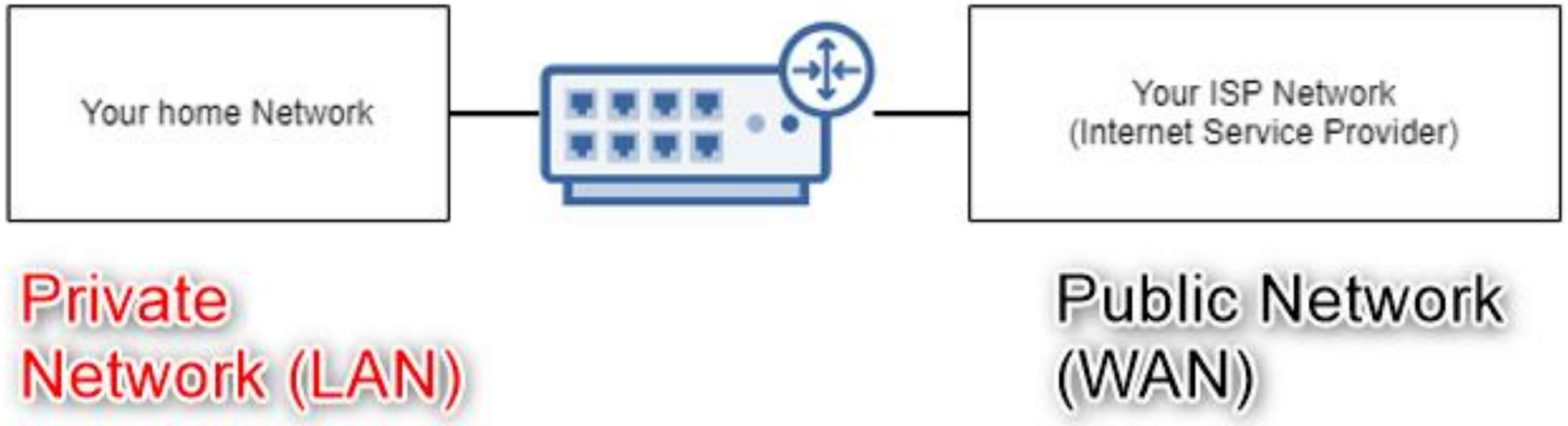


Network Address Translation

Techniques like NAT (Network Address Translation) have been used to maximize address usage within local networks.

IP Network Address Translator
https://datatracker.ietf.org/doc/html/rfc1631
https://datatracker.ietf.org/doc/html/rfc3022

NAT Function



Virtual Network Ports

Getting in and out

Based on the Binary Math Pattern we covered earlier, each individual NIC or Network Interface Card, has 0-65635 Ports. (Total 65536)

Many Network Protocols rely on specific ports to work seamlessly.

Port Ranges

Style based upon new and innovative technologies of construction, particularly the use of glass, steel, and reinforced concrete.

Administrative Ports (Well-Known Ports):
Range: 0-1023
Description: These ports are reserved for standard services.

Registered Ports:
Range: 1024-49151
Description: These ports are not reserved but are registered for specific applications. For instance, while not as universal as well-known ports, many applications will default to a port in this range.

Ephemeral Ports (Dynamic/Private Ports):
Range: 49152-65535
Description: These ports are not registered or reserved.

They are used for temporary and dynamic purposes, especially for client-side of the client-server communication.

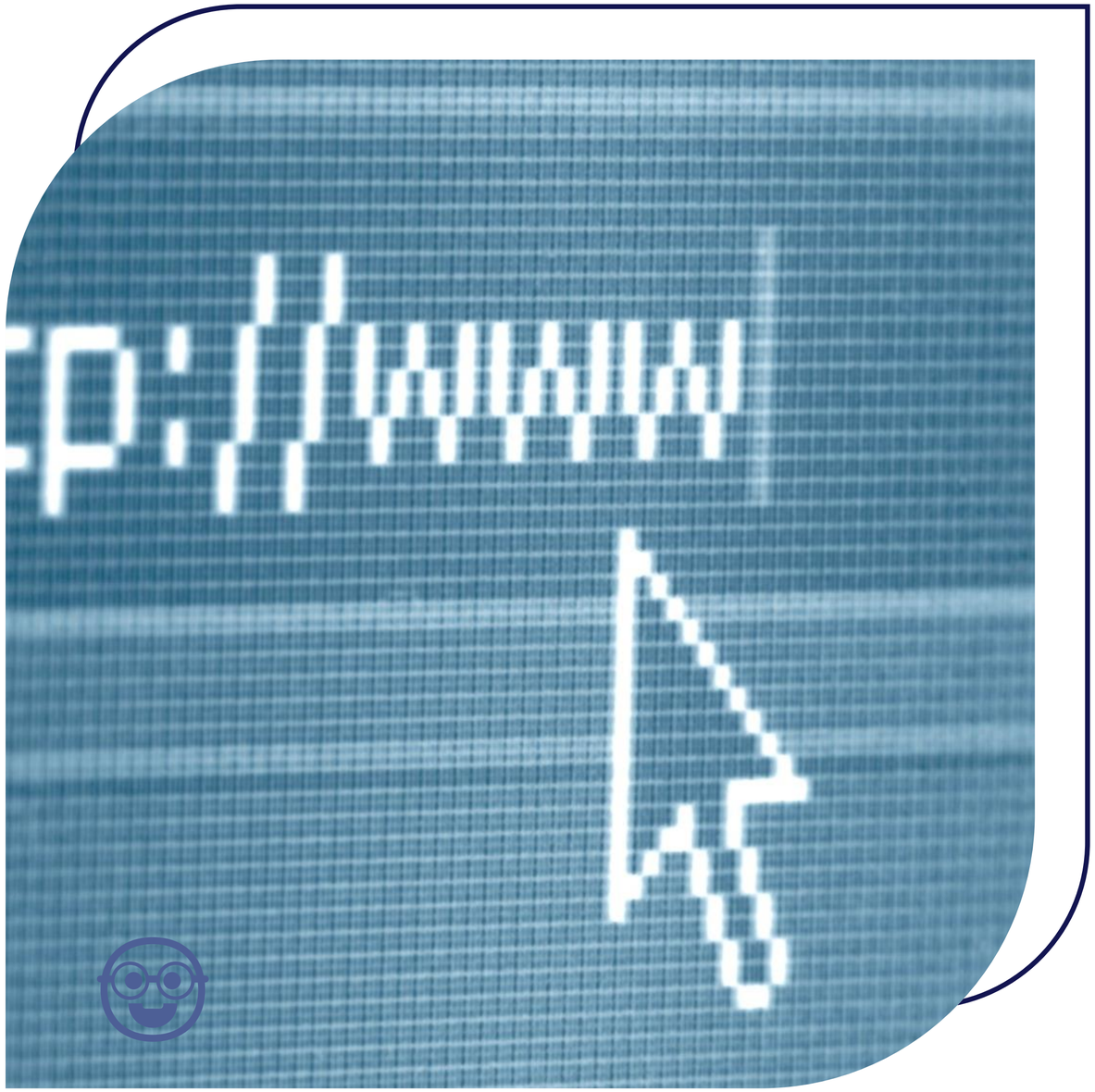
When a client initiates a connection, the operating system picks an available port from this range.

Network Protocols

- Standardization
- Formatting the Data
- Error Handling
- Addressing
- Transmission
- Flow Control
- Security
- Synchronization
- Breaking things up and reassembly
- Interoperability

Small (Incomplete) list of Computer Networking

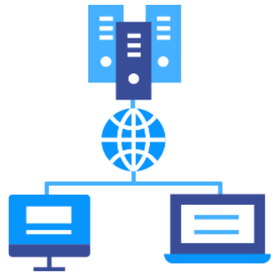
Protocol Acronym	Protocol Name	Transport Protocol	Concept	Port(s)	RFP (For Reference)
DHCP	Domain Host Configuration Protocol	UDP	DHCP provides Dynamic Addresses to Clients that wish to join a Computer Network	67/68	RFC 2131
DNS	Domain Name Service	TCP/UDP	Translates domain names into IP addresses to ensure proper routing.	53	RFC 1034 / RFC 1035
HTTP	Hypertext Transfer Protocol	TCP	The main protocol to transfer HTML Code from Server to Client Browser so End Users can view Web Pages.	80	RFC 2616
HTTPS	Hypertext Transfer Protocol over SSL/TLS	TCP	HTTPS works with HTTP to deliver HTML Code securely using the SSL / TLC Protocols.	443	RFC 2618
Telnet	Teletype over Network Protocol	TCP	A deprecated method that shouldn't be used to manage Network Devices & Unix/Linux Systems via a text-based Shell. (Not Encrypted)	23	RFC 15 RFC 854
SSH	Secure Shell	TCP	The primary method used to manage Network Devices & Unix/Linux Systems via a text-based Shell. (Encrypted)	22	RFC 4250-4256



DNS

Domain Name Service

It is what makes the internet work for humans.



Client Server Model

Domain Name Service

Humans like words

Human beings can remember cnn.com much easier than 151.101.67.5

Computers like numbers

Computers don’t really understand words, they need quantifiable information to know how to get there.

Testing DNS

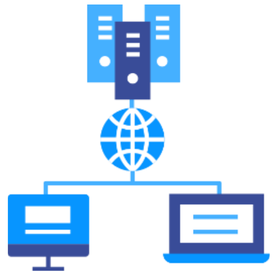
```
C:\Users\yenri>nslookup cnn.com
Server:  UnKnown
Address:  192.168.4.1

Non-authoritative answer:
Name:    cnn.com
Addresses:  2a04:4e42:800::773
          2a04:4e42:e00::773
          2a04:4e42:c00::773
          2a04:4e42:200::773
          2a04:4e42:400::773
          2a04:4e42::773
          2a04:4e42:a00::773
          2a04:4e42:600::773
          151.101.67.5
          151.101.195.5
          151.101.131.5
          151.101.3.5


C:\Users\yenri>
```

DHCP

(Or, the reason people are able to use the internet at all)



Client Server Model

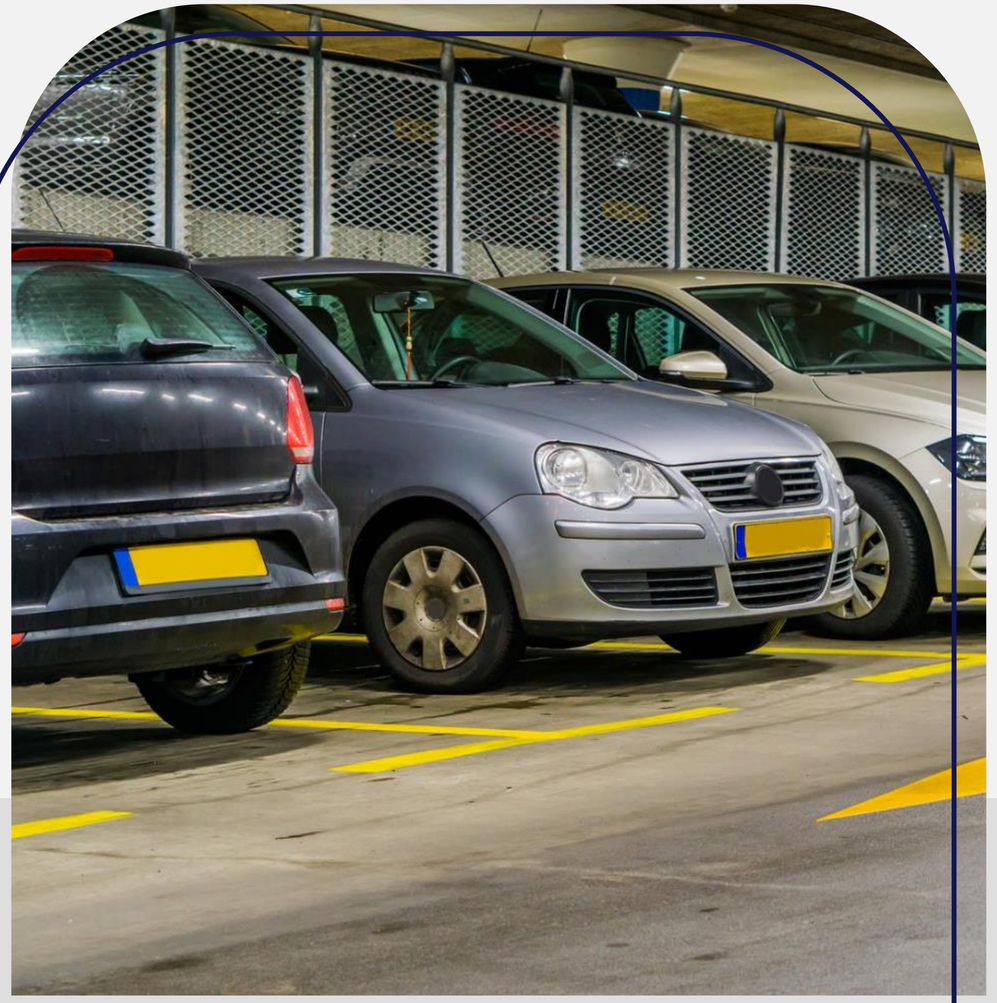
Dynamic Host Configuration Protocol

Joining a Computer Network

Settings must be right

Proper network planning and architecture

Managing IP addresses within a LAN is foundational to maintaining a secure, efficient, and organized network environment.



Making your network easy, reliable, and secure to use.

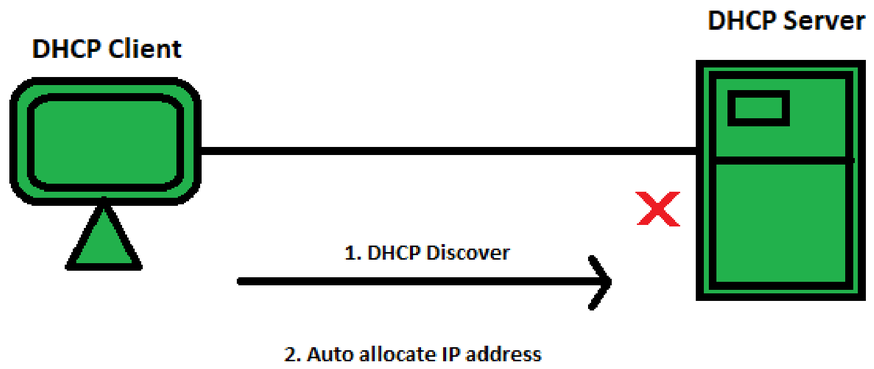
DHCP

https://www.flaticon.com/free-icons/engineer

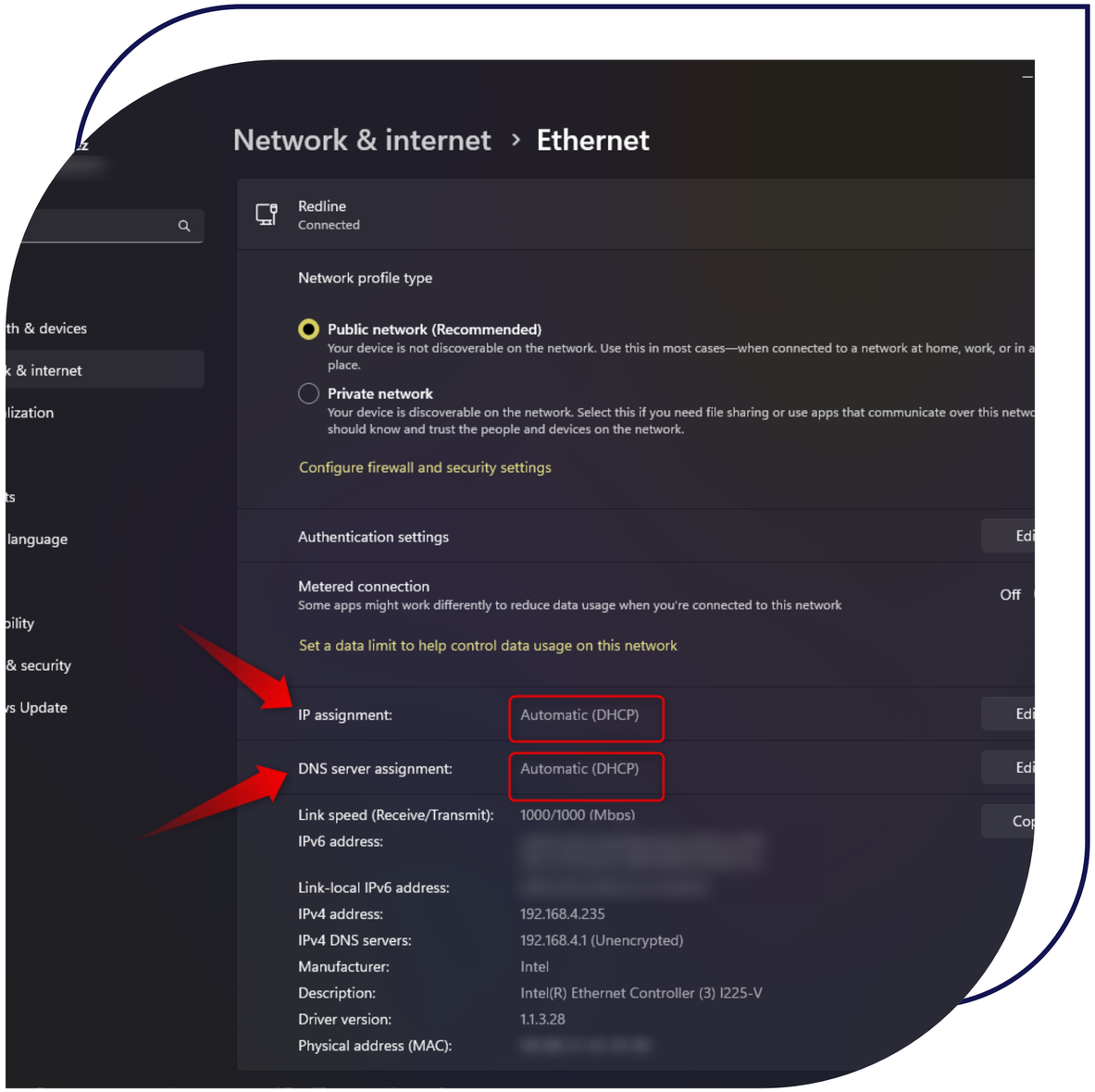
AUTOMATIC
PRIVATE
INTERNET
PROTOCOL
ADDRESSING

APIPA

What happens if DHCP Fails?



https://www.geeksforgeeks.org/what-is-apipa-automatic-private-ip-addressing/

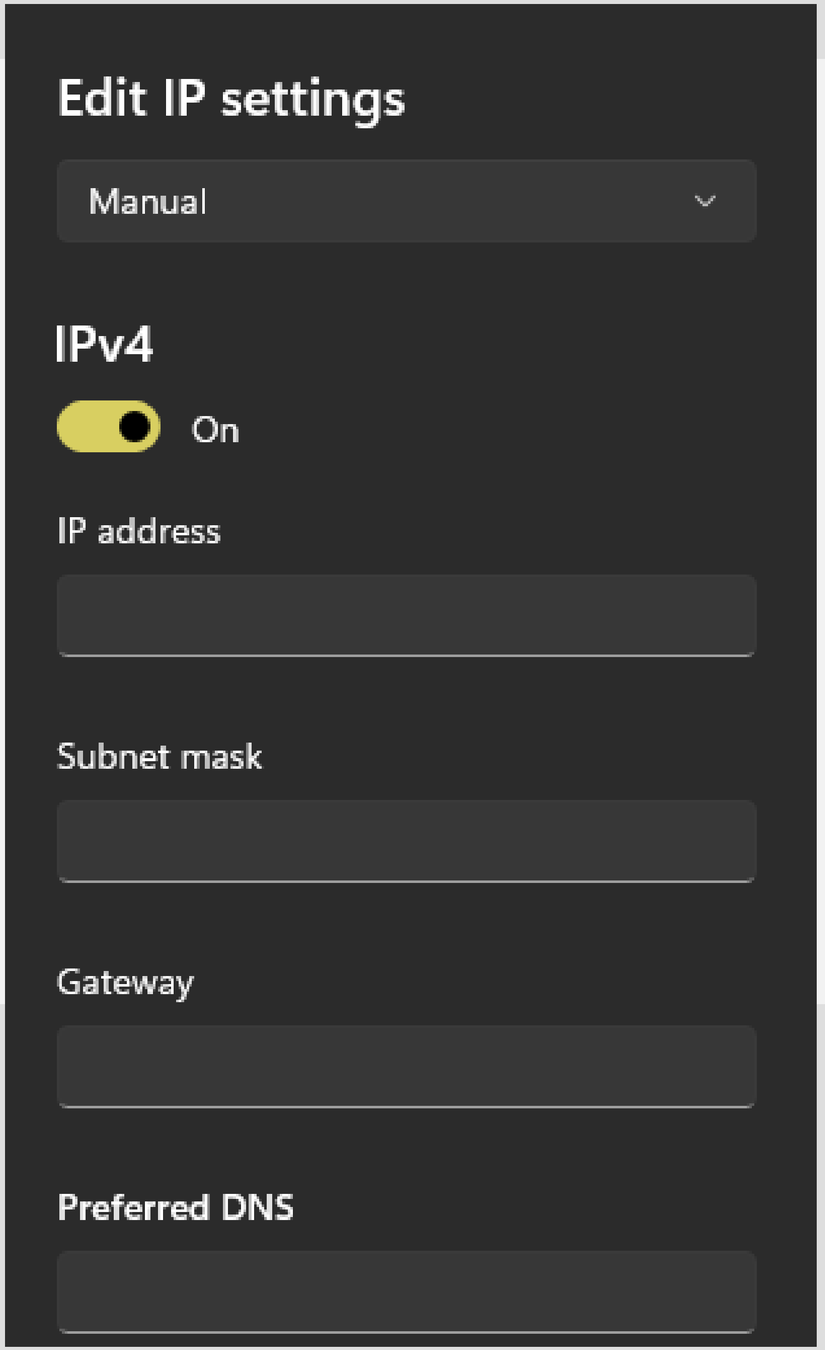


Windows Network Configuration

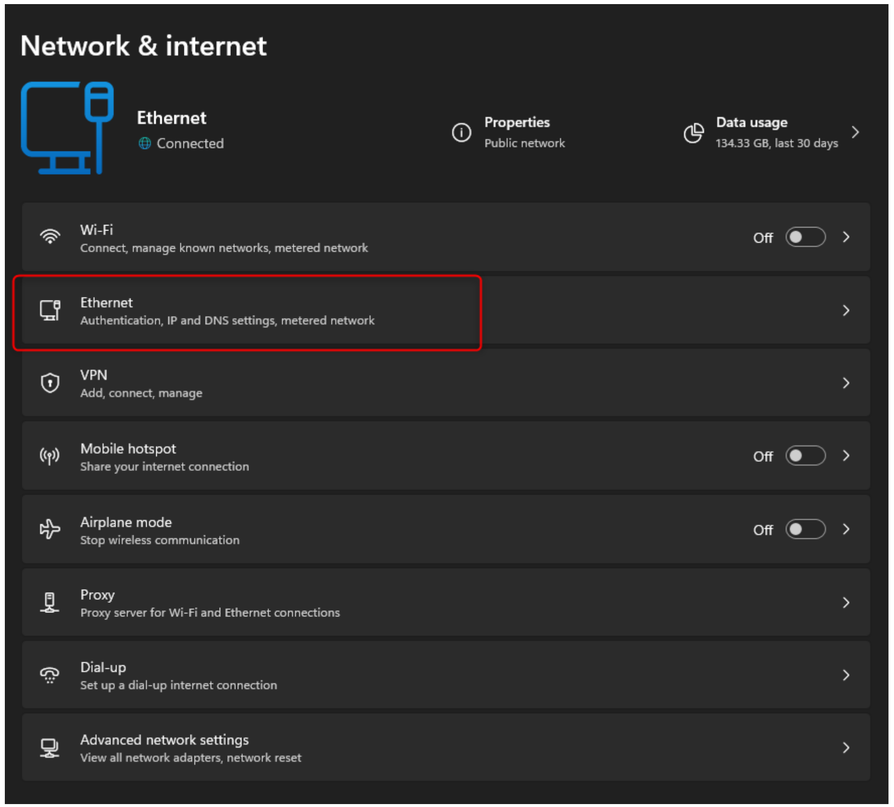
When you select the Network Interface you will be using to connect to the local network, you will typically see the DHCP configuration for both IP ADDRESS and DNS in the settings.

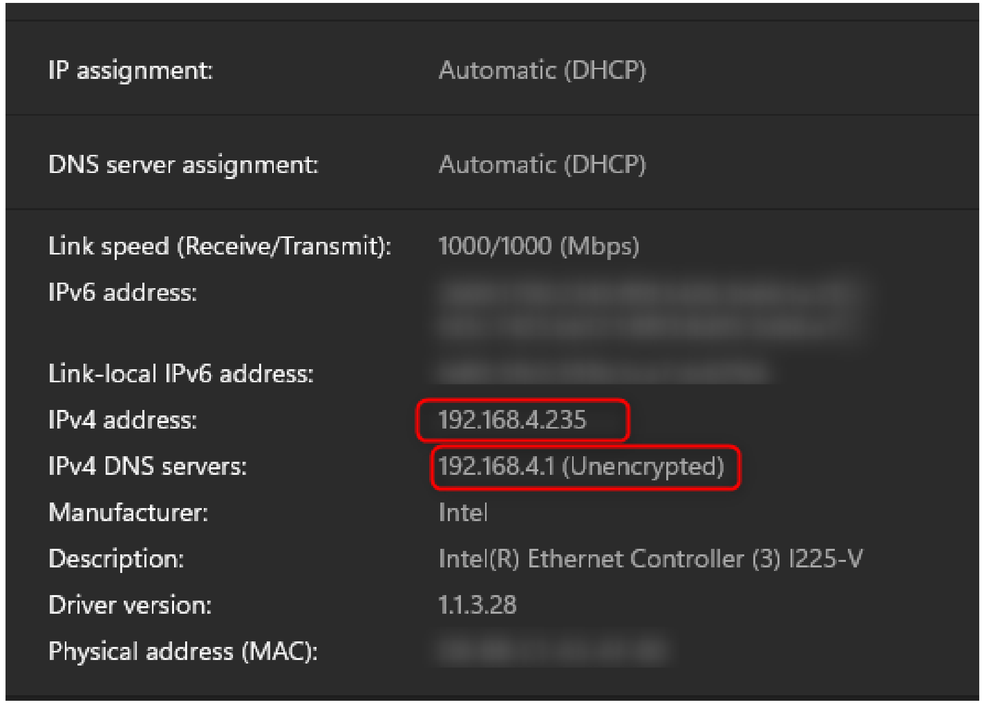
Manually Configuring your computer to join a network you know the settings to

Based on knowing the scope of the IP Range, the Subnet, the Gateway, and the DNS, one can successfully join a network that doesn’t prevent you from doing so.

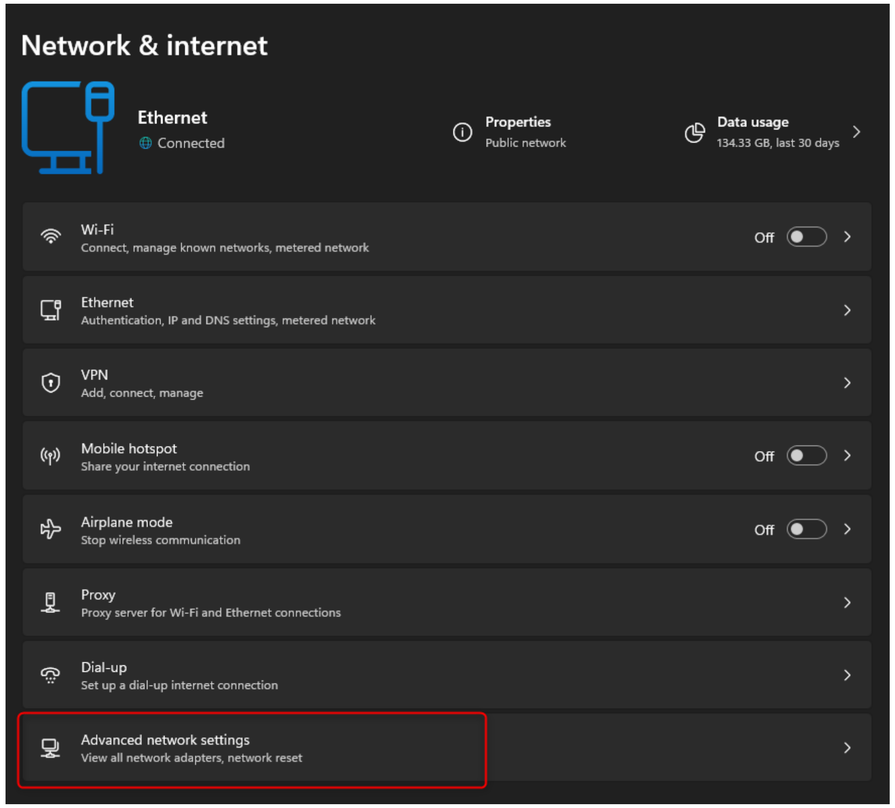


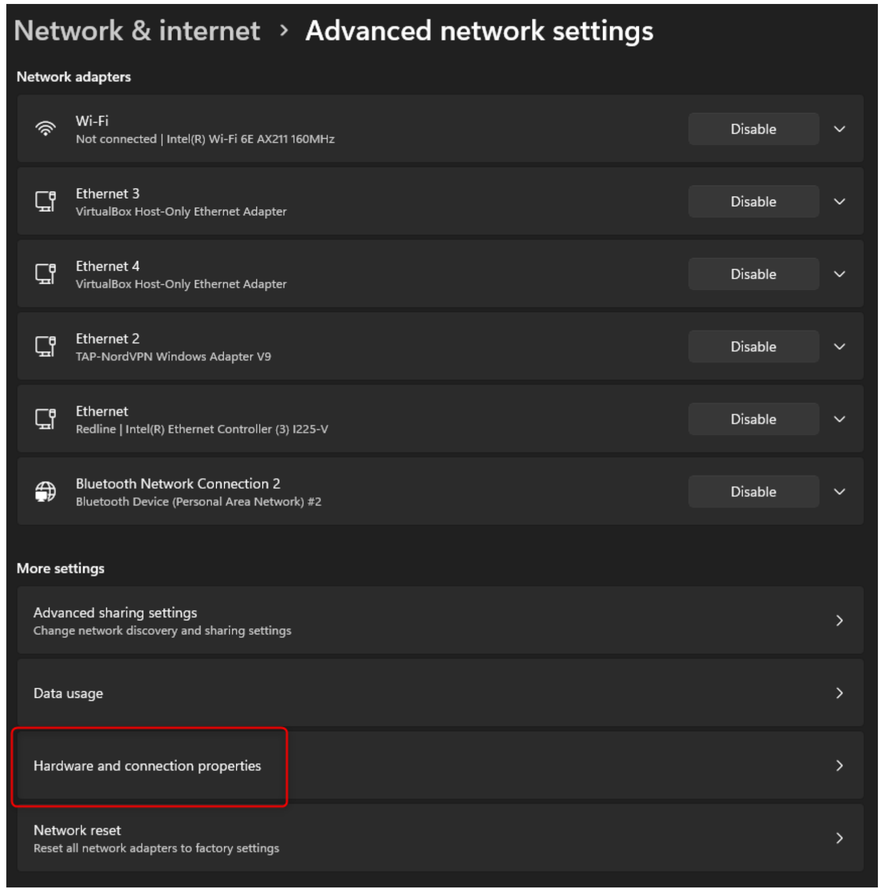
Finding your Basic Network Settings GUI



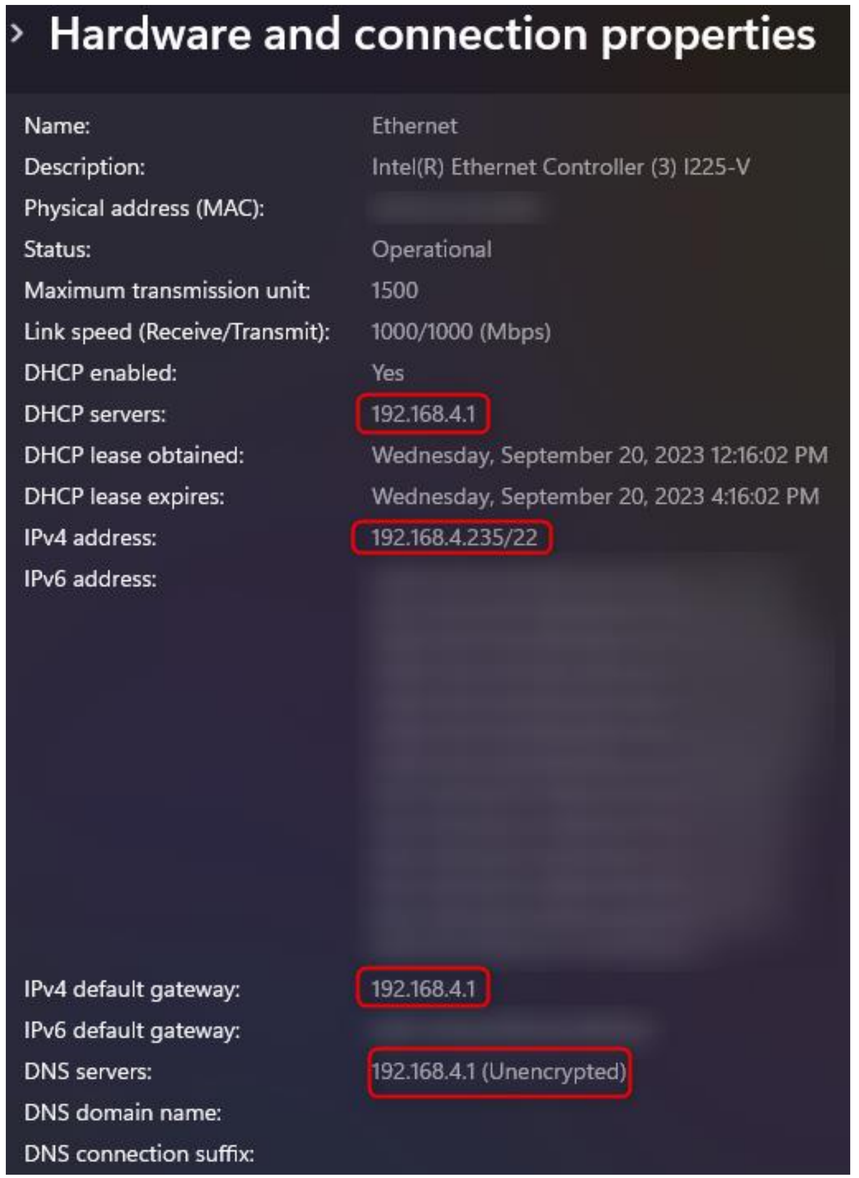


Finding your Advanced Network Settings GUI



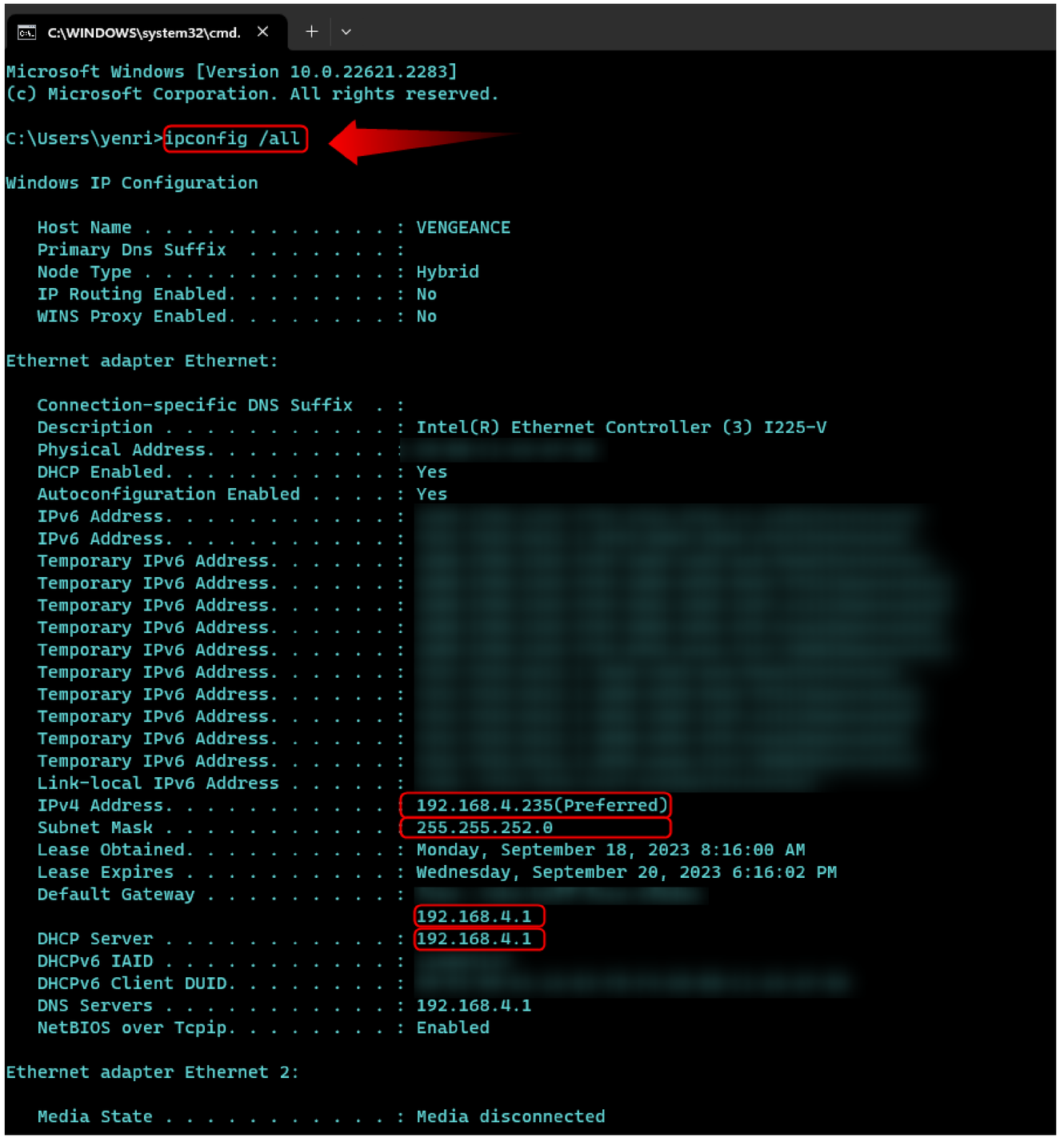


Finding your Advanced Network Settings GUI

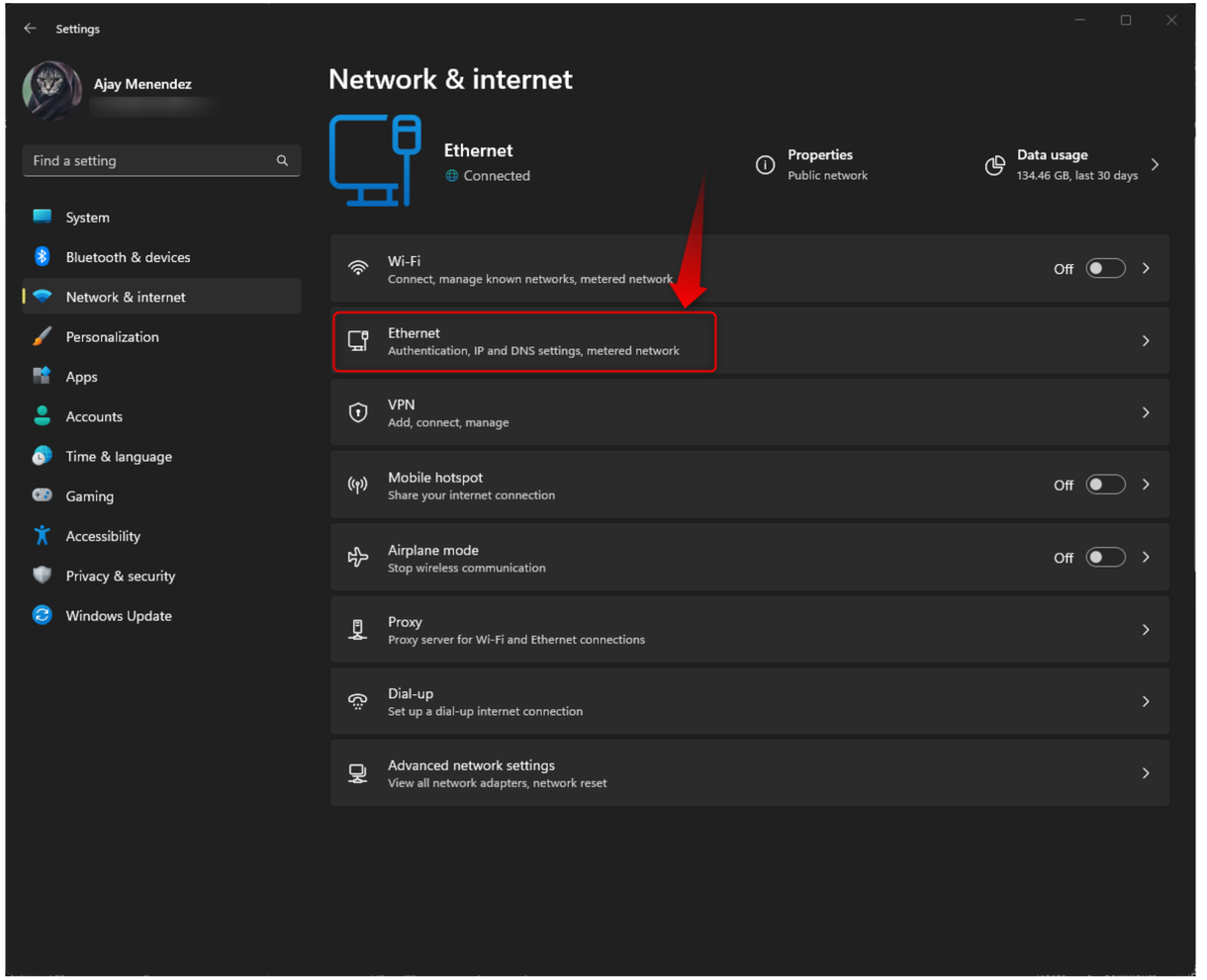


https://www.flaticon.com/free-icons/tools

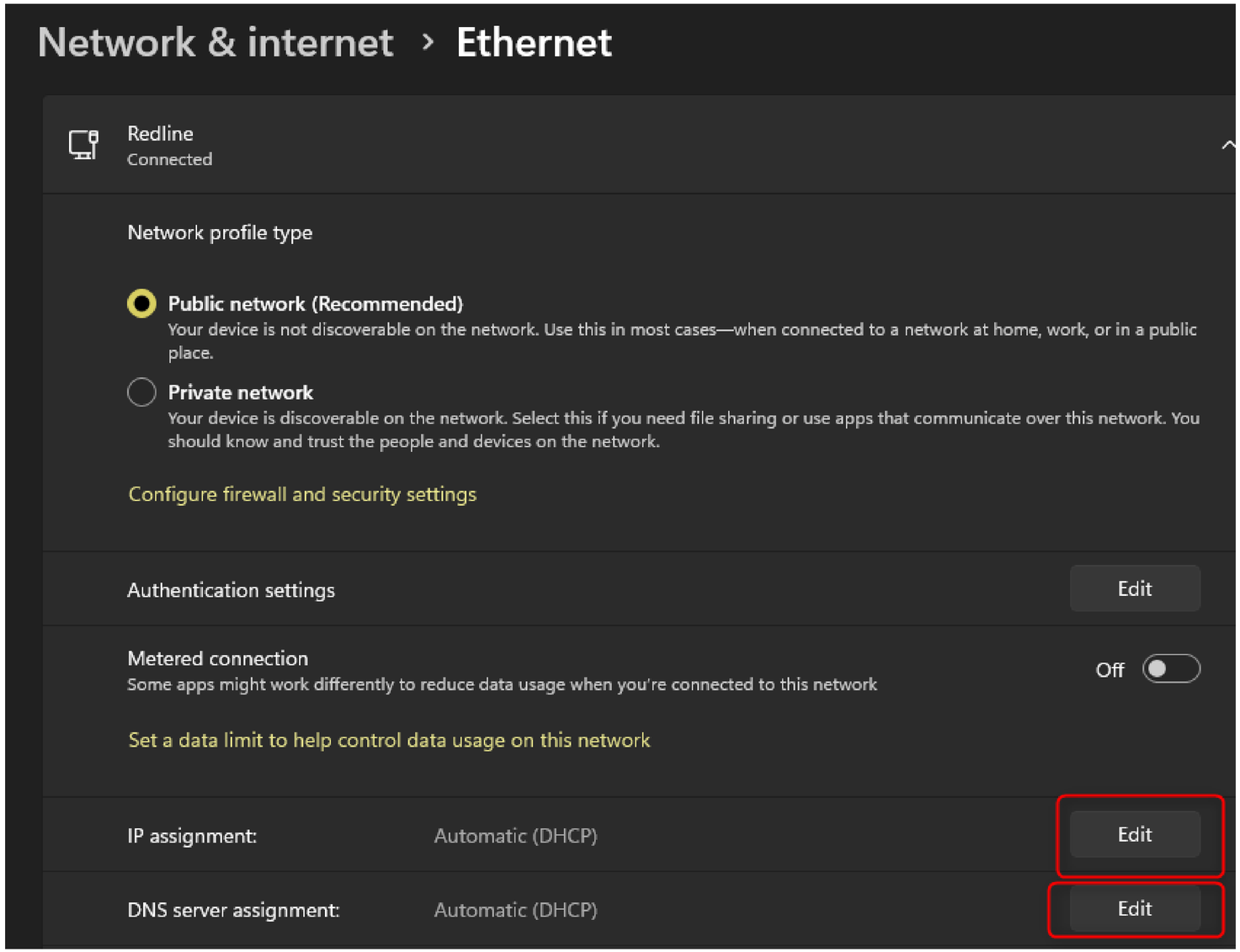
Finding your Advanced Network Settings CLI



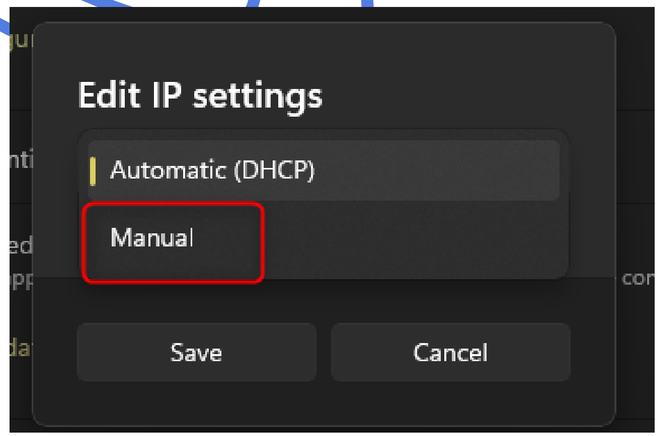
Manually configuring your IP Address

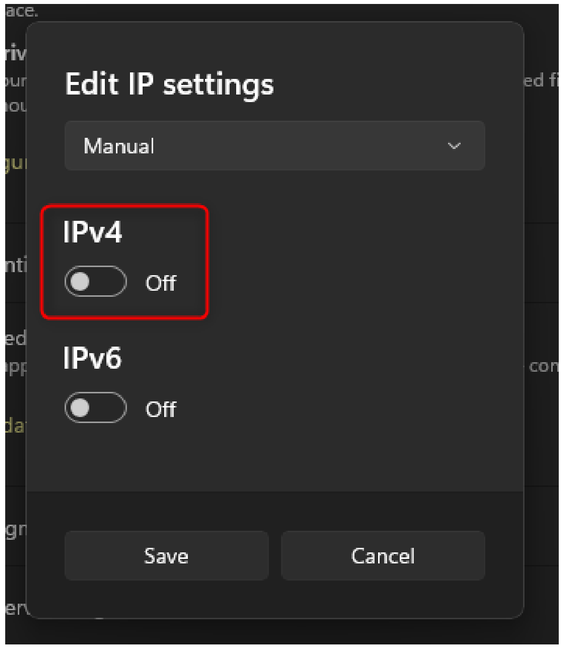


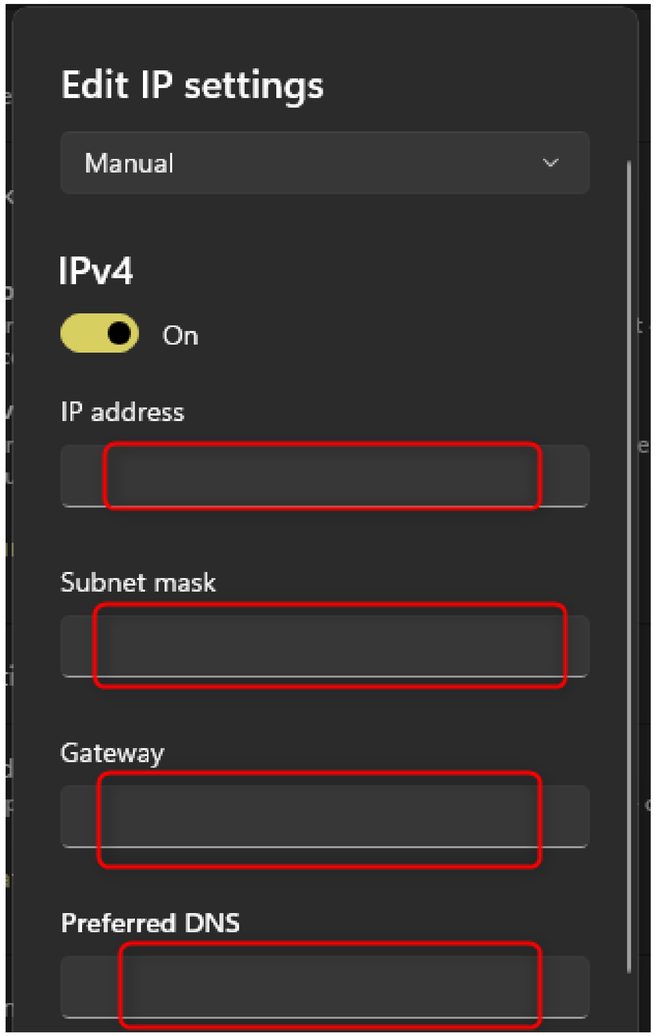
Manually configuring your IP Address



Manually configuring your IP Address







Small Manual IP Configuration Exercise

IP Scope

192.168.1.0

Subnet Mask

255.255.255.0

Gateway

192.168.1.1

DNS Server

4.4.4.4

- Join the WiFi called NetTest
- Notice that you don’t go online
- Using the information on the left configure your Computer manually to join the network
- Make sure you can get to a website online, if so, you’ve successfully completed the lab.

Thank you

Keep a eye out

Building an entire cybersecurity program from zero to HERO over the next few years.

Comprehensive Program

- Economically Viable
- Textbooks
- Videos
- Hands on Labs
- Tutoring & Mentorship

Slides and Handouts available online at:

https://github.com/black-tower/intro-networking