

Networking

UBNetDef, Spring 2023
Week 2

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Administrivia

Learning Goals

- Learn the basics of how network traffic flows
- Interpret a network topology
- Understand OSI network layers 1-3
- Distinguish between network hardware devices
- Configure static networking

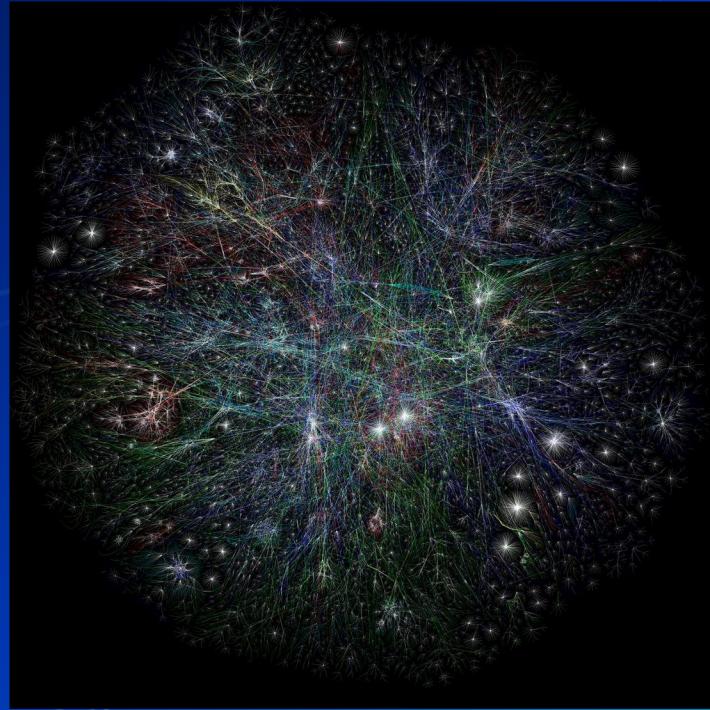
Picture 1



Picture 2



Picture 3

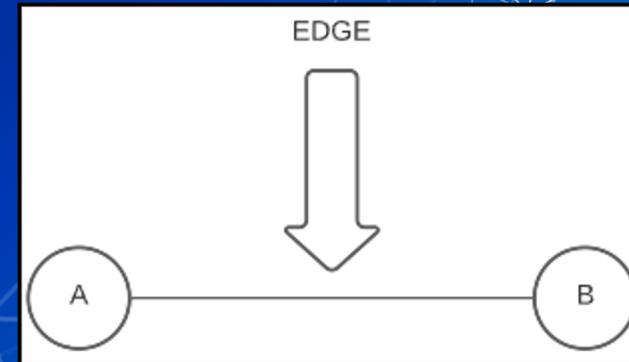


What do all of these have in Common?

- These are all Networks
- Each one has a Node and a Edge

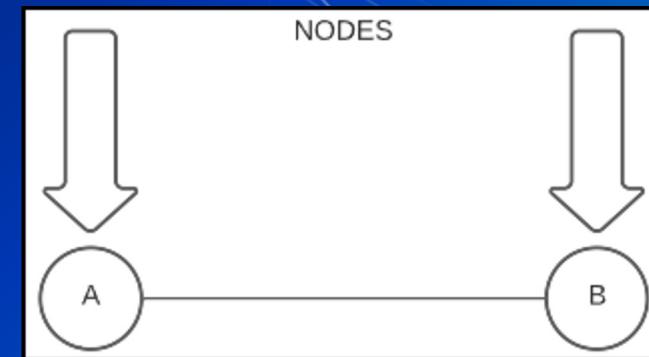
Edges

- The **connections**
 - Roadways between cities
 - Neural pathways



Nodes

- The connection points
 - Cities
 - Neurons



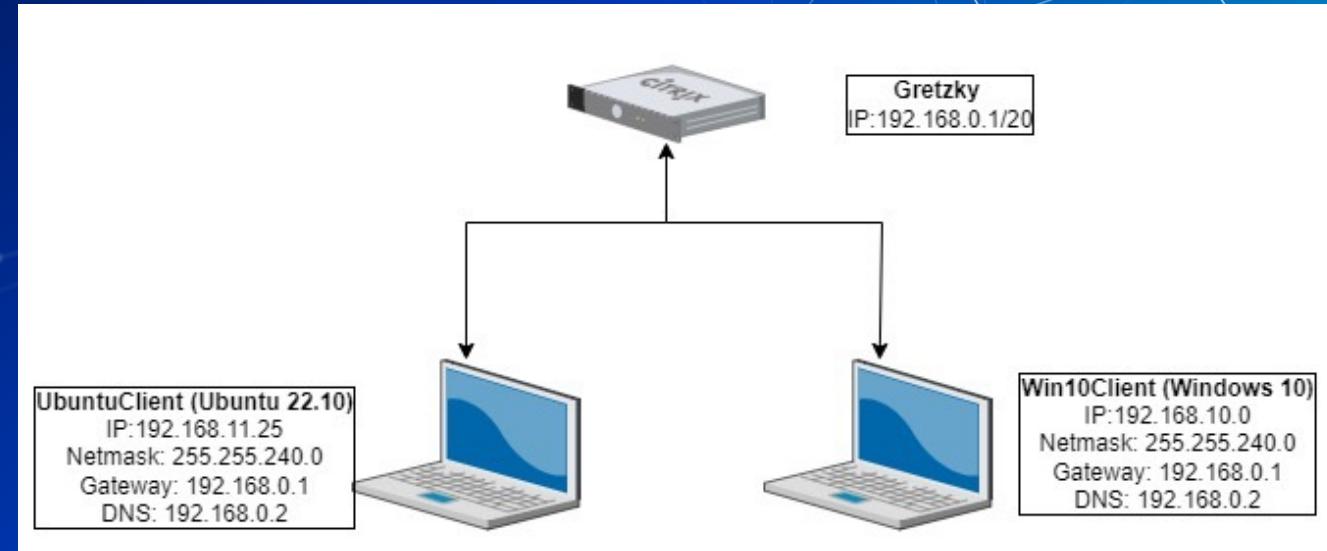
Examples we might see in Class

- Nodes
 - Your physical computer
 - vCenter servers
 - Routers
- Edges
 - Ethernet wires
 - Wireless signals to eduroam

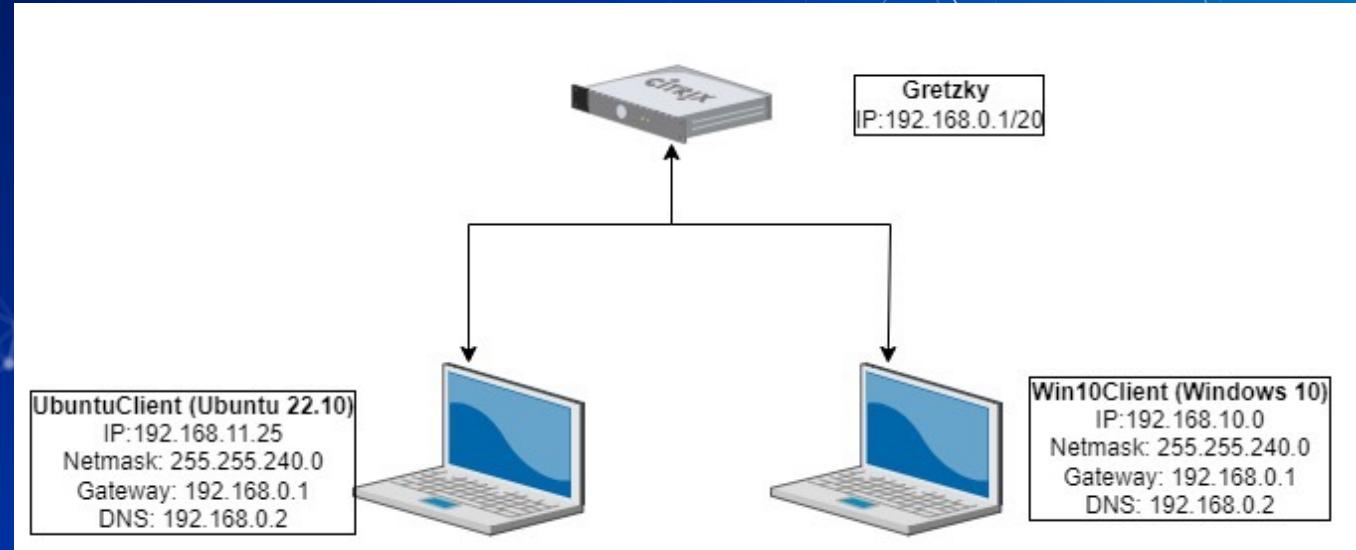
Endpoints vs. Network Devices

- Endpoints: process and manipulate data
 - Also referred to as “hosts”
 - Examples: computers, servers, gaming consoles, mobile devices, IoT devices
- Network Devices: distribute connectivity
 - Examples: routers, modems, switches, other gateways

Which are endpoints?



Which are network devices?



Network Devices

- Gateways
 - Receive incoming messages and send outgoing messages
 - Endpoints only recognize the gateway immediately connected to them
 - Think Doorway
- Routers
 - Pass messages between networks
 - These work with IP addresses

Network Devices

- Switches
 - Distribute messages within an immediate network
 - These work with MAC Addresses
- Gateways, routers, switches are often combined into one piece of hardware

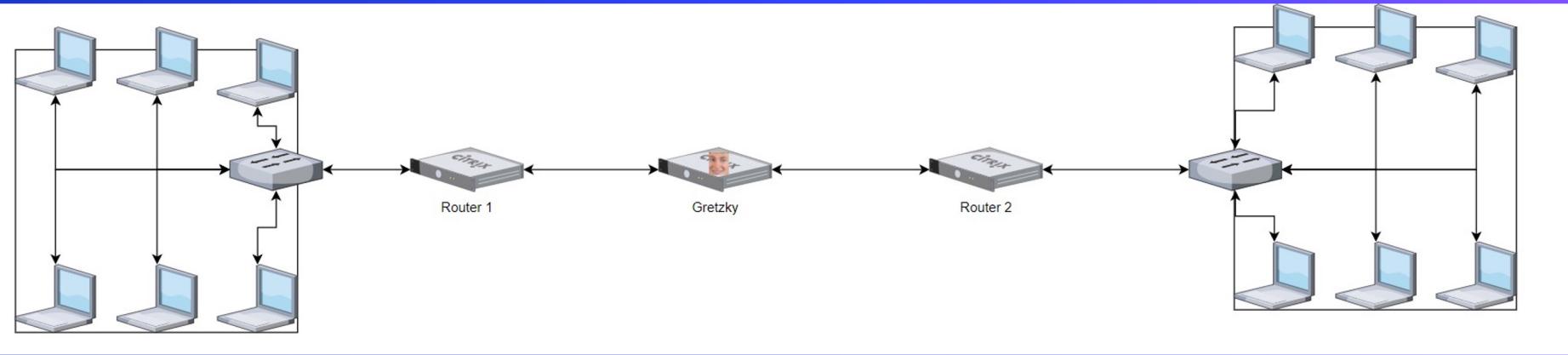
Questions?

In Class Activity

Packet Polo

Packet Polo

- Step 1: Local ARPs
- Step 2: Ping



Break slide

Please return in 10 minutes

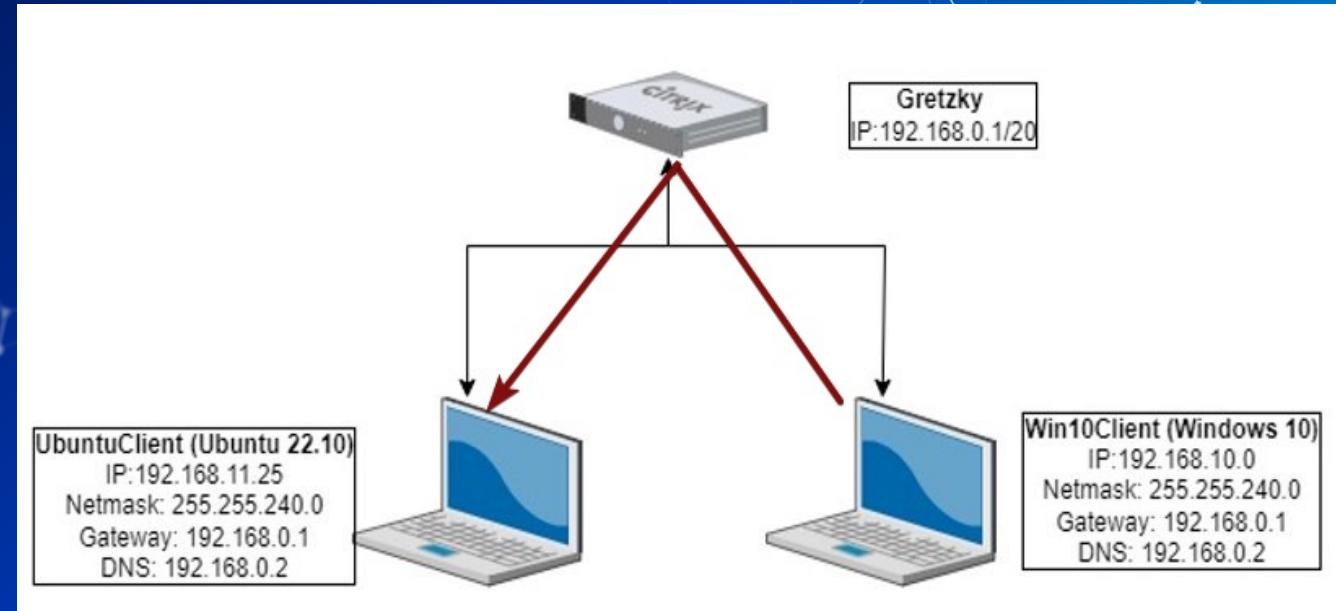
Transmitter vs. Receiver

- Transmitter (Tx): Sender of data
- Receiver (Rx): Recipient of data

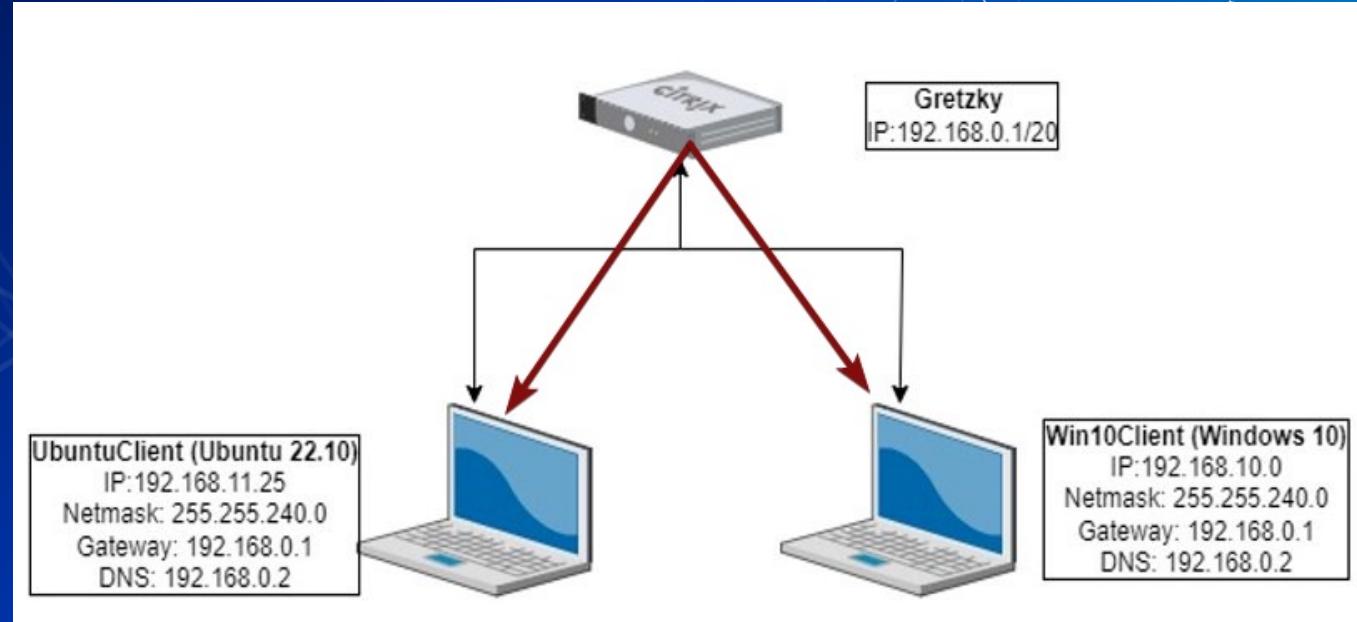
Transmission methods

- Unicast: one transmitter, one receiver
- Multicast: one transmitter, multiple but not all receivers
- Broadcast: one transmitter, all receivers

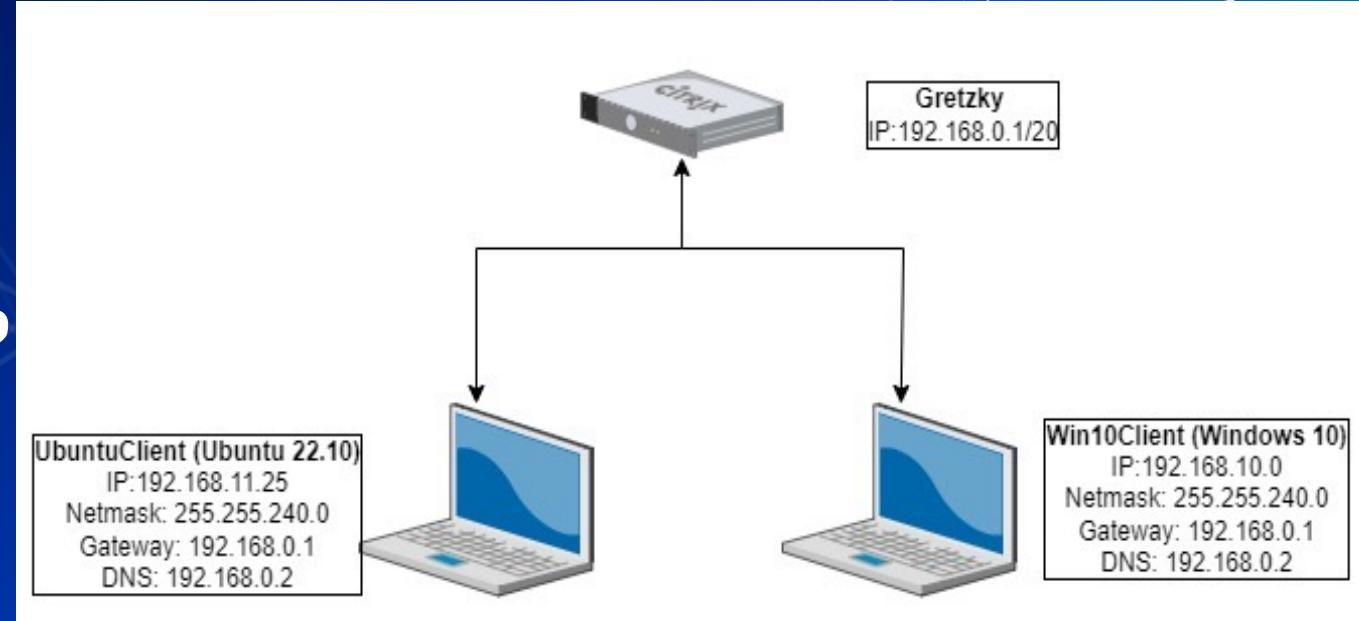
Which broadcast method?



Which broadcast method?



How about a multicast?



Local vs. Remote

- * You are on your laptop at home

Local

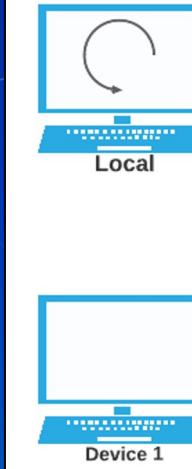
- Information exchanges within a single device

Example: Saving a file to desktop

Remote

- An action you do to a DIFFERENT device from your local.

Example: Printing a document to your printer

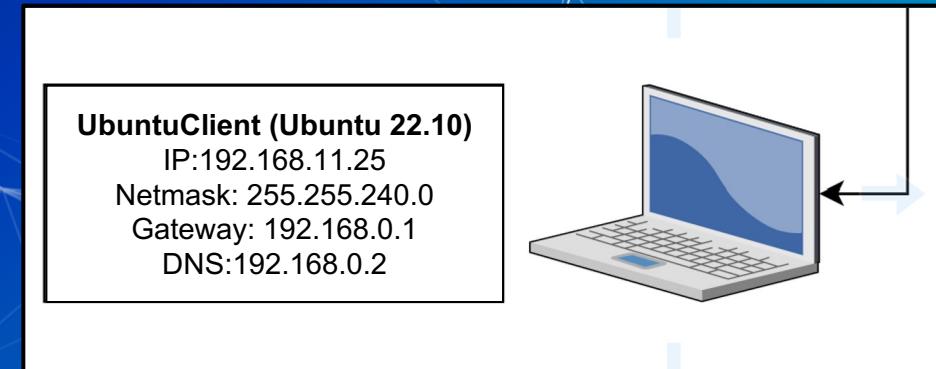


Endpoints: Clients vs. Servers

- **Clients**: primarily request remote services
 - Examples: mobile device, workstation, laptop, computer
 - Behavior: browse the web, receive updates, provide credentials
- **Servers**: primarily provide remote services
 - Examples: web servers, intrusion detection systems, active directory
 - Behavior: store and provide web pages, distribute updates, verify credentials

Breakdown of Topology

- IP Address: Identifies a machine on a network
- Subnet Mask: Range of IP addresses allowed on a network
- Gateway: A routing device that allows you to connect an external network
- DNS: translates domain names (e.g., buffalo.edu) into IP Addresses



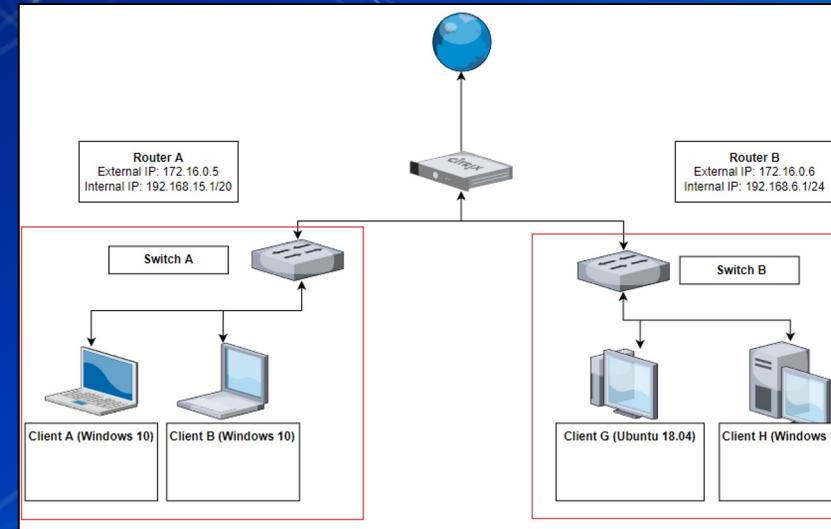
Break slide

Please return in 5 minutes

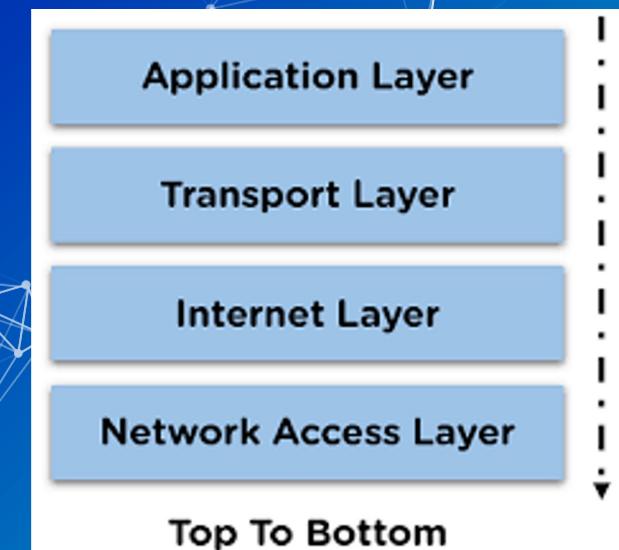
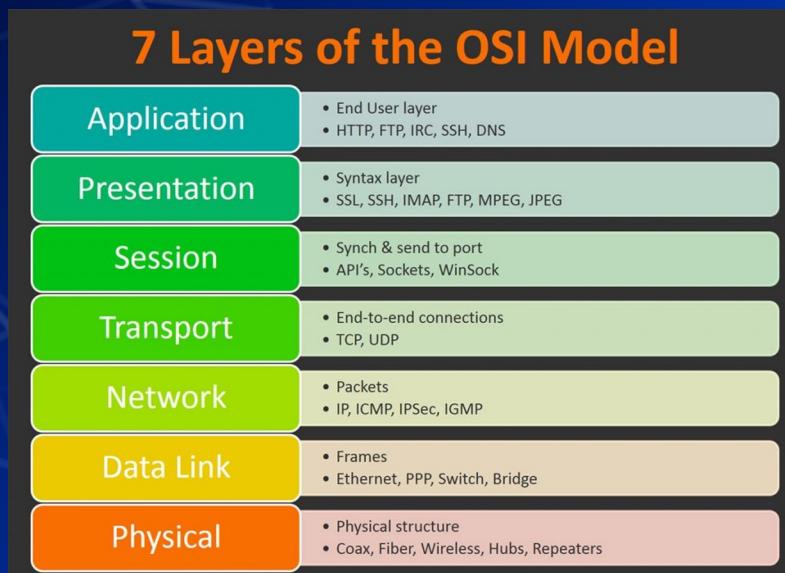
LANs

■ Local Area Network

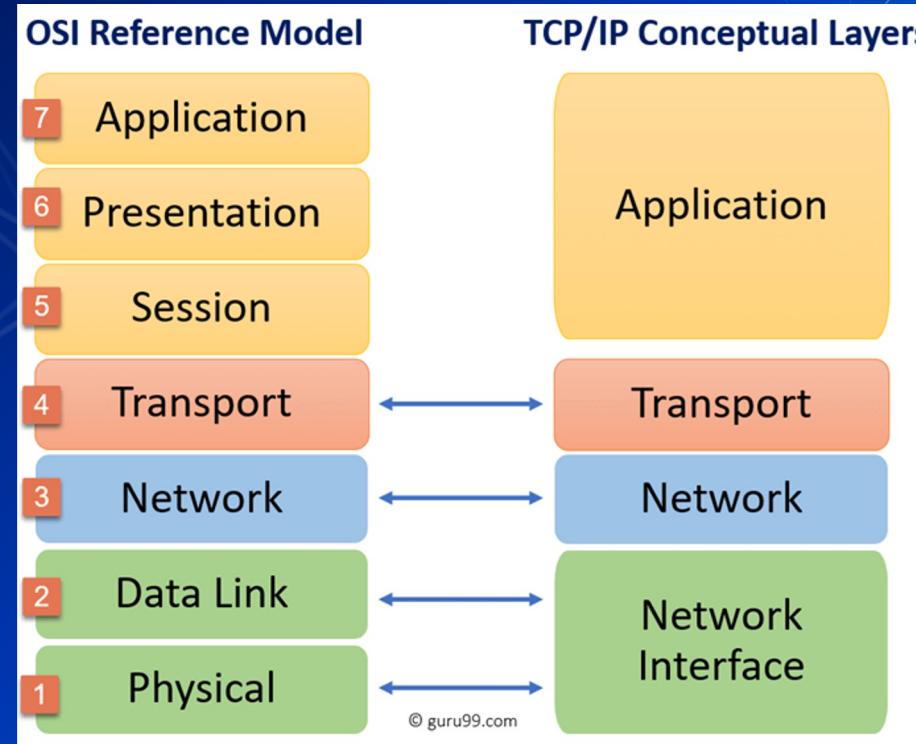
- Devices on the same network share the same communication paths (e.g., cables or wireless links)



Computer Layering Models



Computer Layering Models



OSI Layer 1: Physical Layer

- Layer 1: Physical Layer
 - Physical connections
 - Mediums
Examples: Fiber & Radio
 - Signals
Examples: 1s & 0s

OSI Layer 2: Datalink Layer

- Layer 2: Datalink Layer
 - Receives bits and delivers them to a processor
 - Physical receivers are identified by MAC Addresses
 - On Your Network Interface Card (NIC)
 - Only seen within the Local Area Network

OSI Layer 3: Network Layer

- Layer 3: Network Layer
 - Interconnects networks
 - IP Addresses
 - Public and private
 - Requires a network connection to exist
 - 2 different versions of IP addresses
 - IPv4: 10.1.42.15
 - IPv6: 2001:0db8:85a3:0000:0000:8a2e:0370:7334

IPv4 Addresses: Private Address

- Class A: 10.0.0.0 to 10.255.255.255
- Class B: 172.16.0.0 to 172.31.255.255
- Class C: 192.168.0.0 to 192.168.255.255

IPv4 Addresses

- Decimal-octal form (Base 8 bits)
- Separated by octets in range 0-255
 - [octet 1].[octet 2].[octet 3]. [octet 4]
 - Octet 1 - leftmost
 - Octet 4 - rightmost
- For every IP address: **192.168.12.10**
- Some characters represent a network.
 - Some characters represent the individual device.

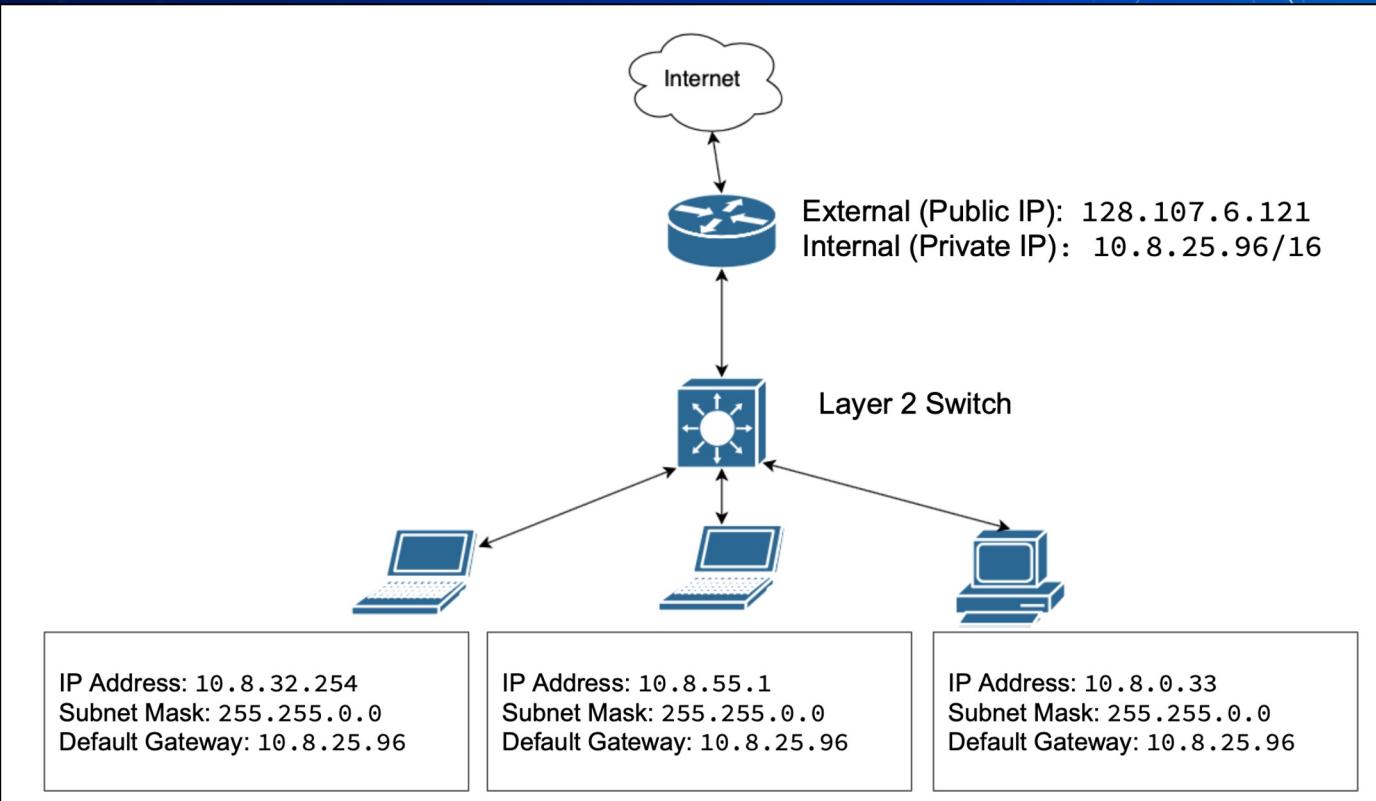
IPv4 Addresses: NAT

- Network Address Translation
 - We would run out of IPv4 address, can only have ~4.3 Billion IPv4 address.
 - Estimated that there was 12.3 Billion IoT devices in 2021
 - How do we save room?

IPv4 Addresses: NAT

- Network Address Translation
 - We have external and internal IPs
 - External, your Public IP, what the internet sees you as
 - Internal, Private IP, what people on your network see you as
 - Router makes the translation

IPv4 Addresses: NAT



In Class Activity

IP Assignment Walkthrough

Subnet Masks

- The Subnet indicates how many endpoints we can have on a network
 - Really neat*
 - Subnets can be written as “255.255.255.0” (decimal-octal) or CIDR notation (e.g., 192.168.12.0/24)
 - /24 gives us 254 different address. No 0 (Network Identifier) or 255 (Broadcast Address)

Subnet Masks

- The smaller the subnet mask, the more possible addresses
- We can use a calculator to help us

<https://www.calculator.net/ip-subnet-calculator.html>

	Addresses	Hosts	Netmask
/30	4	2	255.255.255.252
/29	8	6	255.255.255.248
/28	16	14	255.255.255.240
/27	32	30	255.255.255.224
/26	64	62	255.255.255.192
/25	128	126	255.255.255.128
/24	256	254	255.255.255.0
/23	512	510	255.255.254.0
/22	1024	1022	255.255.252.0
/21	2048	2046	255.255.248.0
/20	4096	4094	255.255.240.0
/19	8192	8190	255.255.224.0
/18	16384	16382	255.255.192.0
/17	32768	32766	255.255.128.0
/16	65536	65534	255.255.0.0

Domain Name System or DNS

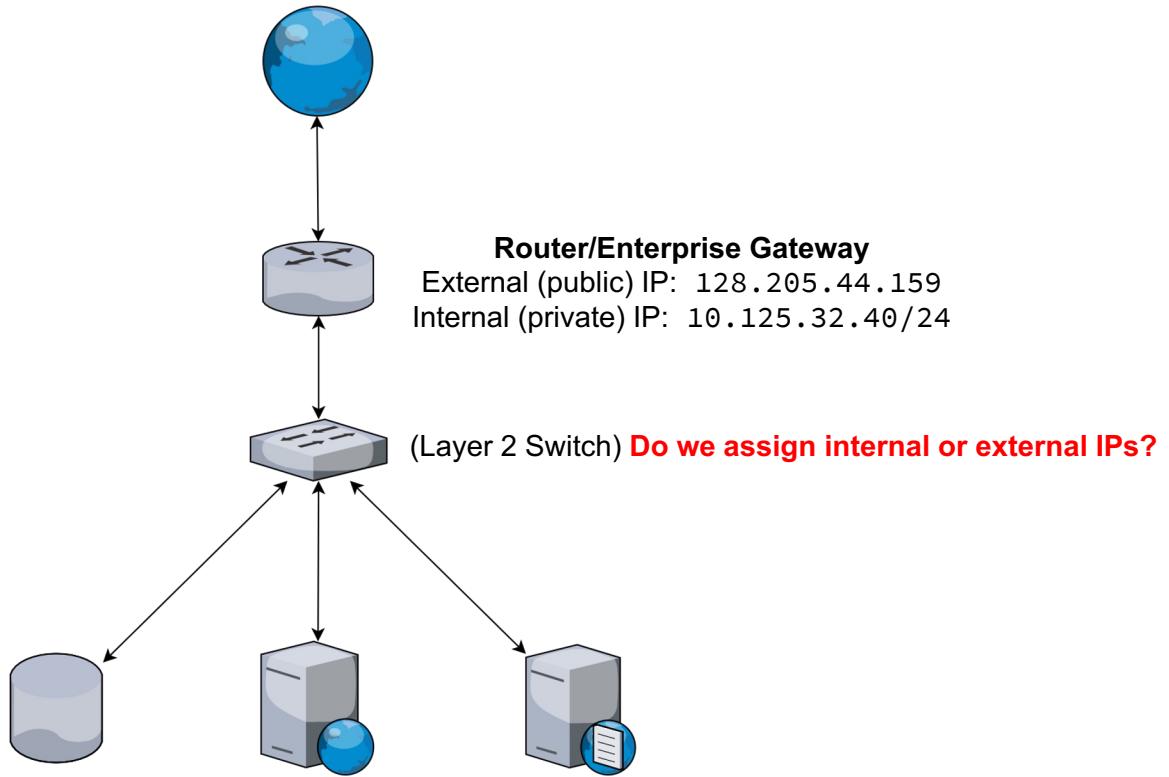
- A Domain is used to identify a system on the Internet
 - Example@buffalo.edu
 - www.buffalo.edu
 - When we type “dns.google.com”, DNS translates to “8.8.8.8”

Questions?

In Class Activity

IP Assignment Walkthrough

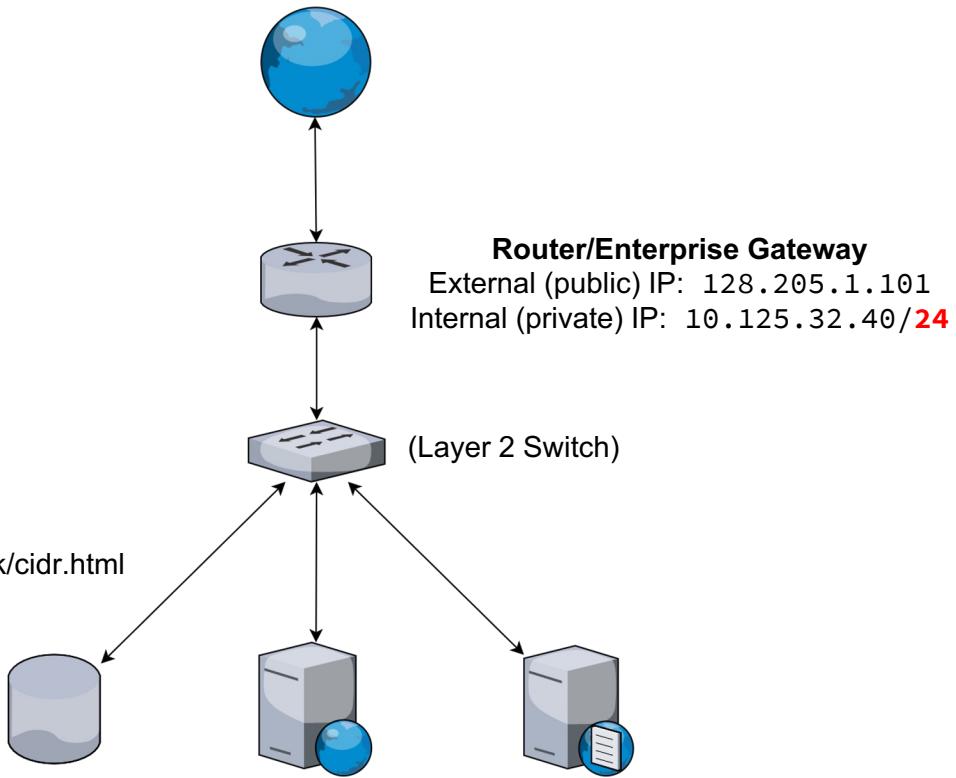
Example 1



IP Address:
Subnet Mask:
Default Gateway:
...

IP Address:
Subnet Mask:
Default Gateway:
...

IP Address:
Subnet Mask:
Default Gateway:
...



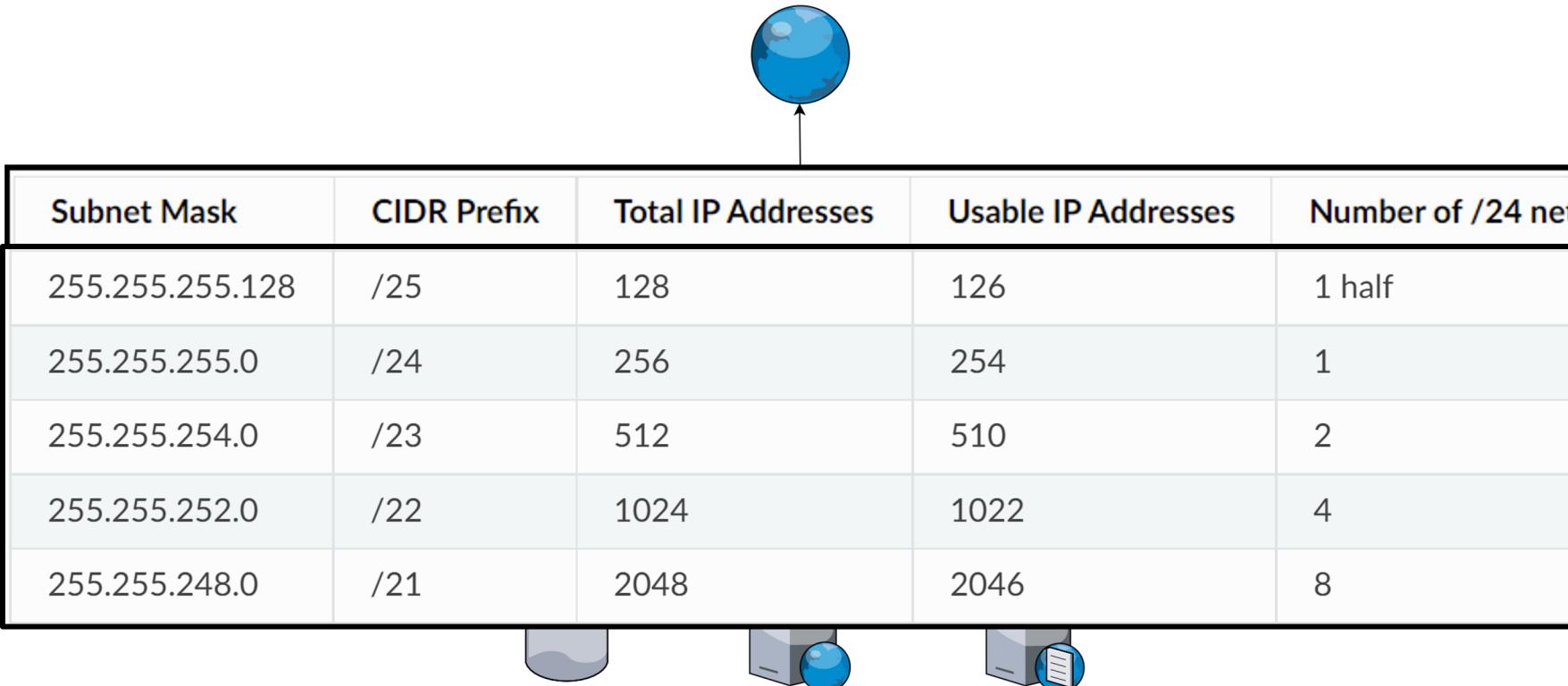
Start with the easy parts first:

<https://docs.netgate.com/pfsense/en/latest/network/cidr.html>

IP Address:
Subnet Mask:
Default Gateway:
...

IP Address:
Subnet Mask:
Default Gateway:
...

IP Address:
Subnet Mask:
Default Gateway:
...

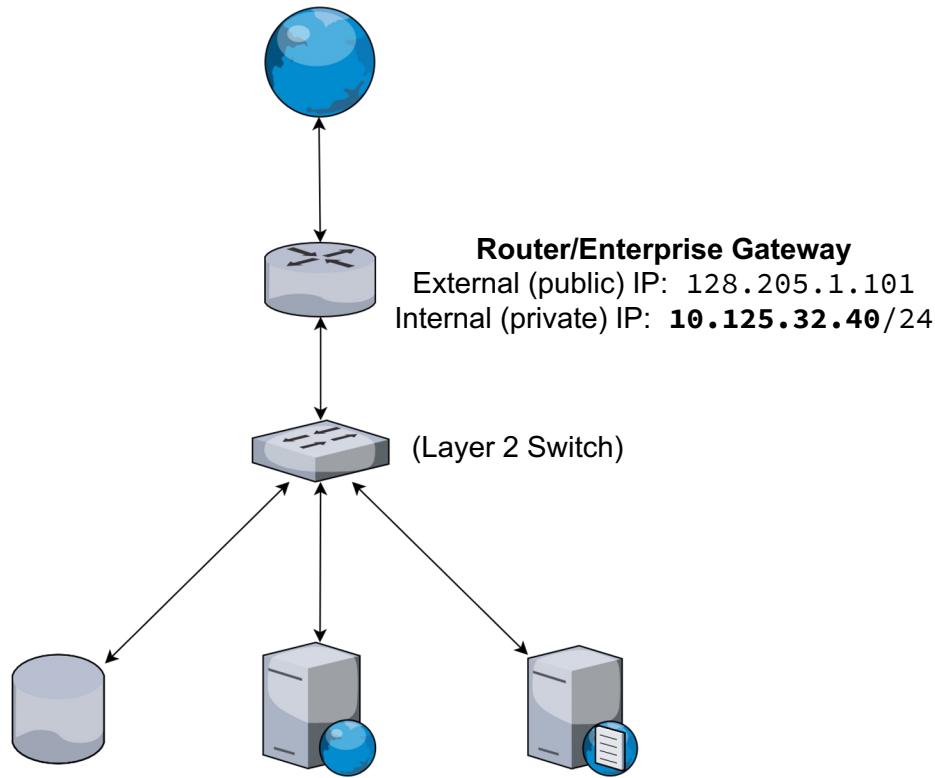


Subnet Mask	CIDR Prefix	Total IP Addresses	Usable IP Addresses	Number of /24 networks
255.255.255.128	/25	128	126	1 half
255.255.255.0	/24	256	254	1
255.255.254.0	/23	512	510	2
255.255.252.0	/22	1024	1022	4
255.255.248.0	/21	2048	2046	8

IP Address:
Subnet Mask: **255.255.255.0**
Default Gateway:
...

IP Address:
Subnet Mask: **255.255.255.0**
Default Gateway:
...

IP Address:
Subnet Mask: **255.255.255.0**
Default Gateway:
...

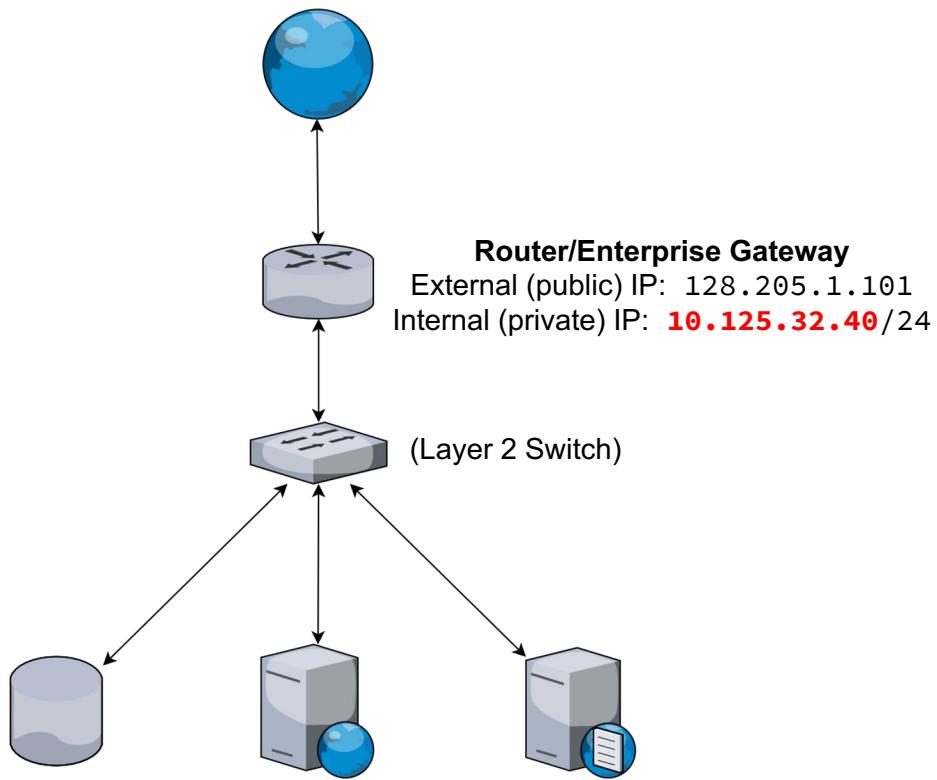


Next easy part:
Default Gateway

IP Address:
Subnet Mask: 255.255.255.0
Default Gateway:
...

IP Address:
Subnet Mask: 255.255.255.0
Default Gateway:
...

IP Address:
Subnet Mask: 255.255.255.0
Default Gateway:
...



Next easy part:
Default Gateway = Internal IP

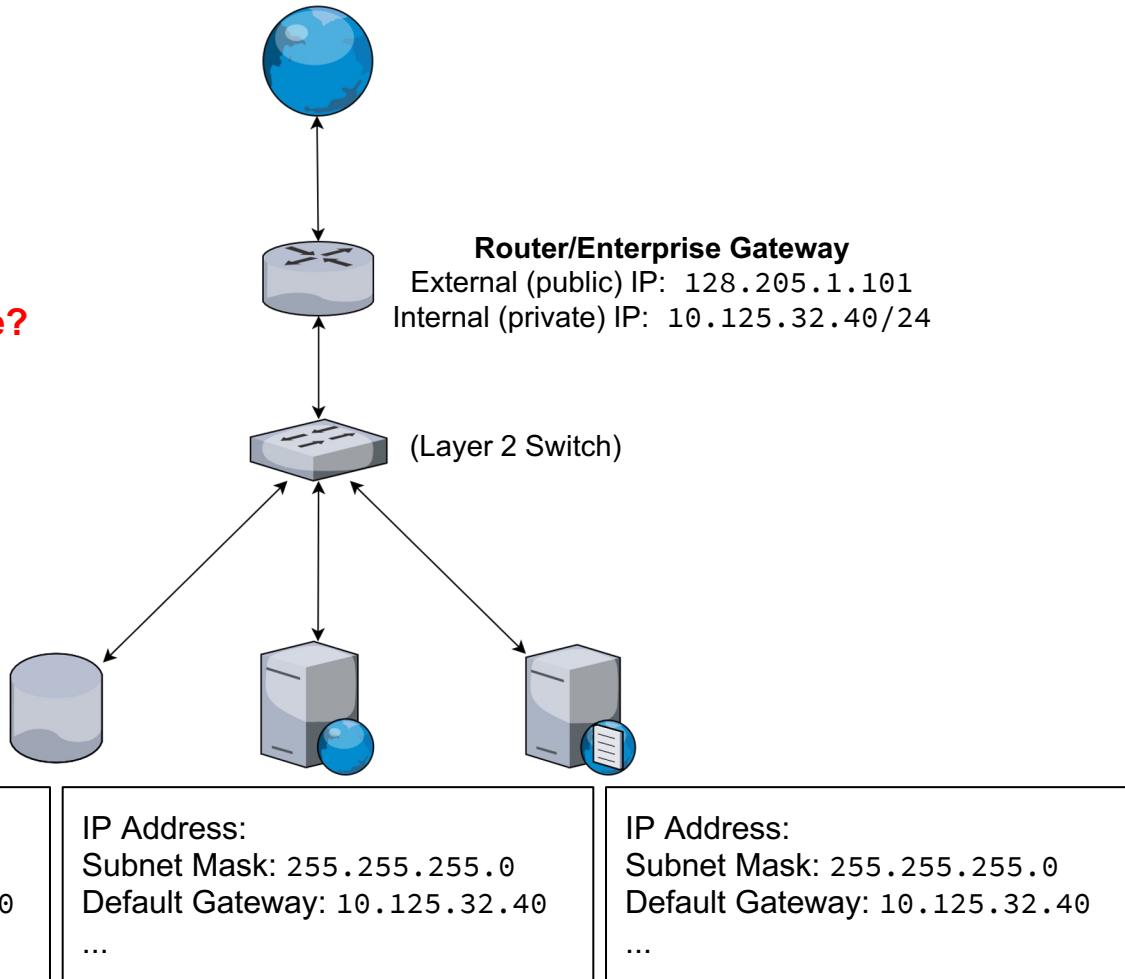
IP Address:
Subnet Mask: 255.255.255.0
Default Gateway: **10.125.32.40**
...

IP Address:
Subnet Mask: 255.255.255.0
Default Gateway: **10.125.32.40**
...

IP Address:
Subnet Mask: 255.255.255.0
Default Gateway: **10.125.32.40**
...

What address space is available?

Consult: <https://www.subnet-calculator.com/>

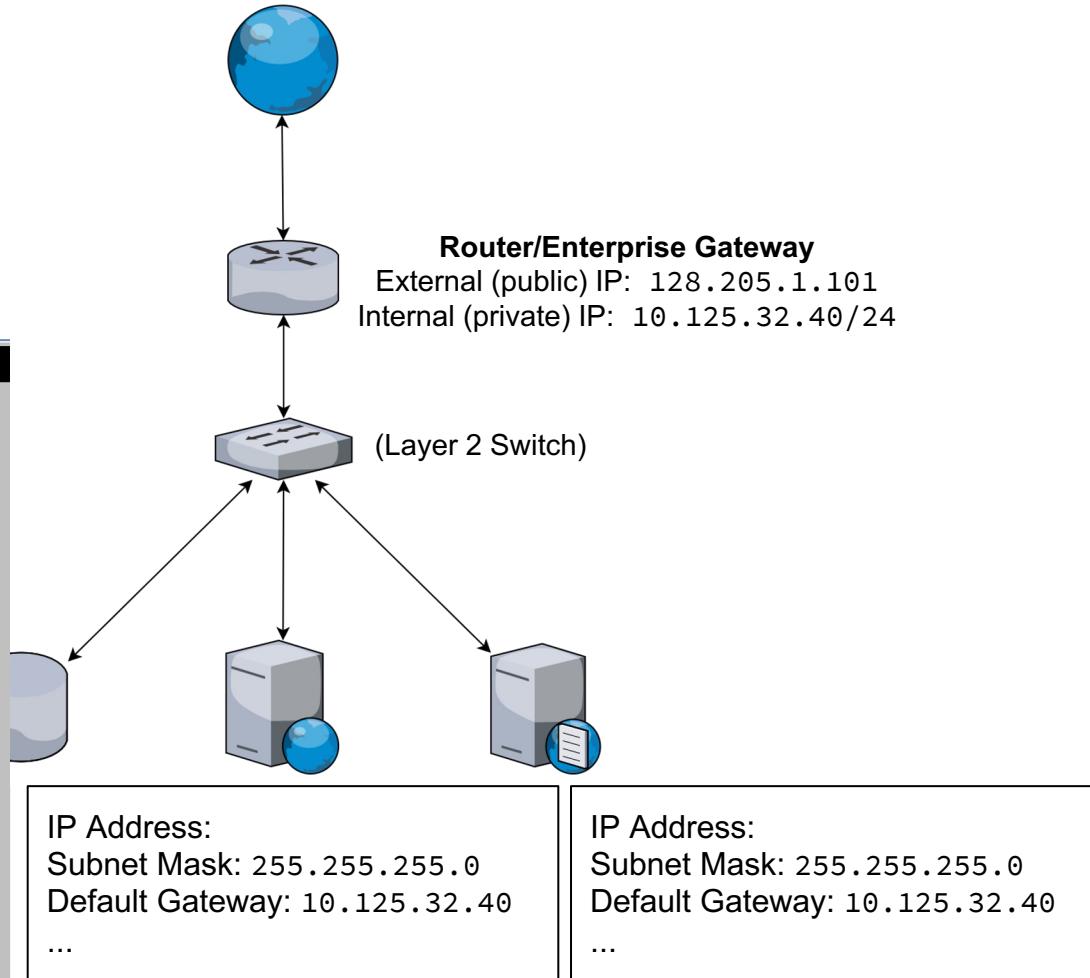


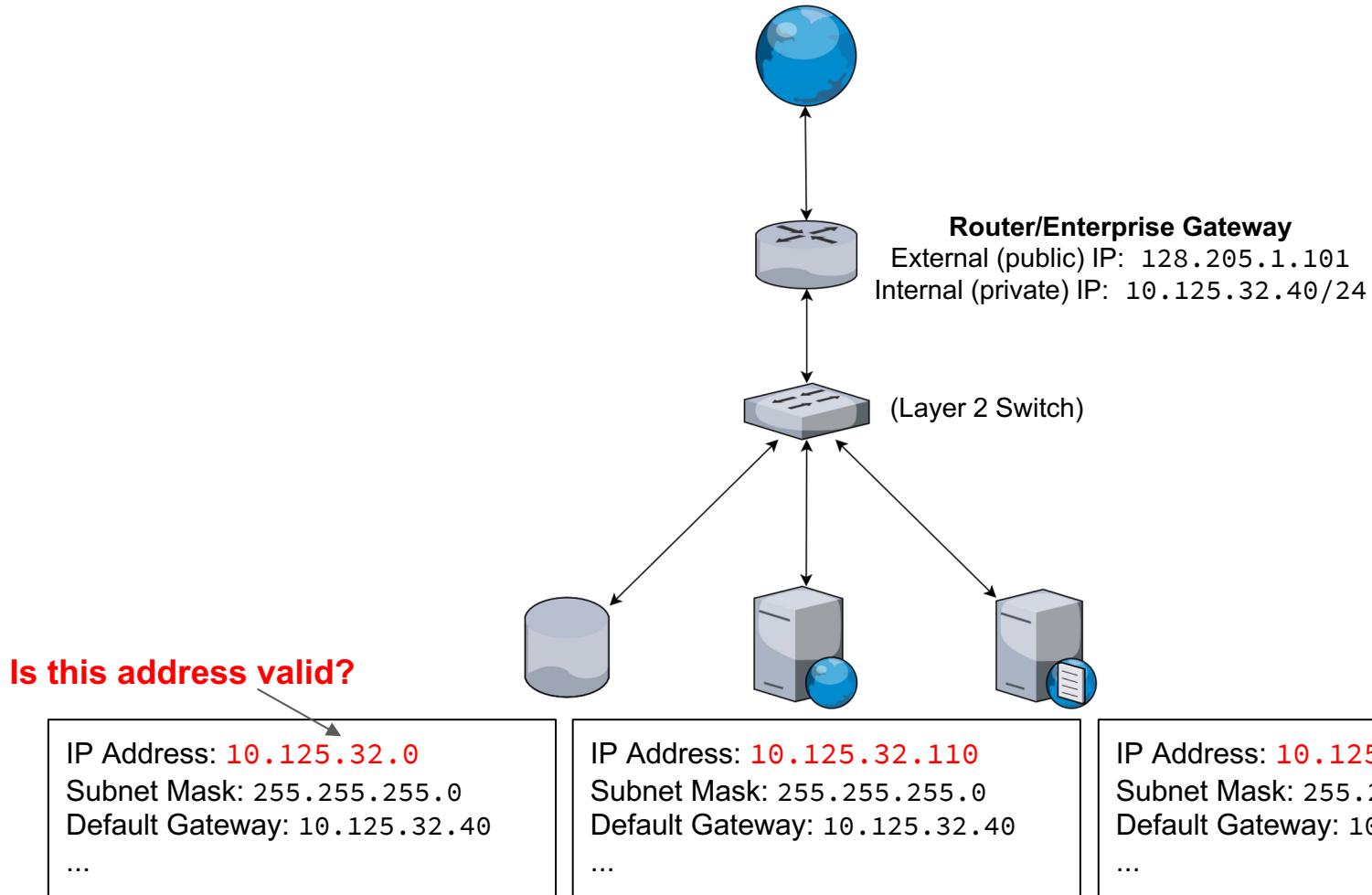
What address space is available?

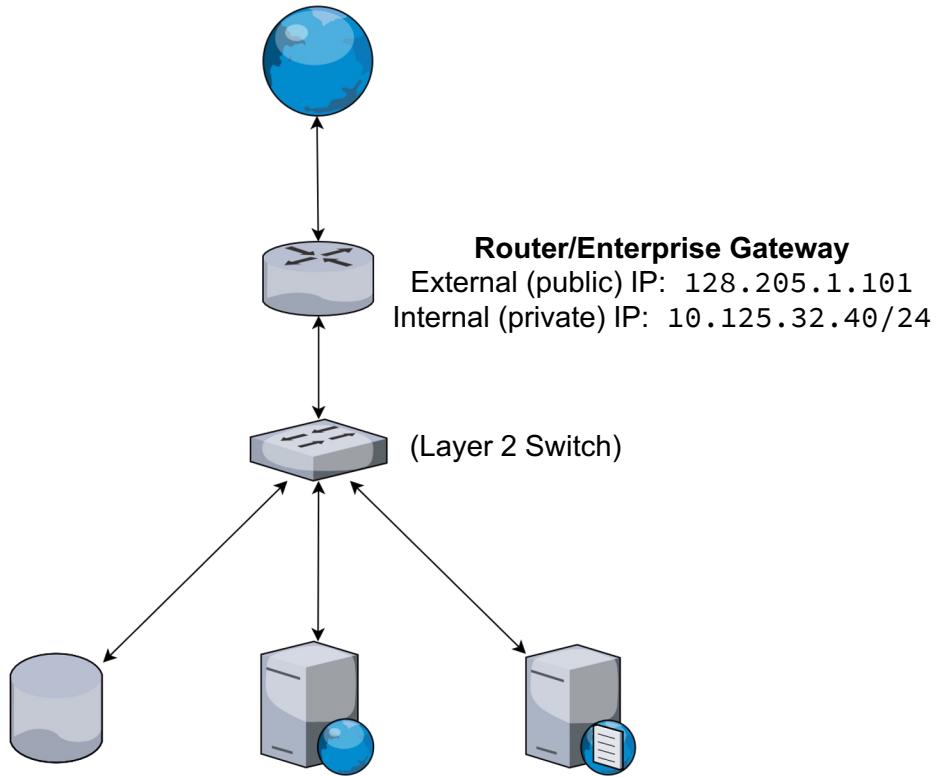
- Subnet ID and Broadcast Address are unusable

Subnet Calculator

Network Class <input checked="" type="radio"/> A	First Octet Range 1 - 126
IP Address 10.125.32.40	Hex IP Address 0A.7D.20.28
Subnet Mask 255.255.255.0	Wildcard Mask 0.0.0.255
Subnet Bits 16	Mask Bits 24
Maximum Subnets 65536	Hosts per Subnet 254
Host Address Range 10.125.32.1 - 10.125.32.254	
Subnet ID 10.125.32.0	Broadcast Address 10.125.32.255
Subnet Bitmap 0nnnnnnn.ssssssss.ssssssss.hhhhhhhh	







IP Address: **10.125.32.14**
Subnet Mask: 255.255.255.0
Default Gateway: 10.125.32.40
...

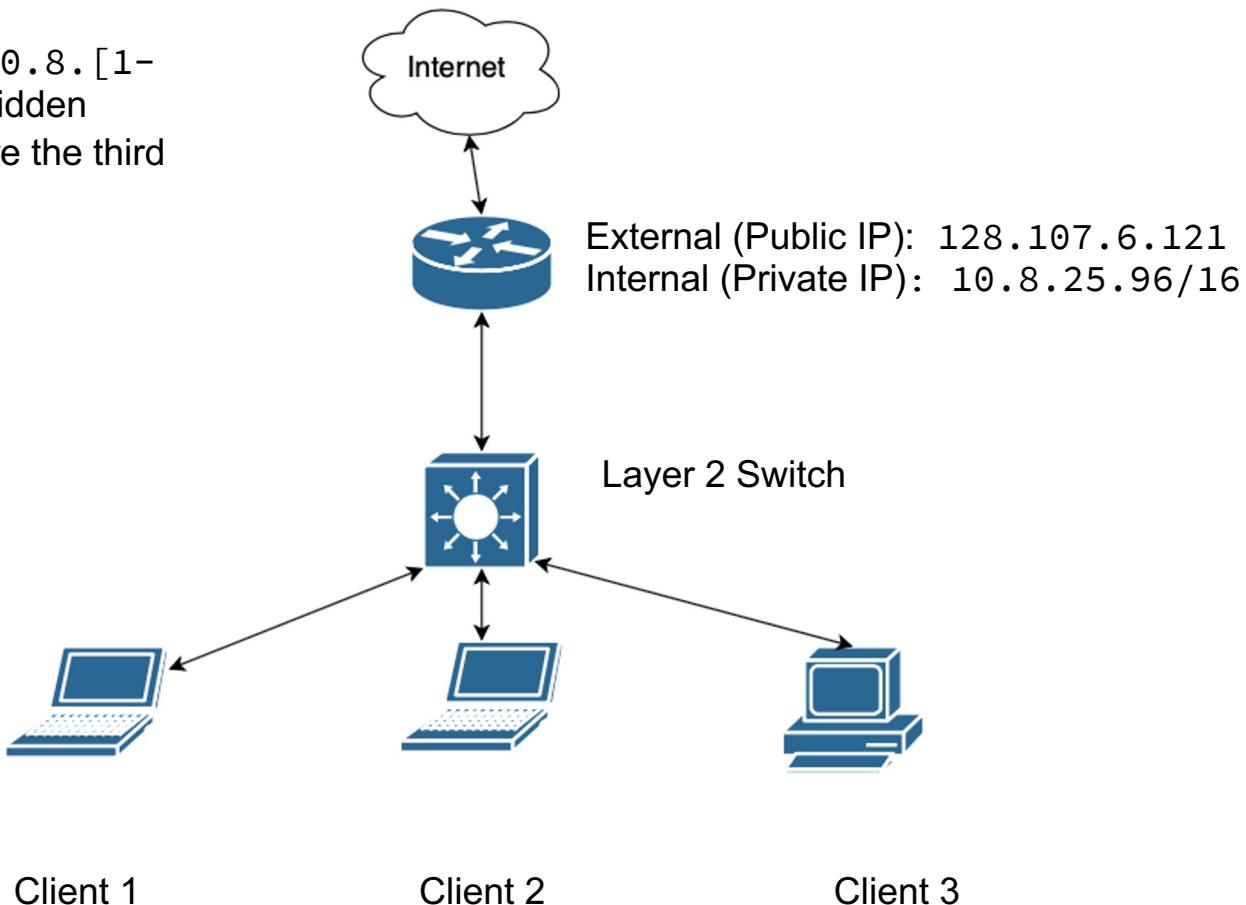
IP Address: **10.125.32.110**
Subnet Mask: 255.255.255.0
Default Gateway: 10.125.32.40
...

IP Address: **10.125.32.210**
Subnet Mask: 255.255.255.0
Default Gateway: 10.125.32.40
...

Example 2

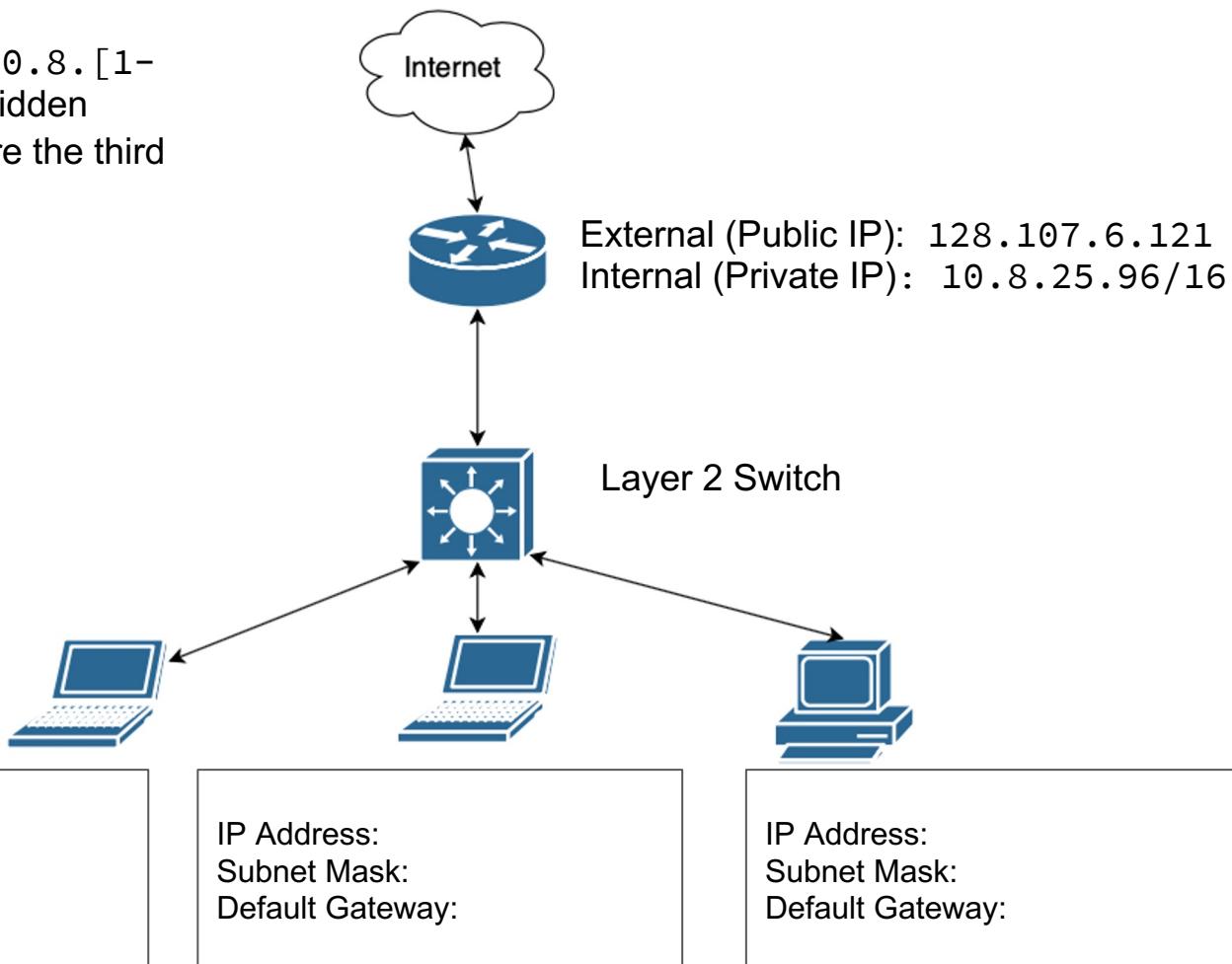
Rules:

- IP address range $10.8.[1-24].[any]$ is forbidden
- No clients can share the third octet



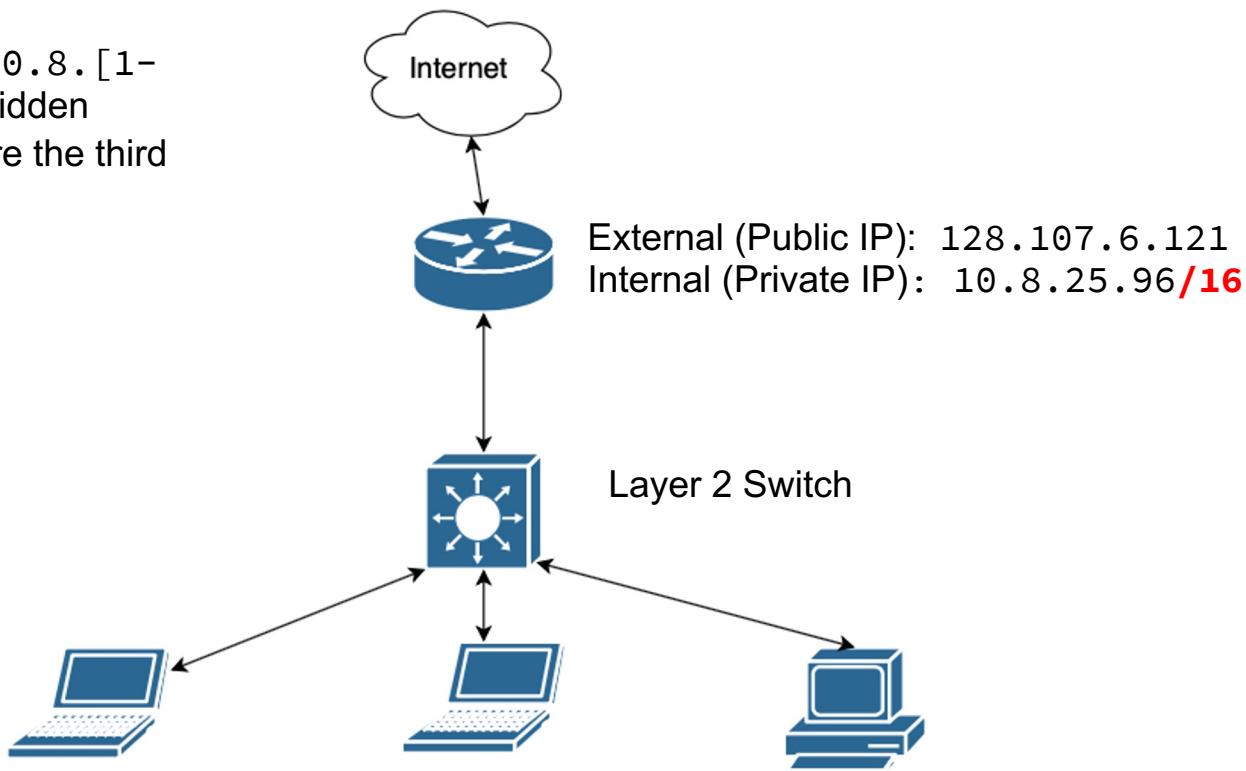
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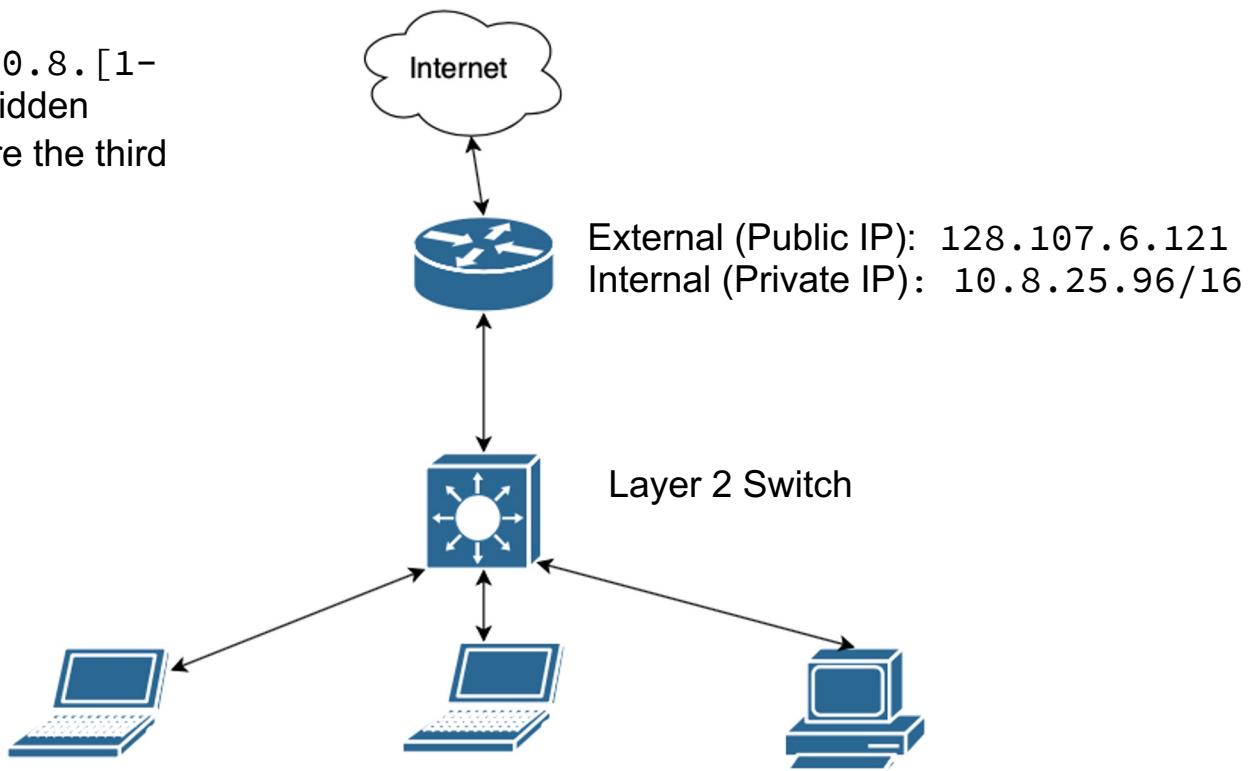


Once again, let's start easy. What are the subnet masks for our 3 clients?

Subnet Mask	CIDR Prefix	Total IP Addresses	Usable IP Addresses	Number of /24 networks
255.255.0.0	/16	65,536	65,534	256

Rules:

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Once again, let's start easy. What are the subnet masks for our 3 clients?

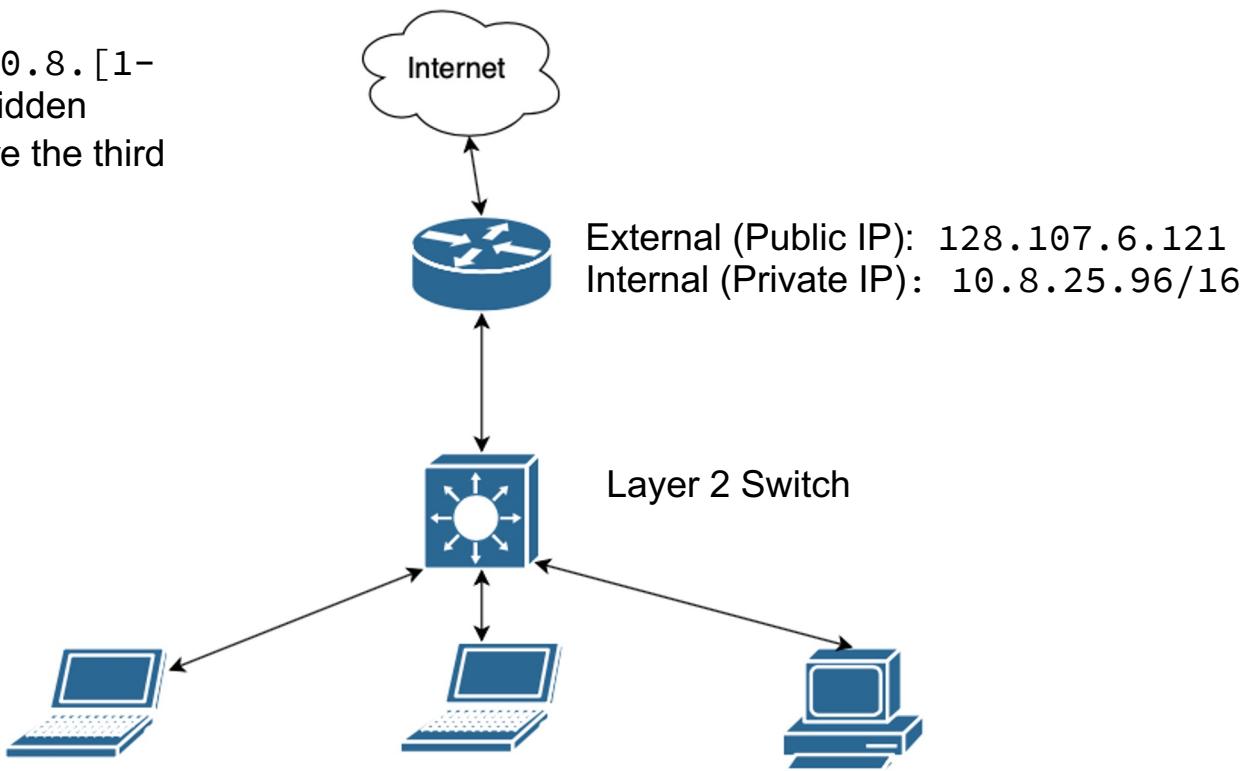
IP Address:
Subnet Mask: **255.255.0.0**
Default Gateway:

IP Address:
Subnet Mask: **255.255.0.0**
Default Gateway:

IP Address:
Subnet Mask: **255.255.0.0**
Default Gateway:

Rules:

- IP address range 10.8.[1-24].[any] is forbidden
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What is our default gateway?

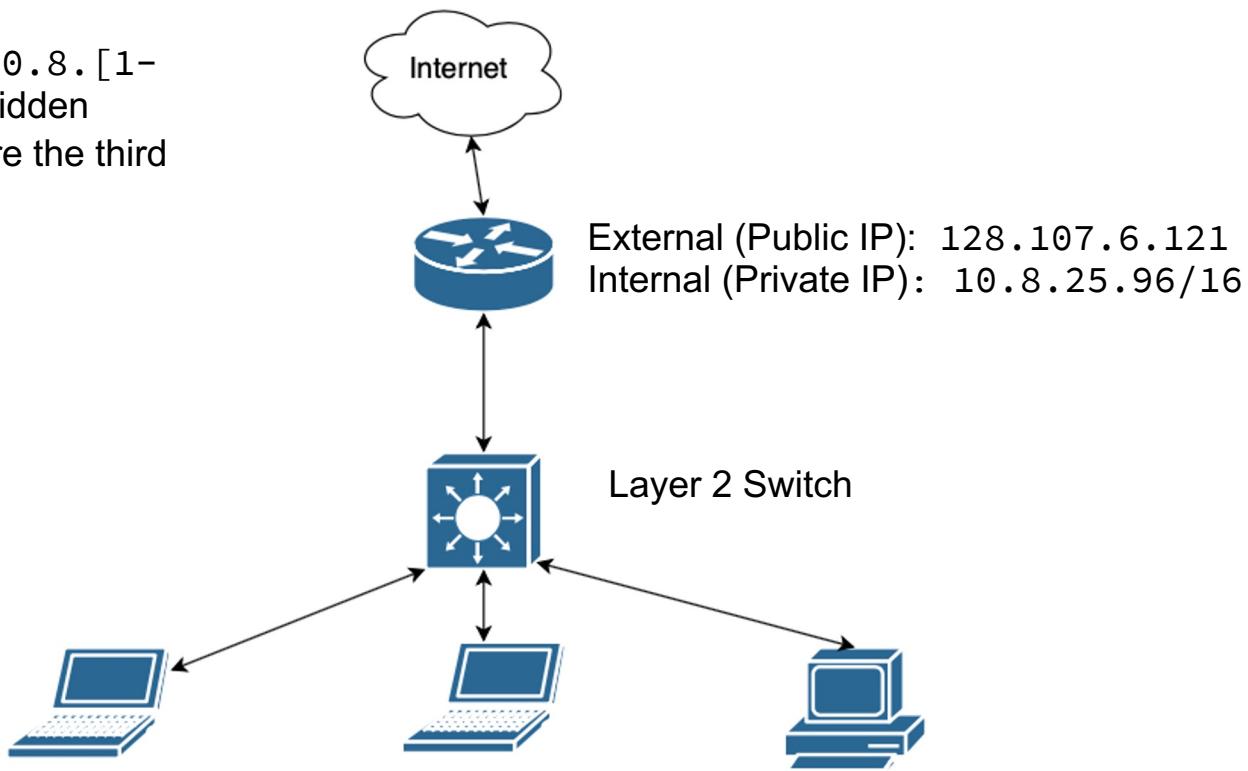
IP Address:
Subnet Mask: 255.255.0.0
Default Gateway:

IP Address:
Subnet Mask: 255.255.0.0
Default Gateway:

IP Address:
Subnet Mask: 255.255.0.0
Default Gateway:

Rules:

- IP address range 10.8.[1-24].[any] is forbidden
- No clients can share the third octet



IP Address:
Subnet Mask: 255.255.0.0
Default Gateway: 10.8.25.96

IP Address:
Subnet Mask: 255.255.0.0
Default Gateway: 10.8.25.96

IP Address:
Subnet Mask: 255.255.0.0
Default Gateway: 10.8.25.96

Rules:

- IP address range 10.8.[1-24].[any] is forbidden
- No clients can share the third octet

What is our IP Address?

Subnet Calculator

Network Class: A (radio button selected)

IP Address: 10.8.25.96

Subnet Mask: 255.255.0.0

Subnet Bits: 8

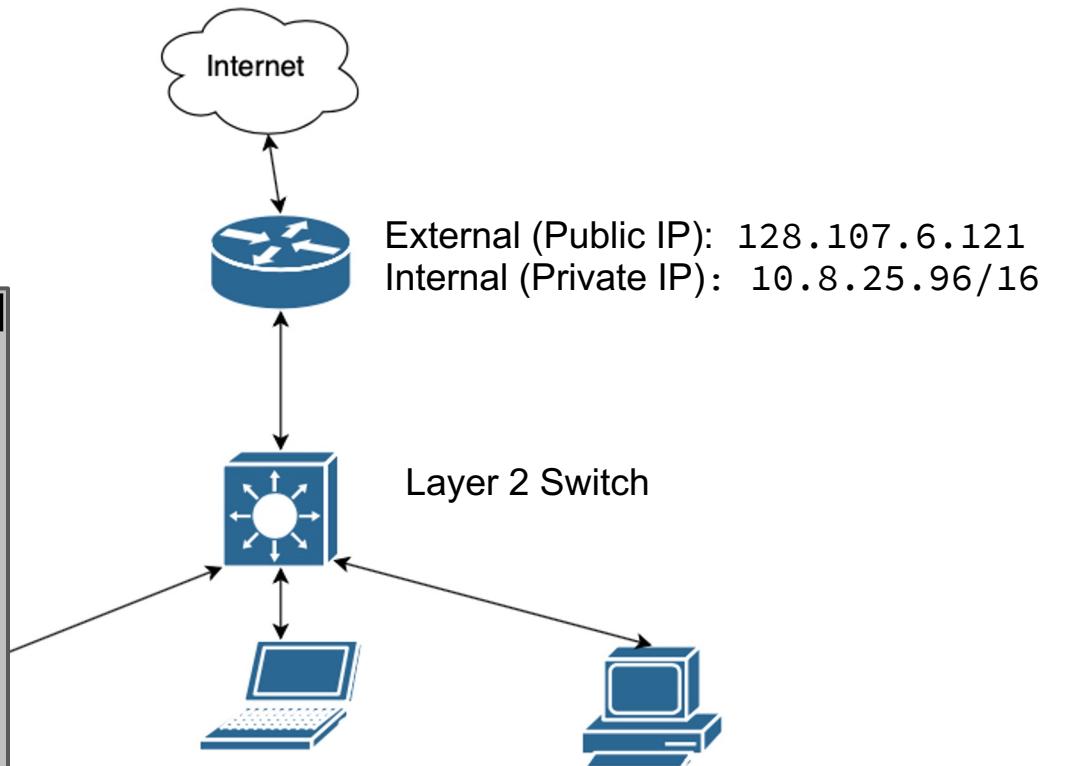
Maximum Subnets: 256

Host Address Range: 10.8.0.1 - 10.8.255.254

Subnet ID: 10.8.0.0

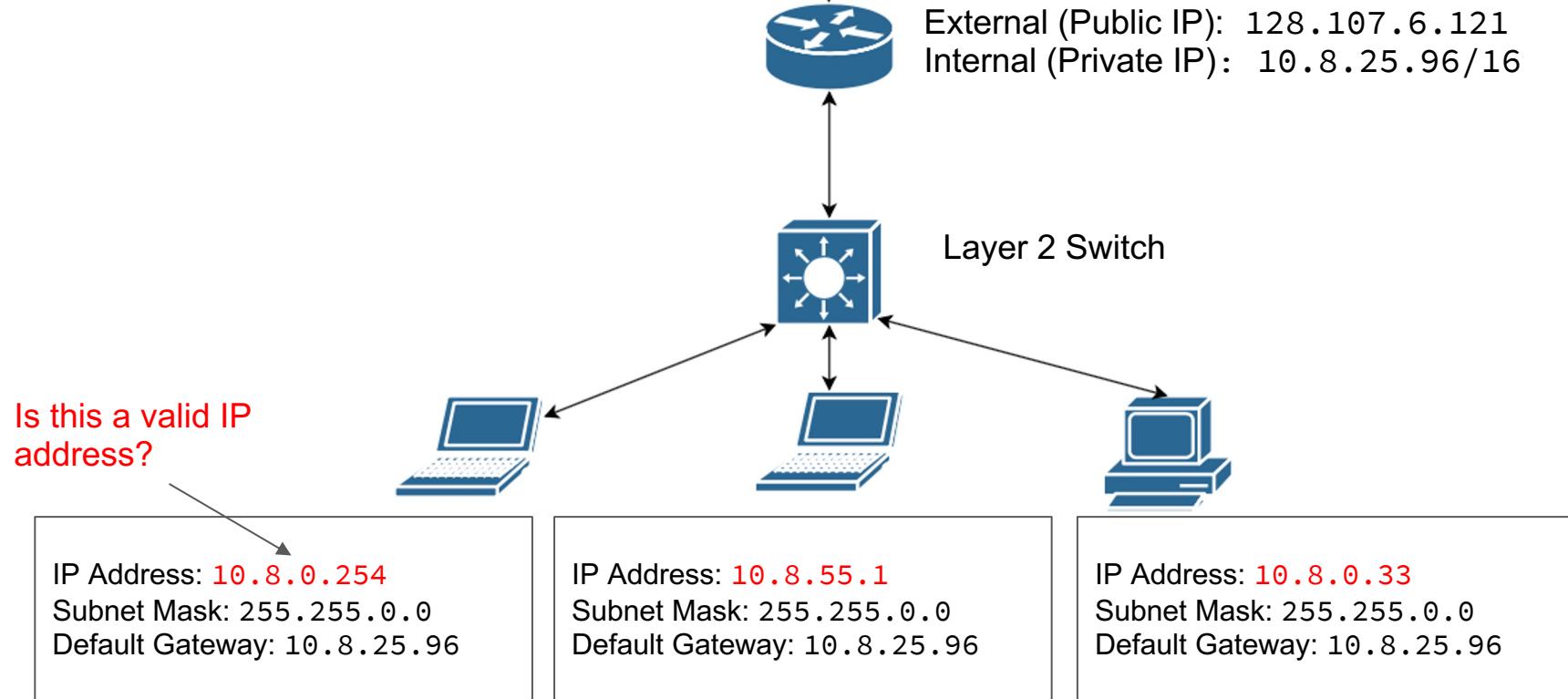
Broadcast Address: 10.8.255.255

Subnet Bitmap: 0nnnnnnn.ssssssss.hhhhhhhh.hhhhhhhh



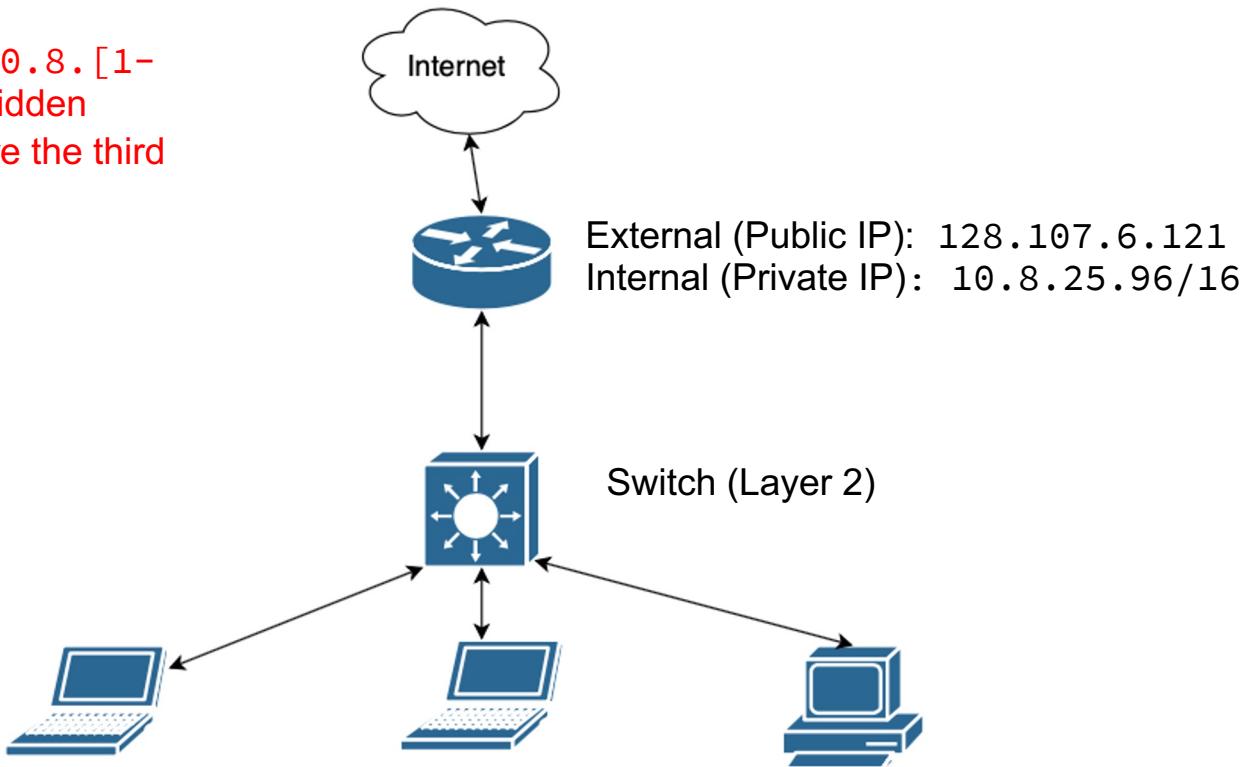
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Rules:

- IP address range 10.8.[1-24].[any] is forbidden
- No clients can share the third octet



IP Address: 10.8.32.254
Subnet Mask: 255.255.0.0
Default Gateway: 10.8.25.96

IP Address: 10.8.55.1
Subnet Mask: 255.255.0.0
Default Gateway: 10.8.25.96

IP Address: 10.8.0.33
Subnet Mask: 255.255.0.0
Default Gateway: 10.8.25.96

Composite Network Device

- When one hardware device manages more than one network interface
- Style guide has a great explanation and example

Why does layering matter?

- Each device will have 2 types of addresses
 - MAC addresses
 - IP addresses
- You will need to properly identify them and their use cases

Why does layering matter?

- There are 2 different types of network devices
 - Layer 2 devices
 - E.g., switches
 - Operate exclusively with MAC addresses
 - Layer 3 devices
 - E.g., routers, gateways, modems
 - Provide connectivity using IP addresses

ARP

- Address Resolution Protocol
 - How devices on the same LAN find out each others MAC address.
 - Stored in ARP cache

Summary and Wrap-up

Today's achievements:

- We learned how network devices work with network traffic.
- We reviewed the components of a network topology.
- We examined the OSI networking layers 1-3.
- We explored why layering matters.

Homework 02

Parting questions

Now is the time!

Class dismissed

See you next week!