

Networking

UBNetDef, Fall 2022
Week 2

Presenter: John Ryan

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

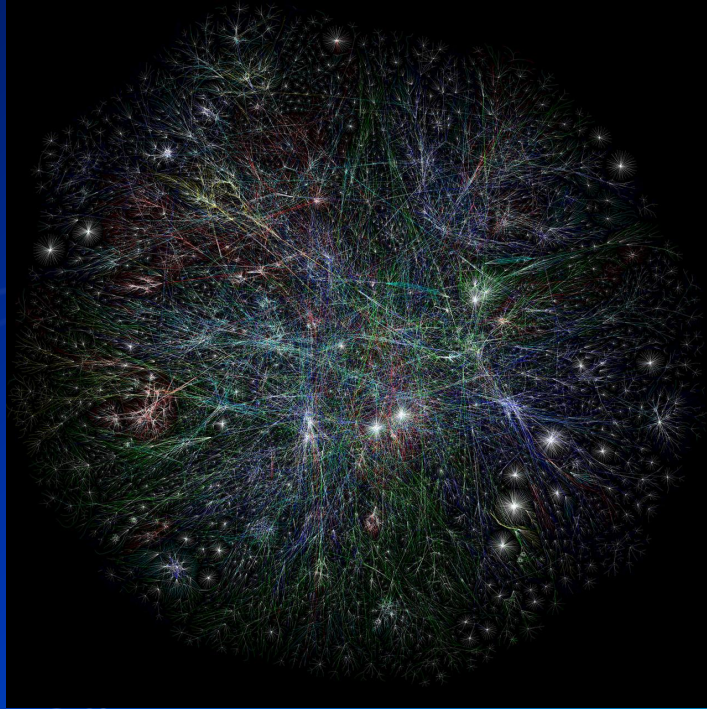
Picture 1



Picture 2



Picture 3

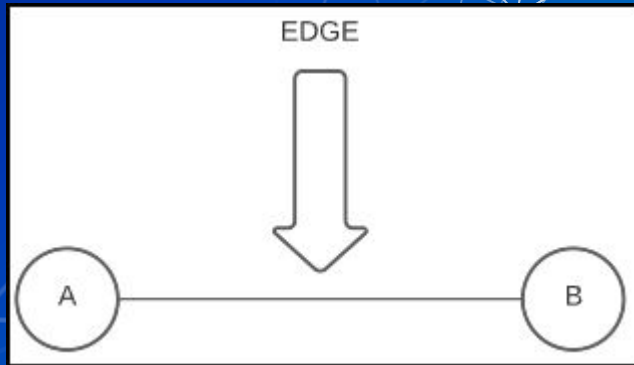


What do all of these have in Common?

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

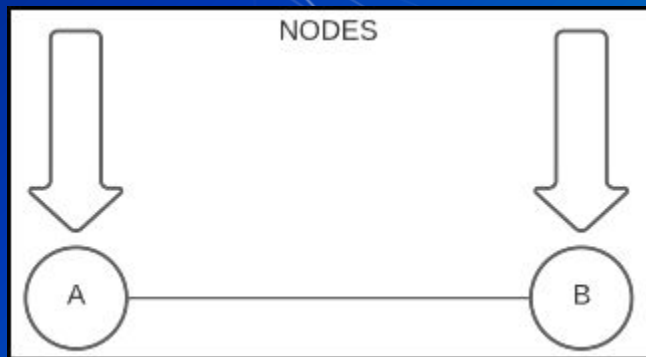
Edges

- 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

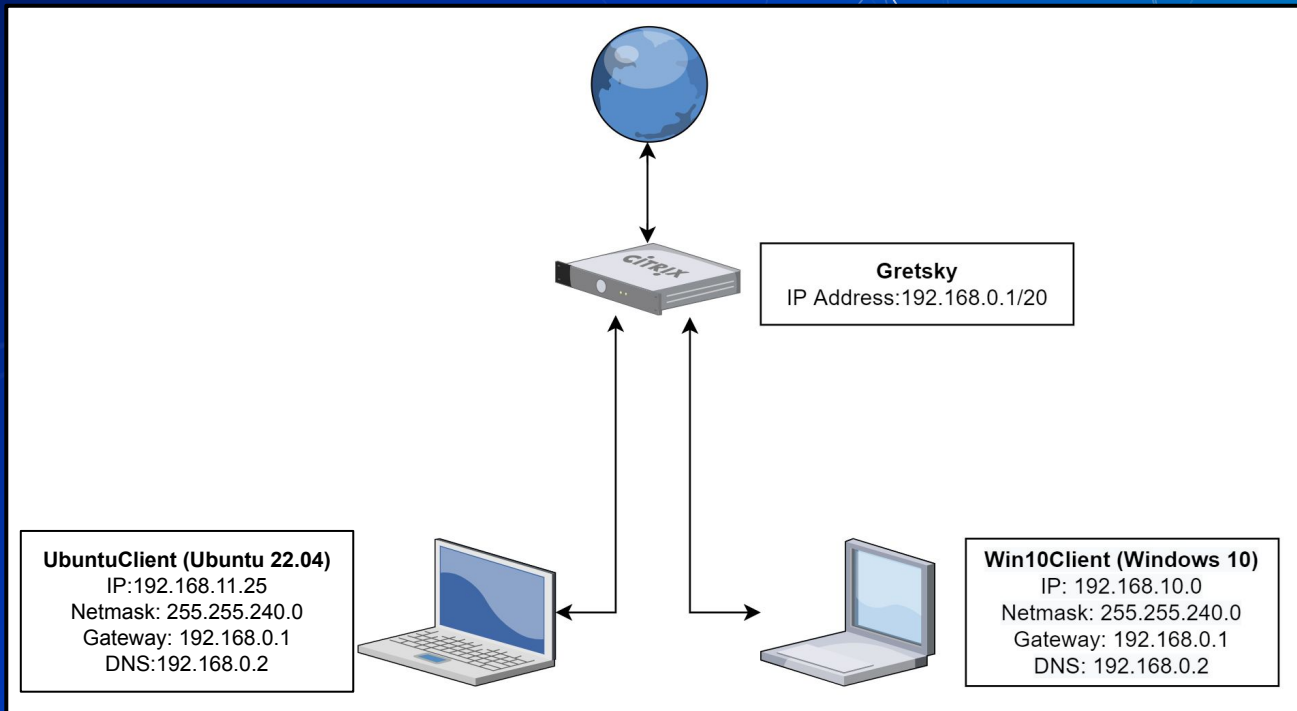
- Edges

- Ethernet wires
- Wireless signals to eduroam

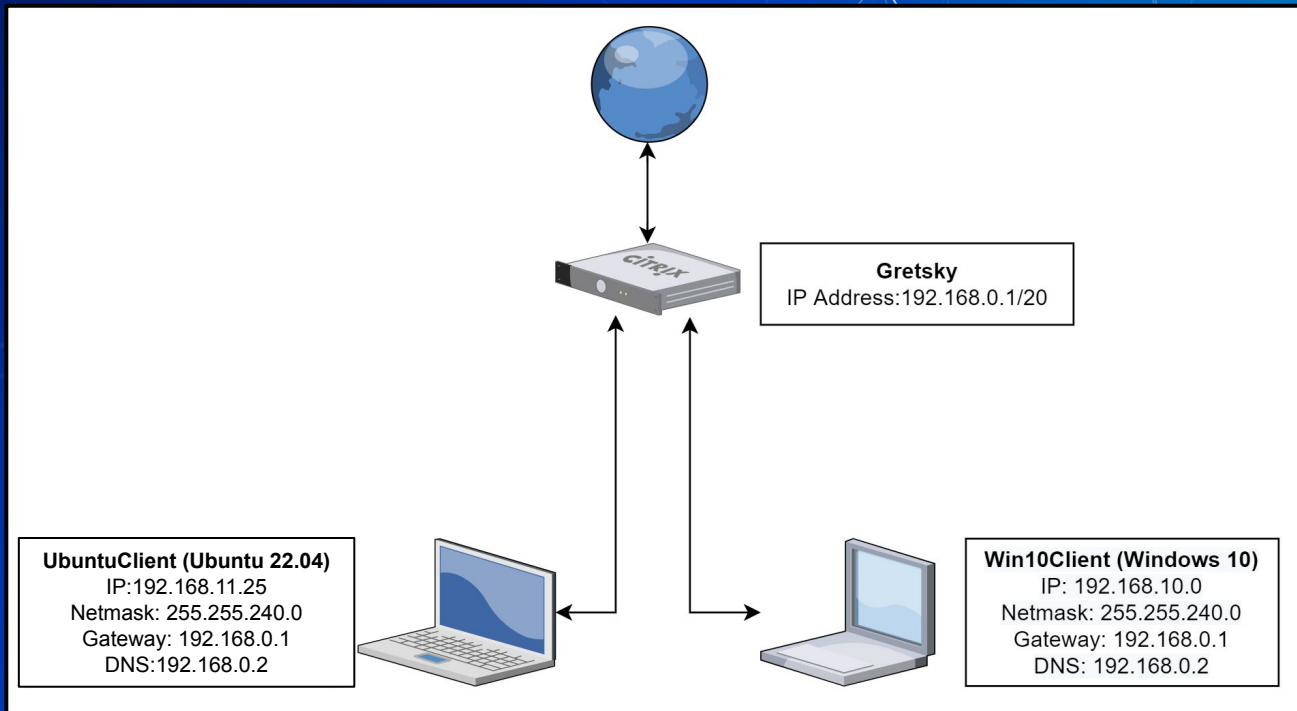
Endpoints vs. Network Devices

- **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

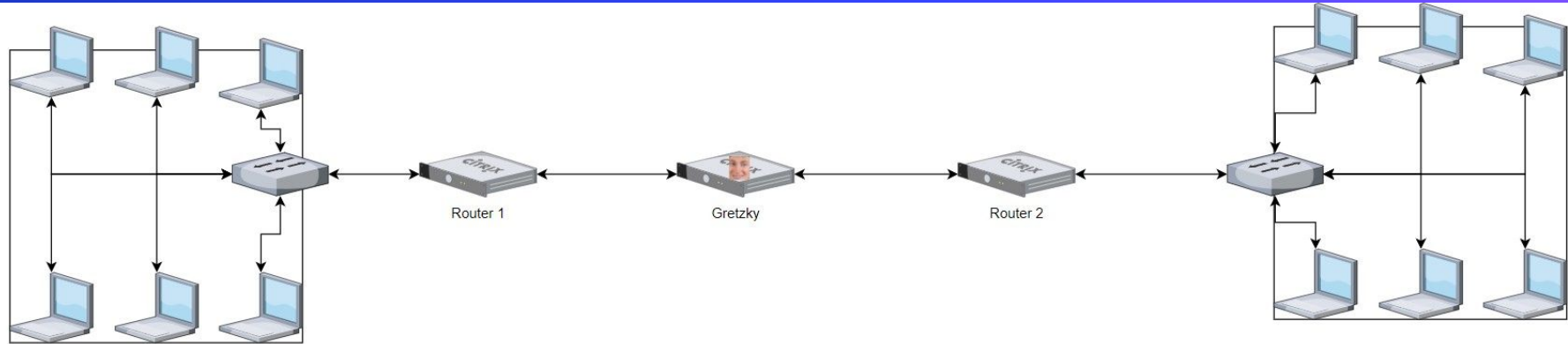
Questions?

In Class Activity

Packet Polo

Packet Polo

- Level 1: Local ARP
- Level 2: Cross Network ARP and Ping
- Level 3: Direct Packet Transfer



Break slide

Please return in 10 minutes

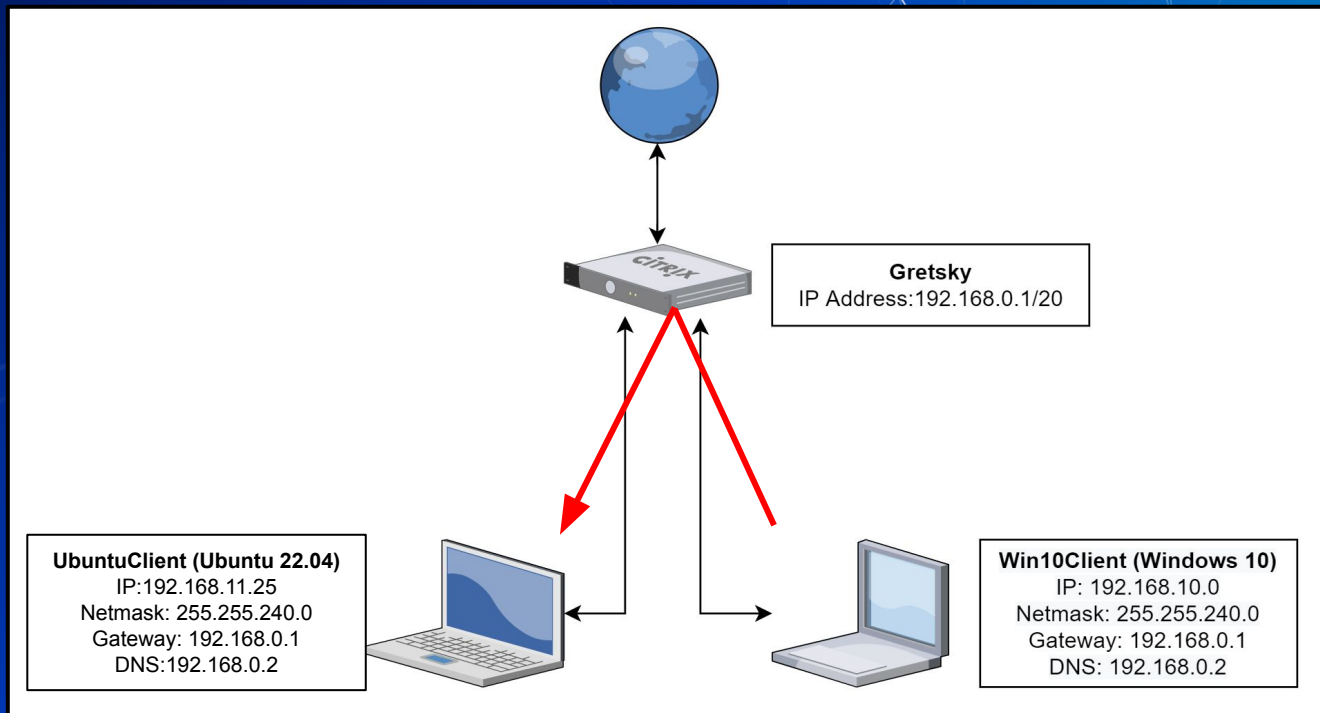
Transmitter vs. Receiver

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

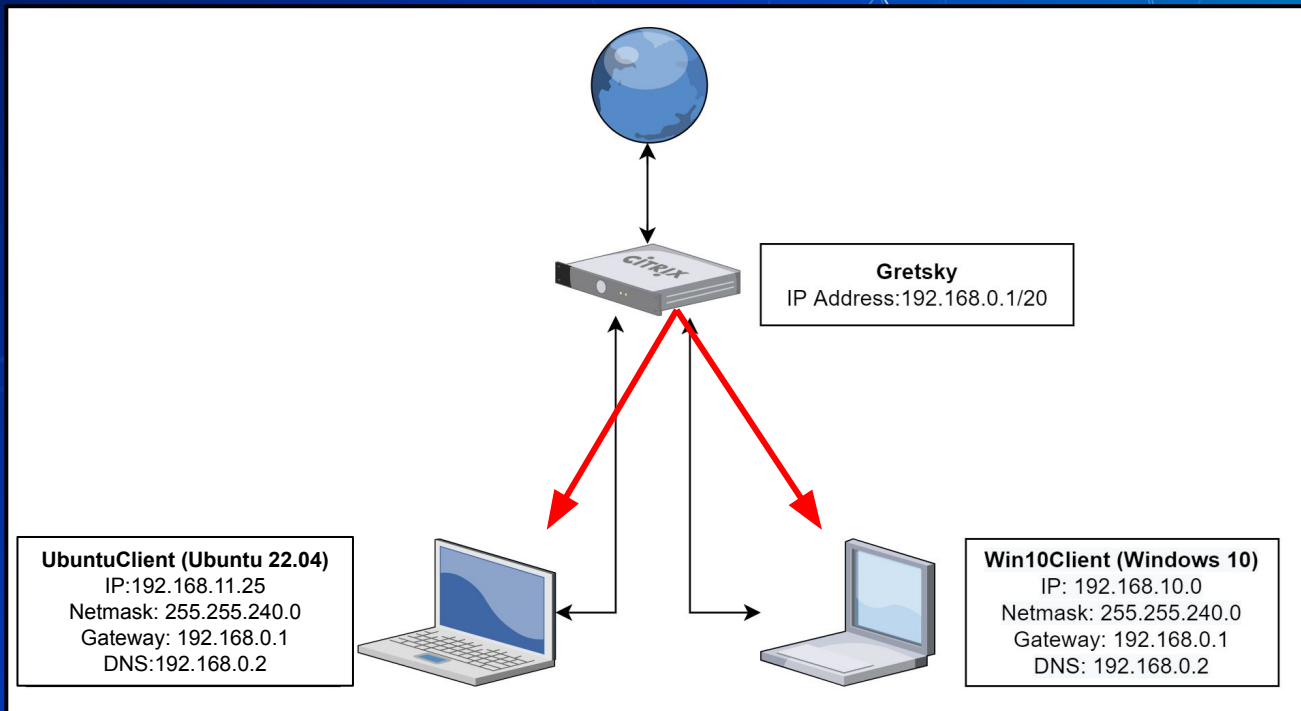
Transmission methods

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

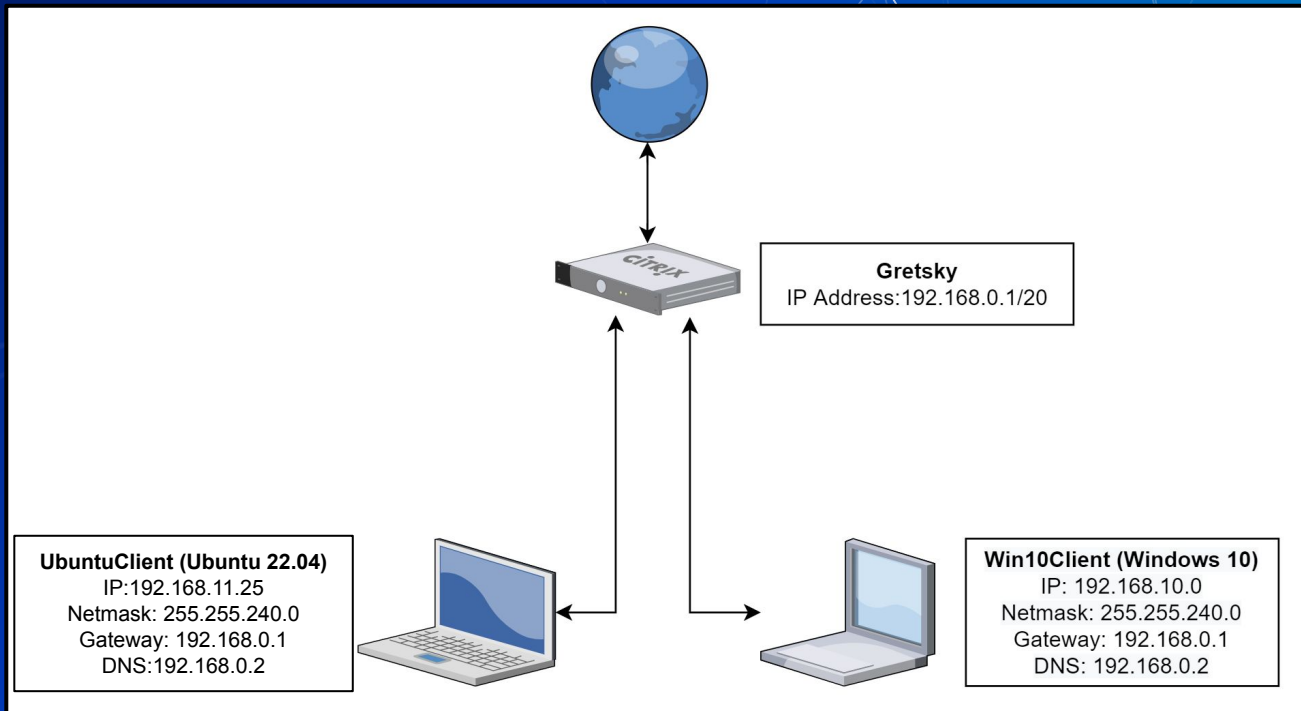
Which broadcast method?



Which broadcast method?



How about a multicast?



Local vs. Remote

* You are on your laptop at home

Local

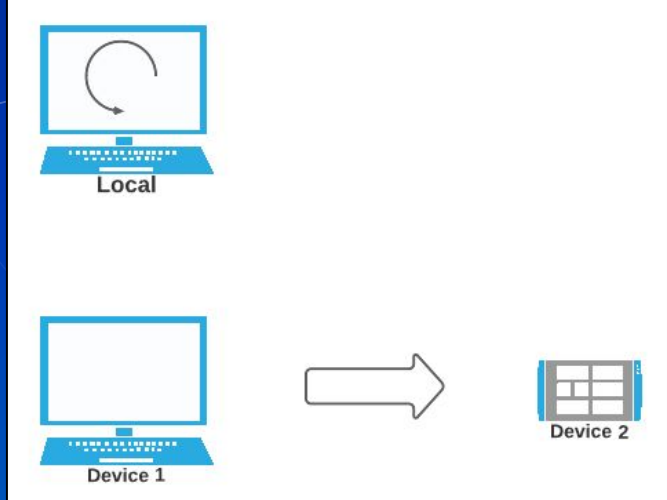
- Information exchanges within a single device

Example: Printing to PDF

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

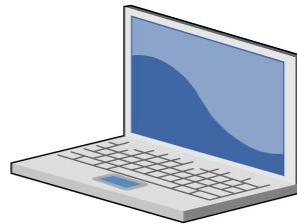
UbuntuClient (Ubuntu 22.04)

IP:192.168.11.25

Netmask: 255.255.240.0

Gateway: 192.168.0.1

DNS:192.168.0.2

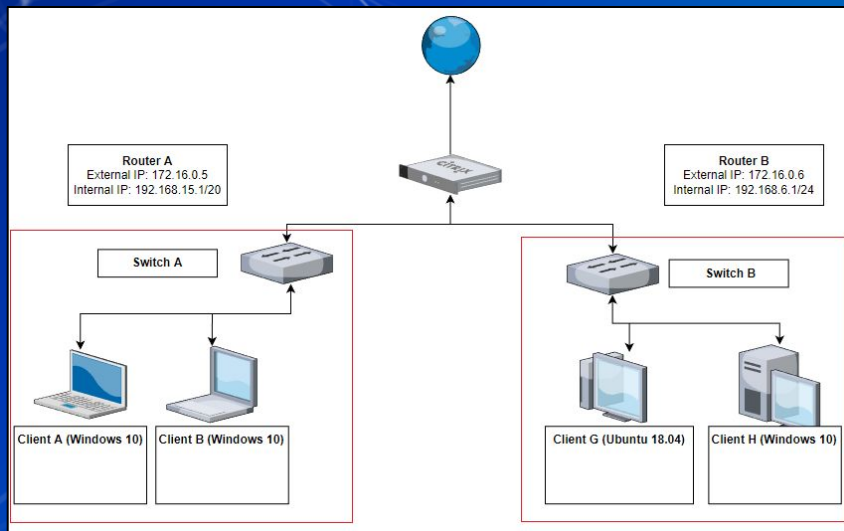


Break slide

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

7 Layers of the OSI Model

Application

- End User layer
- HTTP, FTP, IRC, SSH, DNS

Presentation

- Syntax layer
- SSL, SSH, IMAP, FTP, MPEG, JPEG

Session

- Synch & send to port
- API's, Sockets, WinSock

Transport

- End-to-end connections
- TCP, UDP

Network

- Packets
- IP, ICMP, IPsec, IGMP

Data Link

- Frames
- Ethernet, PPP, Switch, Bridge

Physical

- Physical structure
- Coax, Fiber, Wireless, Hubs, Repeaters

Application Layer

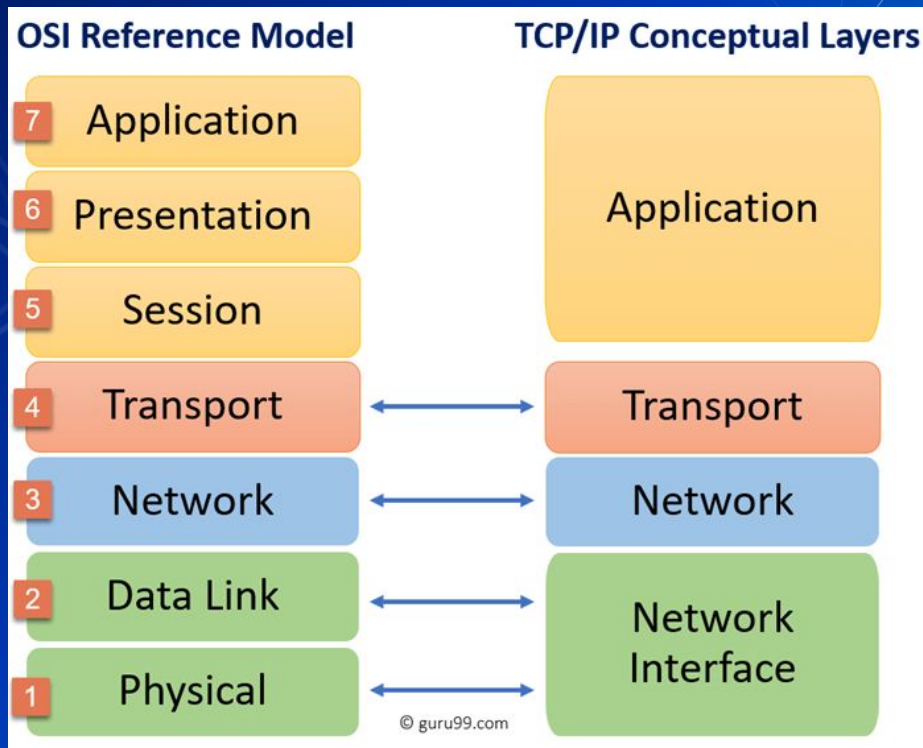
Transport Layer

Internet Layer

Network Access Layer

Top To Bottom

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
- 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.

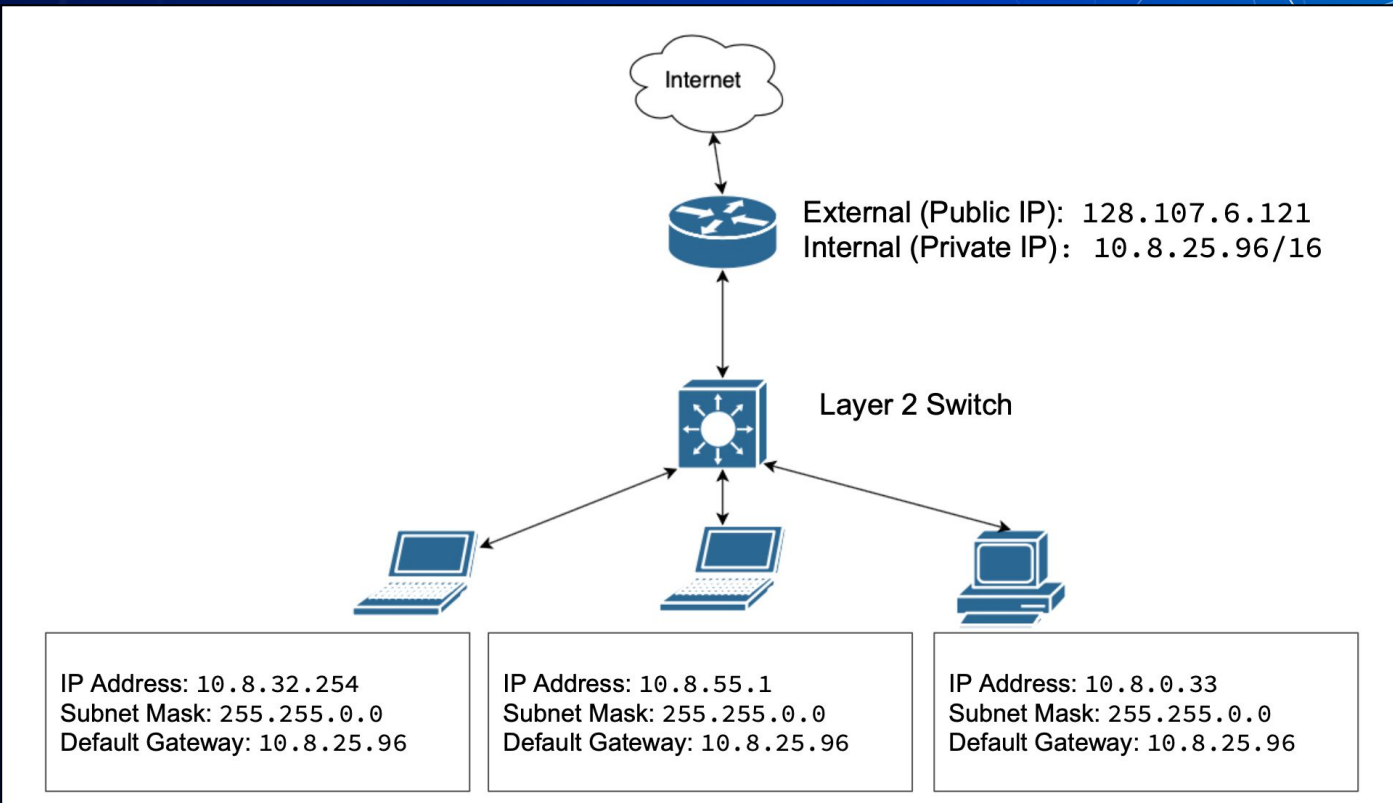
IPv4 Addresses: NAT

- 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

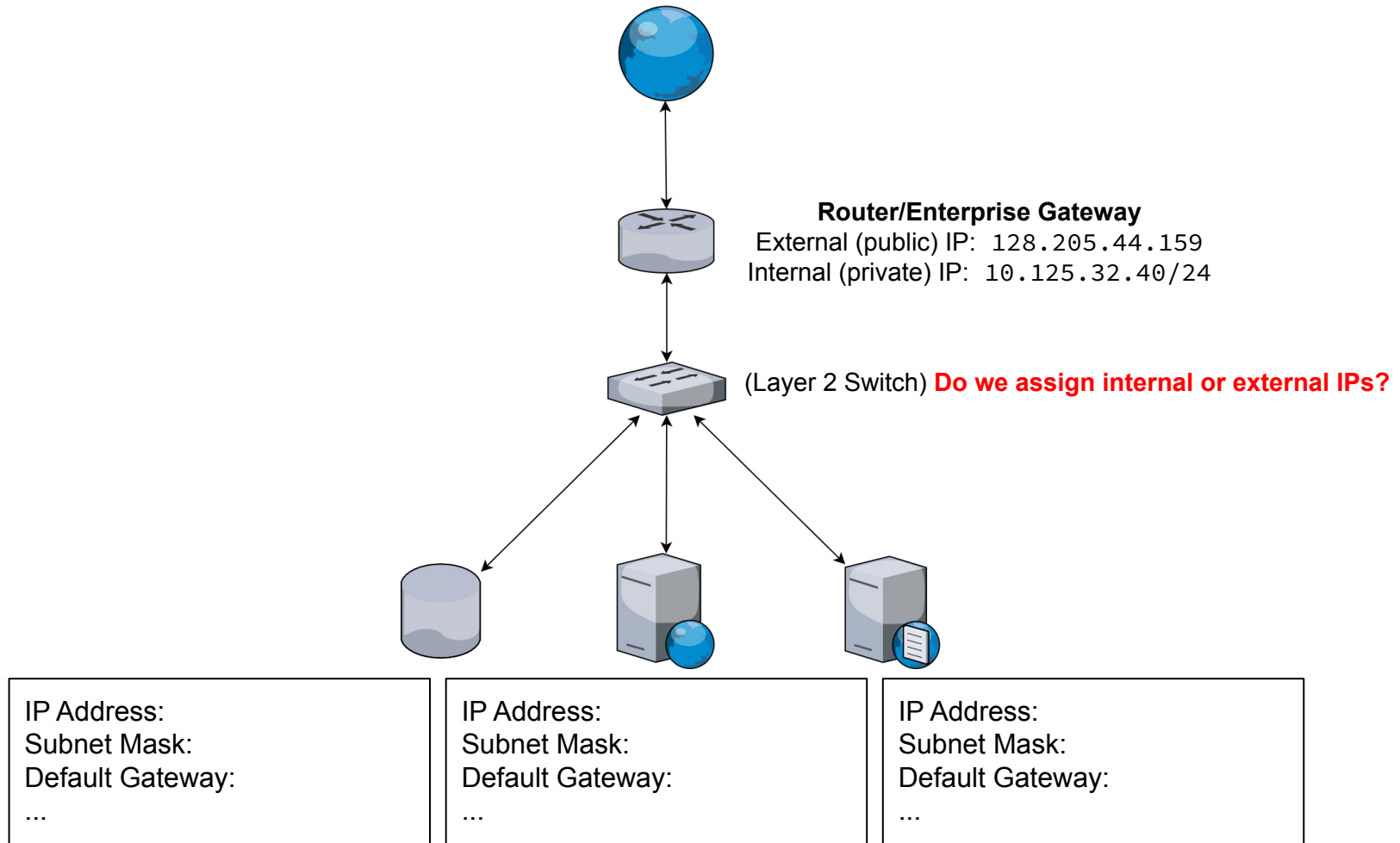
- A Domain is used to identify a system on the Internet
 - Example@buffalo.edu
 - www.buffalo.edu
 - When we type "dns.google.com", DNS translates to "8.8.8.8"

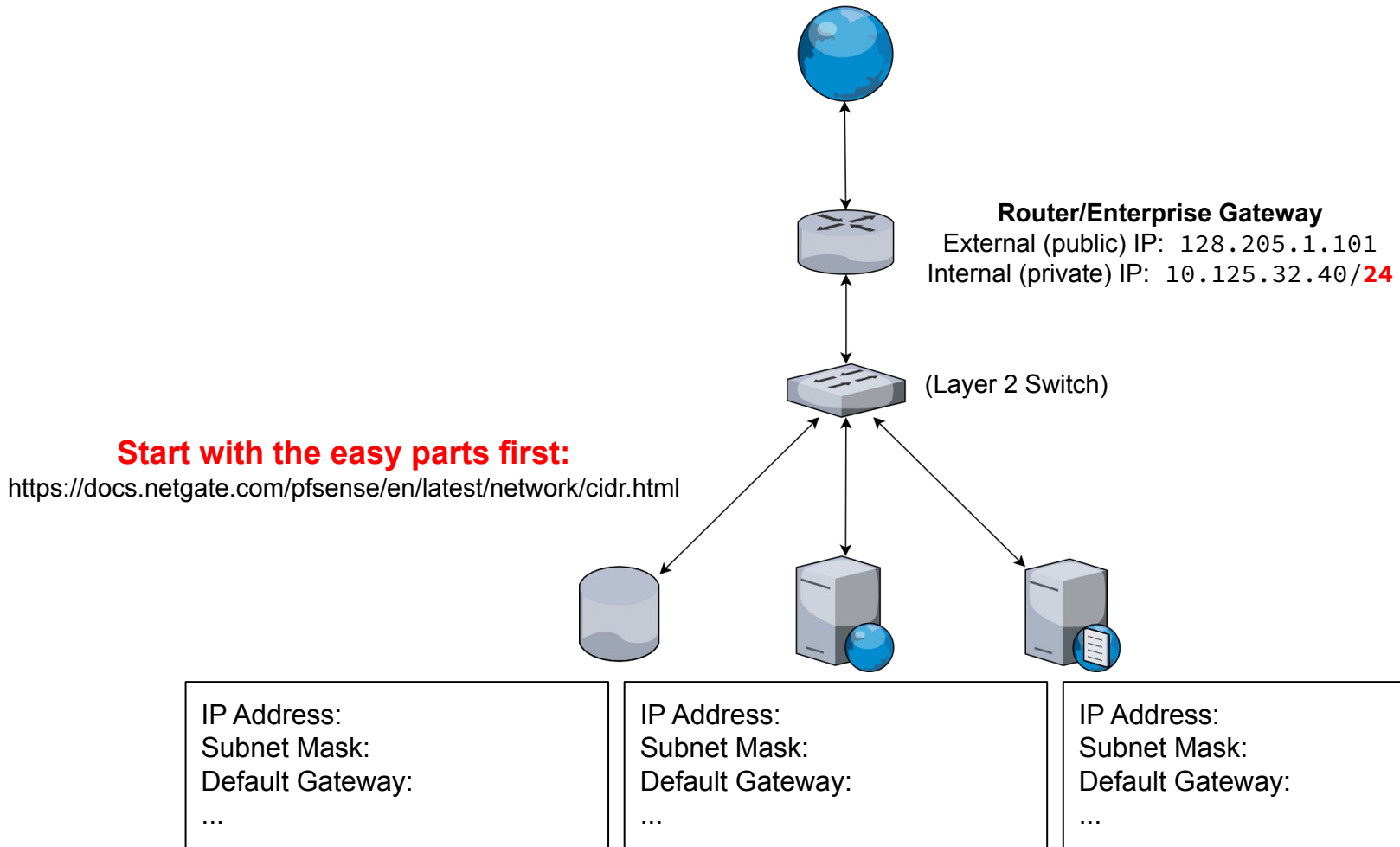
Questions?

In Class Activity

IP Assignment Walkthrough

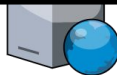
Example 1







Subnet Mask	CIDR Prefix	Total IP Addresses	Usable IP Addresses	Number of /24 ne
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

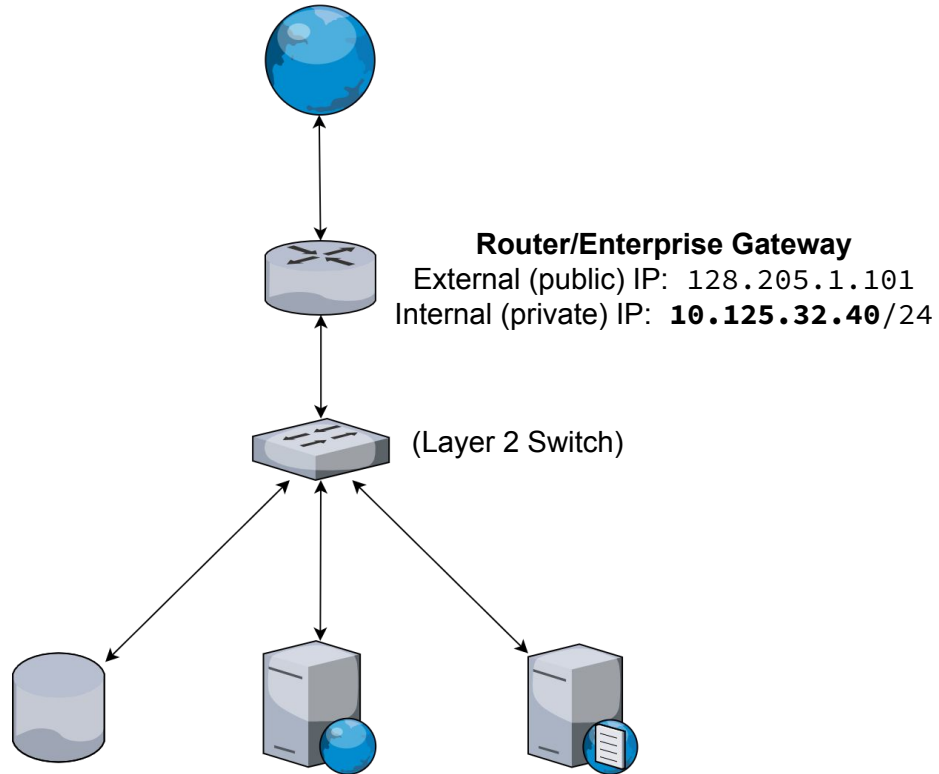


IP Address:
Subnet Mask: 255.255.255.0
Default Gateway:
...

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

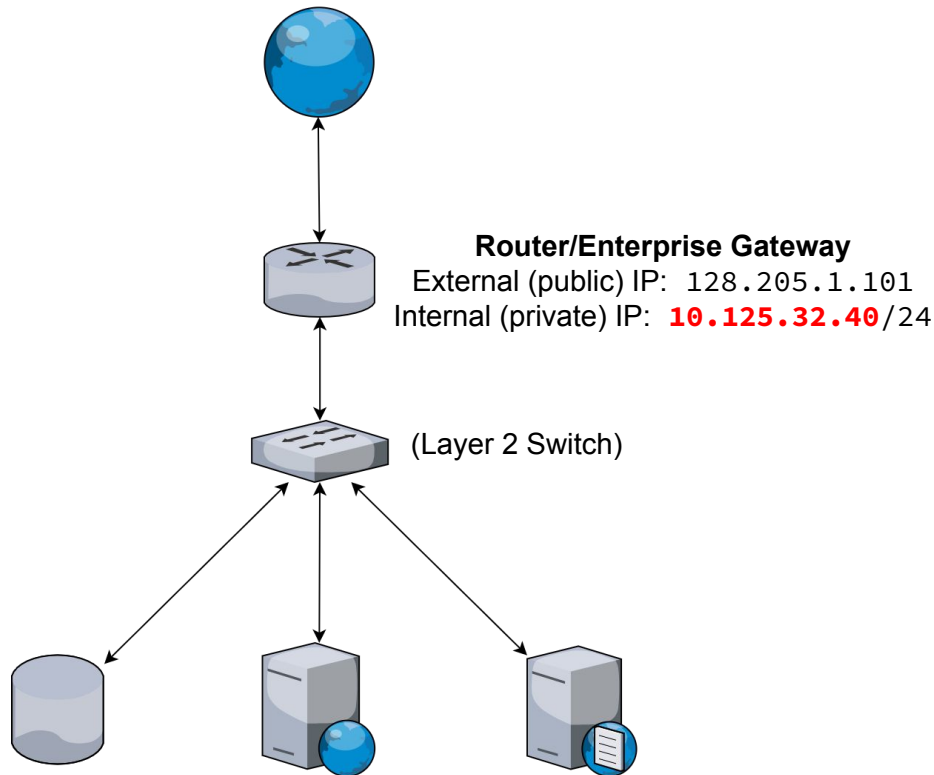


IP Address:
Subnet Mask: 255.255.255.0
Default Gateway:
...

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**
...

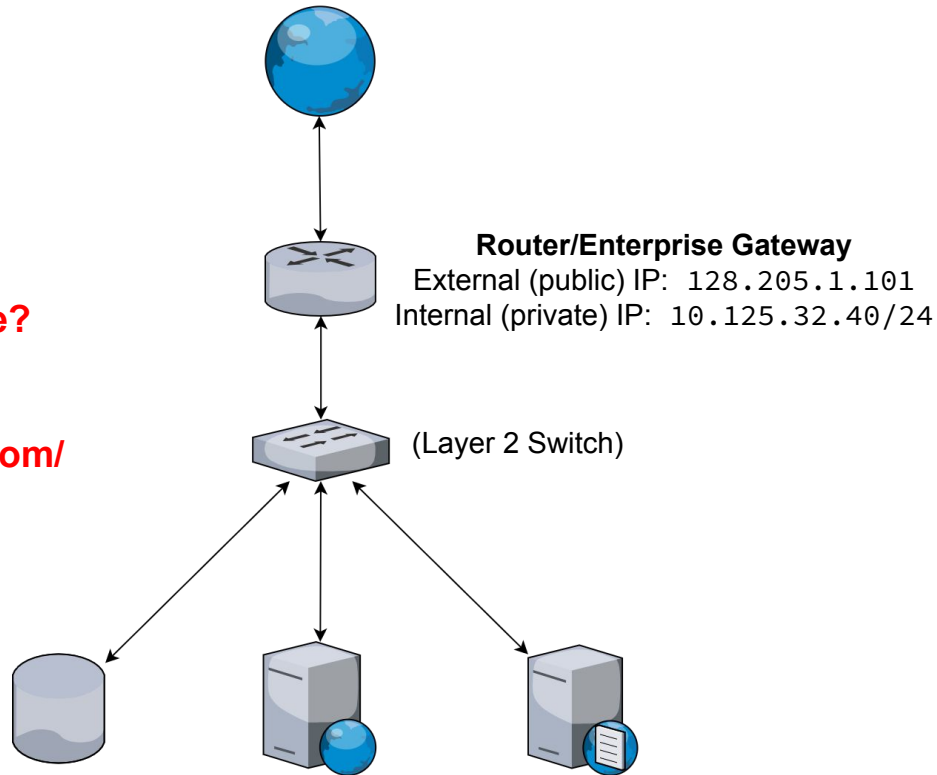
IP Address:
Subnet Mask: 255.255.255.0
Default Gateway: **10.125.32.40**
...

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/>



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
...

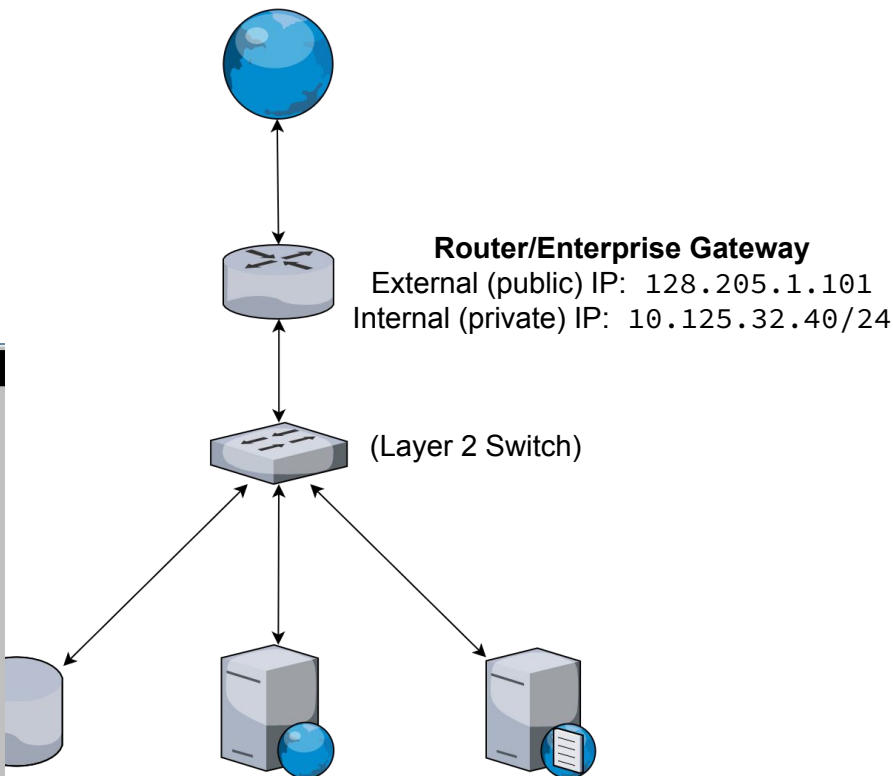
IP Address:
Subnet Mask: 255.255.255.0
Default Gateway: 10.125.32.40
...

What address space is available?

- Subnet ID and Broadcast Address are unusable

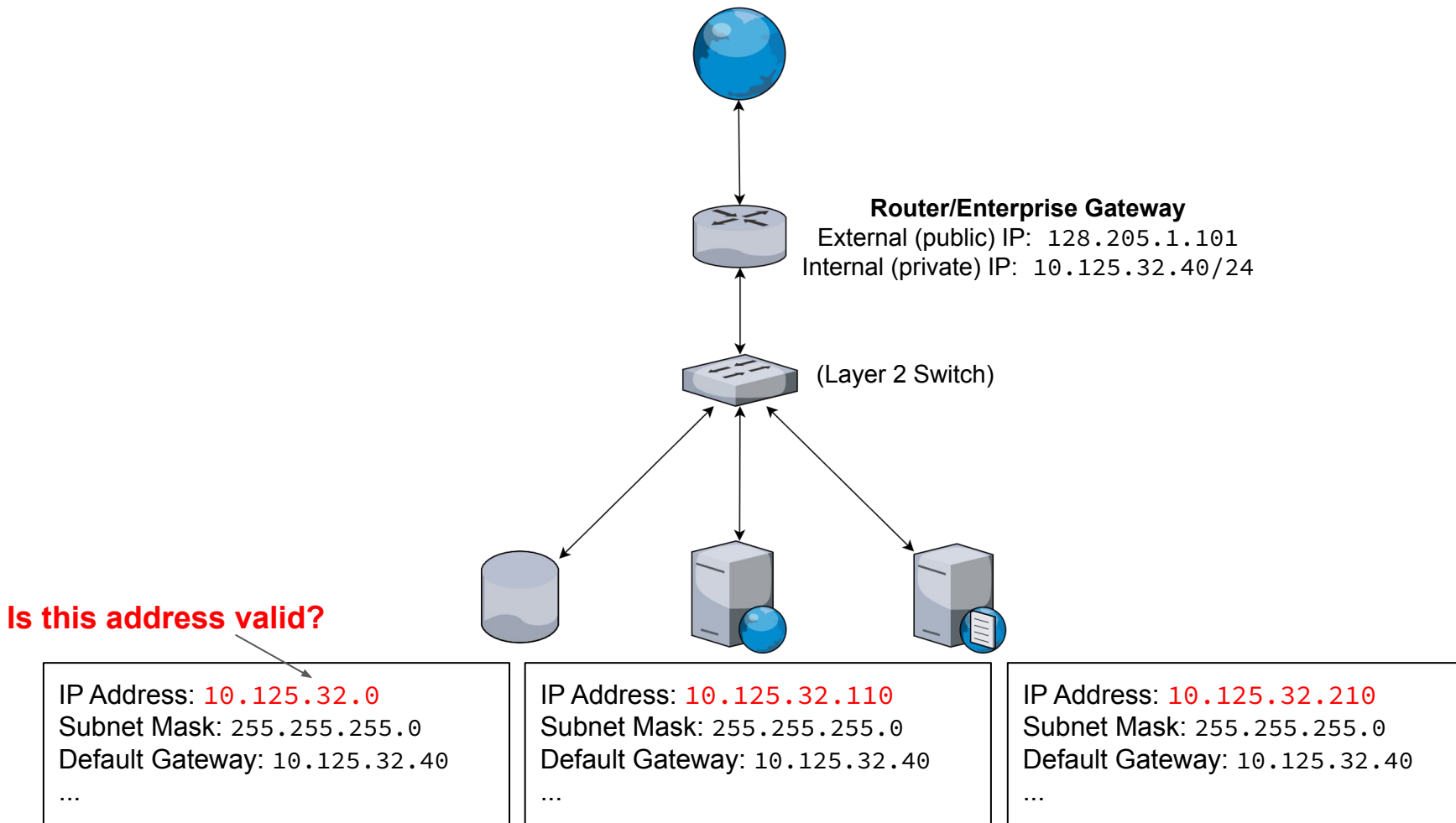
Subnet Calculator

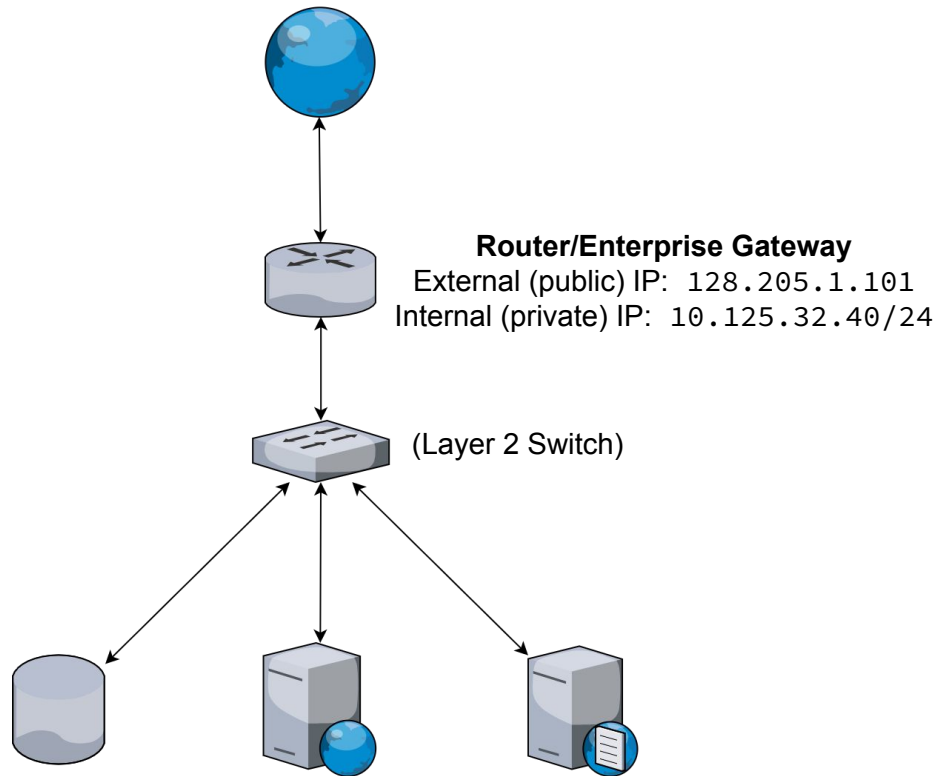
Network Class	First Octet Range
A <input checked="" type="radio"/> B <input type="radio"/> C <input type="radio"/>	1 - 126
IP Address	Hex IP Address
10.125.32.40	0A.7D.20.28
Subnet Mask	Wildcard Mask
255.255.255.0	0.0.0.255
Subnet Bits	Mask Bits
16	24
Maximum Subnets	Hosts per Subnet
65536	254
Host Address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



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: 10.125.32.14
Subnet Mask: 255.255.255.0
Default Gateway: 10.125.32.40
...

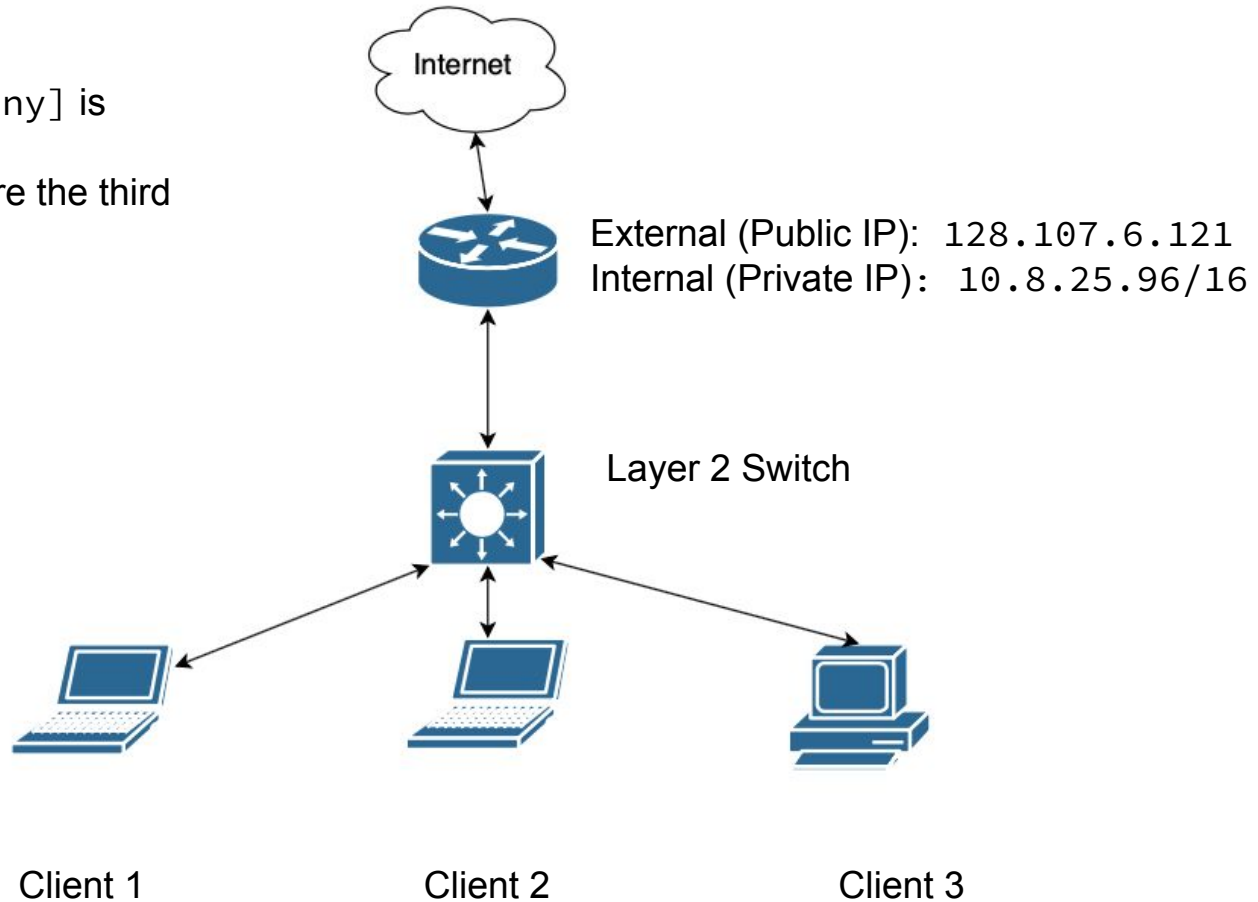
IP Address: 10.125.32.110
Subnet Mask: 255.255.255.0
Default Gateway: 10.125.32.40
...

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

Example 2

Rules:

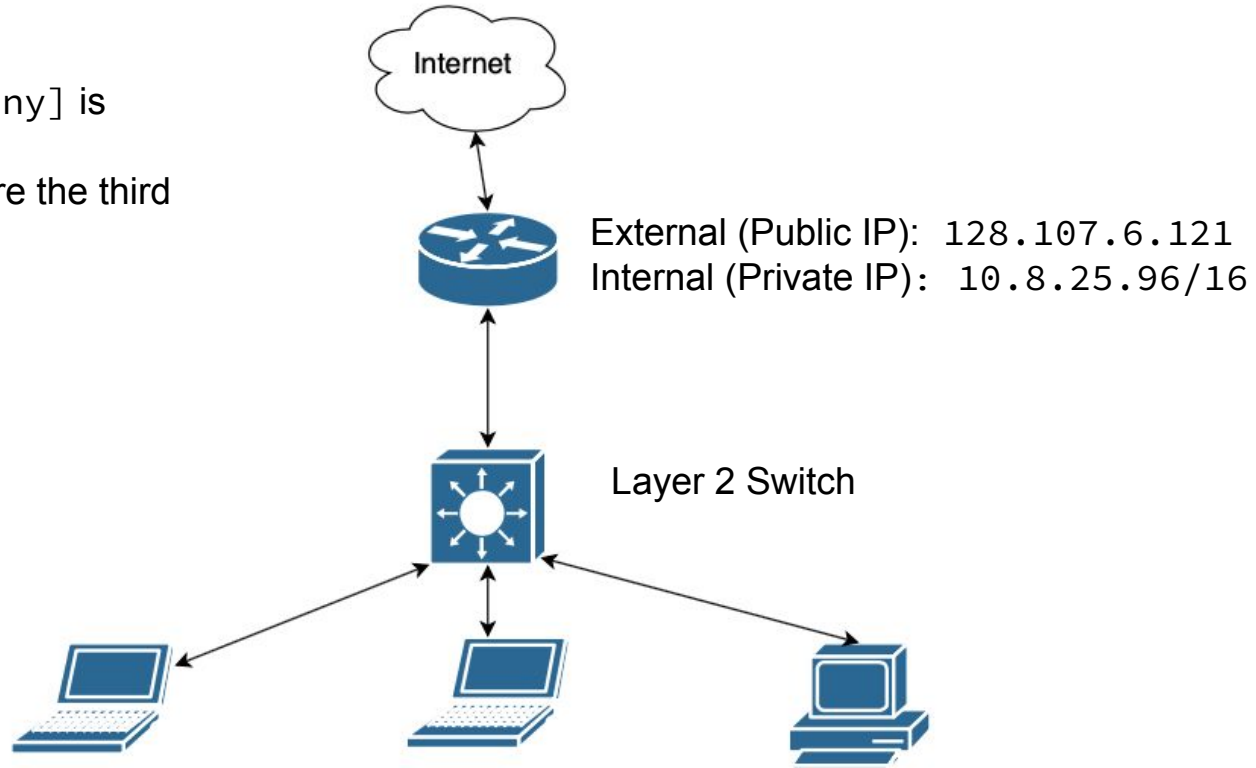
- IP address range
10.8.[1-24].[any] is
forbidden
- No clients can share the third
octet



Rules:

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

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



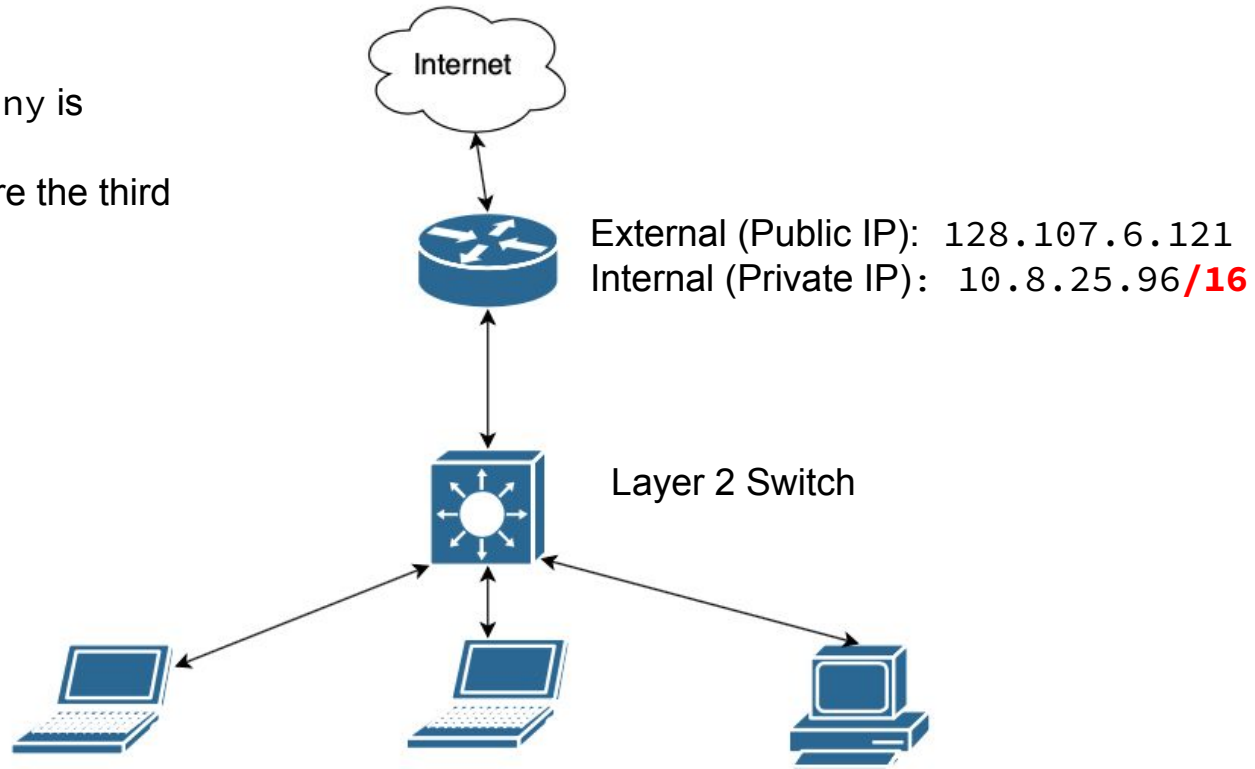
IP Address:
Subnet Mask:
Default Gateway:

IP Address:
Subnet Mask:
Default Gateway:

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Subnet Mask:
Default Gateway:

Rules:

- IP address range
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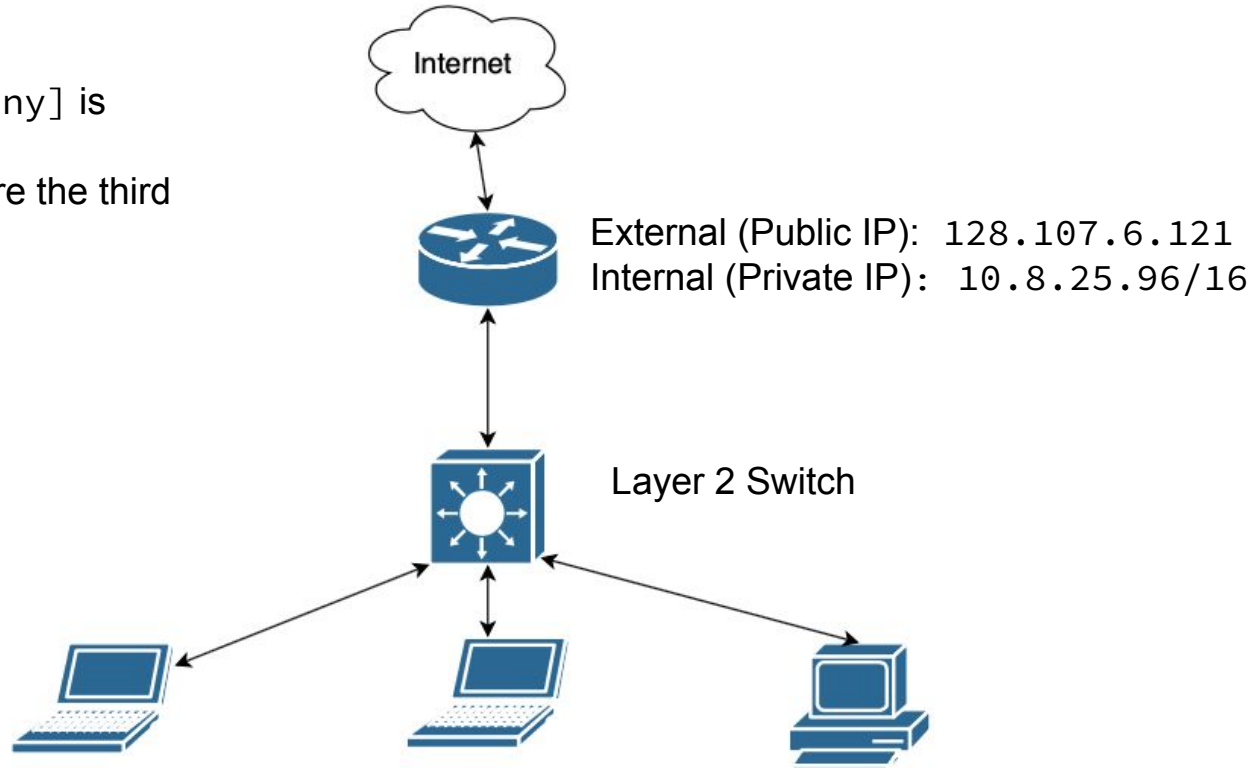
Once again, let's start
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subnet masks for our 3
clients?

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

Rules:

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

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:

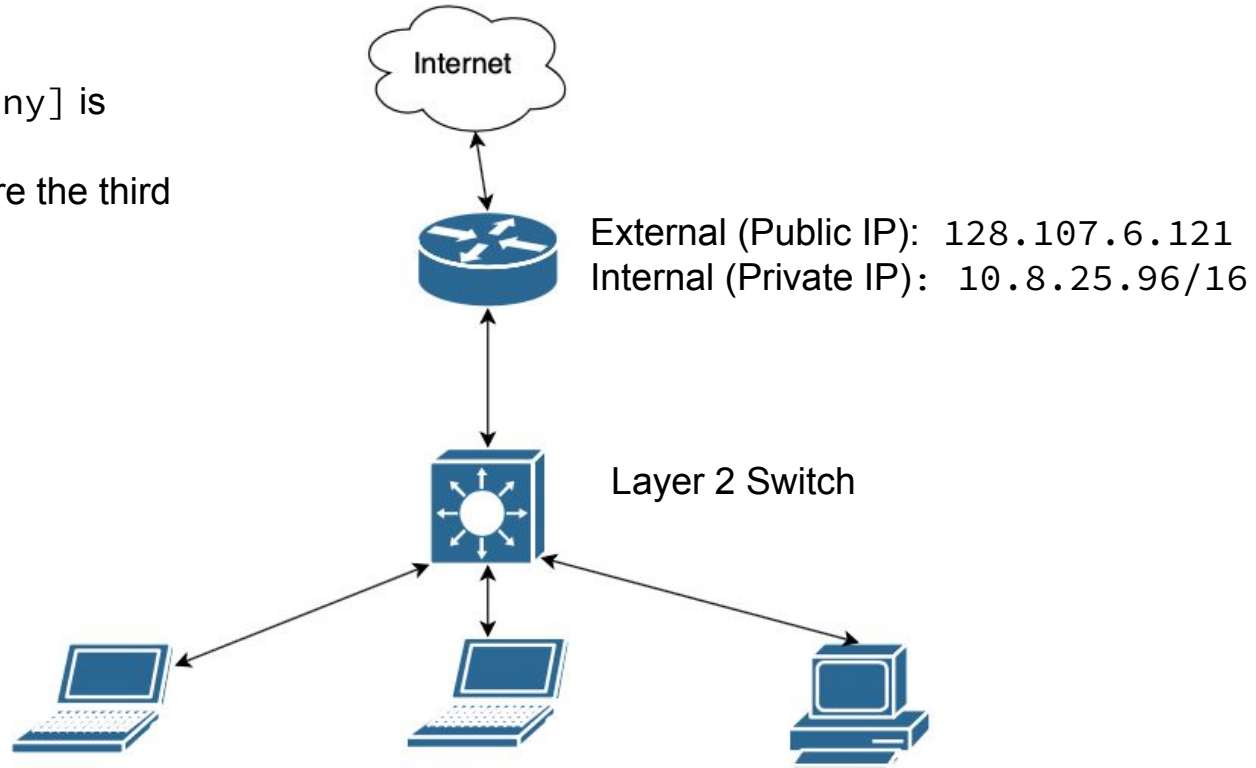
IP Address:
Subnet Mask: 255.255.0.0
Default Gateway:

IP Address:
Subnet Mask: 255.255.0.0
Default Gateway:

Rules:

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

What is our default gateway?



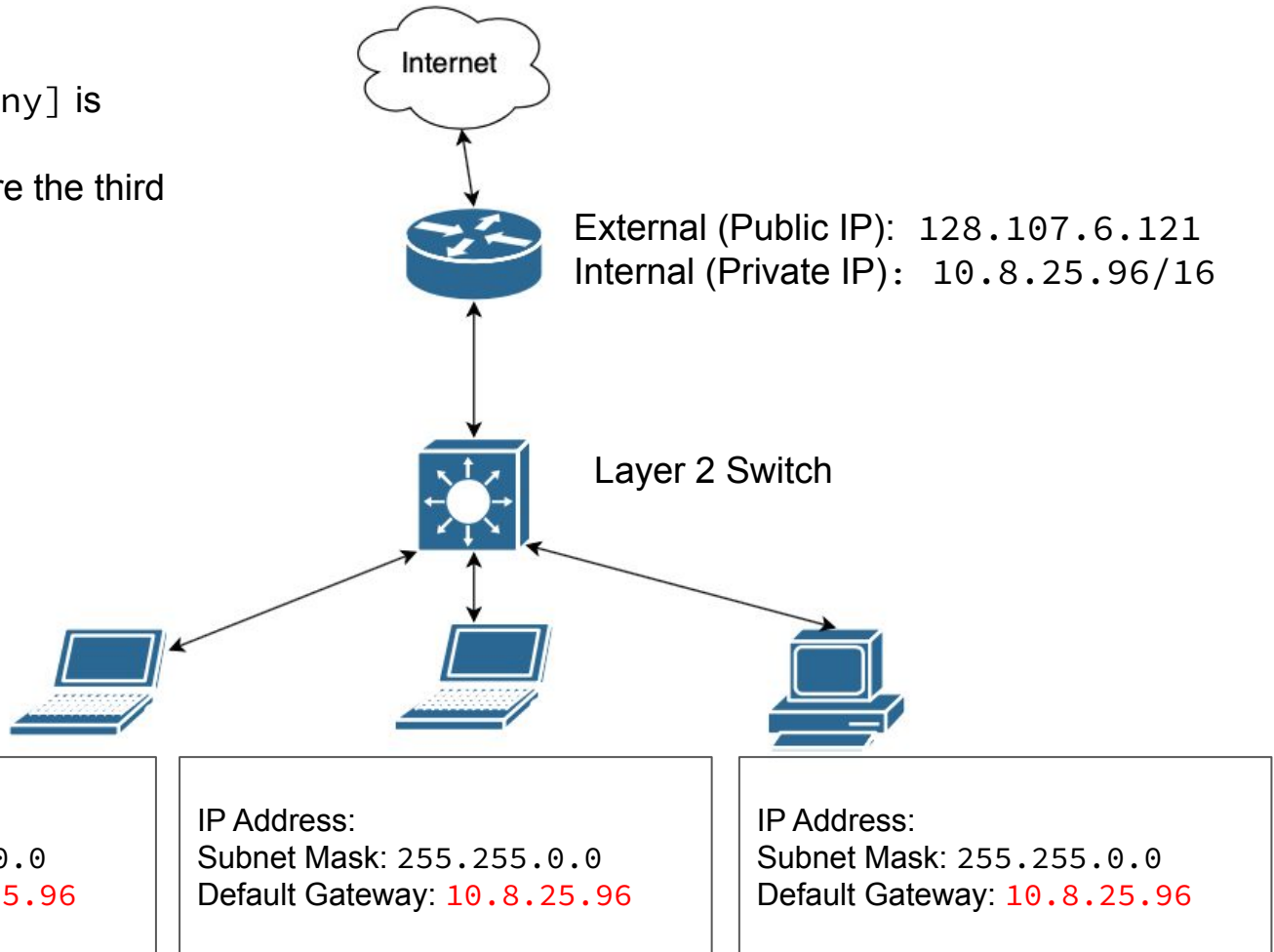
IP Address:
Subnet Mask: 255.255.0.0
Default Gateway:

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



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 ☐ B ☐ C

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

Subnet Bitmap
0nnnnnnn.ssssssss.hhhhhhhh.hhhhhhhh

First Octet Range
1 - 126

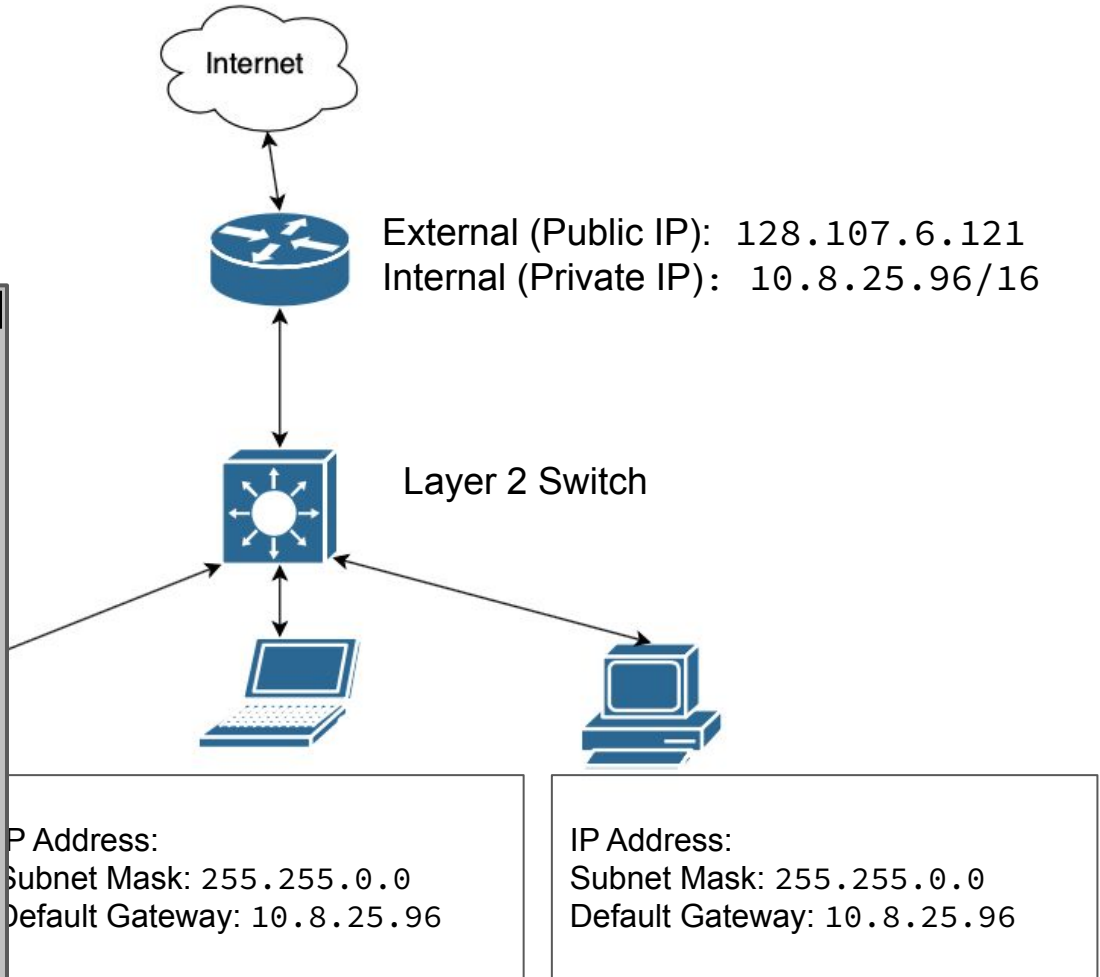
Hex IP Address
0A.08.19.60

Wildcard Mask
0.0.255.255

Mask Bits
16

Hosts per Subnet
65534

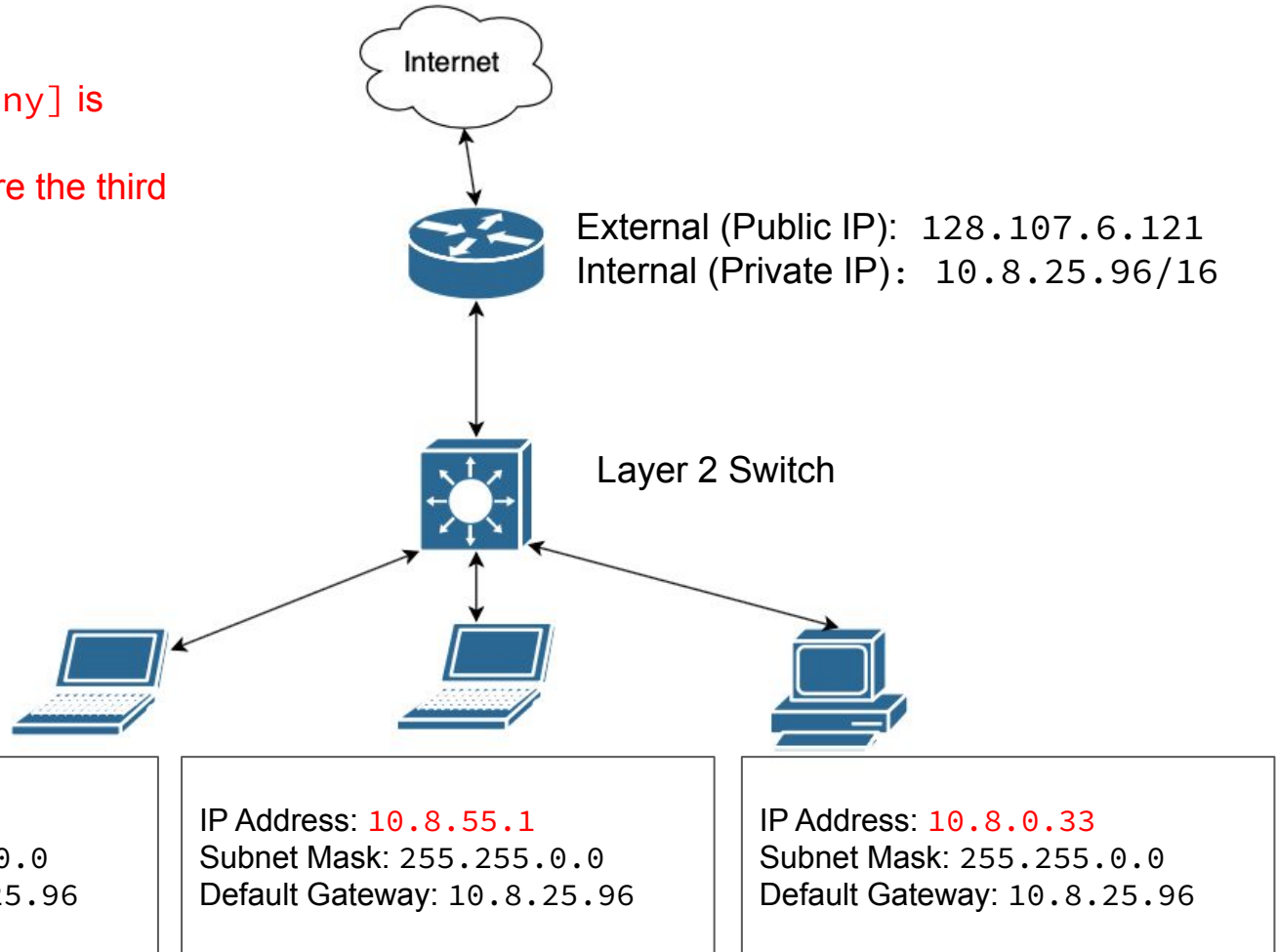
Broadcast Address
10.8.255.255



Rules:

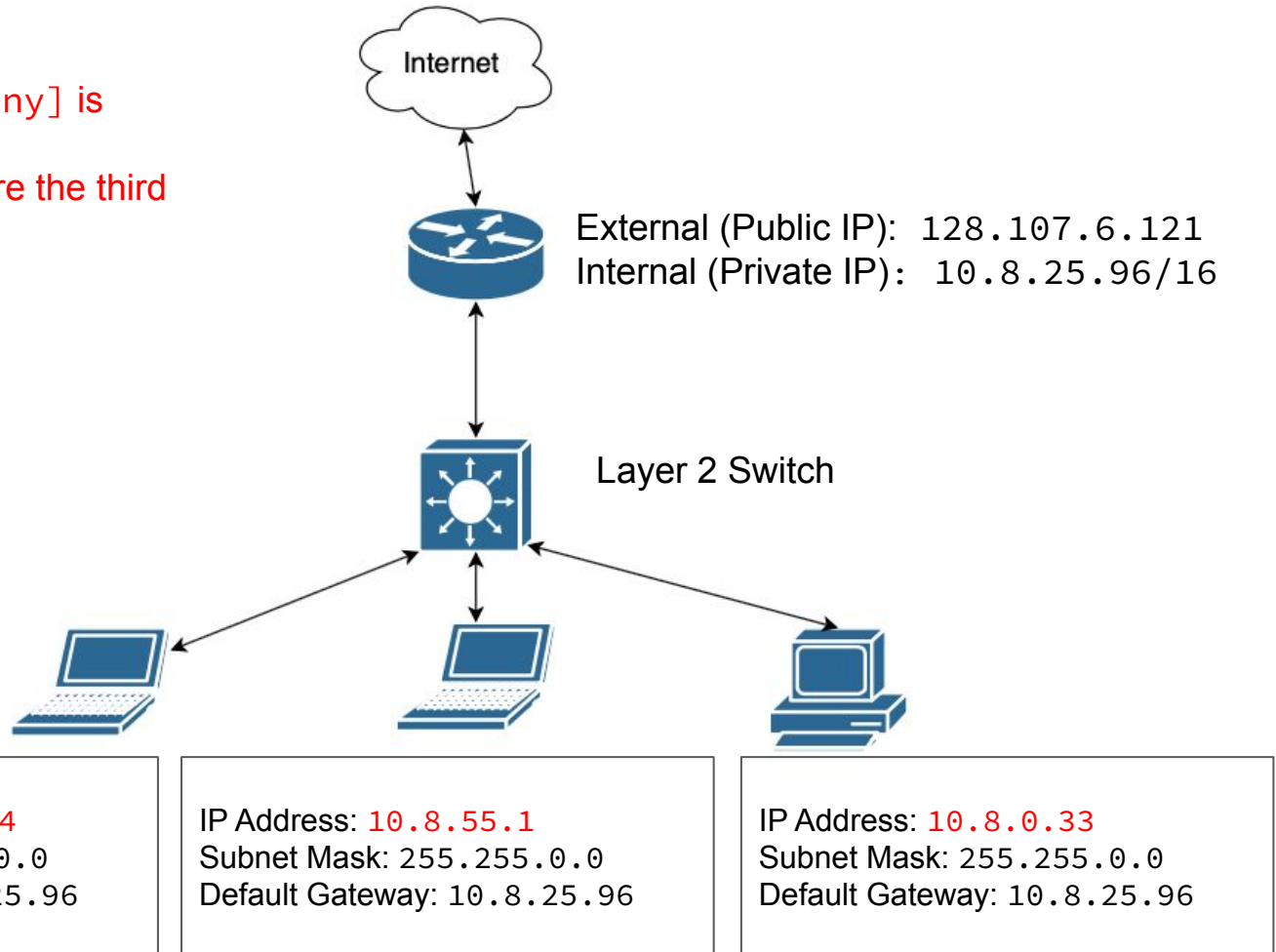
- IP address range 10.8.[1-24].[any] is forbidden
- No clients can share the third octet

Is this a valid IP address?



Rules:

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



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!