Firewalls

UBNetDef, Fall 2022
Week 3

Lead Presenter:
Raymond Harenza

Networking Part 2

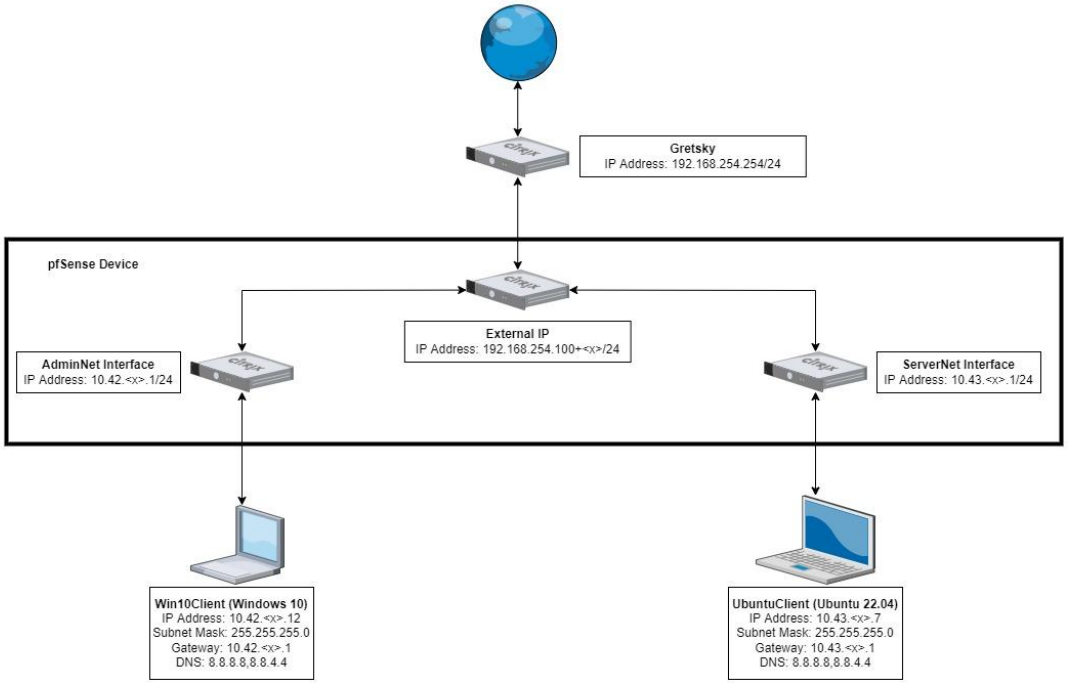
Learning Objectives

- More networking
- Specifics of transport layer of OSI Model
- TCP Handshake
- Understanding of directional flow
- Understanding of the various types of firewalls
- Able to understand firewall rules and configure them yourself

Agenda – Week 3

- Reviewing current network state
- Networking Part 2 with Ports
- Hands-on Activity 1
- The Application layer
- Domain Name Service Demo
- Directional Flow
- Hands-on Activity 2
- The Logic of Firewalls
- Homework System Prep

Current Network State

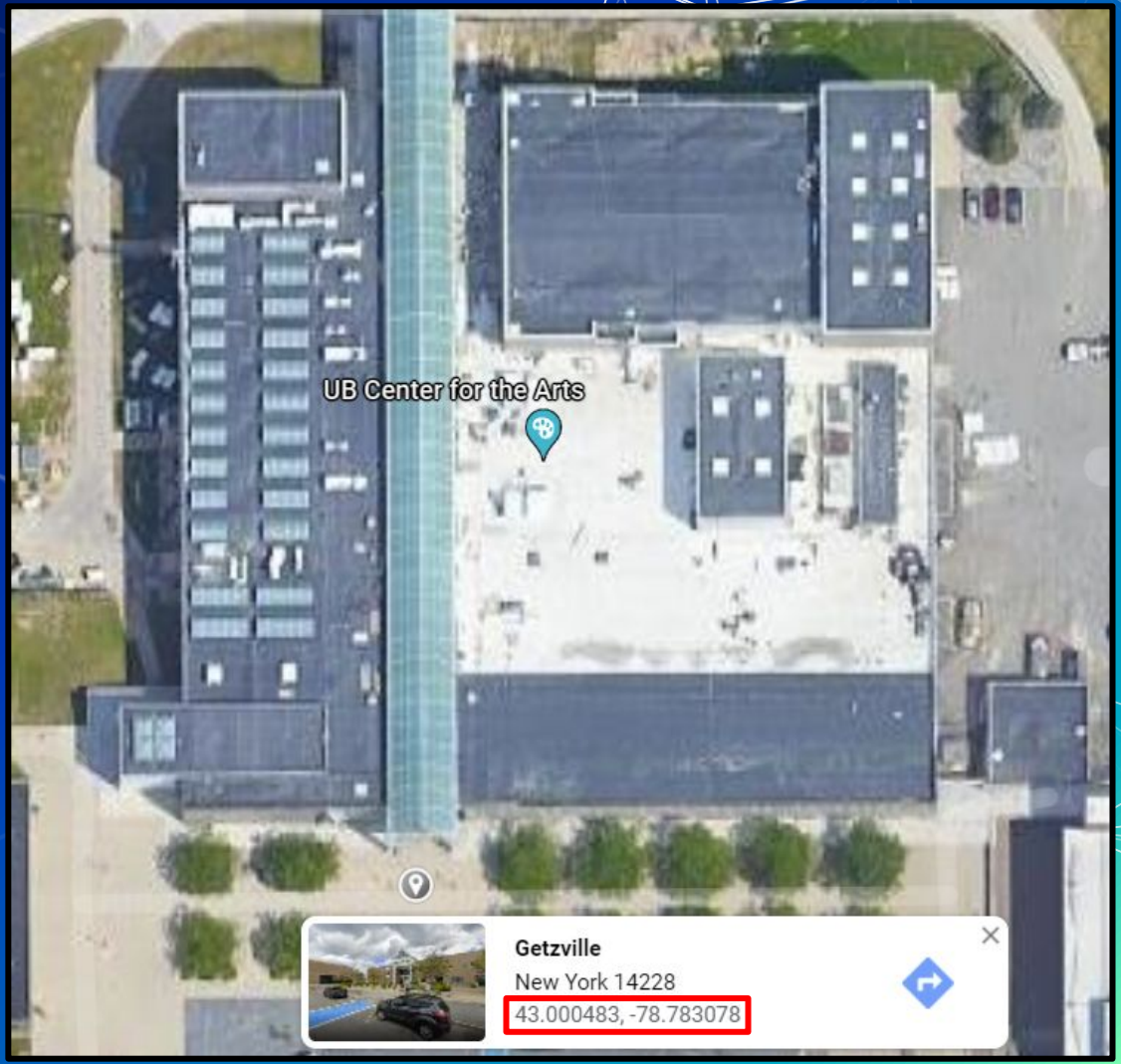


Networking Part 2

- Data is transmitted using network packets
- Packets contain headers
  - Headers tell networking appliances what to do with packets

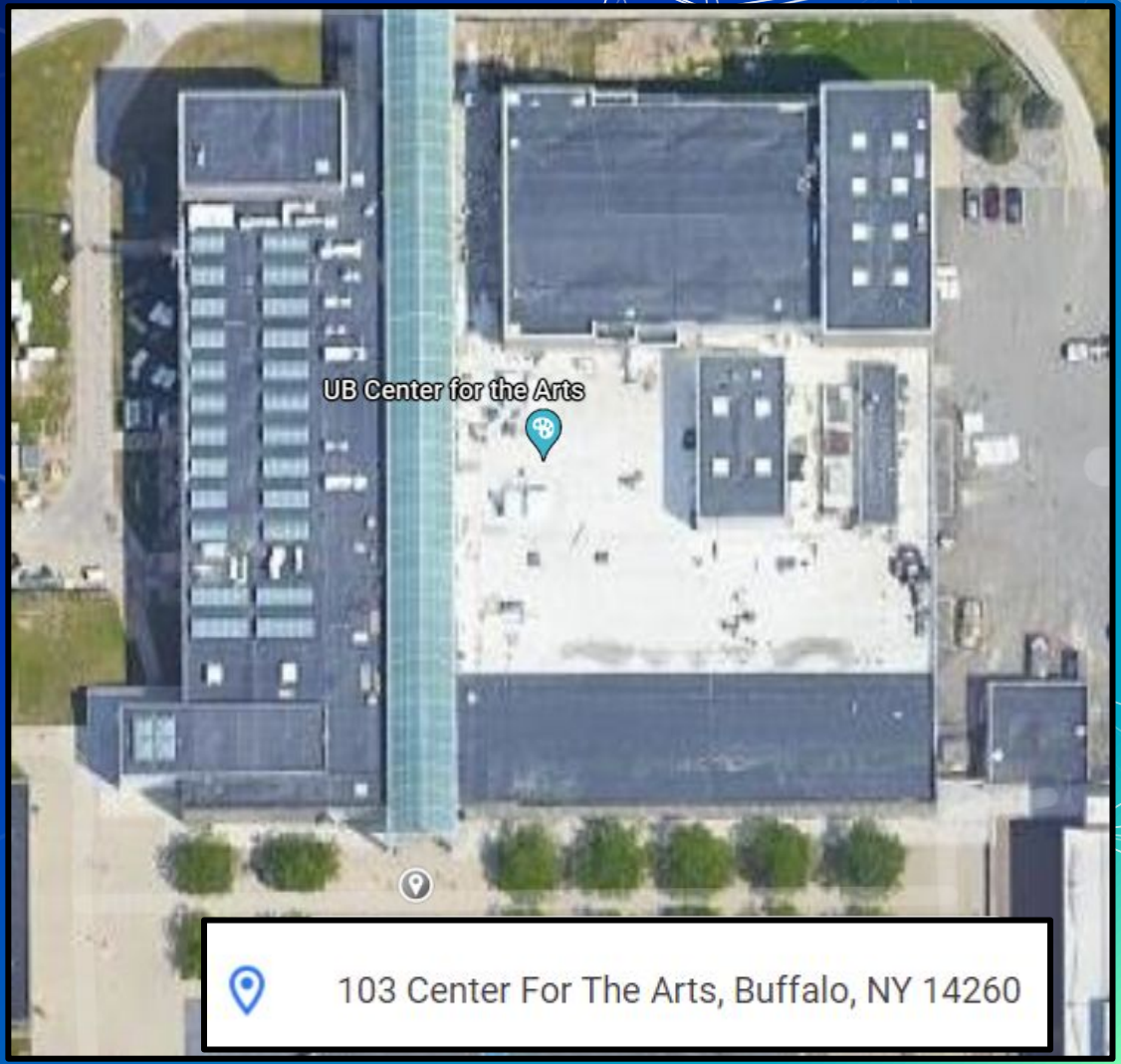
Intro to Ports

- Recall MAC Addresses
- Consider these similar to physical coordinates



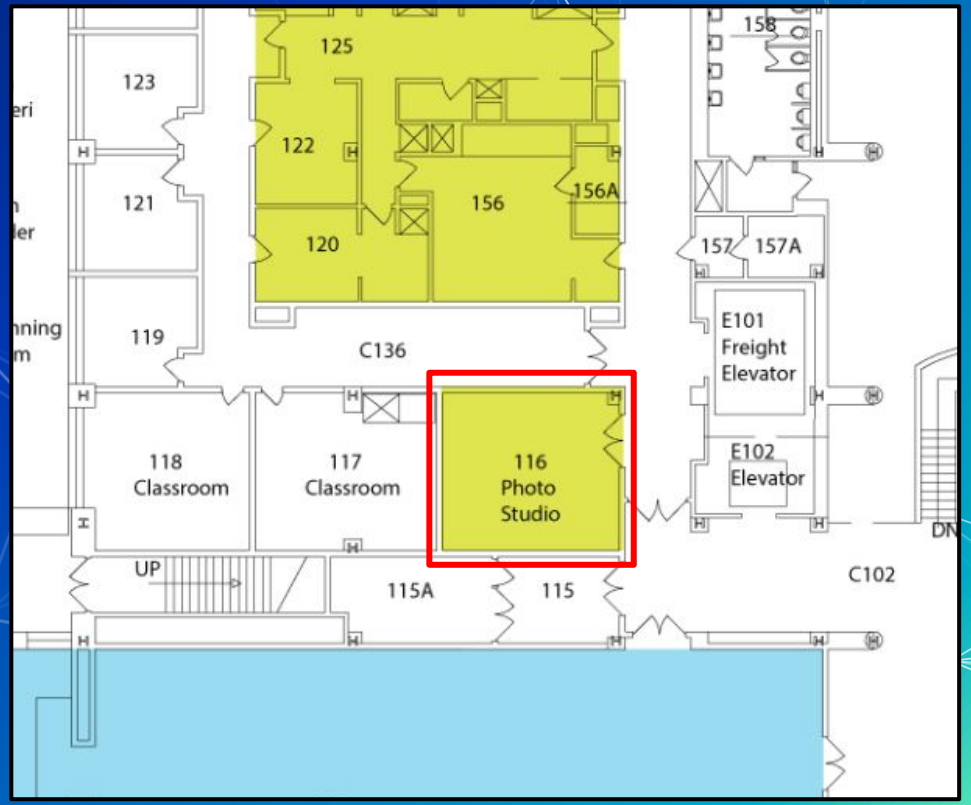
Intro to Ports

- Recall IP Addresses
- Consider these similar to postal addresses for buildings



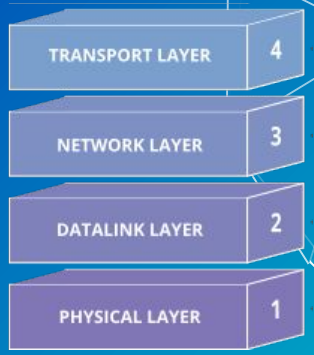
Intro to Ports

- Ports are similar to room numbers
  - MAC: 43.000483, -78.783078
  - IP: 103 Center for the Arts
  - Port: Room 116
- Ports are indicated next to IP addresses
  - 192.168.15.152**:116**



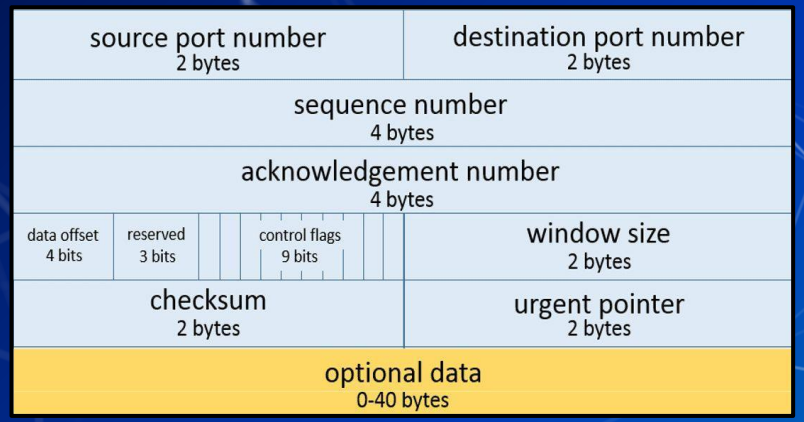
The Transport Layer

- Ports are managed by the OSI network transport layer
- The transport layer also manages packet exchange protocols
  - TCP
    - Downloading a File
  - UDP
    - Streaming or Video Call



Network Packet Headers

TCP Header



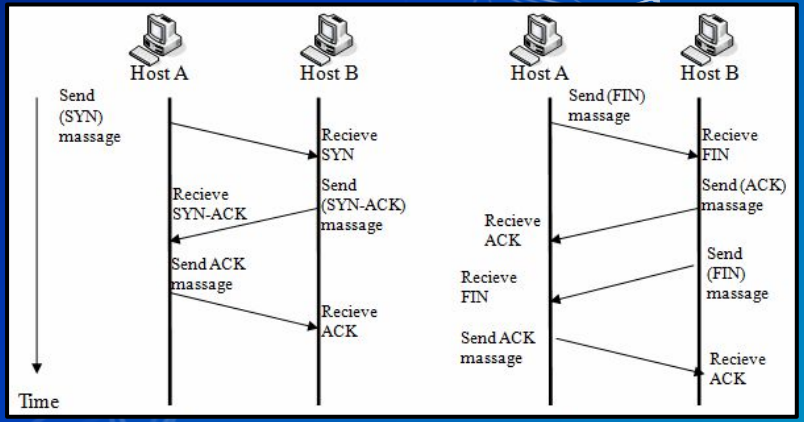
UDP Header

In Class Activity

TCP/UDP Packet Polo

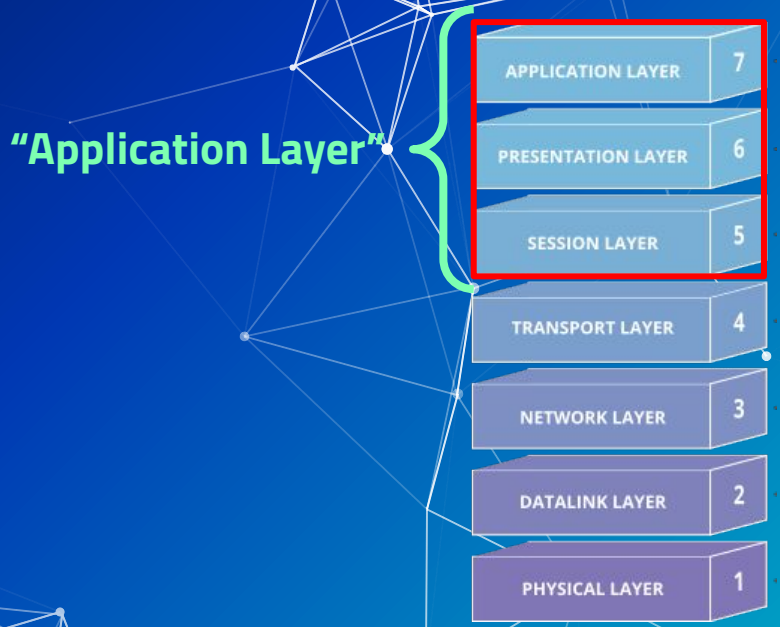
TCP Handshake

```
pfTop: Up State 1-100/114033, View: default, Order: bytes
PR        DIR SRC                    DEST                    STATE                 AGE       EXP     PKTS    BYTES
icmp      Out 192.168.253.18:17838   192.168.253.17:17838     0:0             75:14:36  00:00:10  1060806 29702568
icmp      Out 192.168.253.18:42531   192.168.0.1:42531        0:0             75:14:33  00:00:10  1060796 29702288
tcp       In  192.168.15.137:45602   192.168.253.18:80   ESTABLISHED:ESTABLISHED  00:01:51  23:59:55      983  1102747
tcp       In  192.168.15.137:45604   192.168.253.18:80   ESTABLISHED:ESTABLISHED  00:01:45  24:00:00      989   959986
tcp       In  10.3.1.70:61246        52.177.166.224:443  ESTABLISHED:ESTABLISHED  14:30:20  23:59:49     2654   352606
tcp       Out 192.168.253.18:52428   52.177.166.224:443  ESTABLISHED:ESTABLISHED  14:30:20  23:59:49     2654   352606
```



The Application Layer

- The transport layer cannot do it all
- For example:
  - Domain Name Service (DNS) Protocol
    - May require TCP or UDP protocols
  - Hypertext Transfer Protocol (HTTP)
    - Often requires two different devices
- Common port numbers are assigned to popular application protocols



Port #	Protocol
21	FTP Control
20	FTP Data
23	Telnet
25	SMTP
53	DNS
80	HTTP
110	POP3
143	IMAP
443	HTTPS

DNS

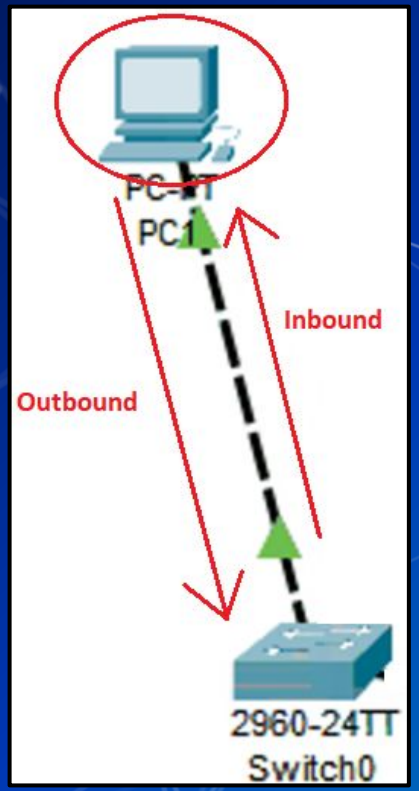
- How does your computer get to www.Google.com?
- A DNS server is used to translate a domain name to an IP address

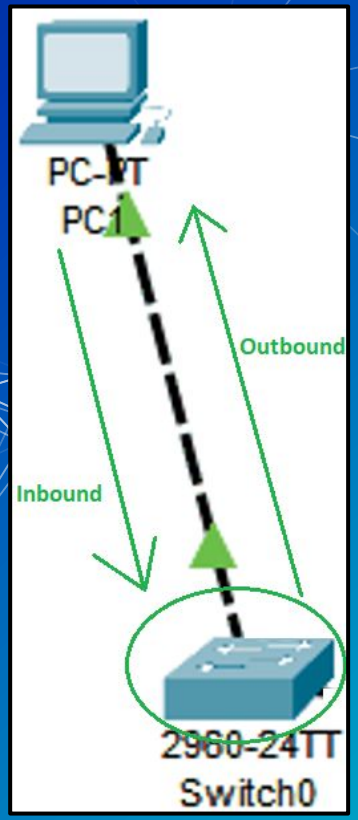
```
Name:     google.com
Addresses:  2607:f8b0:4006:81c::200e
          142.250.176.206
```

DNS Demo

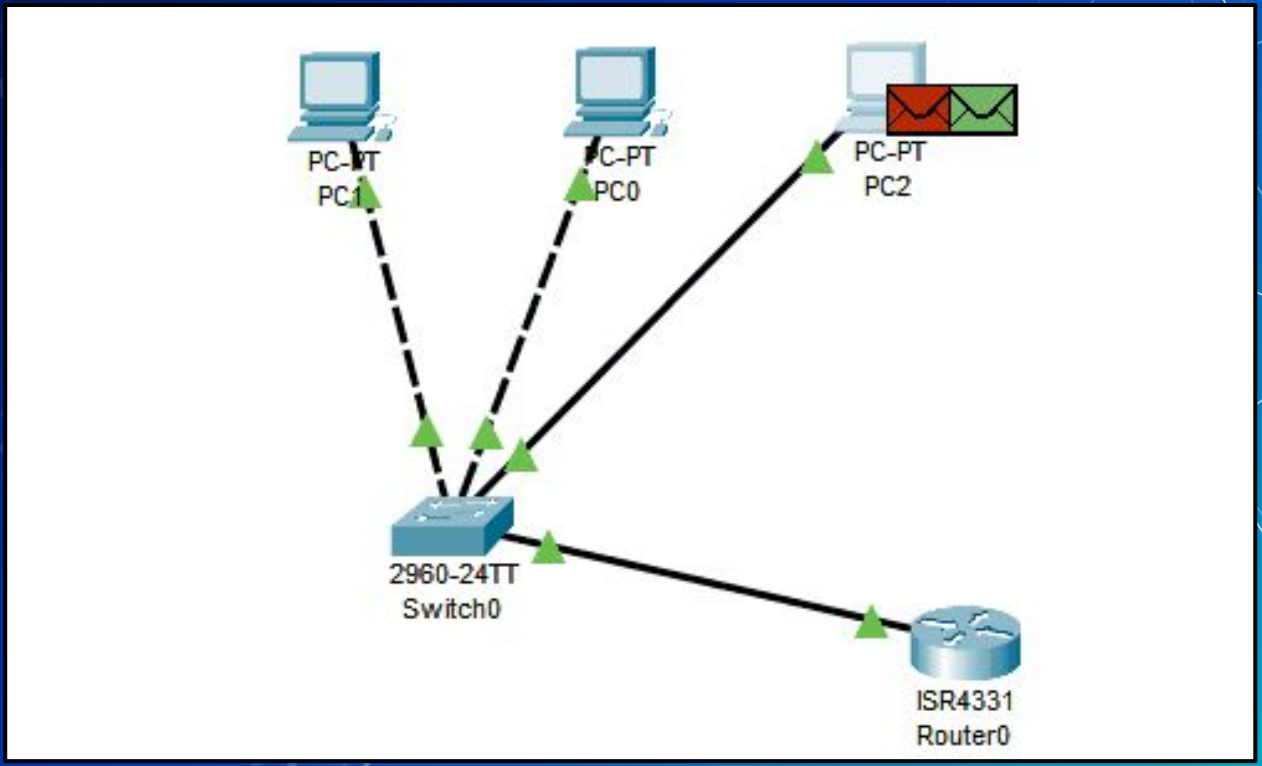
- Open a CLI
- `nslookup washington.edu`
- Copy IP Address into web browser
- You may need to use `http://` as a URL prefix

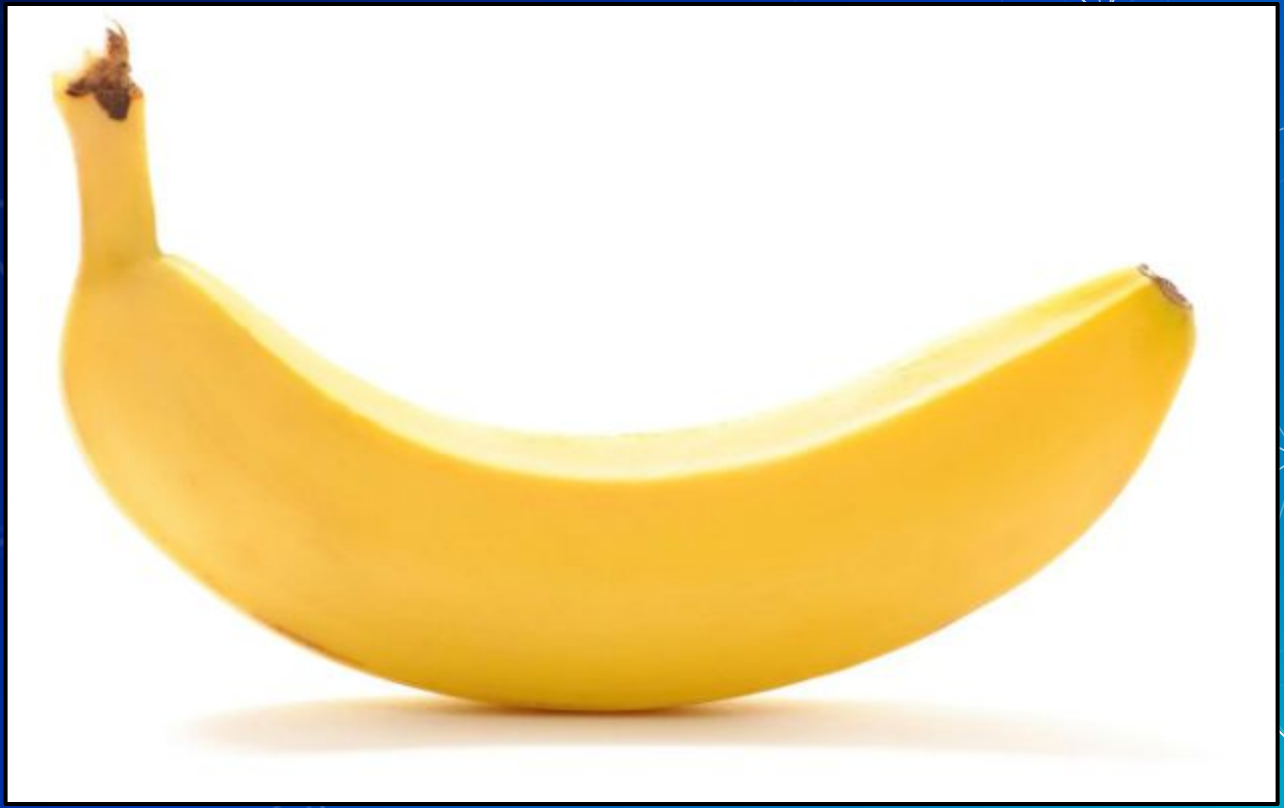
Directional Flow





Data flows freely... for now





Questions?

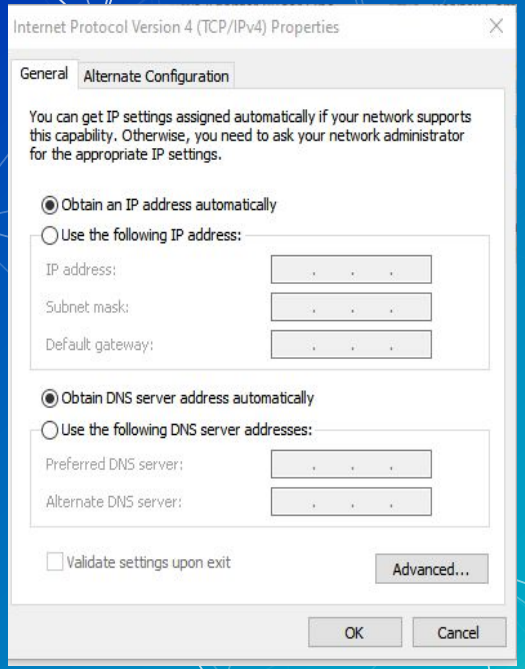
Break slide

Please return in 10 minutes

Also turn on your UbuntuClient

Networking Recap

- IP Addresses contain 4 octets 0-255.0-255.0-255.0-255
  - 0 reserved
  - 255 used to the broadcast address
- Subnet masks let us separate IP addresses
  - We can create Local Area Networks (LAN)
- Default gateway is where data must go to leave our LAN
- Domain Name Service makes life easy for us but is not required




```
PS C:\Users\AnthonyM> resolve-dnsname www.google.com | select Name ,spacer ,IPAddress

Name           spacer IPAddress
----           ------ ---------
www.google.com        2607:f8b0:4006:804::2004
www.google.com        172.217.10.68
```

In Class Activity

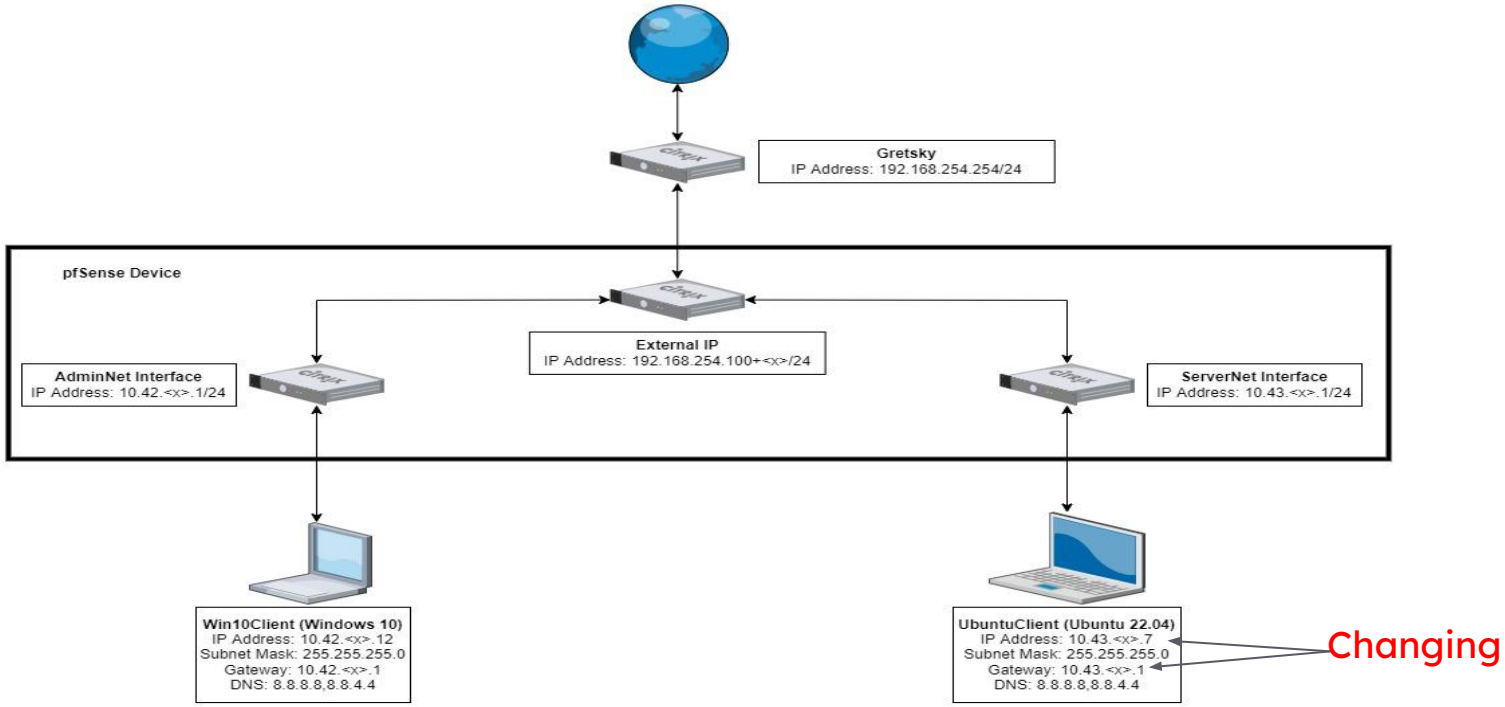
Hands-on Migration

Activity – Migrate Linux to AdminNet

- Migrate UbuntuClient from ServerNet to AdminNet.

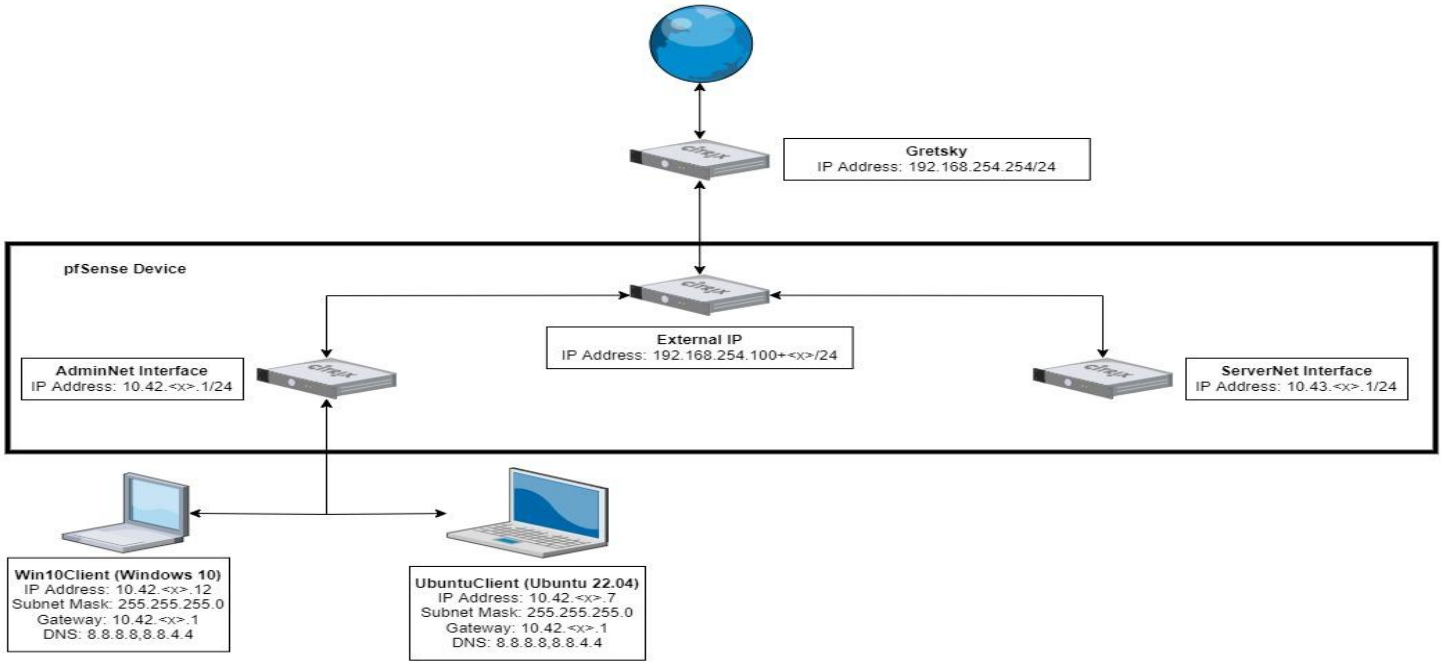
Activity – Migrate Linux to AdminNet

Before



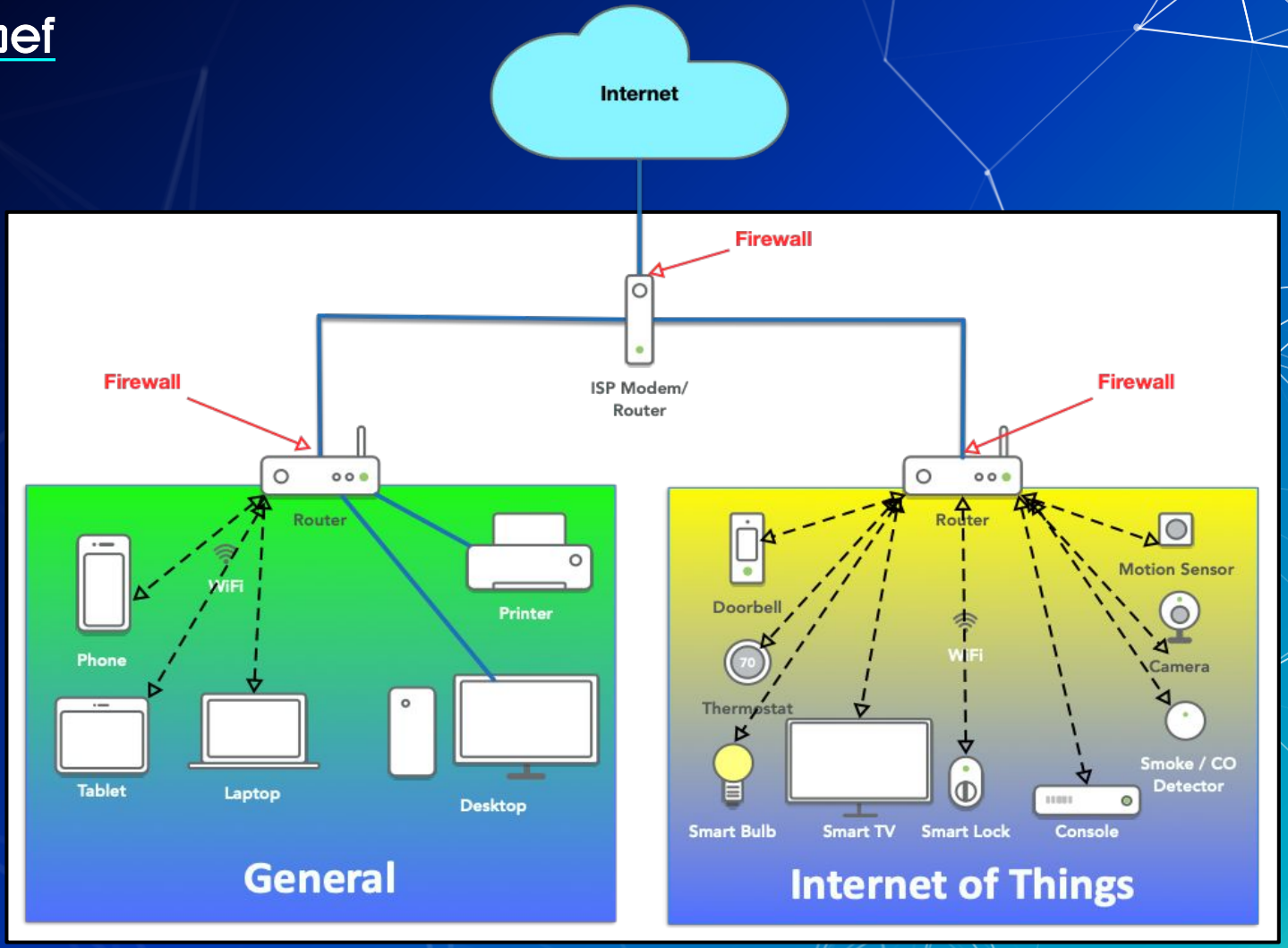
Activity – Migrate Linux to AdminNet

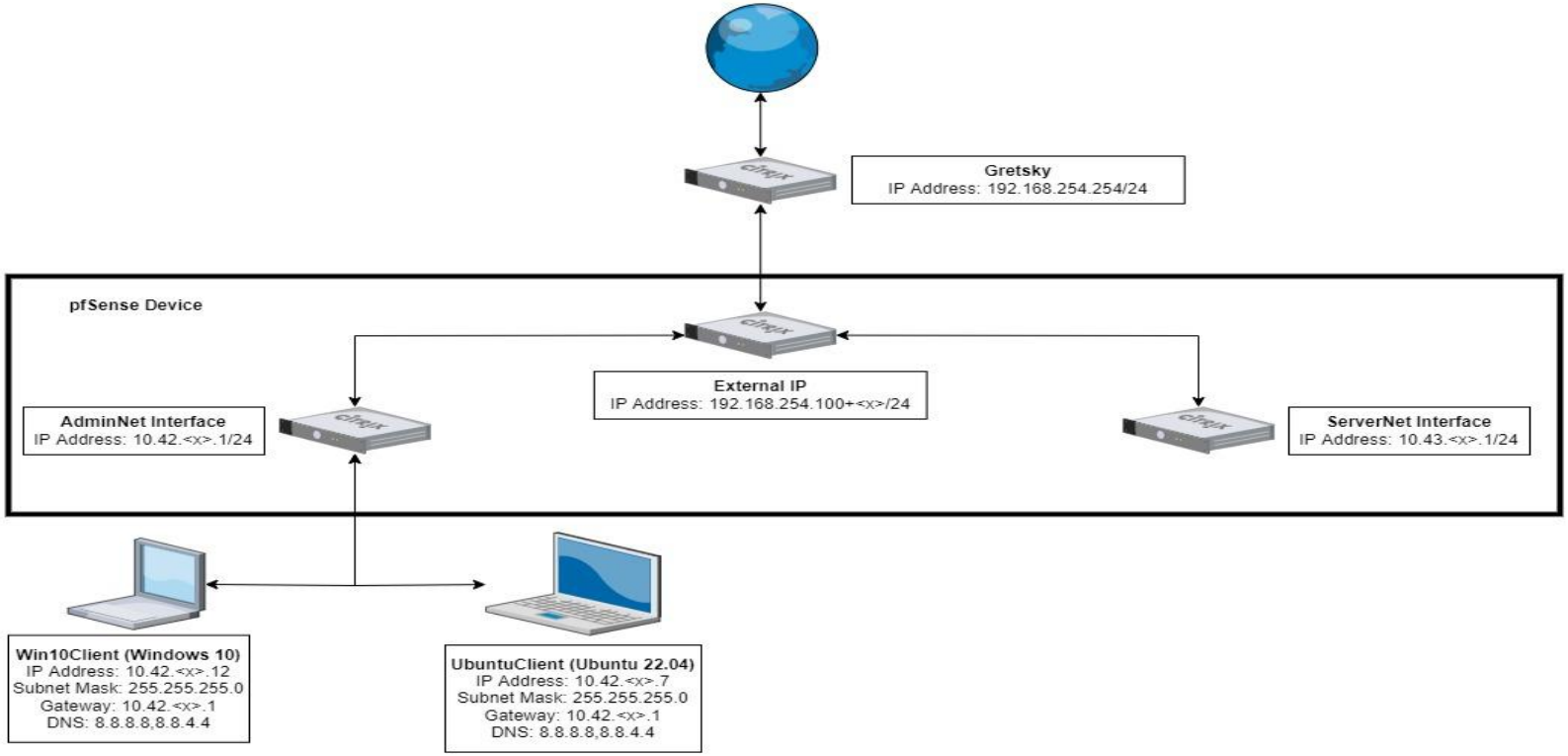
After

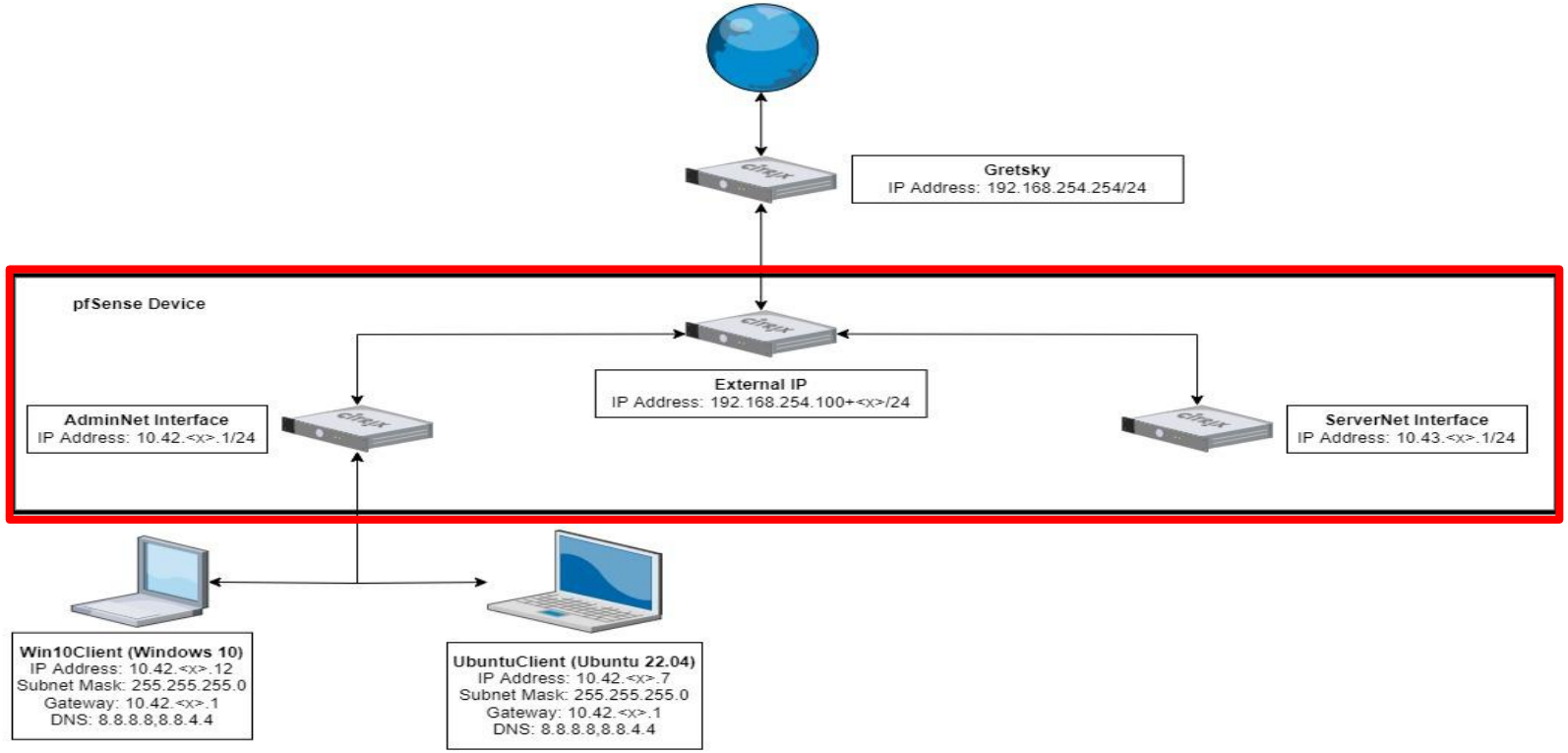


Why Firewalls?

Any networked device can access the mission-critical system


Internet
Firewall
ISP Modem/
Router
Firewall
Firewall
Router
Phone
WiFi
Printer
Tablet
Laptop
Desktop
General
Router
Doorbell
Motion Sensor
WiFi
Camera
Thermostat
Smoke / CO
Detector
Smart Bulb
Smart TV
Smart Lock
Console
Internet of Things


Gretsky
IP Address: 192.168.254.254/24
pfSense Device
External IP
IP Address: 192.168.254.100+<x>/24
AdminNet Interface
IP Address: 10.42.<x>.1/24
ServerNet Interface
IP Address: 10.43.<x>.1/24
Win10Client (Windows 10)
IP Address: 10.42.<x>.12
Subnet Mask: 255.255.255.0
Gateway: 10.42.<x>.1
DNS: 8.8.8.8,8.8.4.4
UbuntuClient (Ubuntu 22.04)
IP Address: 10.42.<x>.7
Subnet Mask: 255.255.255.0
Gateway: 10.42.<x>.1
DNS: 8.8.8.8,8.8.4.4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Subnet Mask: 255.255.255.0
Gateway: 10.42.<x>.1
DNS: 8.8.8.8,8.8.4.4


Internet
DMZ
Secure Servers
Outer Firewall
InnerFirewall

DMZ

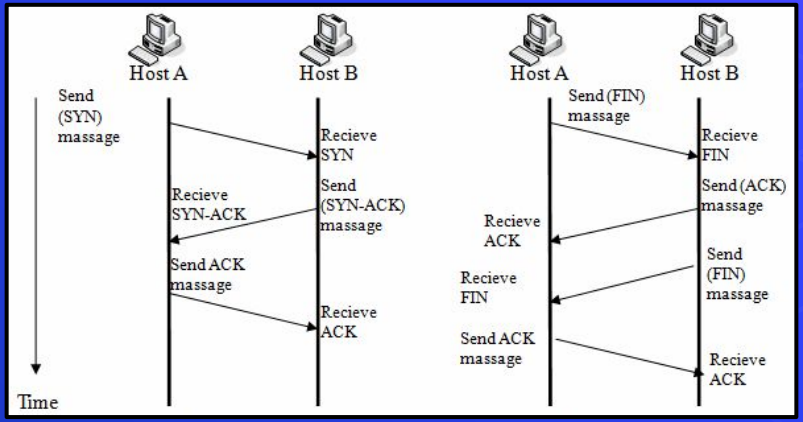
Types of Firewalls

- Packet Filters (GEN 1)
- Stateful Firewalls (GEN 2)
  - Host-Based
  - pfSense
- Next-generation Firewalls (NGFW)
  - Palo Alto (coming soon in this class)

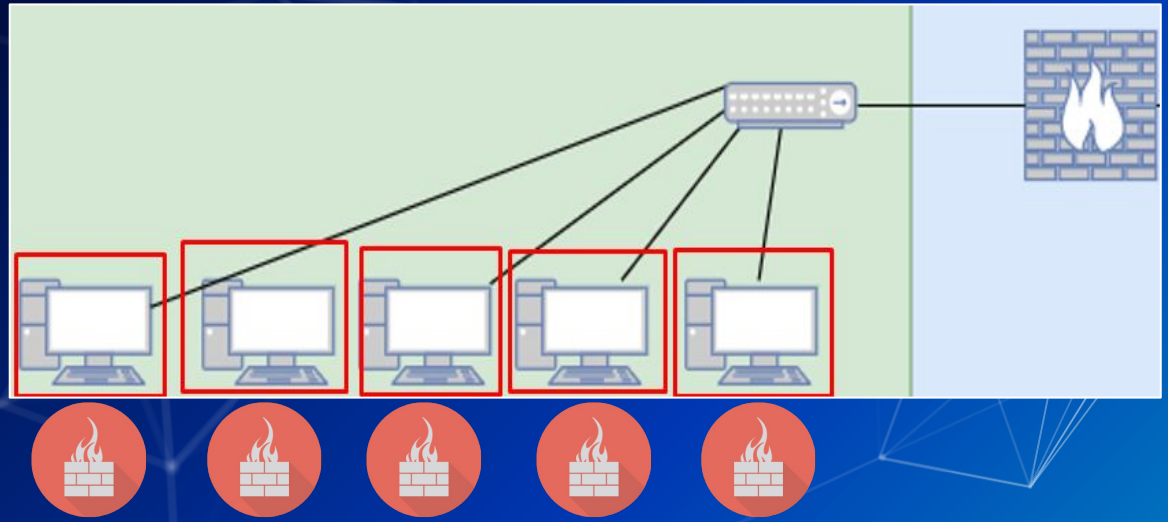
In Class Activity

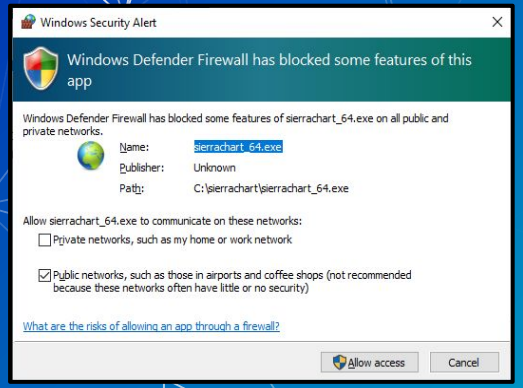
TCP/UDP Packet Polo with Firewall

TCP/UDP Packet Polo with Firewall



Host based Firewalls






```
root@nixcraft:~#
root@nixcraft:~# iptables -A INPUT -s 202.54.1.1 -j DROP -m comment --comment "DROP spam IP address"
root@nixcraft:~#
root@nixcraft:~# iptables -L INPUT -n
Chain INPUT (policy ACCEPT)
target     prot opt source               destination
ACCEPT     tcp  --  0.0.0.0/0            0.0.0.0/0            tcp dpt:53 /* generated for LXD network lxdbr0 */
ACCEPT     udp  --  0.0.0.0/0            0.0.0.0/0            udp dpt:53 /* generated for LXD network lxdbr0 */
ACCEPT     udp  --  0.0.0.0/0            0.0.0.0/0            udp dpt:67 /* generated for LXD network lxdbr0 */
ACCEPT     udp  --  0.0.0.0/0            0.0.0.0/0            udp dpt:53
ACCEPT     tcp  --  0.0.0.0/0            0.0.0.0/0            tcp dpt:53
ACCEPT     udp  --  0.0.0.0/0            0.0.0.0/0            udp dpt:67
ACCEPT     tcp  --  0.0.0.0/0            0.0.0.0/0            tcp dpt:67
DROP       all  --  202.54.1.1           0.0.0.0/0            /* DROP spam IP address */
root@nixcraft:~#
root@nixcraft:~#
root@nixcraft:~# iptables -A INPUT -p tcp --dport 80 -m comment --comment "block HTTPD access" -j DROP
root@nixcraft:~# iptables -A INPUT -p tcp --dport 443 -m comment --comment "block HTTPDS access" -j DROP
root@nixcraft:~#
root@nixcraft:~# iptables -L INPUT -n
Chain INPUT (policy ACCEPT)
target     prot opt source               destination
ACCEPT     tcp  --  0.0.0.0/0            0.0.0.0/0            tcp dpt:53 /* generated for LXD network lxdbr0 */
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ACCEPT     udp  --  0.0.0.0/0            0.0.0.0/0            udp dpt:53
ACCEPT     tcp  --  0.0.0.0/0            0.0.0.0/0            tcp dpt:53
ACCEPT     udp  --  0.0.0.0/0            0.0.0.0/0            udp dpt:67
ACCEPT     tcp  --  0.0.0.0/0            0.0.0.0/0            tcp dpt:67
DROP       all  --  202.54.1.1           0.0.0.0/0            /* DROP spam IP address */
DROP       tcp  --  0.0.0.0/0            0.0.0.0/0            tcp dpt:80 /* block HTTPD access */
DROP       tcp  --  0.0.0.0/0            0.0.0.0/0            tcp dpt:443 /* block HTTPDS access */
```

Break slide

Please return in 10 minutes

Also turn on your Win10Client

In Class Activity

Login to pfSense

Accessing pfSense

- Open your Win10Client
- Open a browser of your choice and a CLI
- Run command ipconfig
- Type the IP of the “default gateway” device into the address bar of your browser
- The credentials for pfSense will be admin as the user and the password is pfsense

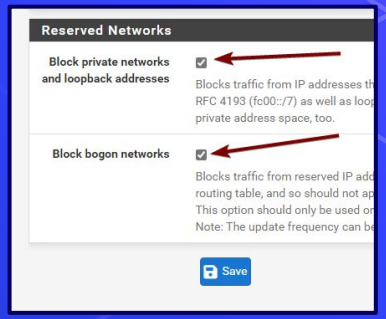
Disabling Default WAN(External) Firewall Rules

- Select the Firewalls dropbox at the top of the menu and select rules
- Click on the gear

Rules (Drag to Change Order)

	States	Protocol	Source	Port	Destination	Port	Gateway	Queue	Schedule	Description	Actions
✕	0 /0 B	*	RFC 1918 networks	*	*	*	*	*		Block private networks	
✕	0 /0 B	*	Reserved Not assigned by IANA	*	*	*	*	*		Block bogon networks	

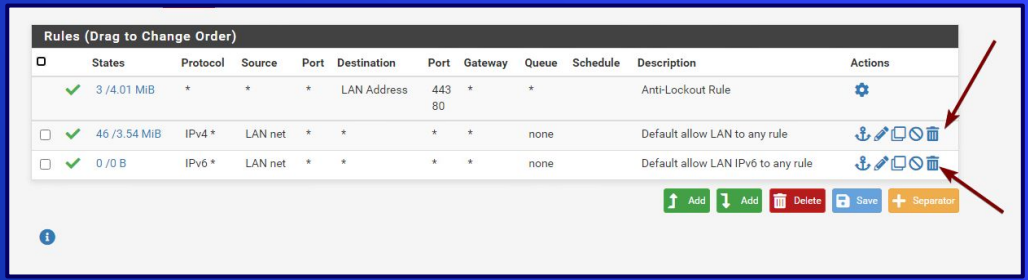
- Scroll to the bottom and uncheck the two checkboxes
- Don't forget to save at the bottom and by pressing apply changes



Disabling Default LAN(AdminNet) Firewall Rules (Cont.)

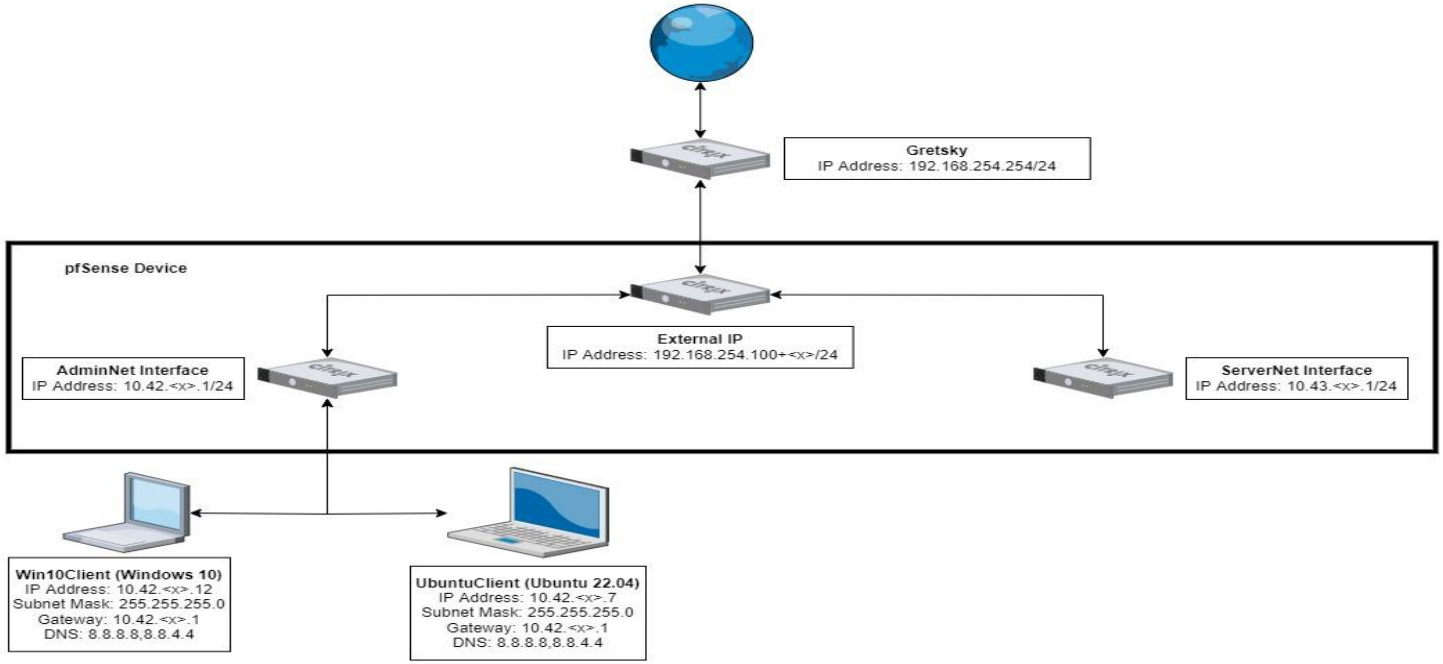
- Change your interface to your LAN (AdminNet)

- Remove the default firewall rules, remember to save and apply after



- **Do not** remove the Anti-Lockout Rule… yet! (Hint: that's part of your HW)

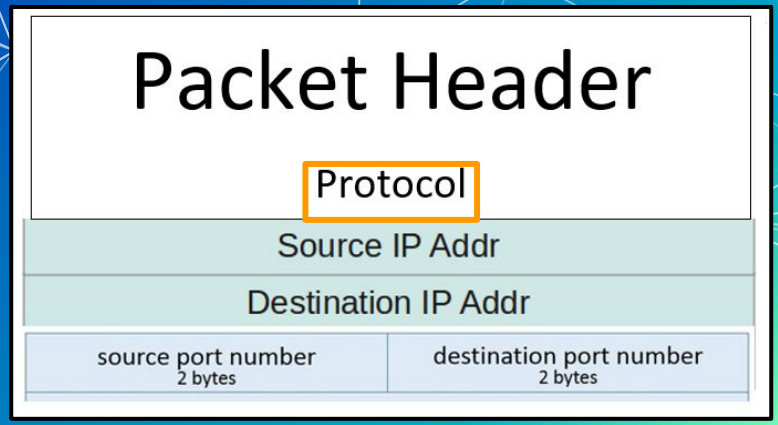
Current Network State



Header to Firewall

Rules (Drag to Change Order)

		States	Protocol	Source	Port	Destination	Port	Gateway	Queue	Schedule	Description	Actions
☐	✓	0 /480 B	IPv4 ICMP any	*	*	8.8.8.8	*	*	none			
☐	✓	0 /217 KiB	IPv4 TCP	*	*	*	443 (HTTPS)	*	none			
☐	✓	0 /877 B	IPv4 TCP	*	*	*	80 (HTTP)	*	none			
☐	✗	0 /1 KiB	IPv4 TCP	*	*	*	*	*	none			



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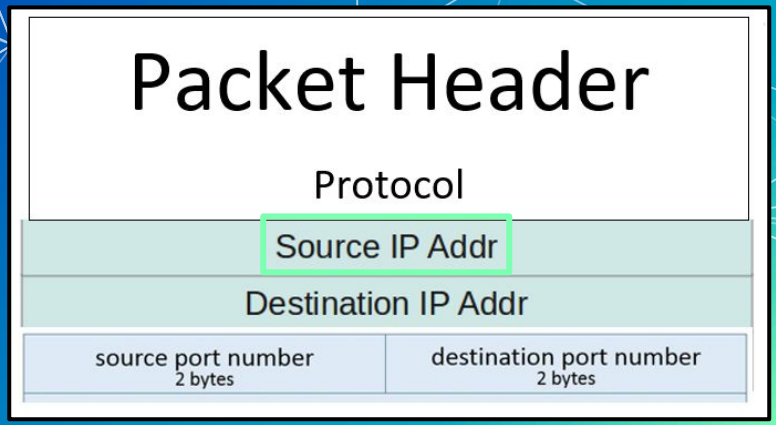
✓	0 /217 KiB	IPv4 TCP	*	*	*	443 (HTTPS)	*	none			
✓	0 /877 B	IPv4 TCP	*	*	*	80 (HTTP)	*	none			
✗	0 /1 KiB	IPv4 TCP	*	*	*	*	*	none			



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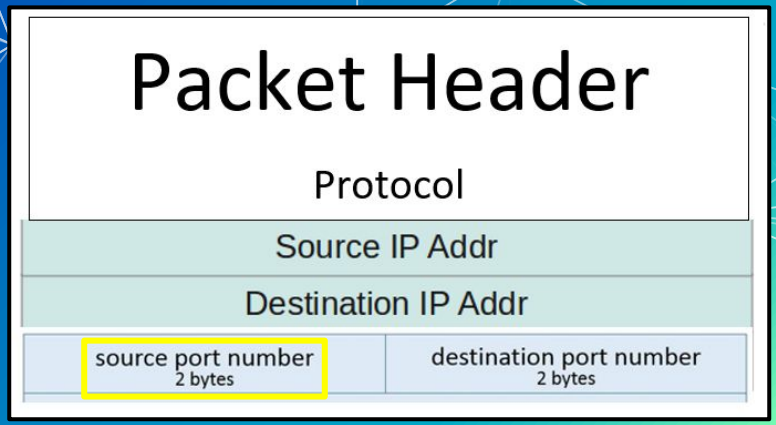
✓	0 /217 KiB	IPv4 TCP	*	*	*	443 (HTTPS)	*	none			
✓	0 /877 B	IPv4 TCP	*	*	*	80 (HTTP)	*	none			
✗	0 /1 KiB	IPv4 TCP	*	*	*	*	*	none			



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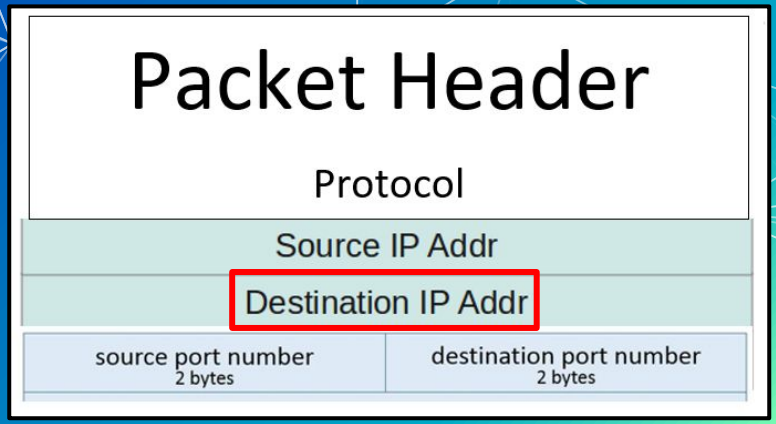
✓	0 /877 B	IPv4 TCP	*	*	*	80 (HTTP)	*	none			
✗	0 /1 KiB	IPv4 TCP	*	*	*	*	*	none			



Header to Firewall

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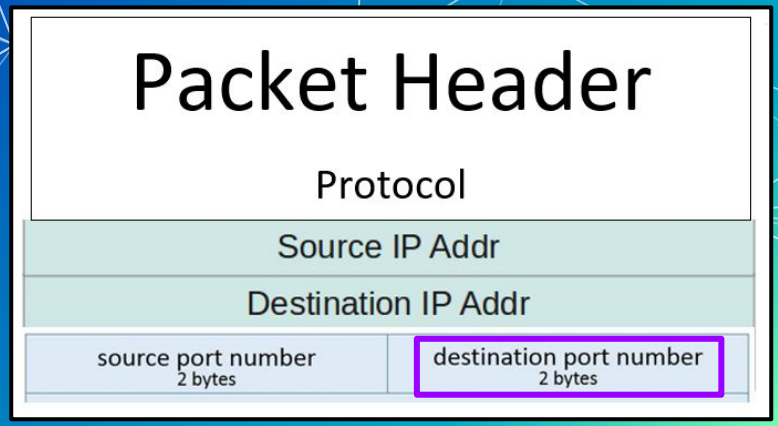
☐	✓	0 /217 KiB	IPv4 TCP	*	*	*	443 (HTTPS)	*	none			
☐	✓	0 /877 B	IPv4 TCP	*	*	*	80 (HTTP)	*	none			
☐	✗	0 /1 KiB	IPv4 TCP	*	*	*	*	*	none			



Header to Firewall

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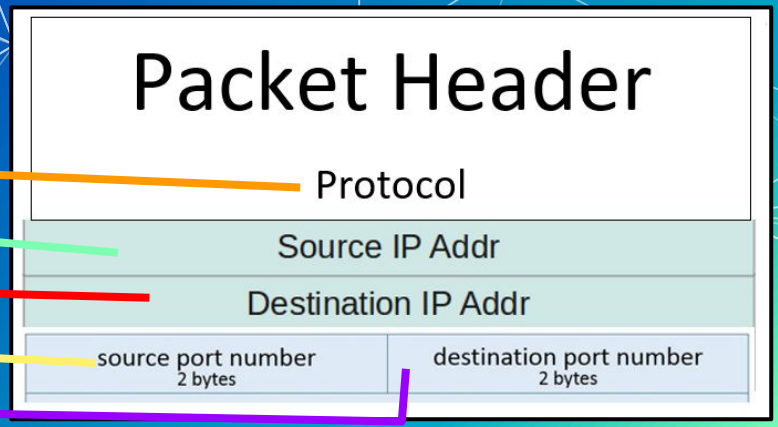
✓	0 /217 KiB	IPv4 TCP	*	*	*	443 (HTTPS)	*	none			
✓	0 /877 B	IPv4 TCP	*	*	*	80 (HTTP)	*	none			
✗	0 /1 KiB	IPv4 TCP	*	*	*	*	*	none			



Host Based Firewalls Hands-On

Activity – Host Based Firewalls

- Disable the default WAN rules
- Block all Ping requests using your Linux host based firewall.
  - Test by having someone at your table try to ping your device before and after
- Allow all ping requests using your Windows host based firewall.
  - Test by having someone at your table try to ping your device before and after.

The Logic of Firewalls

Rule Hierarchy

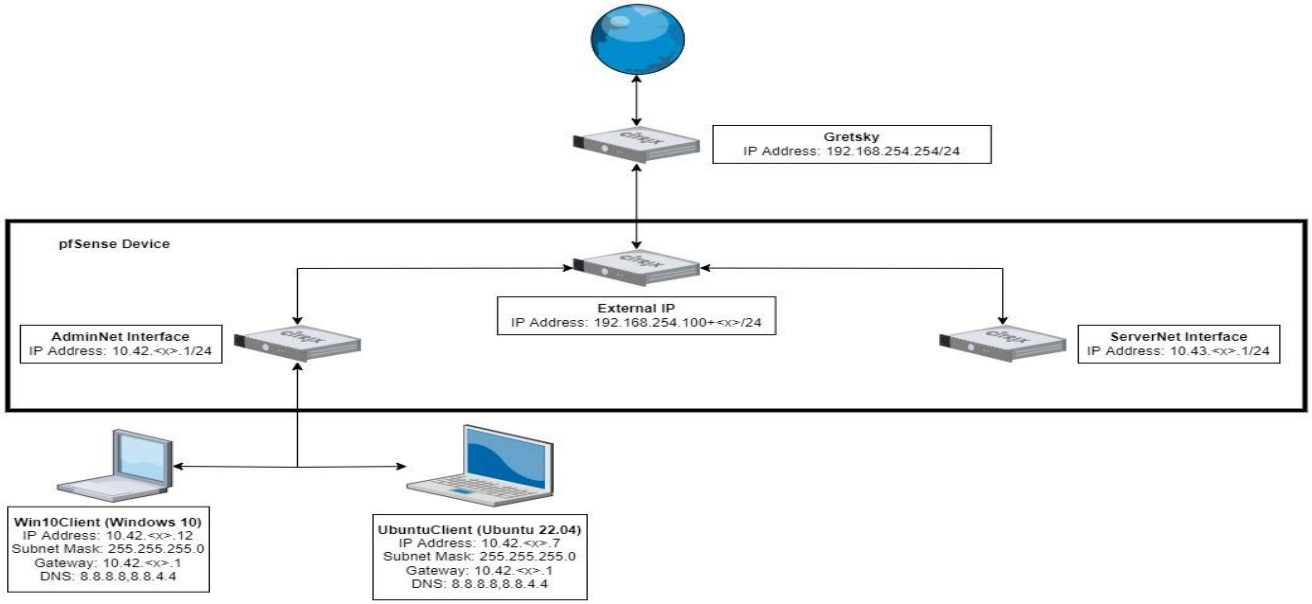
- Each packet is checked against rules.
  - Rules are enforced from top to bottom
    - Packets can be:
      - Rejected
      - Dropped
      - Allowed

Rules (Drag to Change Order)

		States	Protocol	Source	Port	Destination	Port	Gateway	Queue	Schedule	Description	Actions
☐	✔	0 /480 B	IPv4 ICMP any	*	*	8.8.8.8	*	*	none			
☐	✔	0 /217 KiB	IPv4 TCP	*	*	*	443 (HTTPS)	*	none			
☐	✔	0 /877 B	IPv4 TCP	*	*	*	80 (HTTP)	*	none			
☐	✘	0 /1 KiB	IPv4 TCP	*	*	*	*	*	none			

How Traffic Flows

- Your network

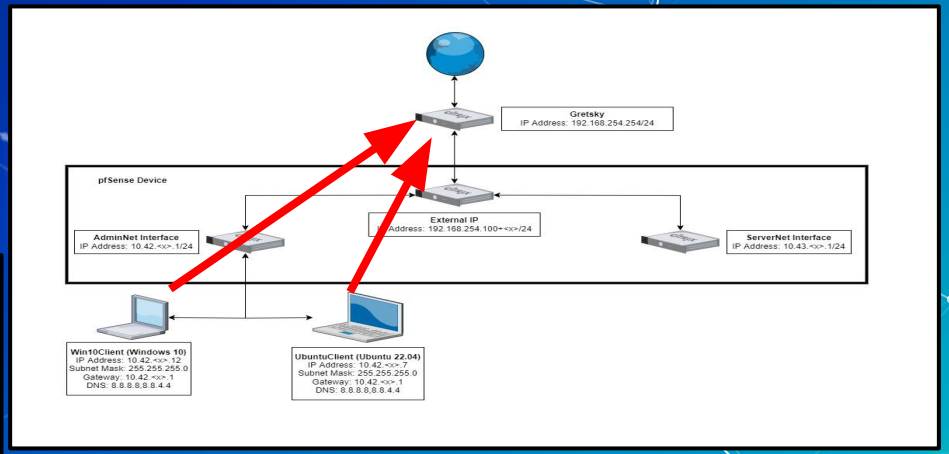


How Traffic Flows

- From LAN (AdminNet) to Web

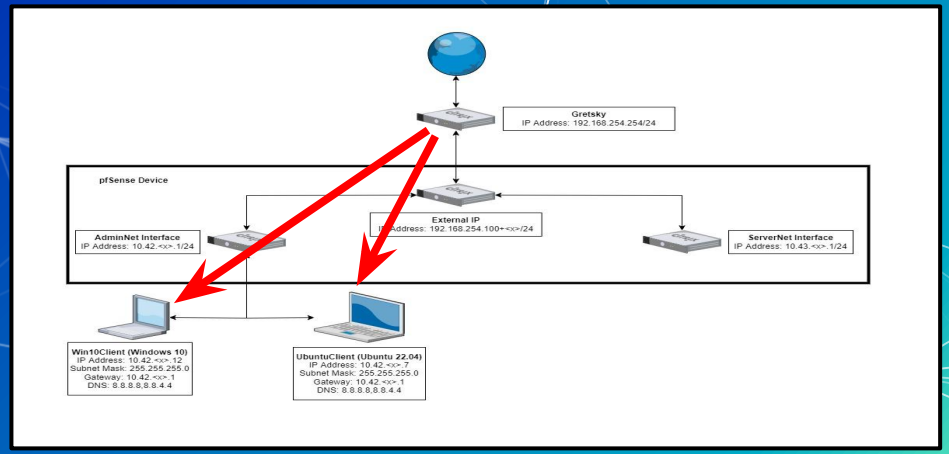
Rules (Drag to Change Order)

	States	Protocol	Source	Port	Destination	Port	Gateway
✓	0 /480 B	IPv4 ICMP any	*	*	8.8.8.8	*	*



How Traffic Flows

- From Web to LAN (`AdminNet`)
- Web inbound is managed by the WAN (`External`) interface



Catch all rule

- What if a packet doesn't match any of our rules?

Catch all rule

- What if a packet doesn't match any of our rules?
  - Firewalls use one or more default "catch all rule(s)" that is enforced when a packet does not match any listed rules.
  - The default behavior depends on firewall manufacturer

Define Your Own Default Rule(s)

- Default firewall rule(s) need to be at the bottom of the firewall's rule list

	States	Protocol	Source	Port	Destination	Port	Gateway	Queue
✖	0 /2 KiB	IPv4+6 *	*	*	*	*	*	none

✔	5 /7.08 MiB	IPv4 *	LAN net	*	*	*	*	none	Default allow LAN to any rule
✔	0 /0 B	IPv6 *	LAN net	*	*	*	*	none	Default allow LAN IPv6 to any rule

Logic of Firewalls
Questions?

In Class Activity

Compromised Device & pfSense Hands-On

Activity – pfSense Firewall

- Prevent all ping requests from inside AdminNet to anywhere on External (Anywhere on Gretzky's LAN or the internet)
  - Test by attempting to ping IP address 8.8.8.8
- If this is too easy
  - Make it so you can ping Gretzky (192.168.254.254) but not 8.8.8.8

Activity – Compromised Windows 10 Host

- Prevent me from being able to access your system.
  - Credentials:
    - Username: sysadmin
    - Password: Change.me!
- Hint[0]: get-nettcpconnection
- Hint[1]: What are the remote control protocols that Windows uses?

Homework Prep

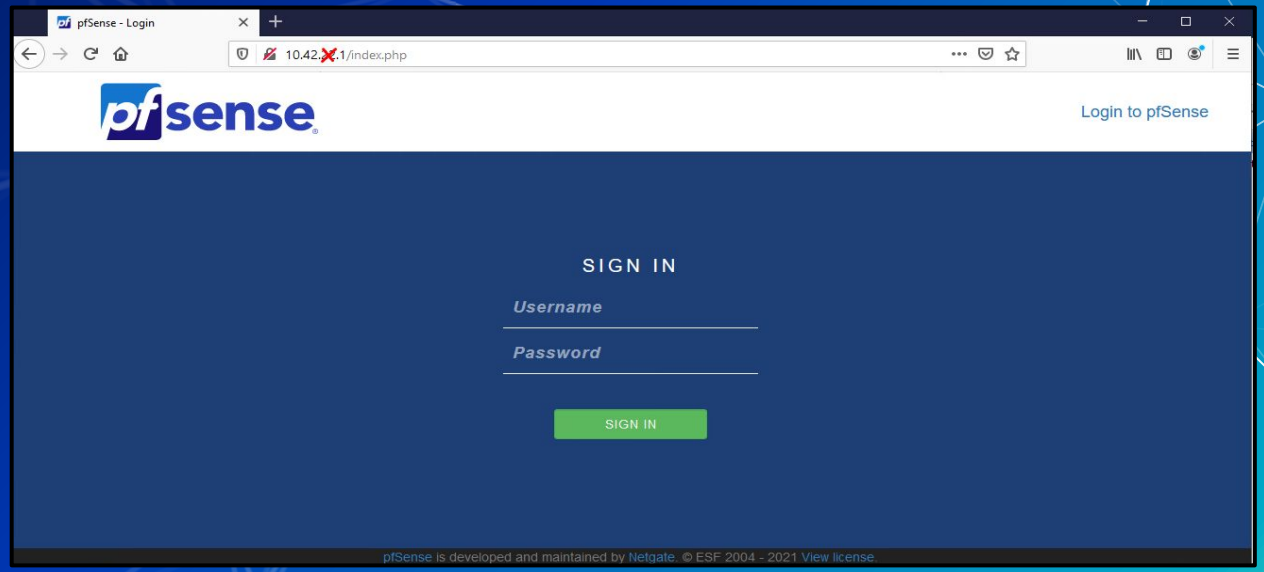
System Prep

- Prep 1: Install SSH on your Linux client
  - Package name: openssh-server
    - `sudo apt install openssh-server`
    - https://youtu.be/HJXo68LnNOs
- Prep 2: Run script from GitHub on Windows Client (PrepareWindowsSystem.ps1)
  - https://github.com/ubnetdef/WindowsScriptsForLecture
  - https://www.youtube.com/watch?v=Z6kNyfZiNxg

Homework Starter

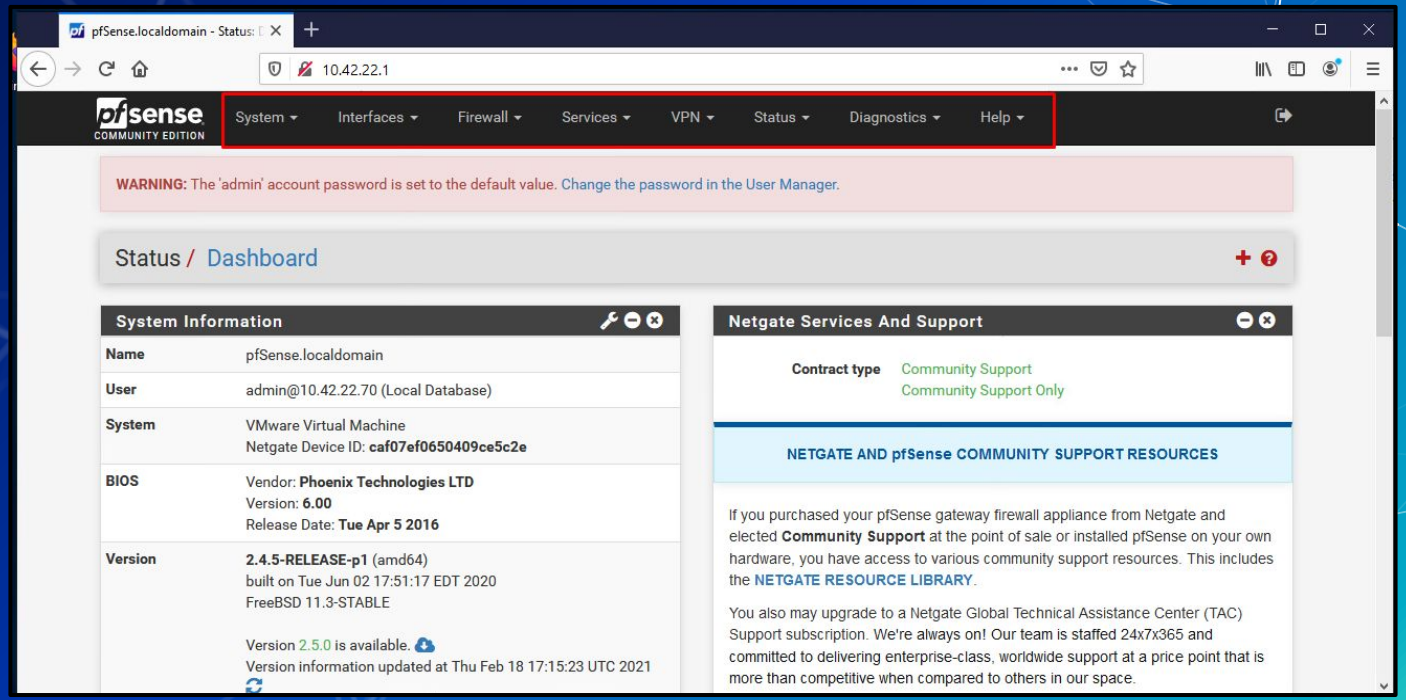
Homework Starter

- Credentials
  - Username: `admin`
  - Password: `pfsense`



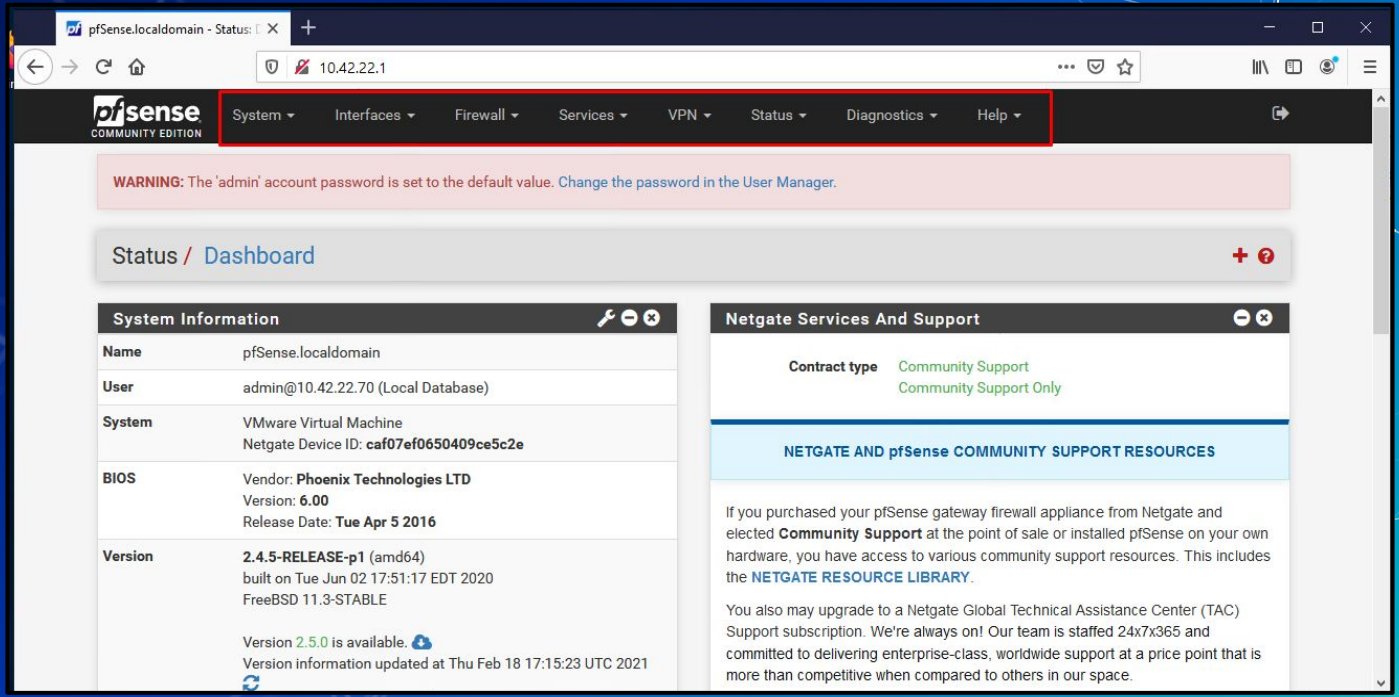
Homework Starter

- Navigation through pfSense UI can generally be done using the top bar



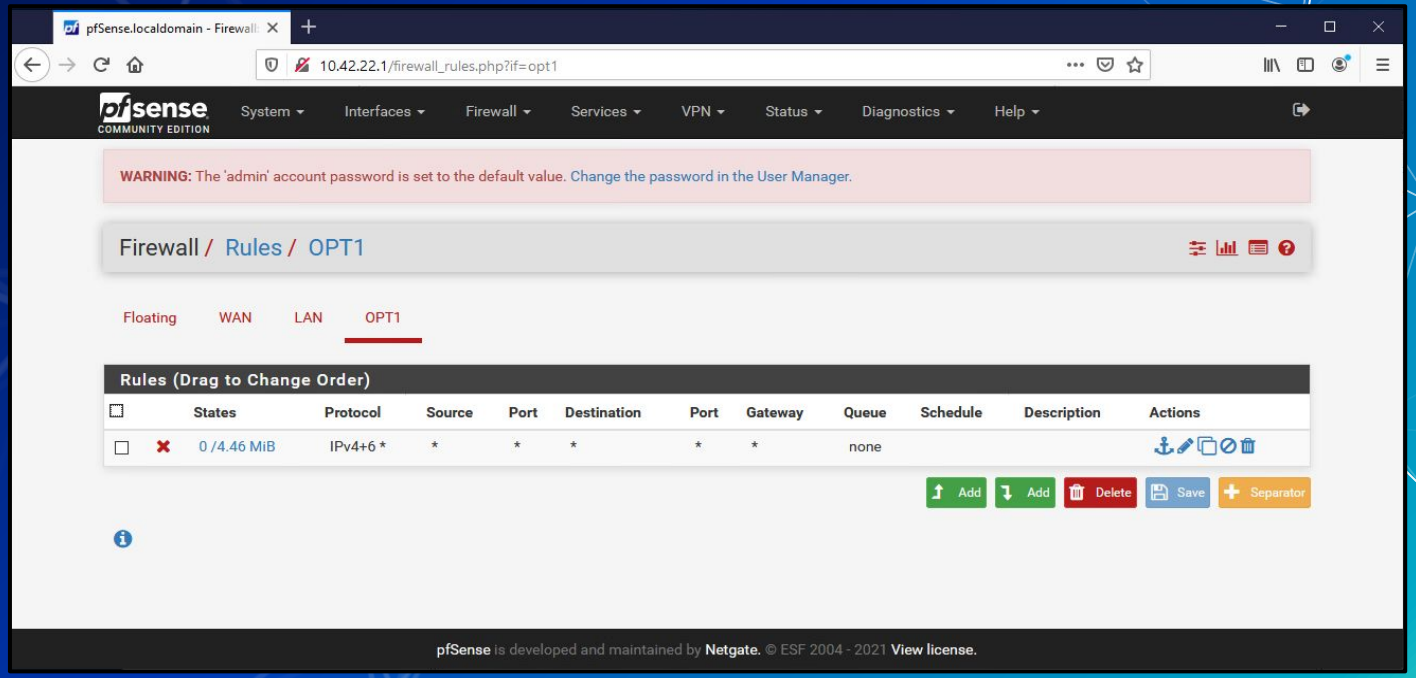
Homework Starter

- Rules menu is under `Firewall > Rules`



Homework Starter

- Rules are grouped by the interface that handles the packets



Homework Hint

- If after you apply a firewall rule you can no longer connect to your pfsense router through the Web Interface it is likely you have a firewall rule that is blocking you.
  - Use `pfctl -d` to disable the firewall and make sure to fix the offending rule before applying and additional rules.
- Everytime you modify any rule and commit the change your firewall will be reenabled
- Changing one rule at a time and testing may be best practice

Summary and Wrap-up

Today's achievements:

- Reviewed networking
- Further dive into OSI model specifically in the transport layer with the TCP handshake and UDP
- Migrated UbuntuClient to AdminNet
- Learned about firewalls and the different types
- Configured firewall rules to block a compromised device

Parting Question

Class dismissed

See you next week!