

Firewalls

UBNetDef, Spring 2024
Week 3

Lead Presenter:
Ethan Viapiano

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

■ Networking

- Current Network State
- Networking Part 2: Ports and Packets
- In class exercise: TCP Packet Polo

■ Migration Activity

■ Firewalls

- Types of Firewalls
- In class exercise: TCP Packet Polo (with a firewall)
- In class exercise: Login to pfSense

■ Firewall and Packet Headers

■ The Logic of Firewalls

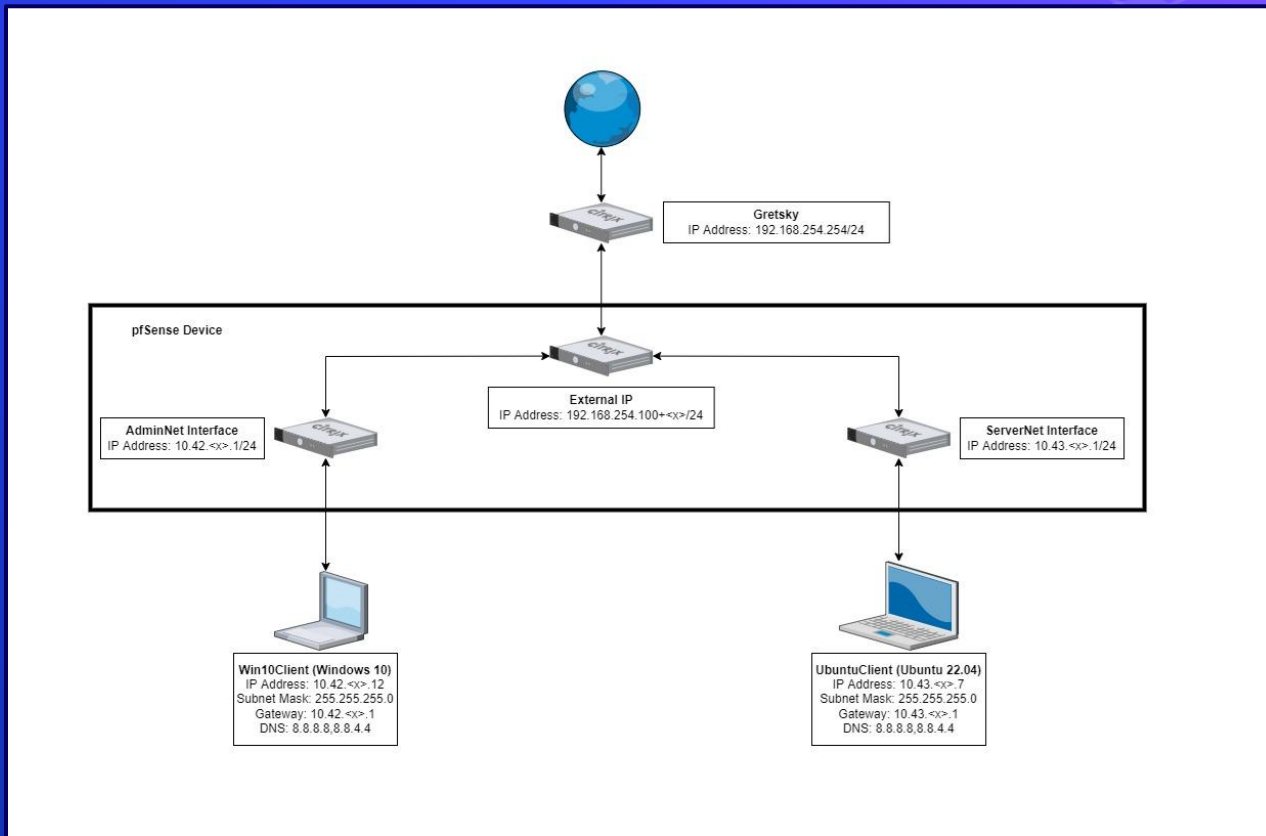
- How Traffic Flows
- Default Rules

■ pfSense Activity

■ Homework Prep

■ Summary/Wrap Up

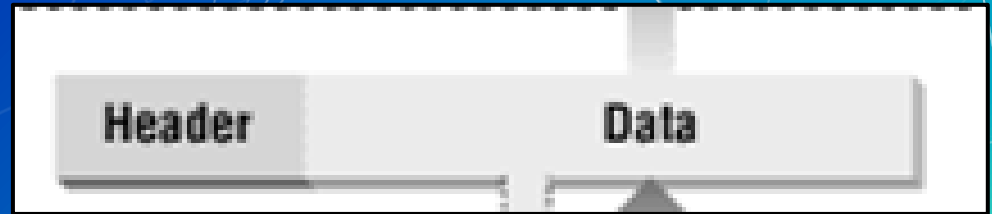
Current Network State



Intro to the Transport Layer

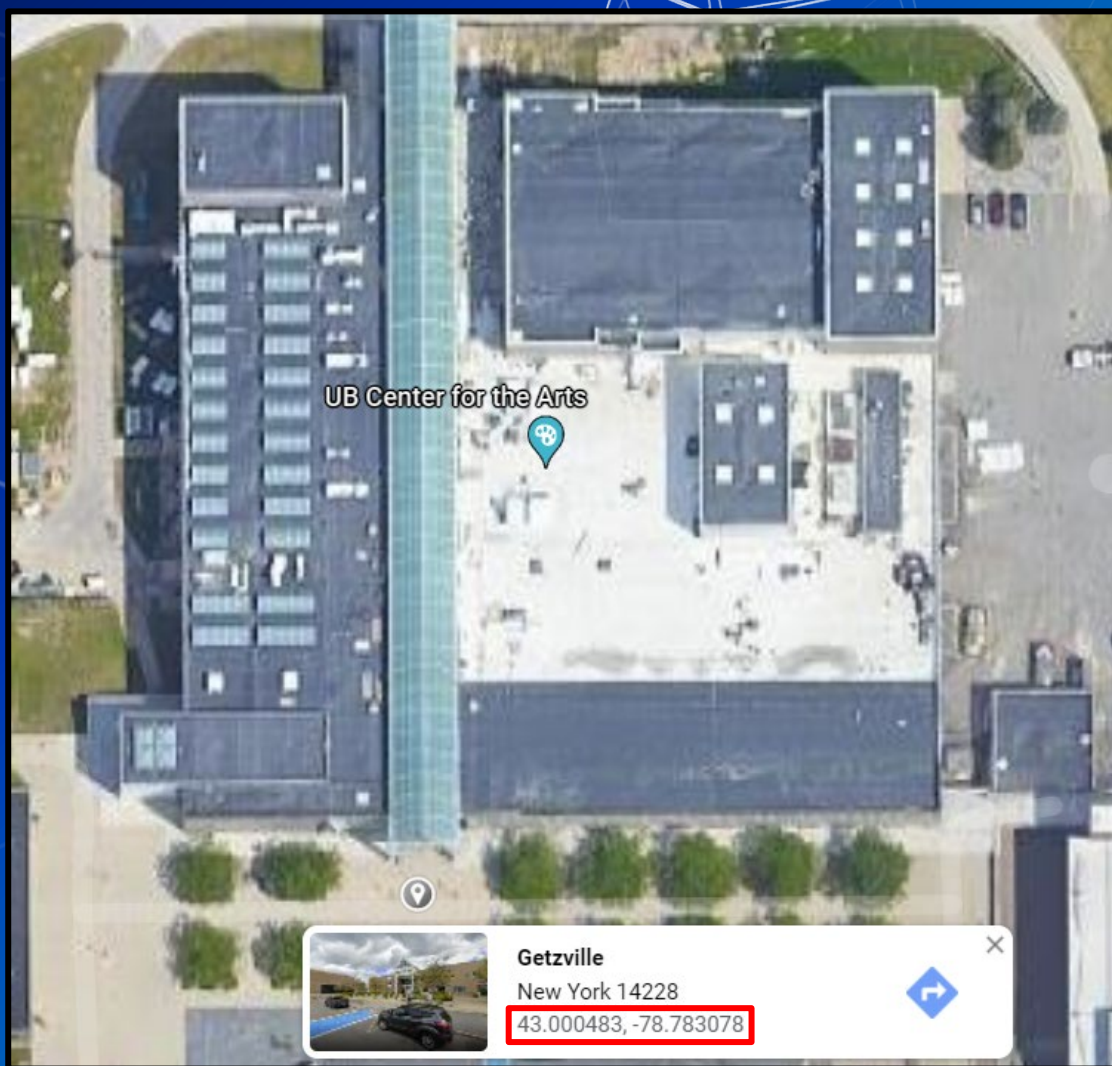
Transport Layer

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



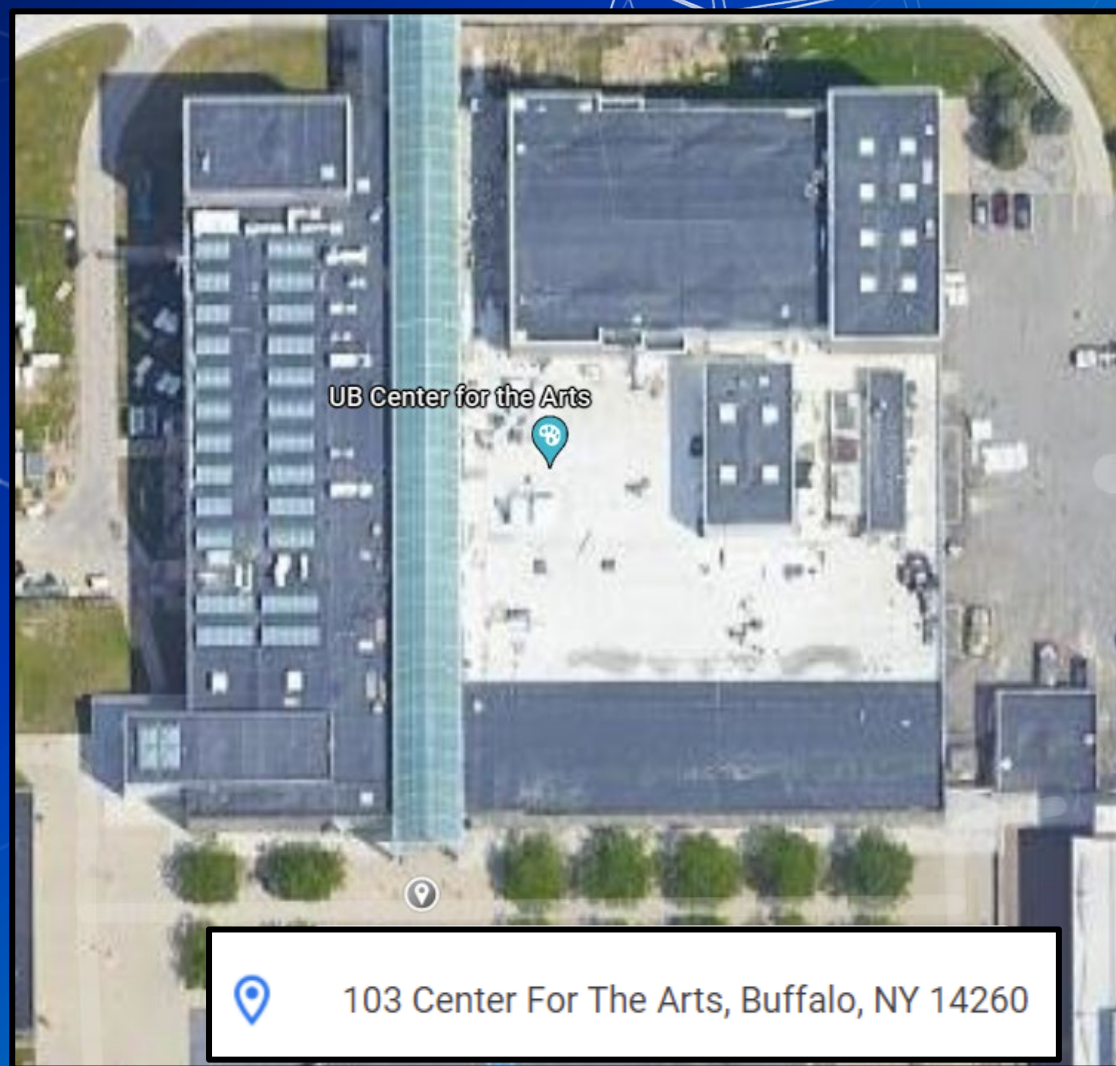
Intro to Ports

- Recall MAC Addresses
 - Eg. 00-10-FA-6E-38-4A
- Consider these similar to physical coordinates



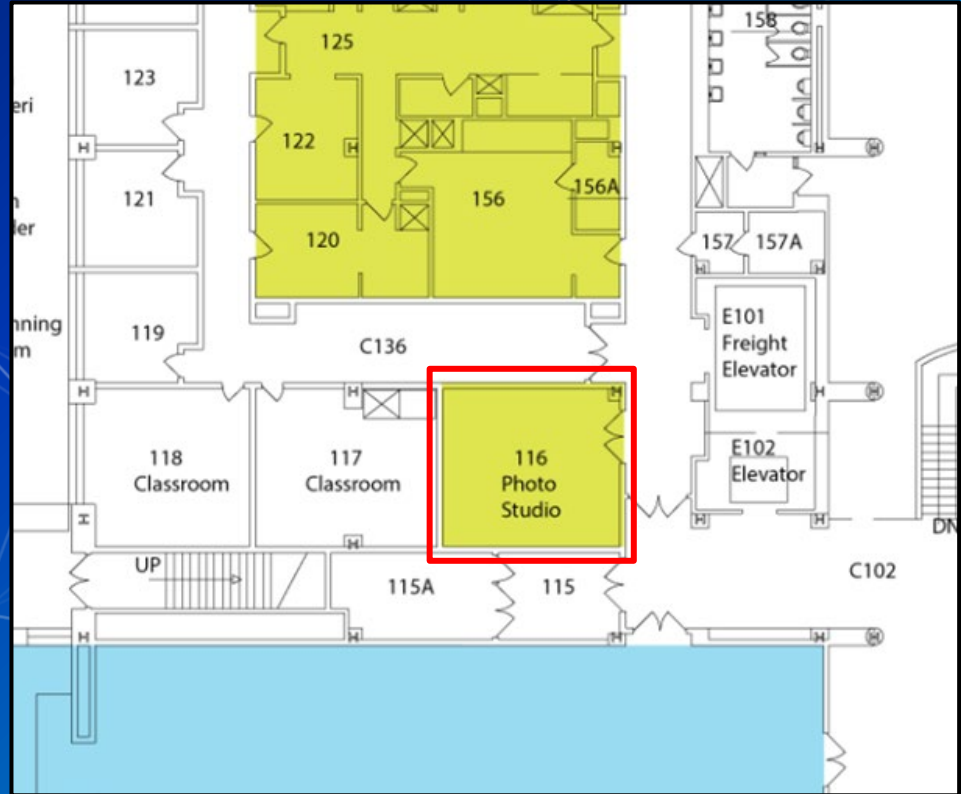
Intro to Ports

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

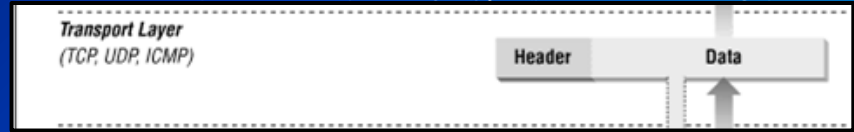


Intro to Ports

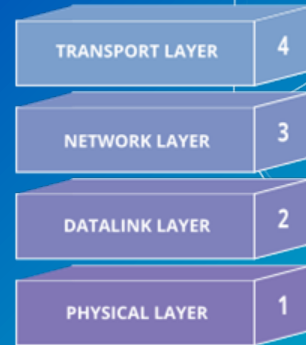
- Ports are similar to room numbers
 - MAC: 43.000483, -78.783078
 - IP: 103 Center for the Arts
 - Port: Room 116
- Ports are indicated next to IP addresses
 - 192.168.15.152:**116**



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

source port number 2 bytes		destination port number 2 bytes	
sequence number 4 bytes			
acknowledgement number 4 bytes			
data offset 4 bits	reserved 3 bits	control flags 9 bits	window size 2 bytes
checksum 2 bytes		urgent pointer 2 bytes	
optional data 0-40 bytes			

UDP Header

Source port	Destination port
UDP length	Checksum

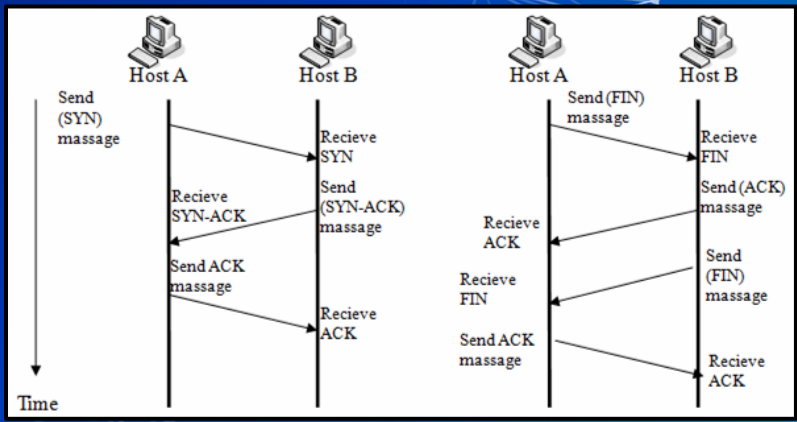
In Class Activity

TCP/UDP Packet Polo

TCP Handshake

```

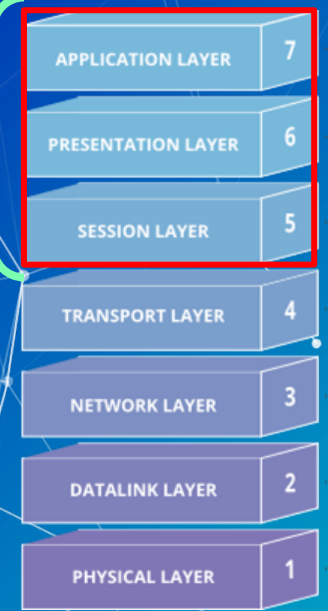
pfTop: Up State 1-100/114033, View: default, Order: bytes
PR   DIR SRC                               DEST                               STATE                               AGE                               EXP                               PKTS  BYTES
icmp Out 192.168.253.18:17838             192.168.253.17:17838             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

“Application Layer”



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

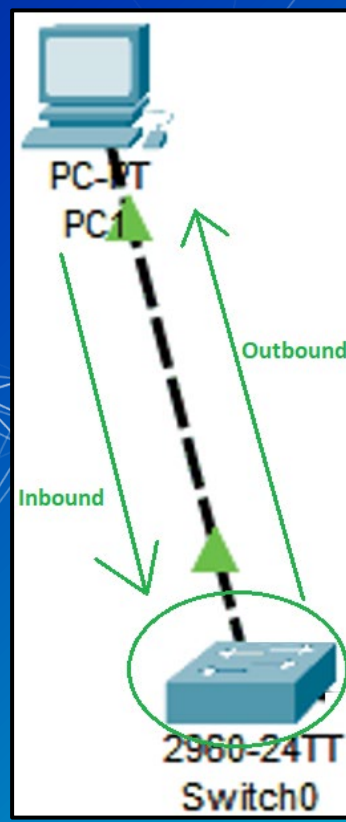
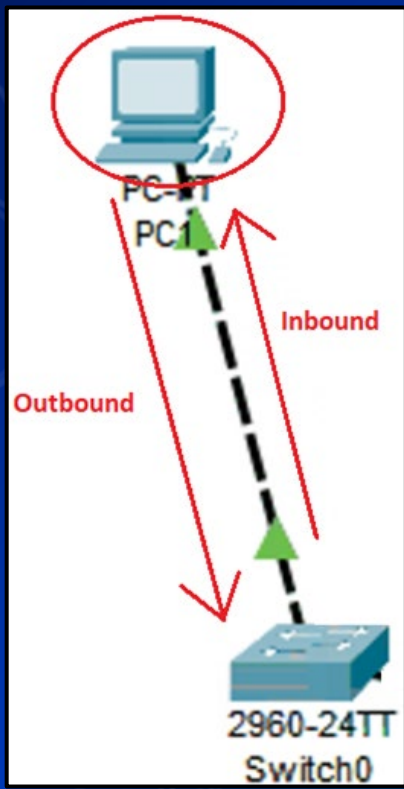
```
Name: google.com
Addresses: 2607:f8b0:4006:81c::200e
           142.250.176.206
```

DNS Demo

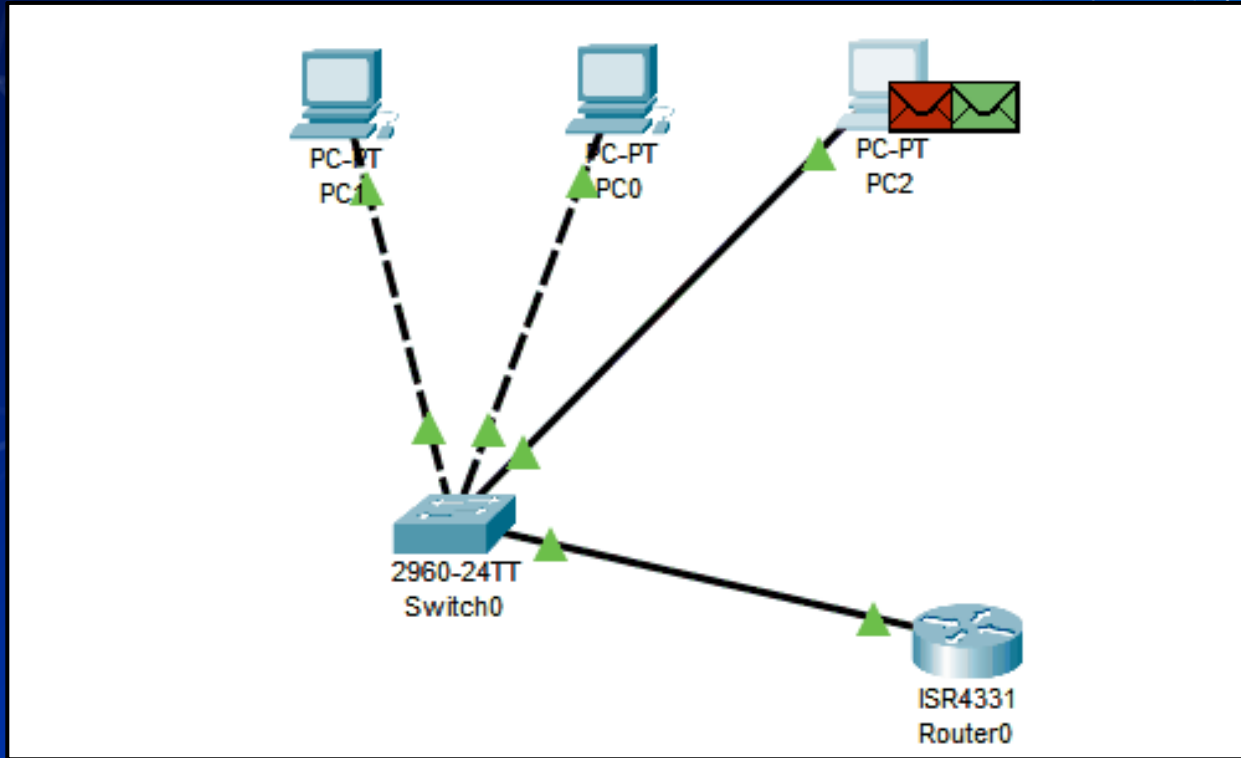
- ⬡ Open a CLI
- ⬡ `nslookup washington.edu`
- ⬡ Copy IP Address into web browser
- ⬡ You may need to use `http://` as a URL prefix

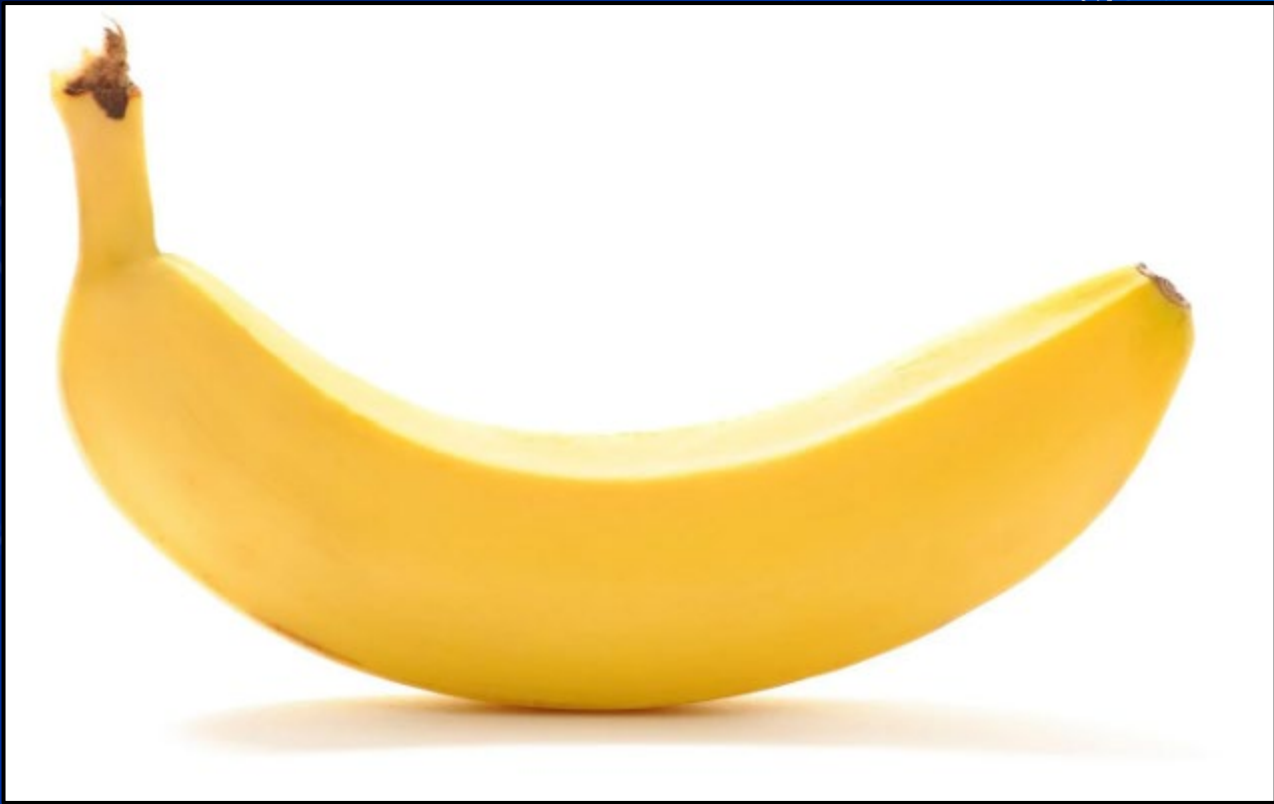


Directional Flow



Data flows freely... for now





Questions?

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■ Firewall and Packet Headers

■ The Logic of Firewalls

- How Traffic Flows
- Default Rules

■ pfSense Activity

■ Homework Prep

■ Summary/Wrap Up

In Class Activity

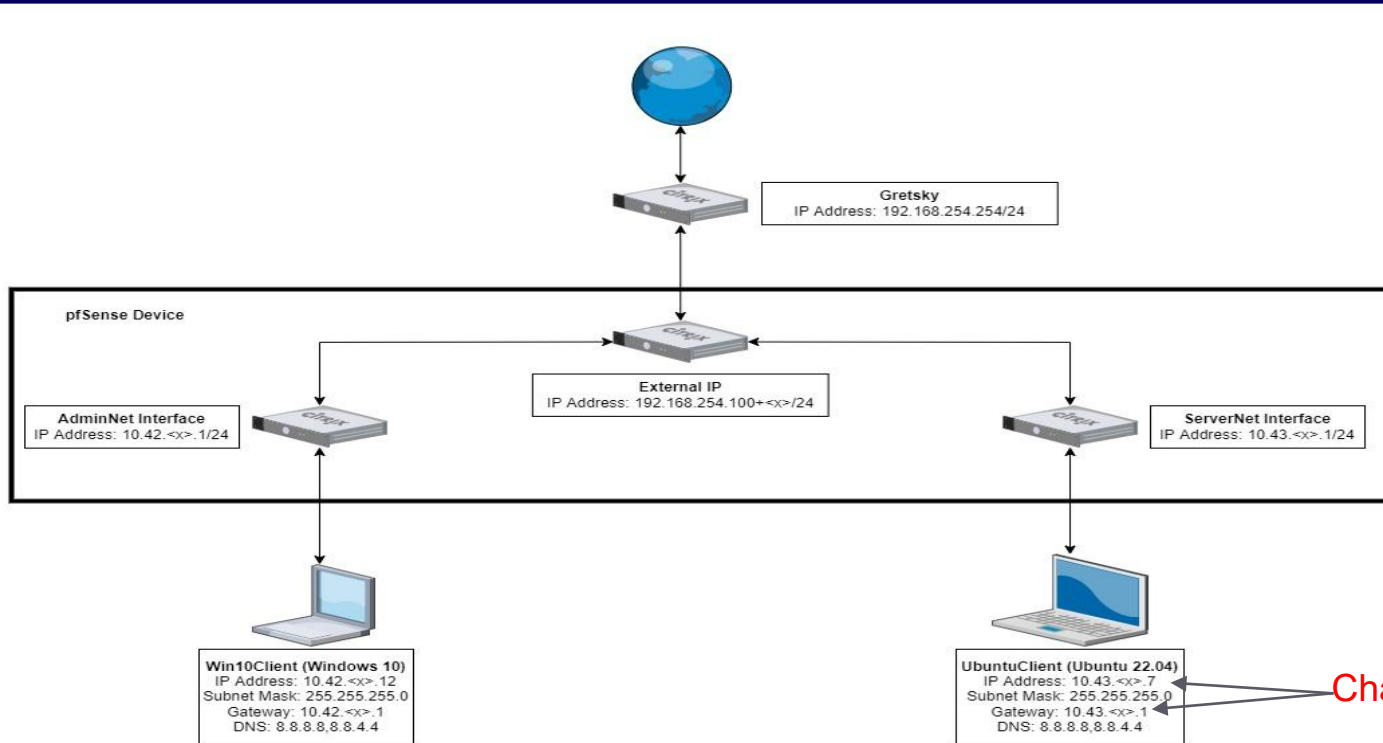
Hands-on Migration

Activity – Migrate Linux to AdminNet

- Migrate UbuntuClient from ServerNet to AdminNet.

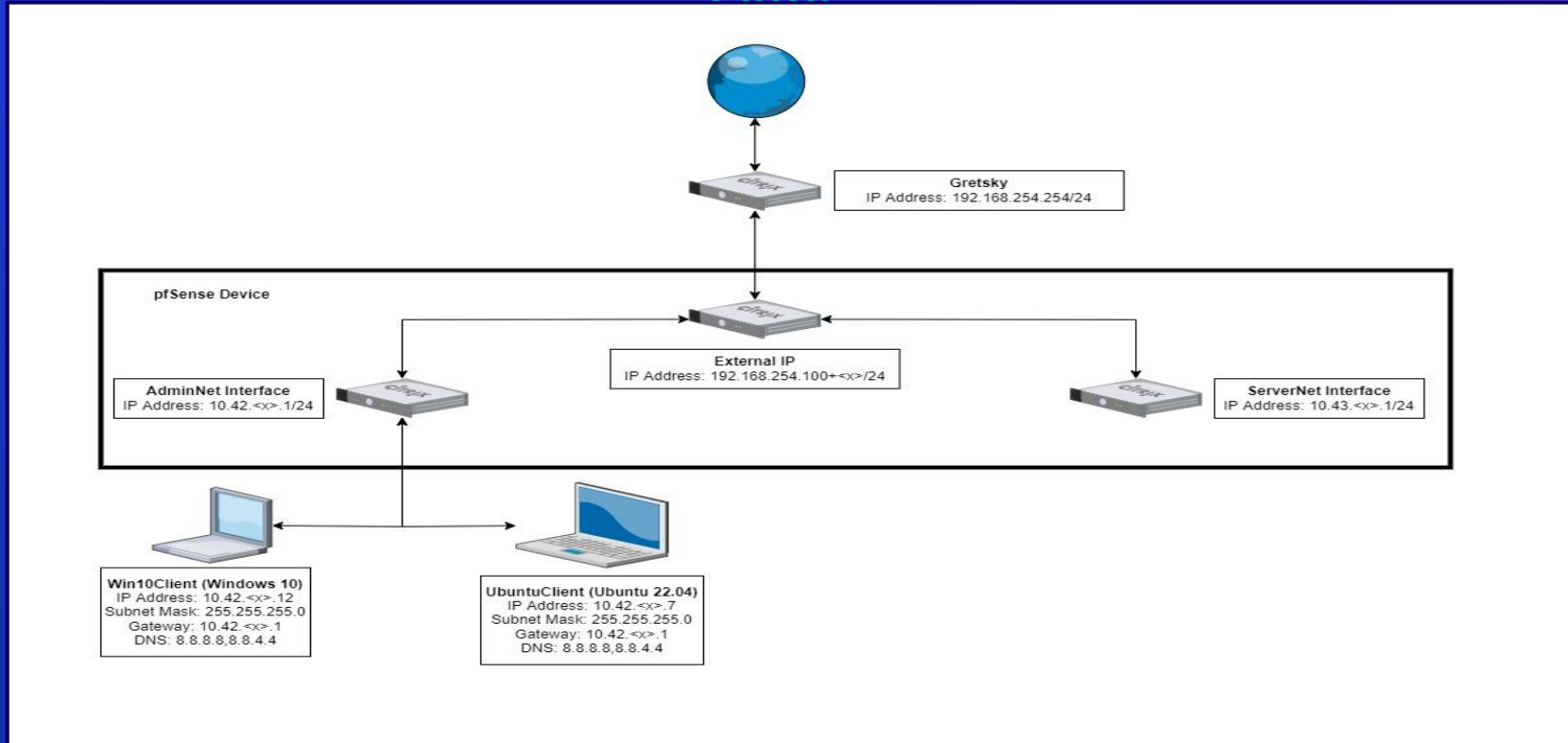
Activity – Migrate Linux to AdminNet

Before



Activity – Migrate Linux to AdminNet

After



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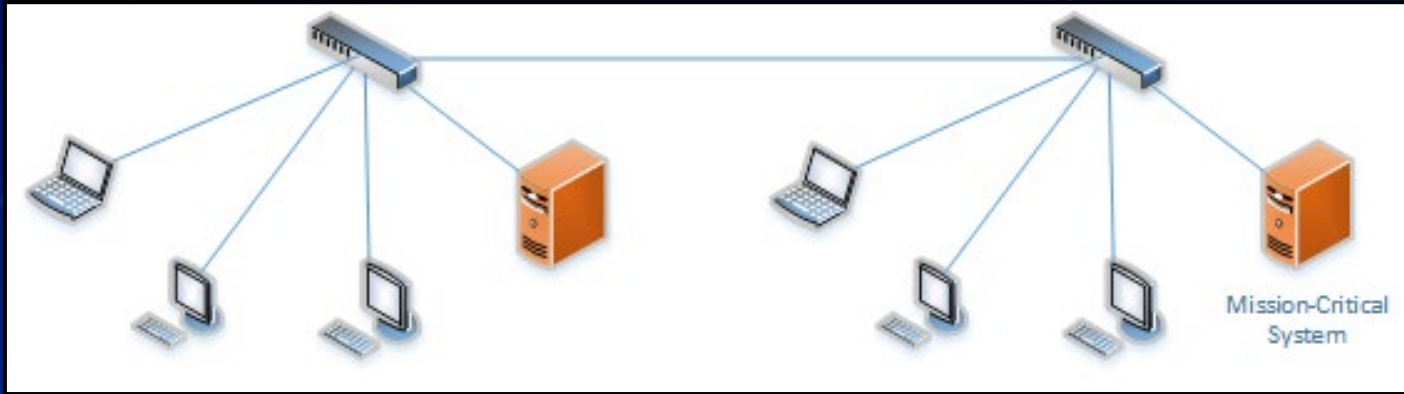
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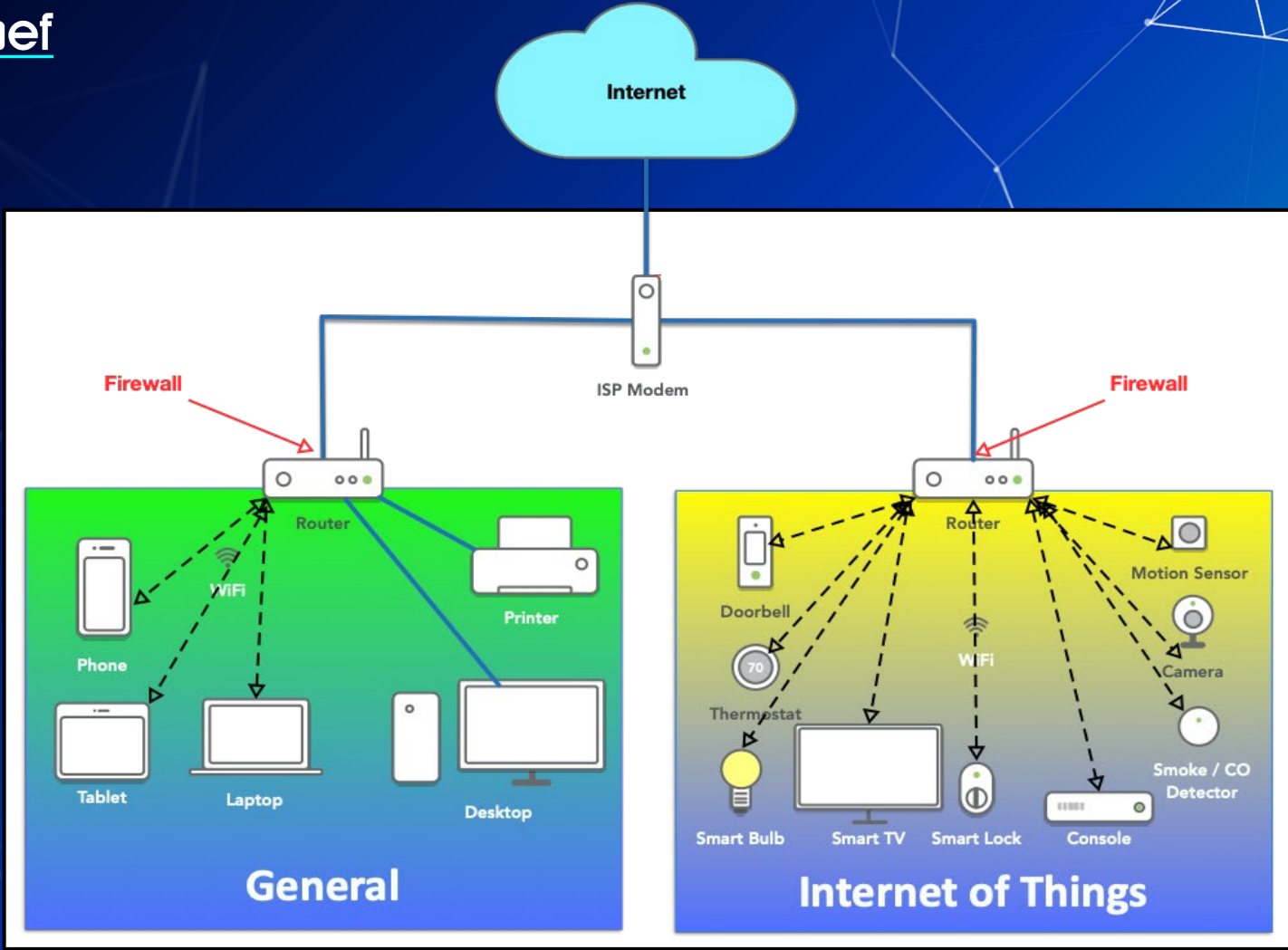
Types of Firewalls

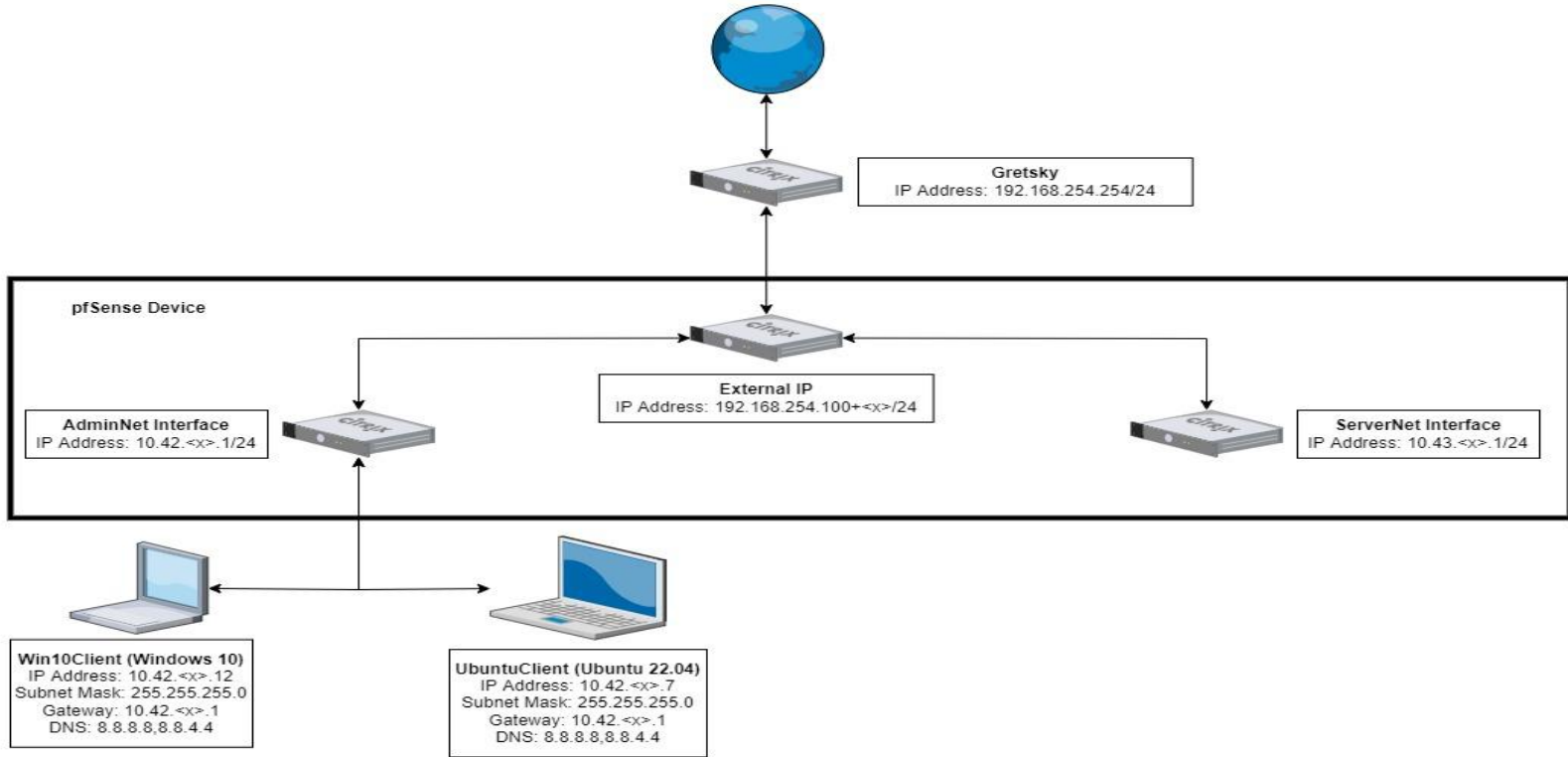
- Packet Filters (GEN 1)
- Stateful Firewalls (GEN 2)
- Next-generation Firewalls (NGFW)
 - Palo Alto (coming soon in this class)
- Vantage Point
 - Network Perimeter
 - Host-Based

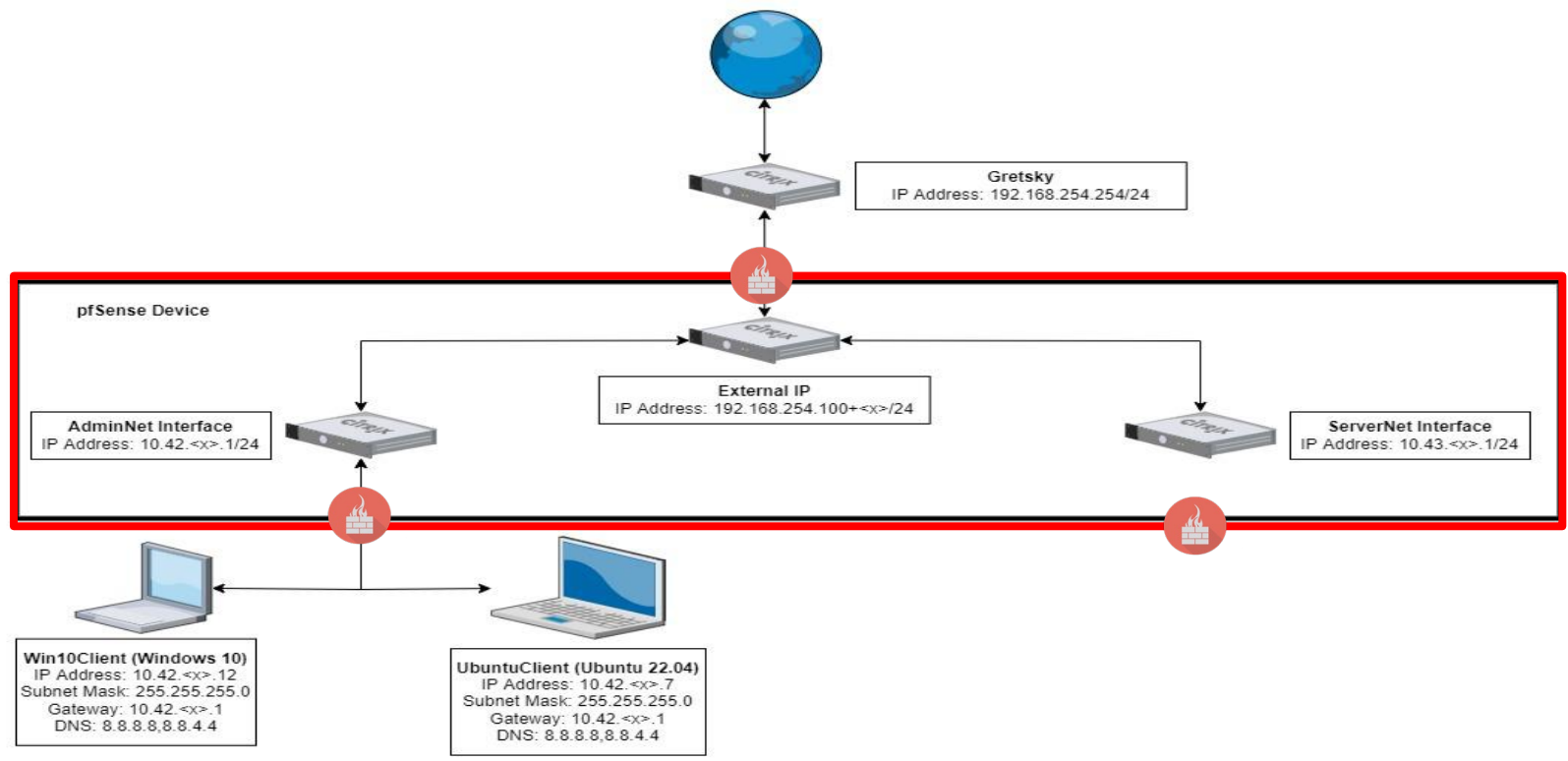
Why Firewalls?



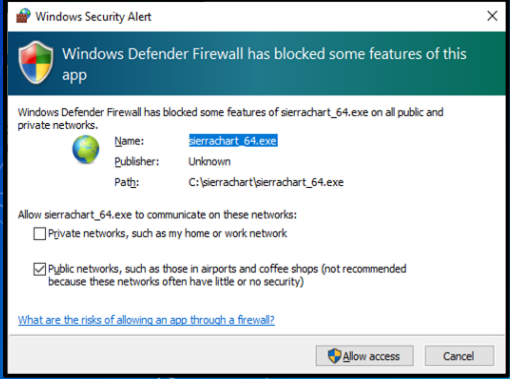
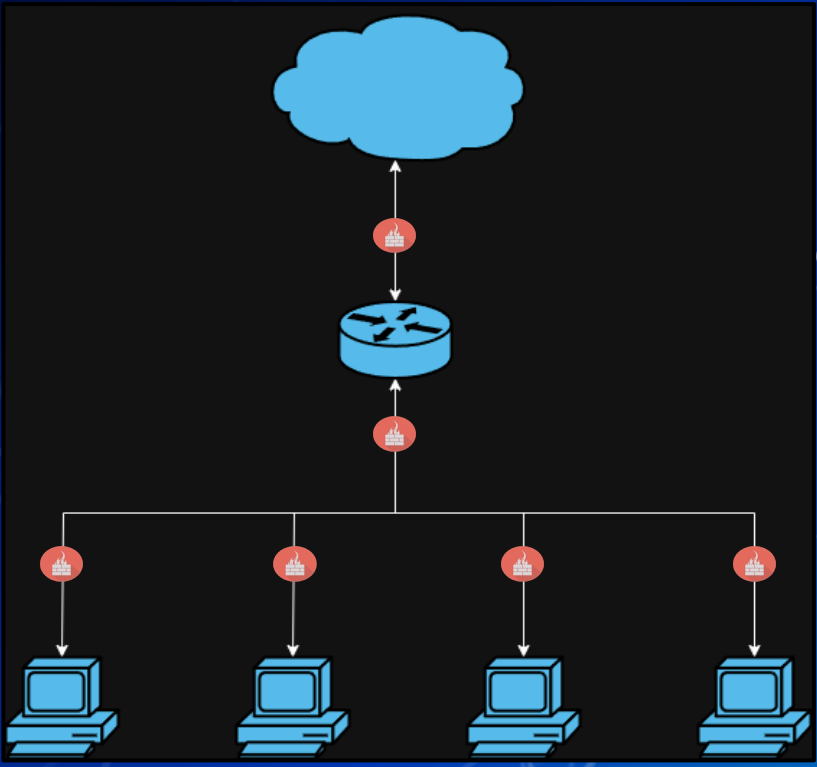
**Any networked device can
access the mission-critical
system**







Host based Firewalls

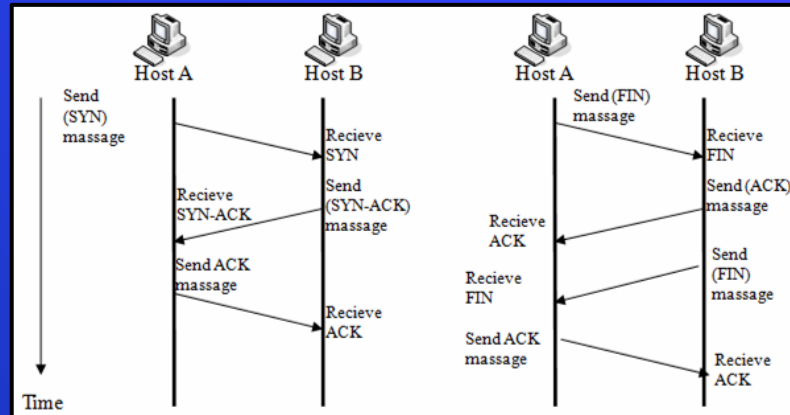


```
root@nixcraft:~# iptables -A INPUT -s 202.54.1.1 -j DROP -m comment --comment "DROP spam IP address"
root@nixcraft:~# iptables -L INPUT -n
Chain INPUT (policy ACCEPT)
target prot opt source destination
ACCEPT tcp -- 0.0.0.0/0 0.0.0.0/0 tcp dpt:53 /* generated for LXD network lxdbr0 */
ACCEPT udp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

In Class Activity

TCP/UDP Packet Polo with Firewall

TCP/UDP Packet Polo with Firewall



Break slide

Please return in 10 minutes

In Class Activity



Login to pfSense

Accessing pfSense

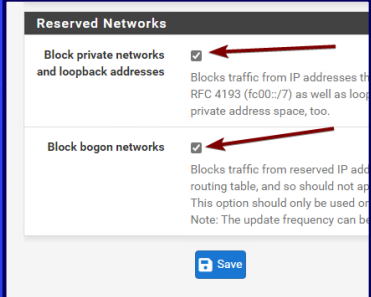
- Open Win10Client
- Open a browser of your choice and a CLI
- Run command `ipconfig`
- Type the IP of the “default gateway” device into the address bar of your browser
- The credentials for pfSense will be `admin` as the user and the password is `pfSense`

Disabling Default WAN(External) Firewall Rules

- Select the Firewalls dropdown 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



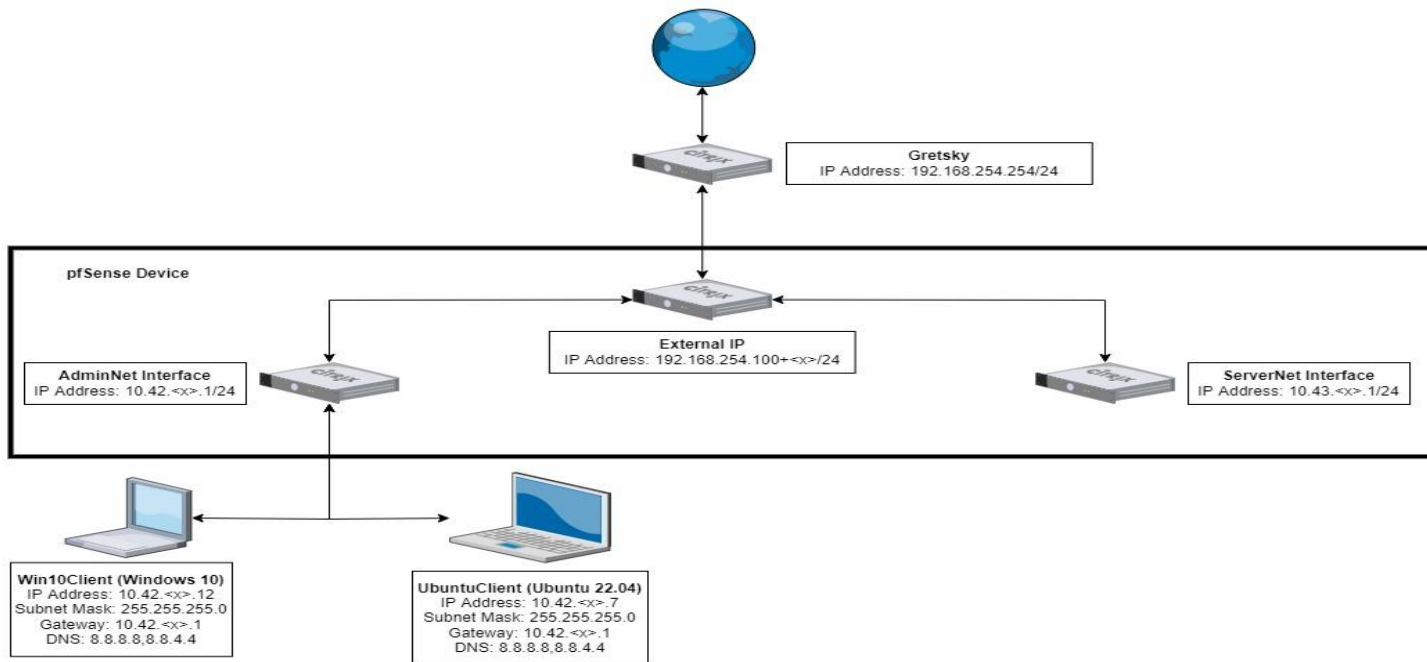
Reserved Networks

Block private networks and loopback addresses
Blocks traffic from IP addresses that are reserved for private use, as well as loopback addresses. This option should only be used on private networks.

Block bogon networks
Blocks traffic from reserved IP addresses that are not in the routing table, and so should not appear in the routing table. This option should only be used on private networks. Note: The update frequency can be configured.



Reminder: Current Network State



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- How Traffic Flows
- Default Rules

■ pfSense Activity

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■ Summary/Wrap Up

Header to Firewall

Rules (Drag to Change Order)											
<input type="checkbox"/>	States	Protocol	Source	Port	Destination	Port	Gateway	Queue	Schedule	Description	Actions
<input type="checkbox"/>	✓	0 /480 B	IPv4 ICMP	*	*	8.8.8.8	*	none			    
<input type="checkbox"/>	✓	0 /217 KiB	IPv4 TCP	*	*	*	443 (HTTPS)	*	none		    
<input type="checkbox"/>	✓	0 /877 B	IPv4 TCP	*	*	*	80 (HTTP)	*	none		    
<input type="checkbox"/>	✗	0 /1 KiB	IPv4 TCP	*	*	*	*	none			    

Packet Header

Protocol

Source IP Addr

Destination IP Addr

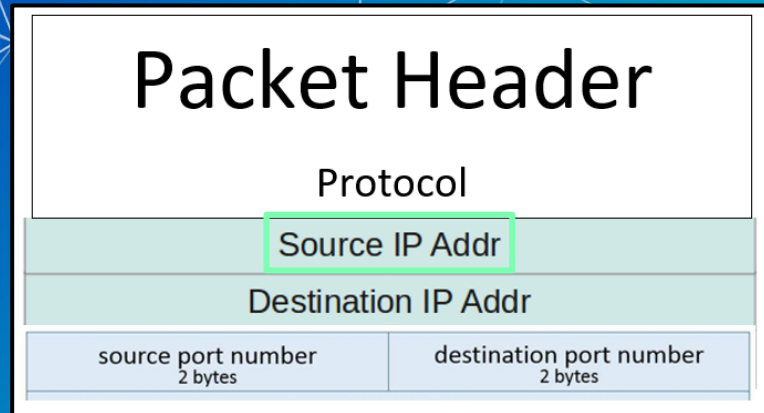
source port number
2 bytes

destination port number
2 bytes

Header to Firewall

Rules (Drag to Change Order)

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



Header to Firewall

Rules (Drag to Change Order)

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

Packet Header

Protocol

Source IP Addr

Destination IP Addr

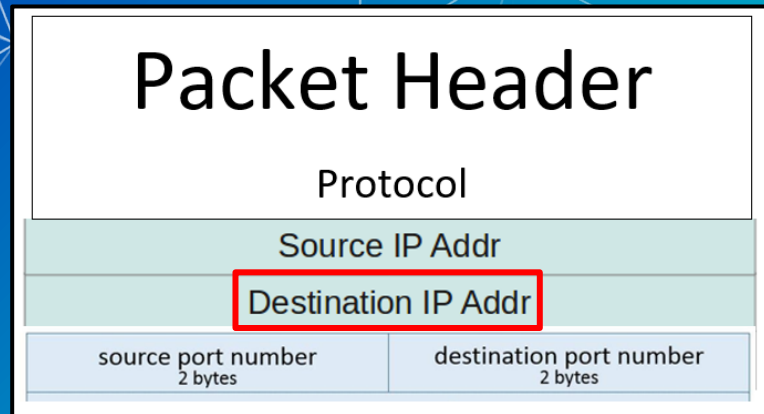
source port number
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<input type="checkbox"/>	✓ 0 /877 B	IPv4 TCP	*	*	*	80 (HTTP)	*	none			
<input type="checkbox"/>	✗ 0 /1 KiB	IPv4 TCP	*	*	*	*	*	none			



Header to Firewall

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<input type="checkbox"/>	✓ 0 /217 KiB	IPv4 TCP	*	*	*	443 (HTTPS)	*	none			
<input type="checkbox"/>	✓ 0 /877 B	IPv4 TCP	*	*	*	80 (HTTP)	*	none			
<input type="checkbox"/>	✗ 0 /1 KiB	IPv4 TCP	*	*	*	*	*	none			

Packet Header

Protocol

Source IP Addr

Destination IP Addr

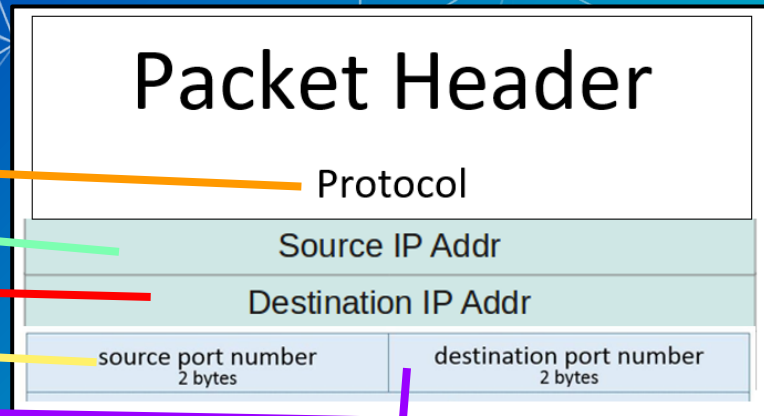
source port number
2 bytes

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2 bytes

Header to Firewall

Rules (Drag to Change Order)

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<input type="checkbox"/>	✓ 0 /217 KiB	IPv4 TCP	*	*	*	443 (HTTPS)	*	none			
<input type="checkbox"/>	✓ 0 /877 B	IPv4 TCP	*	*	*	80 (HTTP)	*	none			
<input type="checkbox"/>	✗ 0 /1 KiB	IPv4 TCP	*	*	*	*	*	none			



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■ Homework Prep

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The Logic of Firewalls

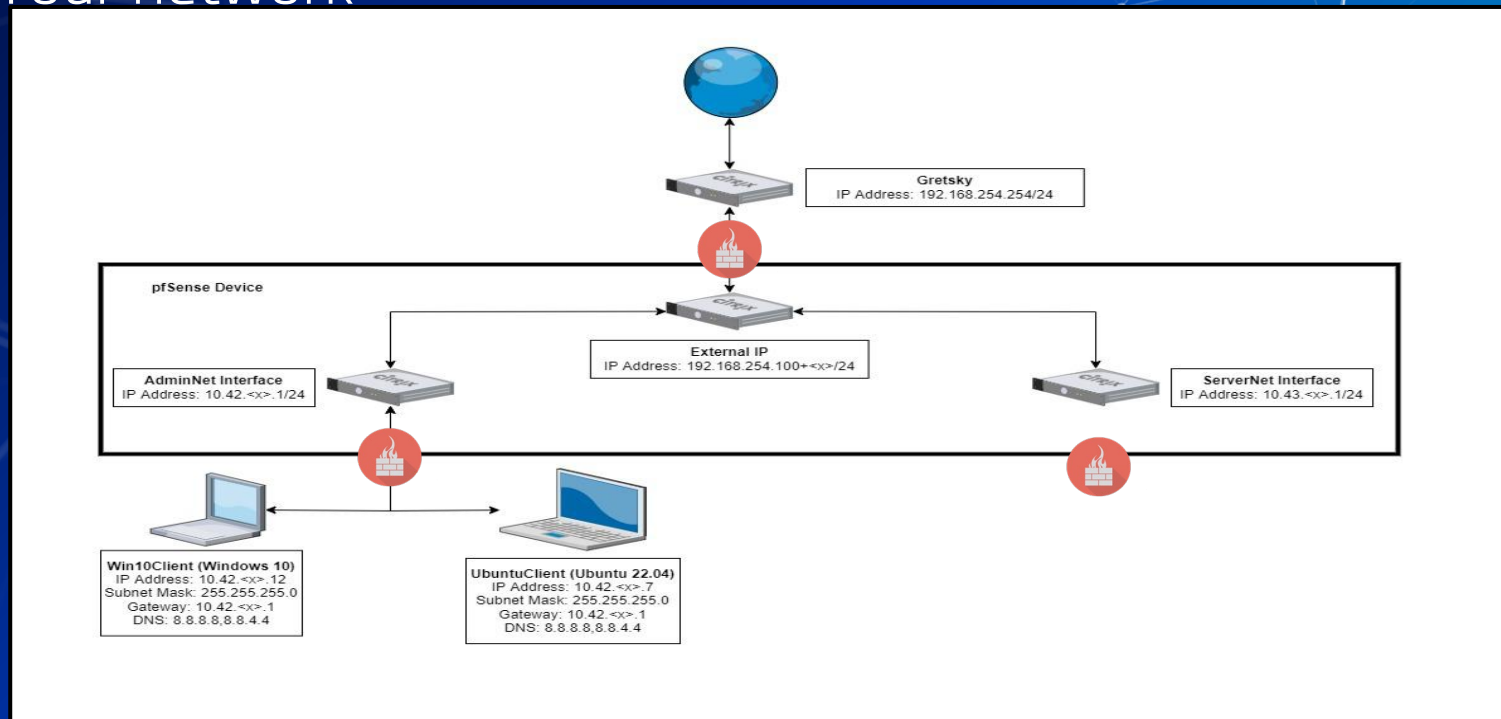
Rule Hierarchy

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

Rules (Drag to Change Order)											
<input type="checkbox"/>	States	Protocol	Source	Port	Destination	Port	Gateway	Queue	Schedule	Description	Actions
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<input type="checkbox"/>	✗ 0 / 1 KiB	IPv4 TCP	*	*	*	*	*	none			    

How Traffic Flows

Your network



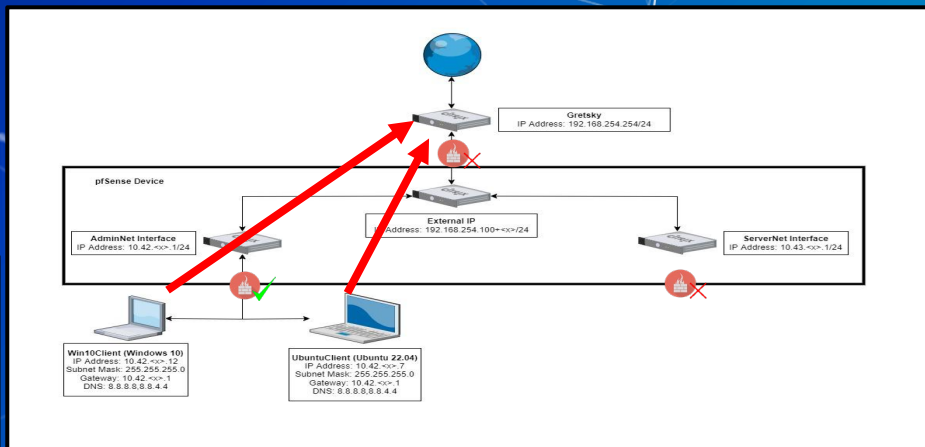
How Traffic Flows

From LAN (AdminNet) to Web

Floating WAN LAN OPT1

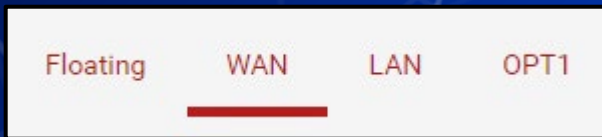
Rules (Drag to Change Order)

<input type="checkbox"/>	States	Protocol	Source	Port	Destination	Port	Gateway
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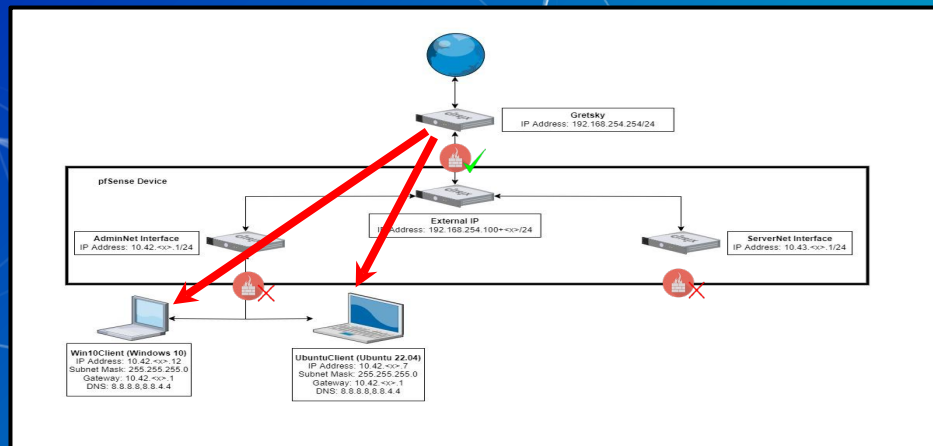
How Traffic Flows

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



Rules (Drag to Change Order)

States	Protocol	Source	Port	Destination	Port	Gateway	
<input type="checkbox"/> <input checked="" type="checkbox"/>	2/249 KiB	IPv4 TCP	192.168.13.71	*	10.42.29.11	3389	*



Default rule

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

Default 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)

- Self defined default firewall rule(s) need to be at the bottom of the firewall's rule list
- What are the advantages of the default rules seen below?

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?

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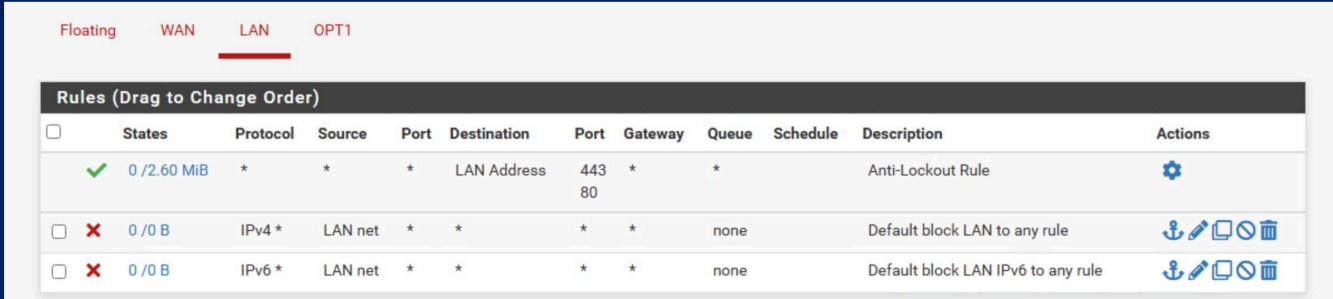
■ Summary/Wrap Up

In Class Activity

pfSense Hands-On

Activity – pfSense Firewall

- Login to pfSense and follow along.
- Create rules to allow Ping, HTTP, and HTTPS from LAN to anywhere.
- Edit default Allow rule to Deny all traffic out of LAN (Place this rule on the bottom as a catch-all).



The screenshot shows the pfSense Firewall Rules configuration page for the LAN interface. The 'LAN' tab is selected. The table below lists the rules, including an Anti-Lockout Rule and two default block rules for IPv4 and IPv6.

	States	Protocol	Source	Port	Destination	Port	Gateway	Queue	Schedule	Description	Actions
<input type="checkbox"/>	✓ 0 /2.60 MiB	*	*	*	LAN Address	443 80	*	*		Anti-Lockout Rule	
<input type="checkbox"/>	✗ 0 /0 B	IPv4 *	LAN net	*	*	*	*	none		Default block LAN to any rule	
<input type="checkbox"/>	✗ 0 /0 B	IPv6 *	LAN net	*	*	*	*	none		Default block LAN IPv6 to any rule	

Activity – Tricky Traffic

- What's being blocked by the Default Deny All?
- Hint[0]: `ping 8.8.8.8` and `ping google.com`
- Hint[1]: How can we see if a rule is being hit.
- Hint[2]: Is there a way to log traffic getting caught by a rule?

Homework Prep

System Prep

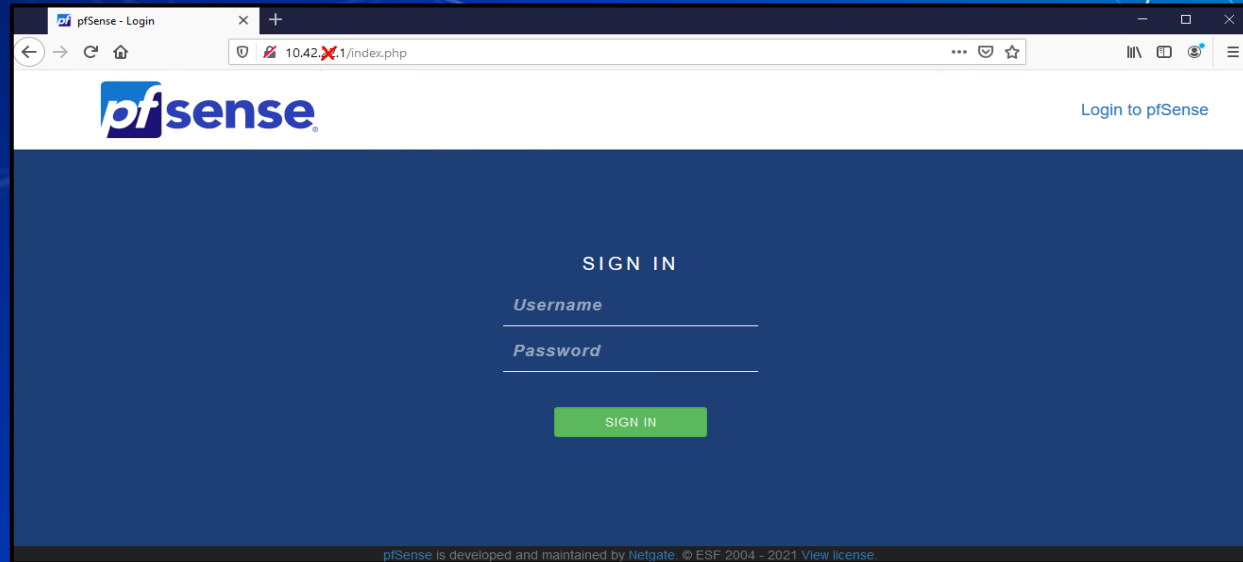
- Prep 1: Install SSH on your Linux client
 - Package name: openssh-server
 - `sudo apt install openssh-server`
 - <https://youtu.be/HJXo68LnNOs>
- Prep 2: Run script from GitHub on Windows Client (PrepareWindowsSystem.ps1)
 - <https://github.com/ubnetdef/WindowsScriptsForLecture>
 - <https://www.youtube.com/watch?v=Z6kNyfZiNyg>

Homework Starter

Homework Starter

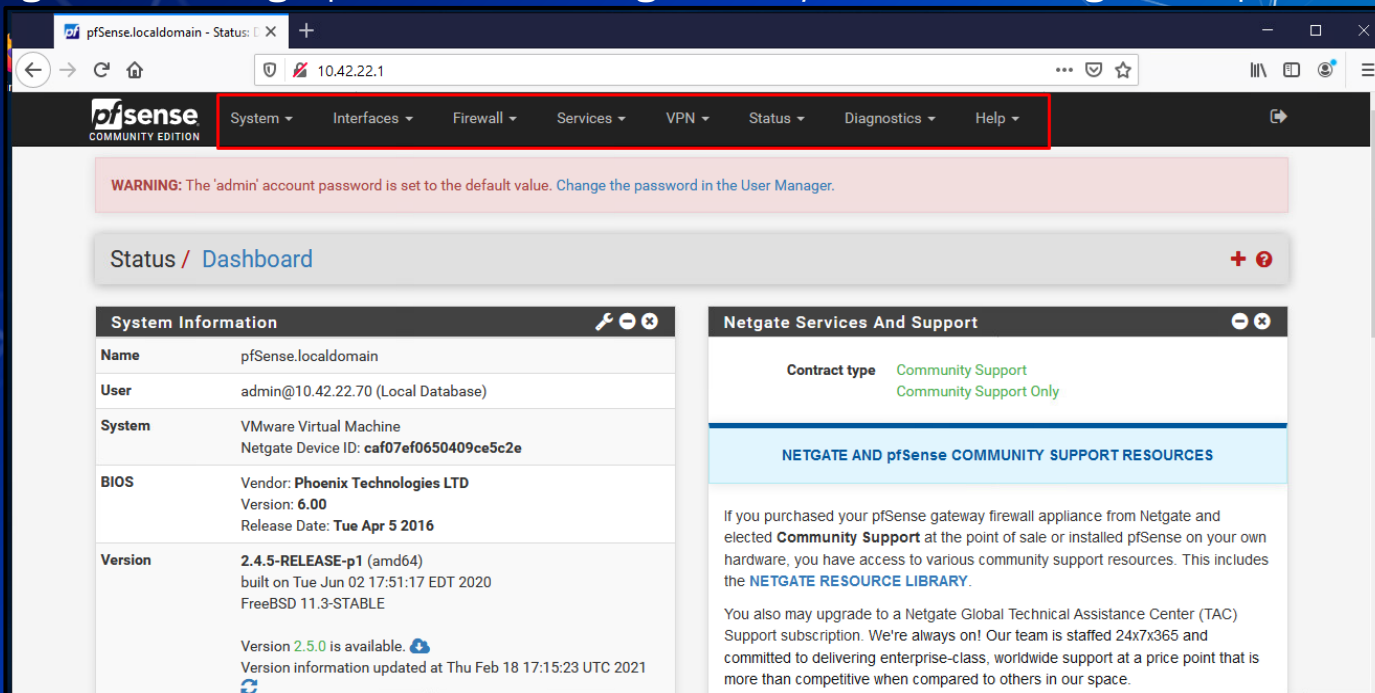
■ Credentials

- Username: admin
- Password: pfsense



Homework Starter

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



The screenshot shows the pfSense web interface. The top navigation bar is highlighted with a red box and contains the following items: System, Interfaces, Firewall, Services, VPN, Status, Diagnostics, and Help. Below the navigation bar, a warning message states: "WARNING: The 'admin' account password is set to the default value. Change the password in the User Manager." The main content area is titled "Status / Dashboard" and is divided into two columns. The left column is titled "System Information" and contains the following data:

System Information	
Name	pfSense.localdomain
User	admin@10.42.22.70 (Local Database)
System	VMware Virtual Machine Netgate Device ID: caf07ef0650409ce5c2e
BIOS	Vendor: Phoenix Technologies LTD Version: 6.00 Release Date: Tue Apr 5 2016
Version	2.4.5-RELEASE-p1 (amd64) built on Tue Jun 02 17:51:17 EDT 2020 FreeBSD 11.3-STABLE Version 2.5.0 is available. Version information updated at Thu Feb 18 17:15:23 UTC 2021

The right column is titled "Netgate Services And Support" and contains the following information:

Contract type: Community Support
Community Support Only

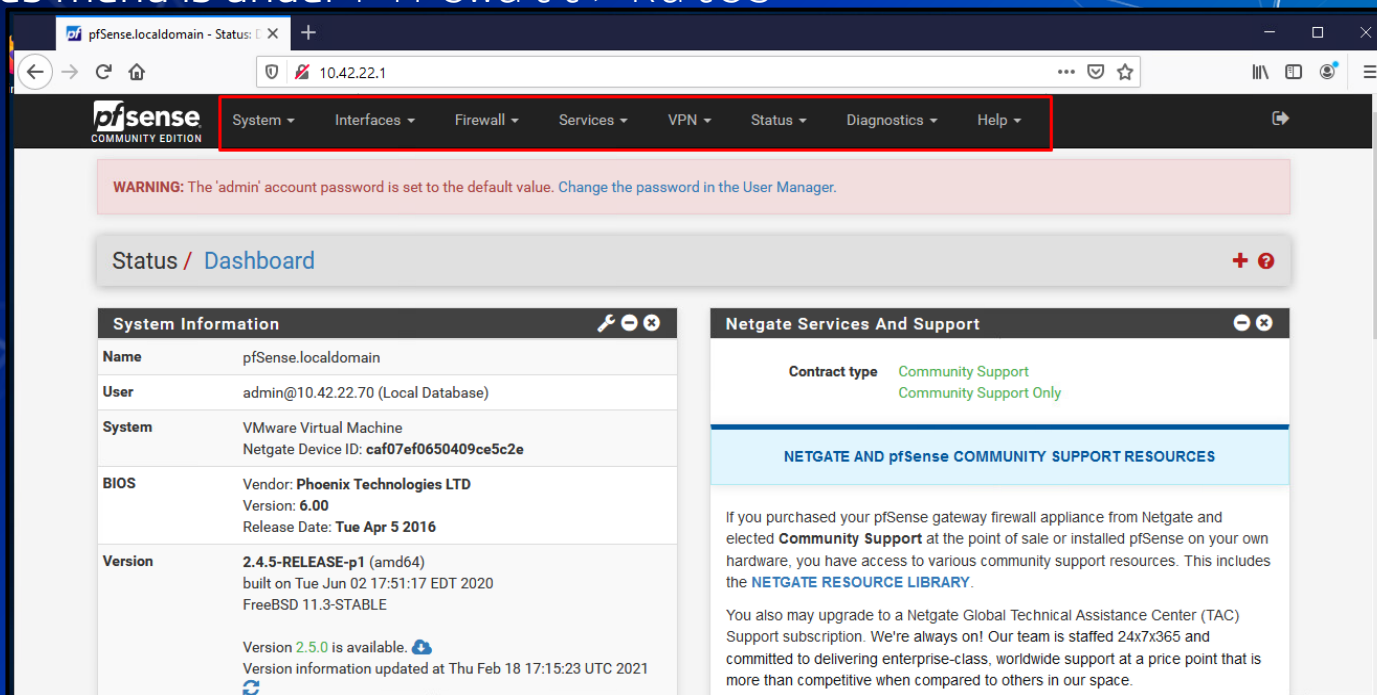
NETGATE AND pfSense COMMUNITY SUPPORT RESOURCES

If you purchased your pfSense gateway firewall appliance from Netgate and elected **Community Support** at the point of sale or installed pfSense on your own hardware, you have access to various community support resources. This includes the [NETGATE RESOURCE LIBRARY](#).



You also may upgrade to a Netgate Global Technical Assistance Center (TAC) Support subscription. We're always on! Our team is staffed 24x7x365 and committed to delivering enterprise-class, worldwide support at a price point that is more than competitive when compared to others in our space.

Homework Starter

Rules menu is under Firewall > Rules



The screenshot shows the pfSense web interface. The navigation menu at the top is highlighted with a red box, showing the following items: System, Interfaces, Firewall, Services, VPN, Status, Diagnostics, and Help. Below the navigation menu, there is a warning message: "WARNING: The 'admin' account password is set to the default value. Change the password in the User Manager." The main content area is titled "Status / Dashboard" and contains two panels: "System Information" and "Netgate Services And Support".

System Information	
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Netgate Services And Support	
Contract type	Community Support Community Support Only

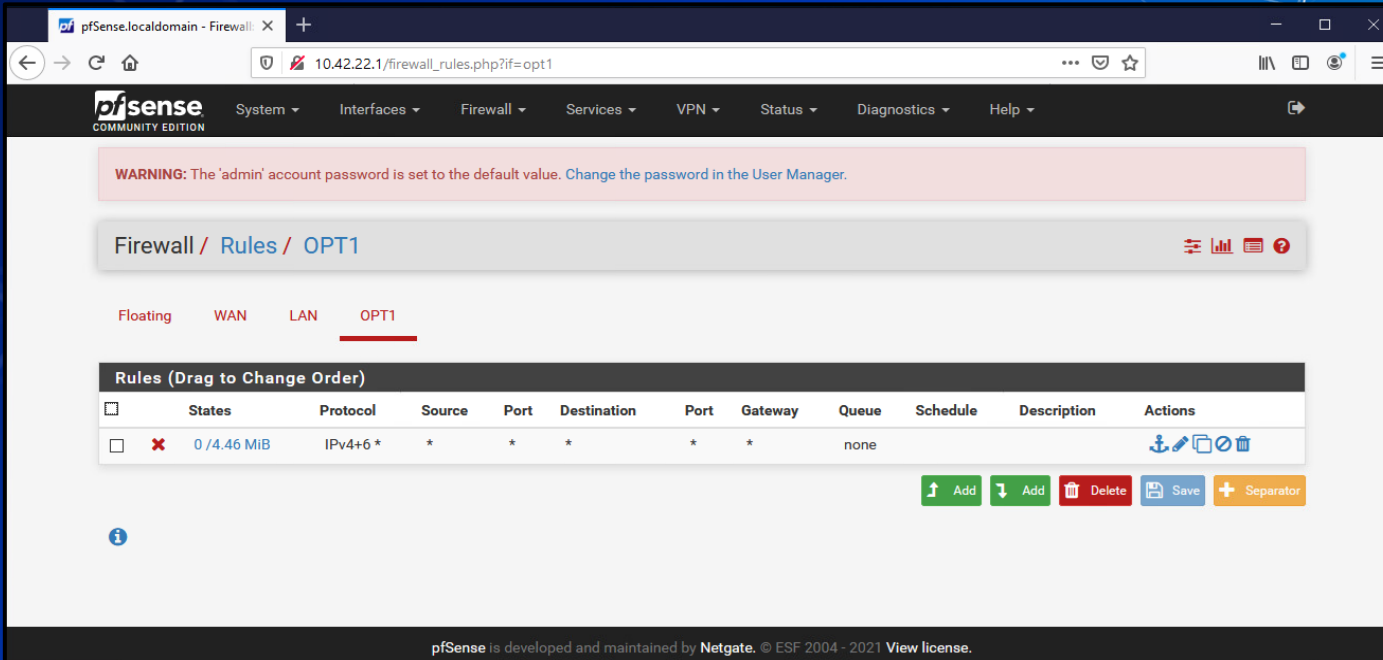
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Homework Starter

- Rules are grouped by the interface that handles the packets







The screenshot shows the pfSense Firewall Rules configuration page for the OPT1 interface. The page includes a navigation menu, a warning message, and a table of rules. The table has columns for States, Protocol, Source, Port, Destination, Port, Gateway, Queue, Schedule, Description, and Actions. A single rule is listed with a red 'X' icon, indicating it is disabled. The rule is for IPv4+6 traffic with a source of 0/4.46 MiB and a destination of *. The Actions column contains icons for anchor, edit, delete, and save.






WARNING: The 'admin' account password is set to the default value. Change the password in the User Manager.

Firewall / Rules / OPT1

Floating WAN LAN OPT1

Rules (Drag to Change Order)

	States	Protocol	Source	Port	Destination	Port	Gateway	Queue	Schedule	Description	Actions
<input type="checkbox"/>	✘ 0/4.46 MiB	IPv4+6 *	*	*	*	*	*	none			   

 Add  Add  Delete  Save  Separator

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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 any 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 Questions

Class dismissed

See you next week!