Firewalls

UBNetDef, Fall 2021
Week 3

Lead Presenter:
Alec Duffy

Agenda – Week 3

- 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

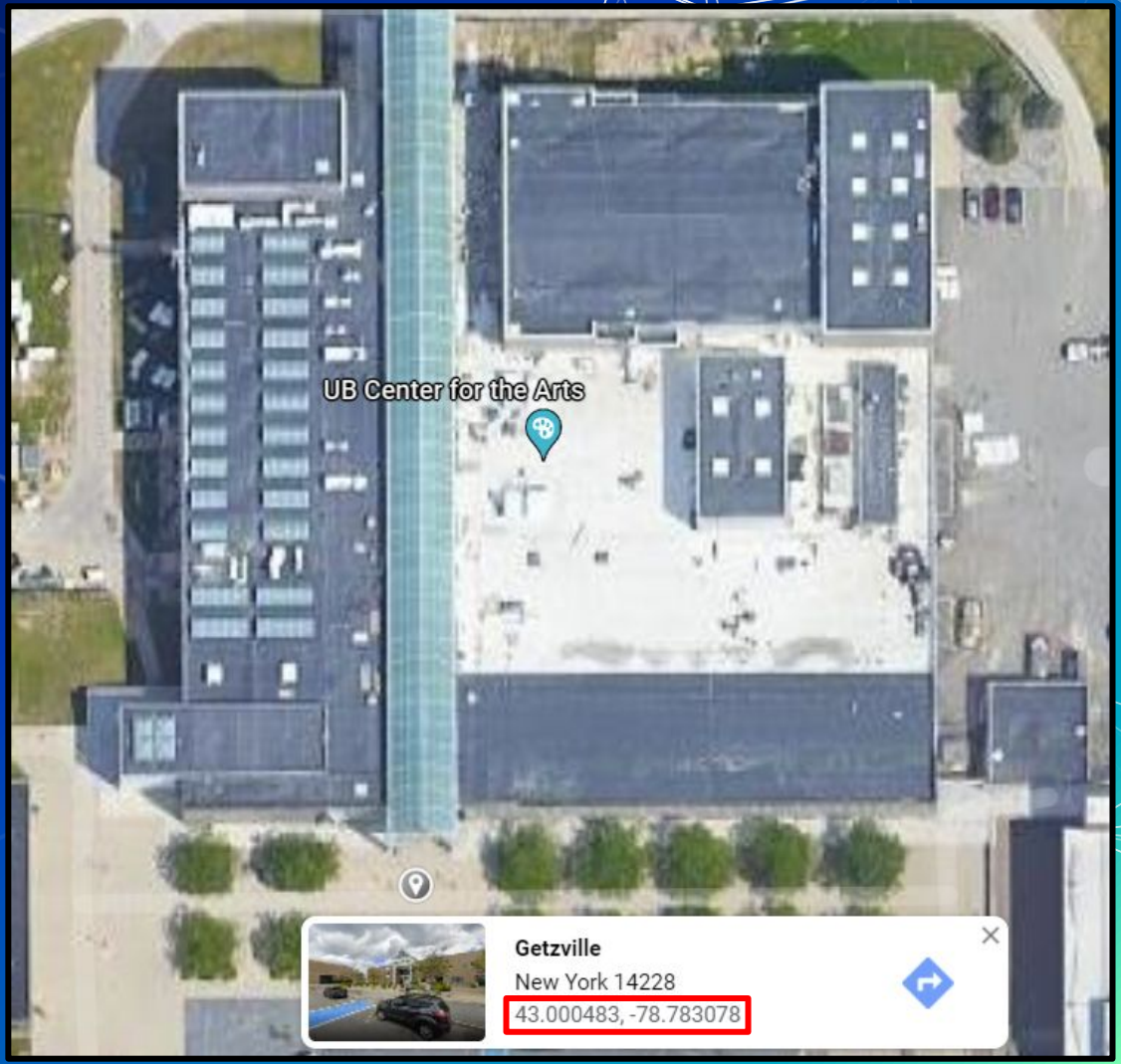
Networking
Part 2

Networking Part 2

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

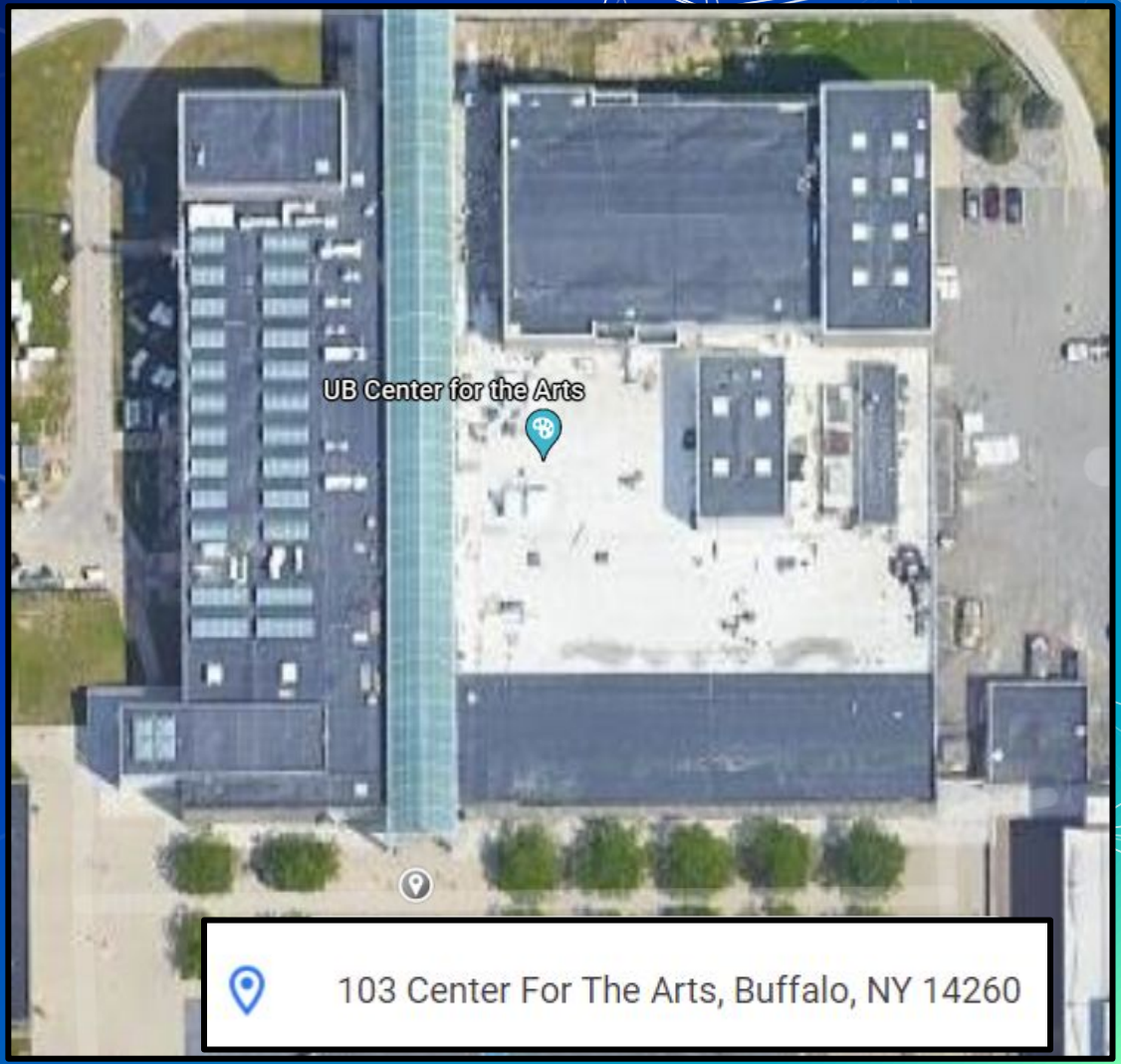
Intro to Ports

- Recall MAC Addresses
- Consider these similar to physical coordinates



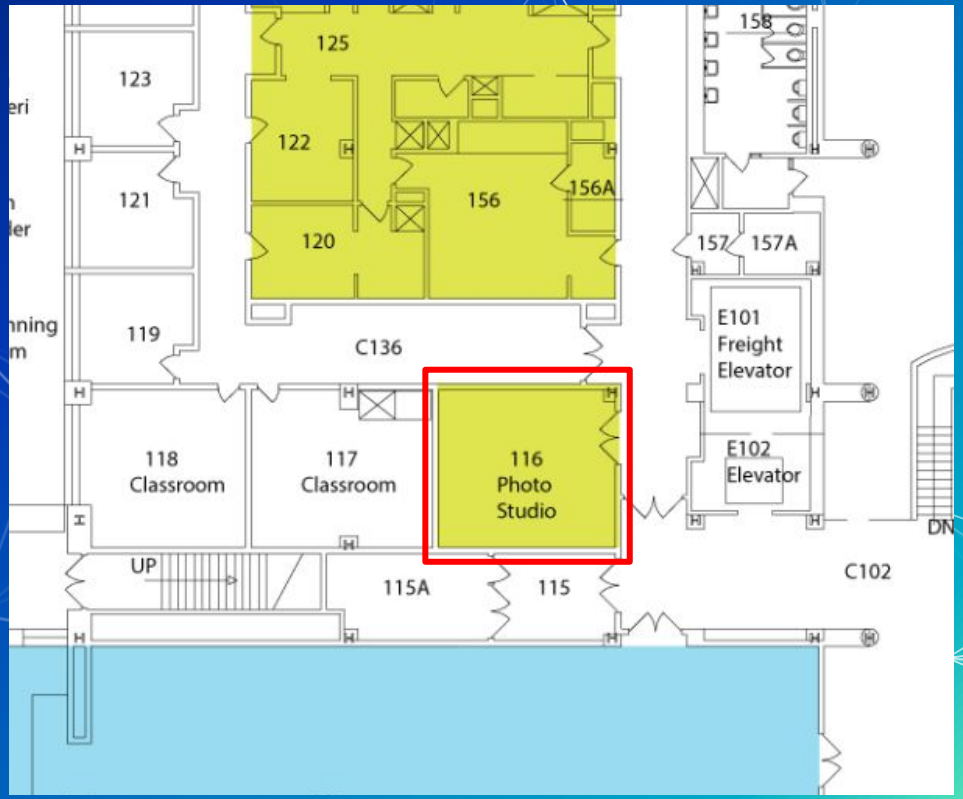
Intro to Ports

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



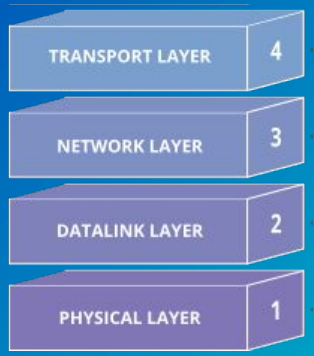
Intro to Ports

- 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
  - ICMP

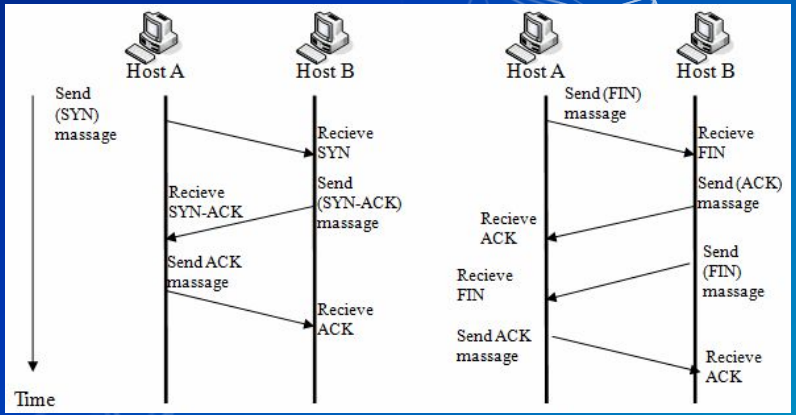


In Class Activity

TCP/UDP Packet Polo

TCP Handshake

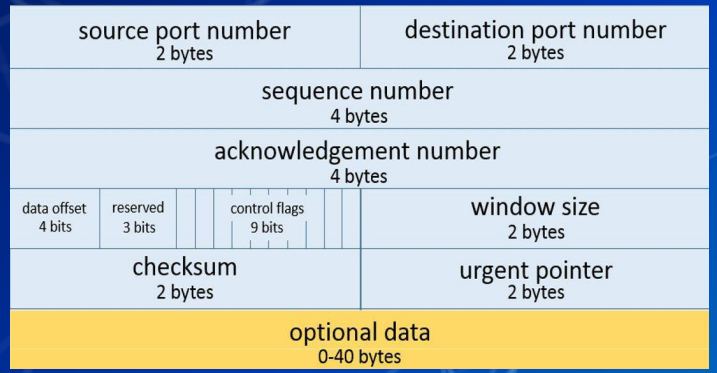
```
pfTop: Up State 1-100/114033, View: default, Order: bytes
PR        DIR SRC                        DEST                        STATE                  AGE       EXP     PKTS    BYTES
icmp      Out 192.168.253.18:17838       192.168.253.17:17838         0:0                 75:14:36  00:00:10  1060806 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
```



Activity Takeaways

- TCP has sessions
- UDP does not have sessions

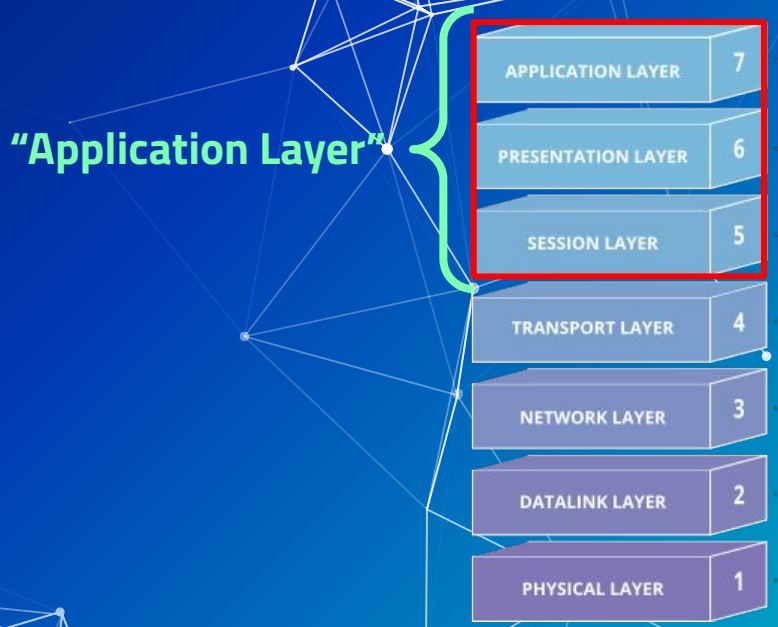
TCP Header



UDP Header

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

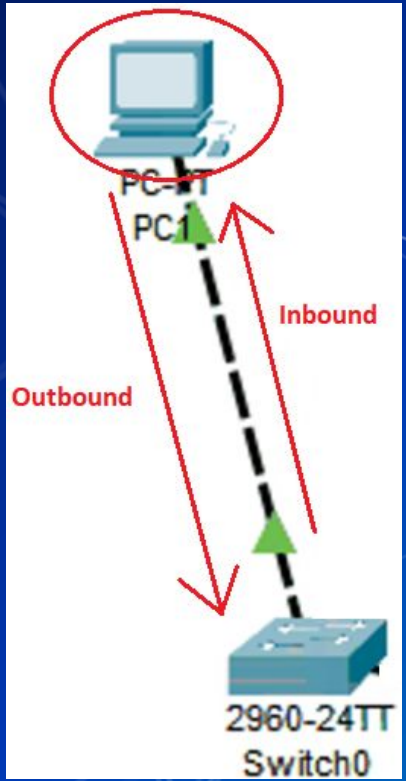
- How does your computer get to www.Google.com?
- A DNS server is used to translate a website name to and IP address

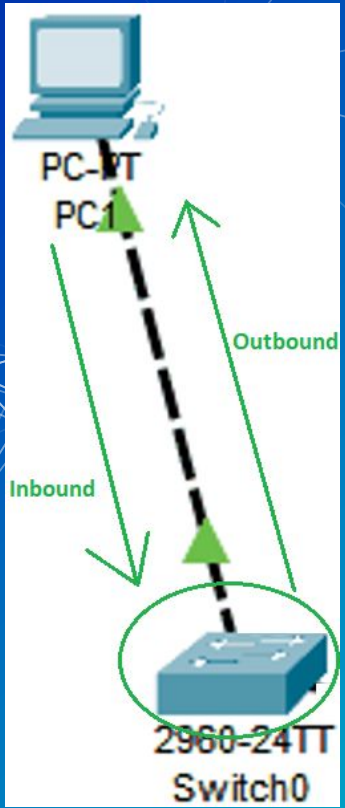
```
Name:     google.com
Addresses:  2607:f8b0:4006:81c::200e
          142.250.176.206
```

DNS Demo

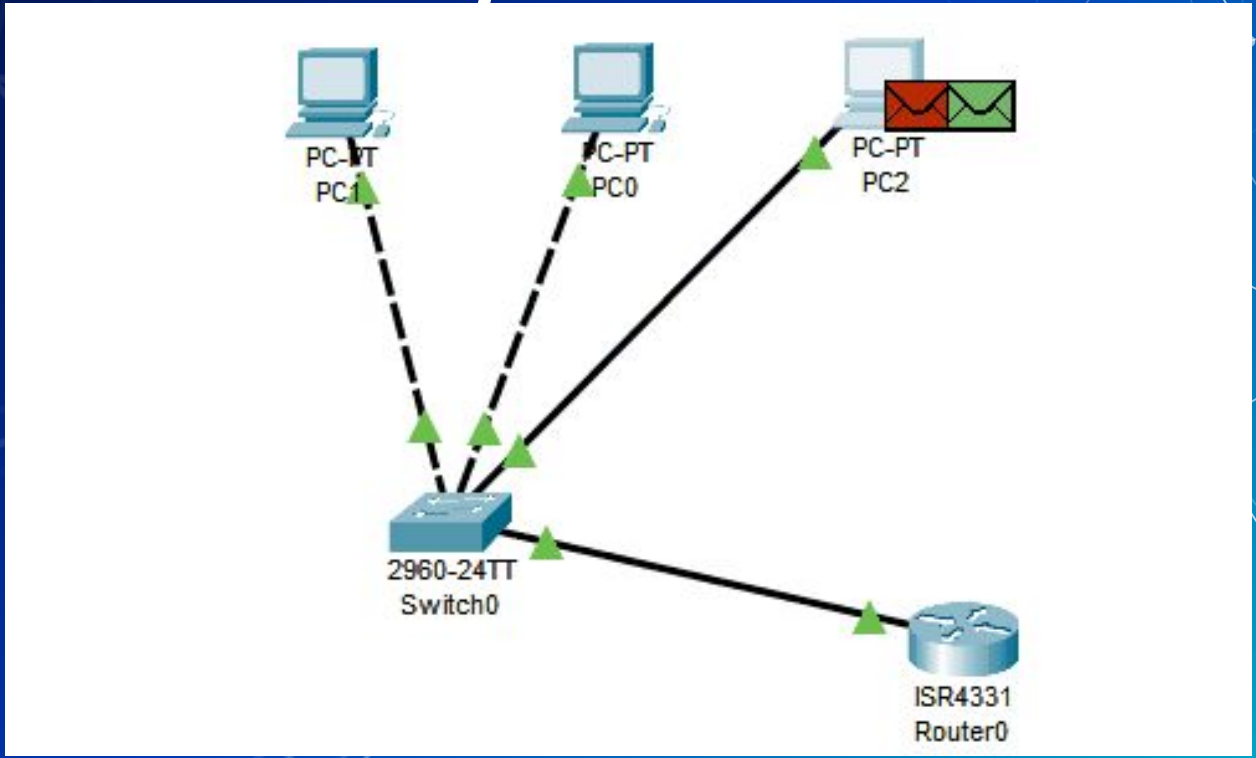
- Open a CLI
- `nslookup washington.edu`
- Copy IP Address into web browser
- You may need to use `http://` as a URL prefix

Directional Flow





Data flows freely... for now



Questions?

Break slide

Please return in 10 minutes

In Class Activity

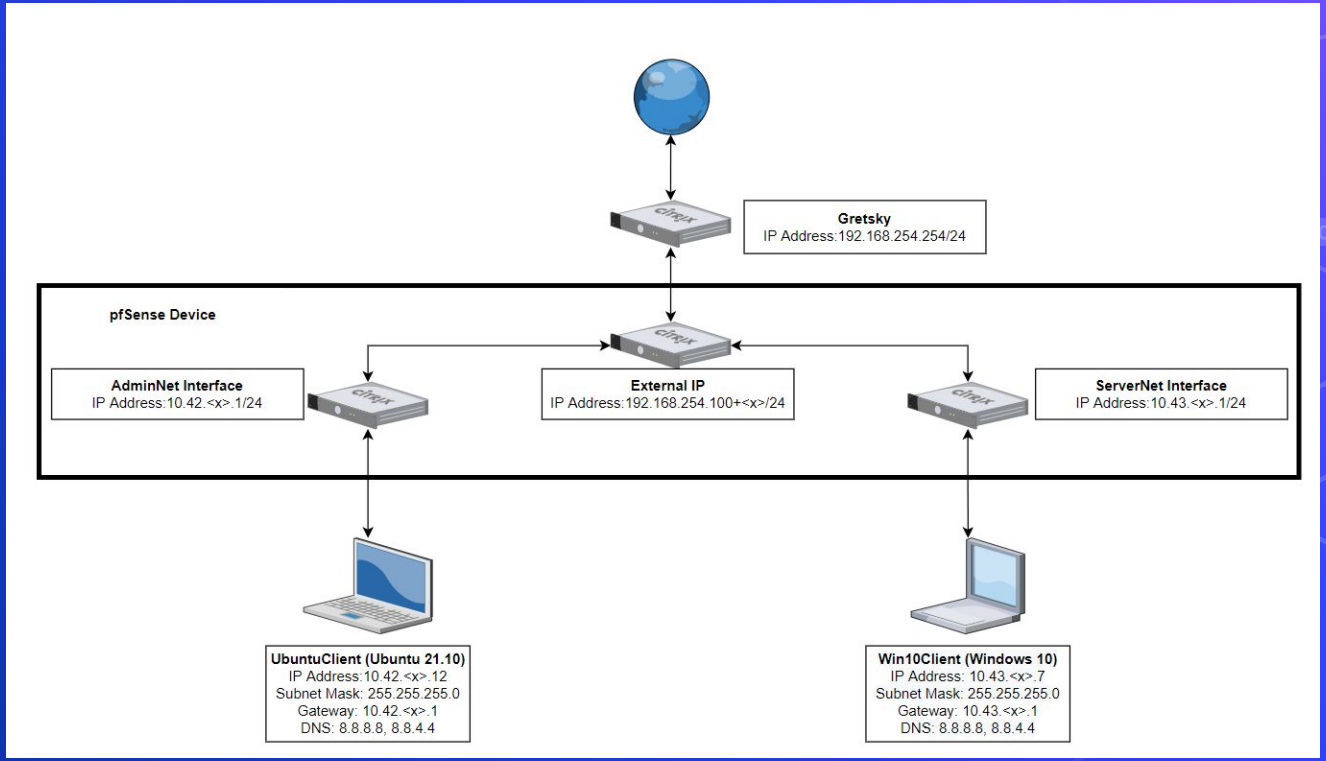
Hands-on Migration

Activity – Migrate Windows to AdminNet

- Migrate your Windows client from ServerNet to AdminNet.

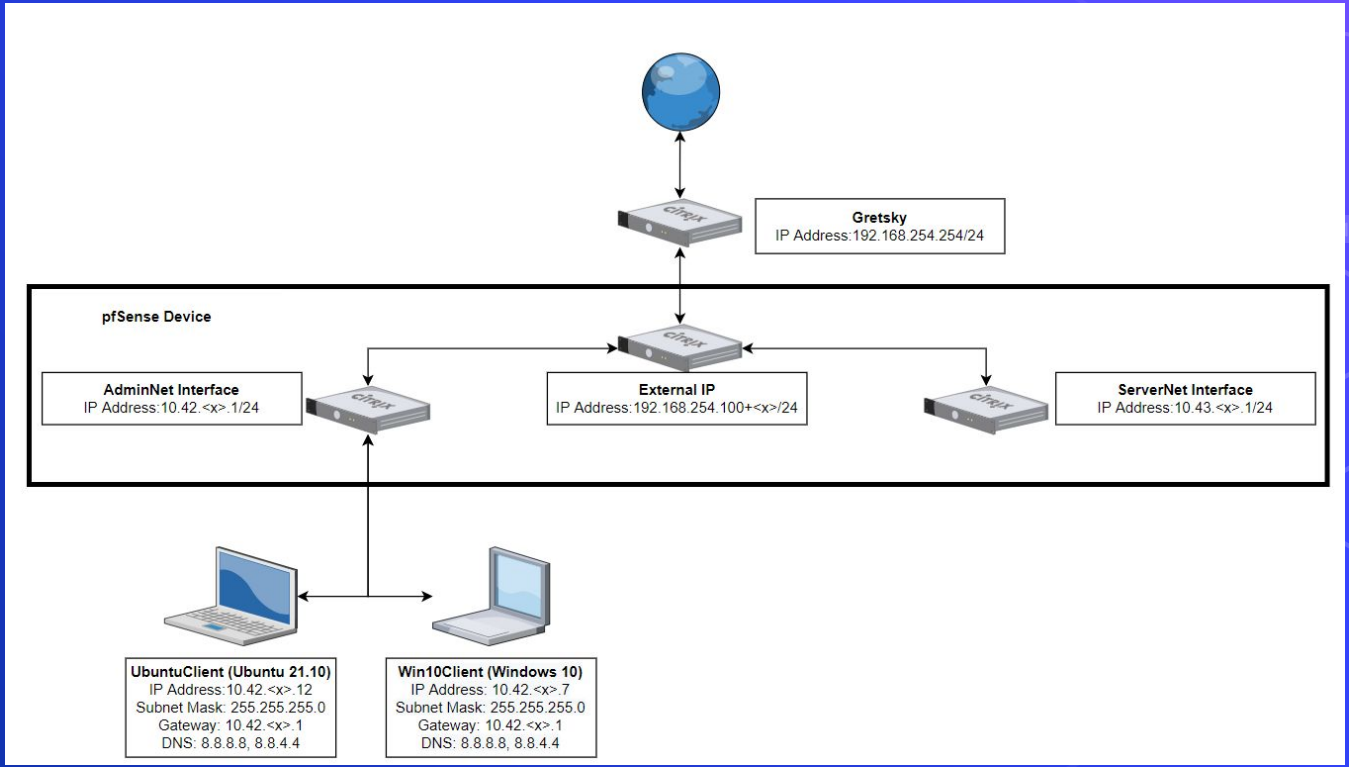
Activity – Migrate Windows to AdminNet

Before

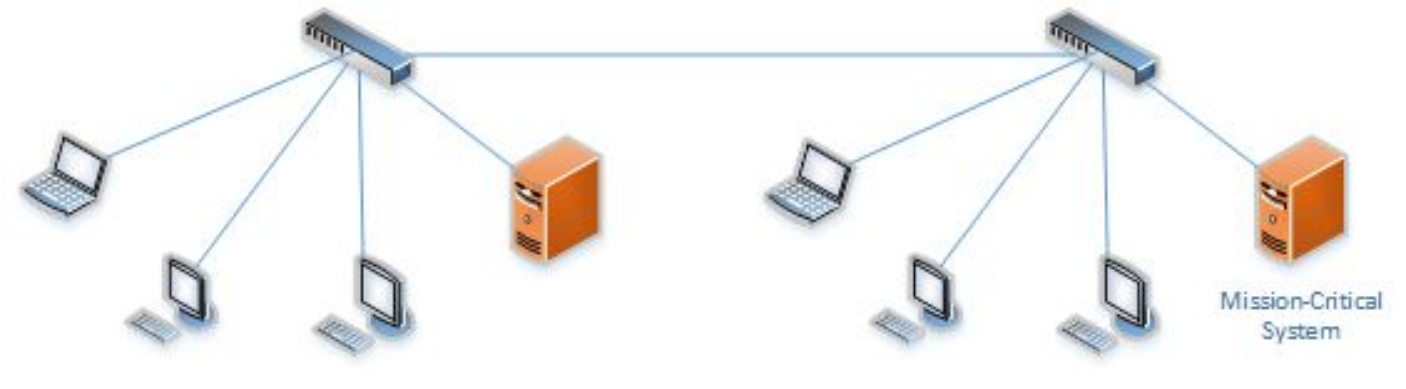


Activity – Migrate Windows to AdminNet

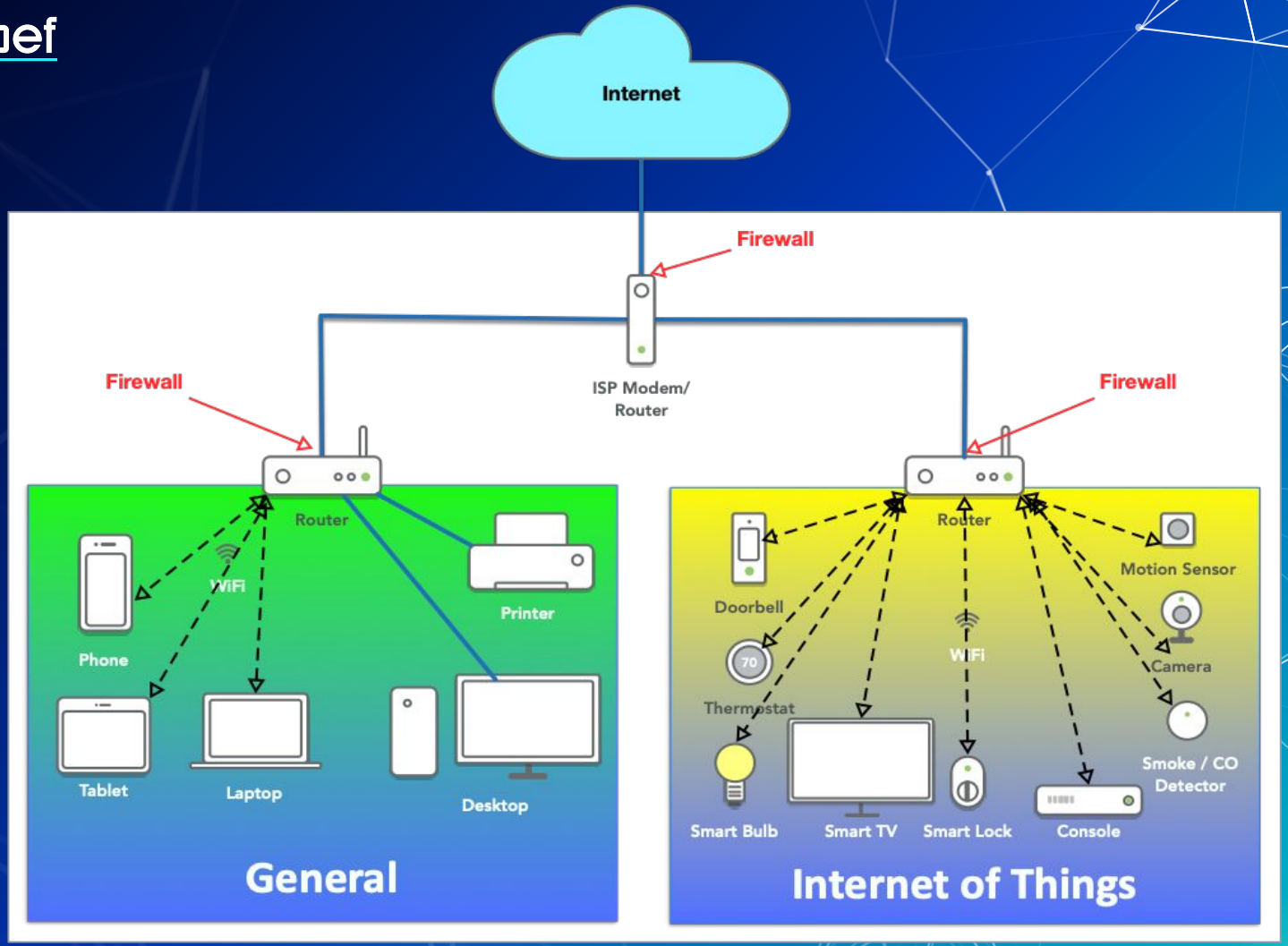
After

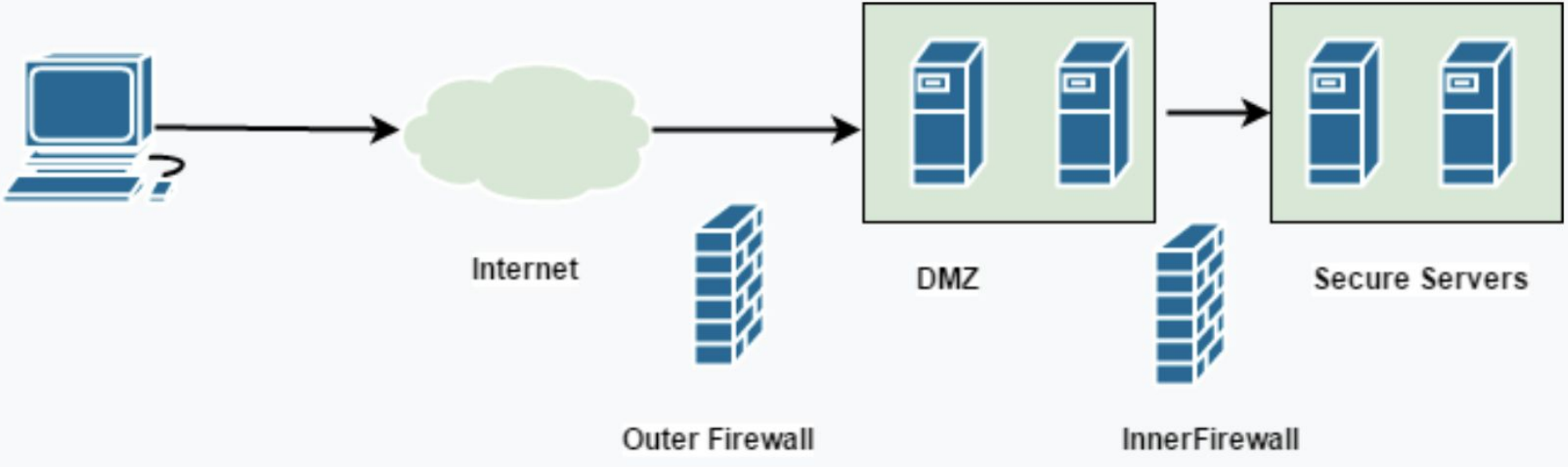


Why Firewalls?



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

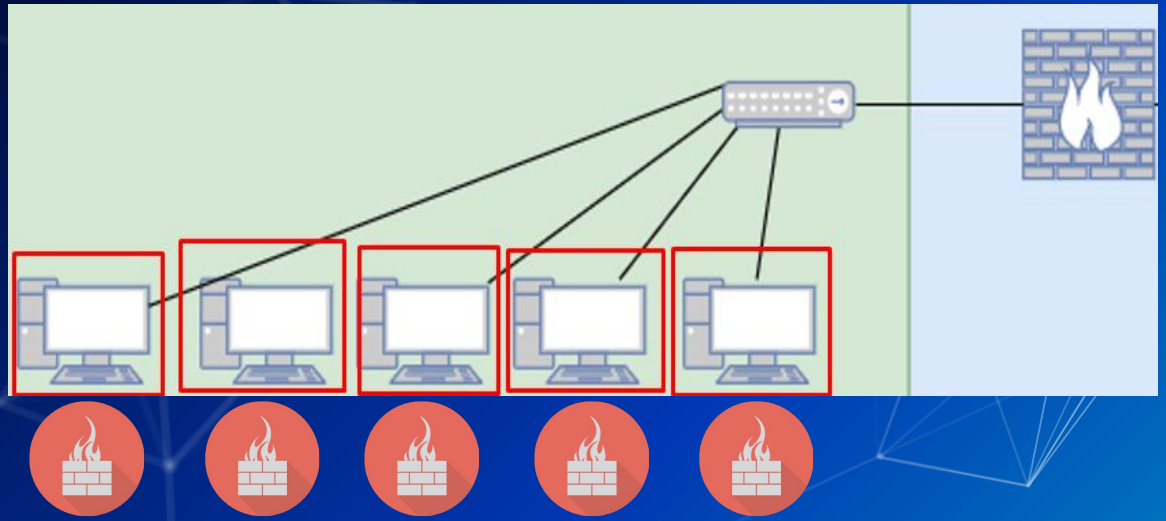

Internet
DMZ
Secure Servers
Outer Firewall
InnerFirewall

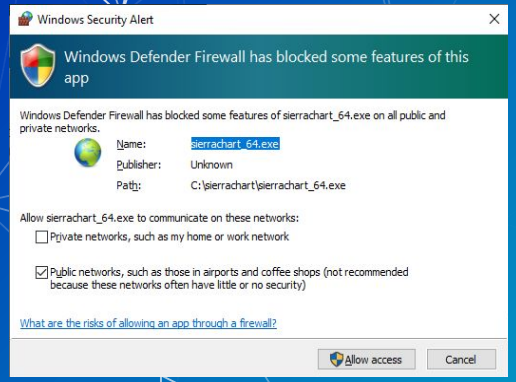
DMZ

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)

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: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 */
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 */
```
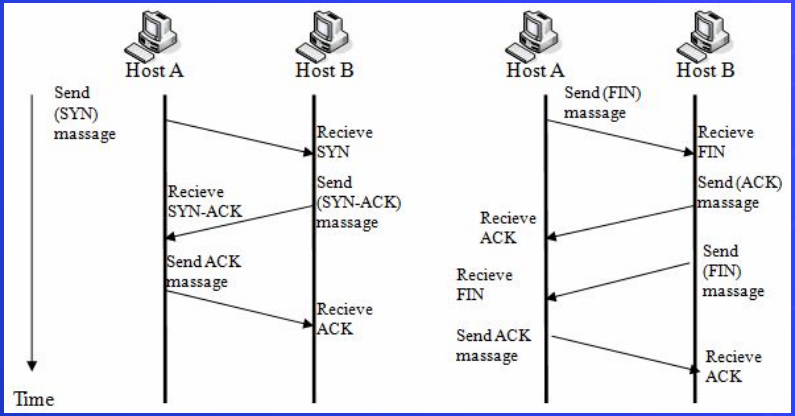

In Class Activity

TCP/UDP Packet Polo with Firewall

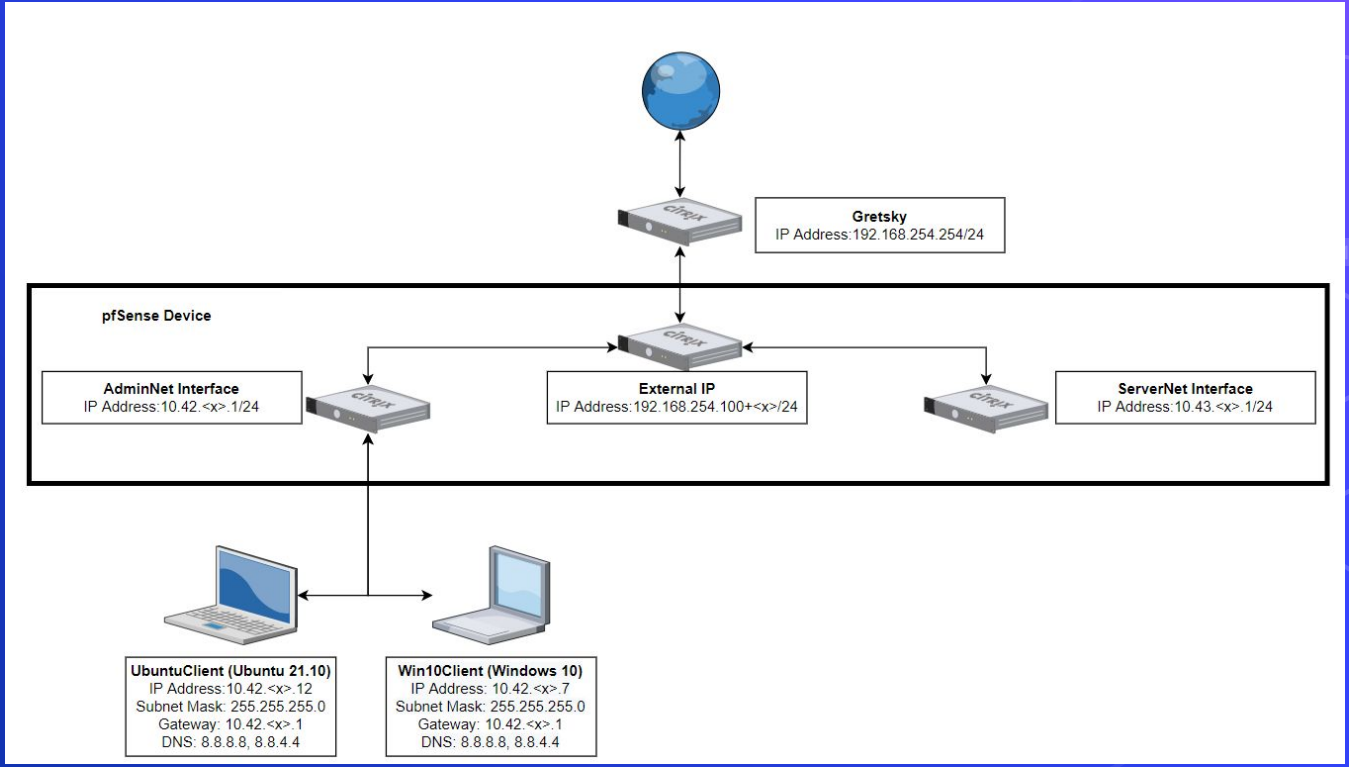
TCP/UDP Packet Polo with Firewall



In Class Activity

Login to pfSense

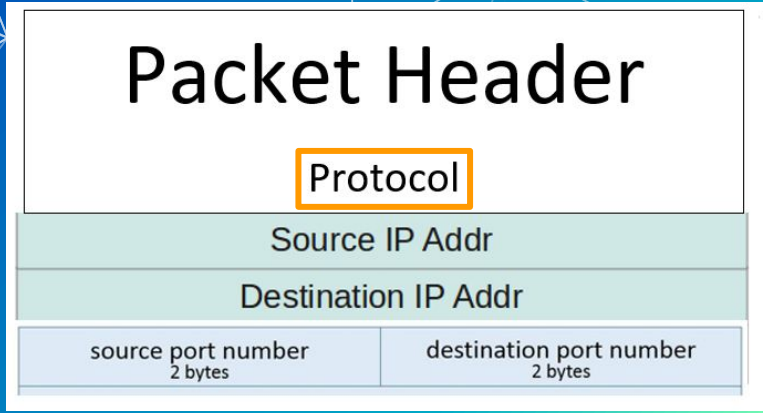
Current Network State



Header to Firewall

Rules (Drag to Change Order)

		States	Protocol	Source	Port	Destination	Port	Gateway	Queue	Schedule	Description	Actions
	✔	1 /2.30 MiB	*	*	*	LAN Address	80	*	*		Anti-Lockout Rule	⚙
☐	✖	0 /0 B	IPv4 TCP	LAN net	*	*	443 (HTTPS)	*	none		HHTPS Traffic Block	⚓ ✎ ⧉ ⊘ 🗑
☐	✔	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	⚓ ✎ ⧉ ⊘ 🗑



Header to Firewall

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	States	Protocol	Source	Port	Destination	Port	Gateway	Queue	Schedule	Description	Actions
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☐ ✖	0 /0 B	IPv4 TCP	LAN net	*	*	443 (HTTPS)	*	none		HHTPS Traffic Block	⚓ ✎ ⧉ ⊘ 🗑
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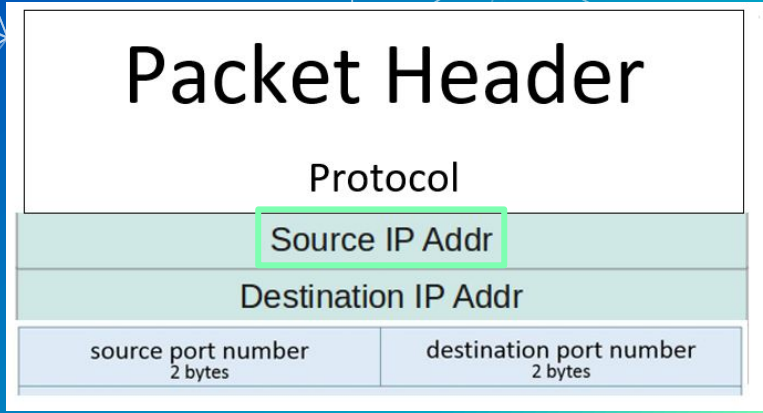

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☐	✖	0 /0 B	IPv4 TCP	LAN net	*	*	443 (HTTPS)	*	none		HHTPS Traffic Block	⚓ ✎ ⧉ ⊘ 🗑
☐	✔	5 /7.08 MiB	IPv4 *	LAN net	*	*	*	*	none		Default allow LAN to any rule	⚓ ✎ ⧉ ⊘ 🗑
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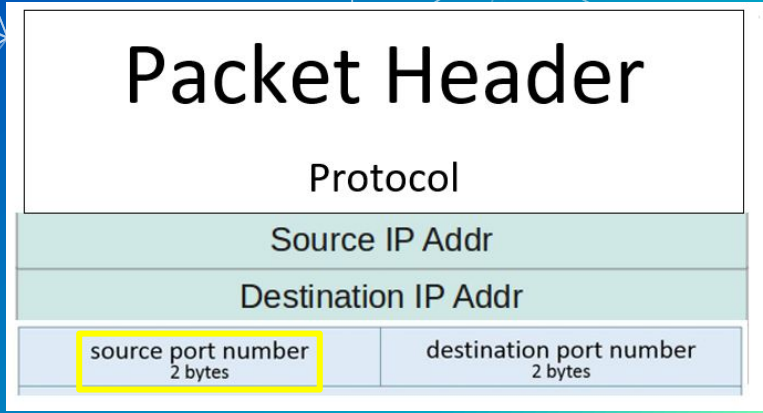

Header to Firewall

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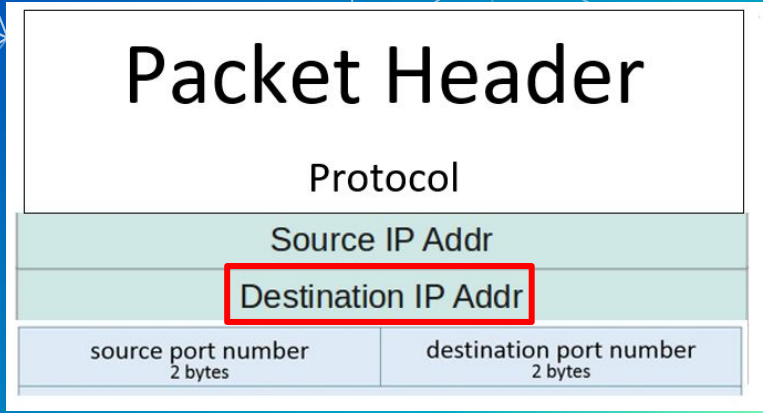
	States	Protocol	Source	Port	Destination	Port	Gateway	Queue	Schedule	Description	Actions
✔	1 /2.30 MiB	*	*	*	LAN Address	80	*	*		Anti-Lockout Rule	⚙
☐ ✖	0 /0 B	IPv4 TCP	LAN net	*	*	443 (HTTPS)	*	none		HHTPS Traffic Block	⚓ ✎ ⧉ ⊘ 🗑
☐ ✔	5 /7.08 MiB	IPv4 *	LAN net	*	*	*	*	none		Default allow LAN to any rule	⚓ ✎ ⧉ ⊘ 🗑
☐ ✔	0 /0 B	IPv6 *	LAN net	*	*	*	*	none		Default allow LAN IPv6 to any rule	⚓ ✎ ⧉ ⊘ 🗑



Header to Firewall

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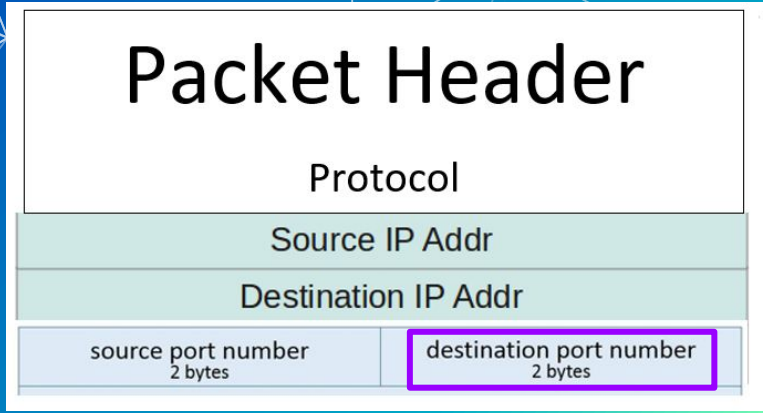

Header to Firewall

Rules (Drag to Change Order)

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	1 /2.30 MiB	*	*	*	LAN Address	80	*	*		Anti-Lockout Rule	
	0 /0 B	IPv4 TCP	LAN net	*	*	443 (HTTPS)	*	none		HHTPS Traffic Block	
	5 /7.08 MiB	IPv4 *	LAN net	*	*	*	*	none		Default allow LAN to any rule	
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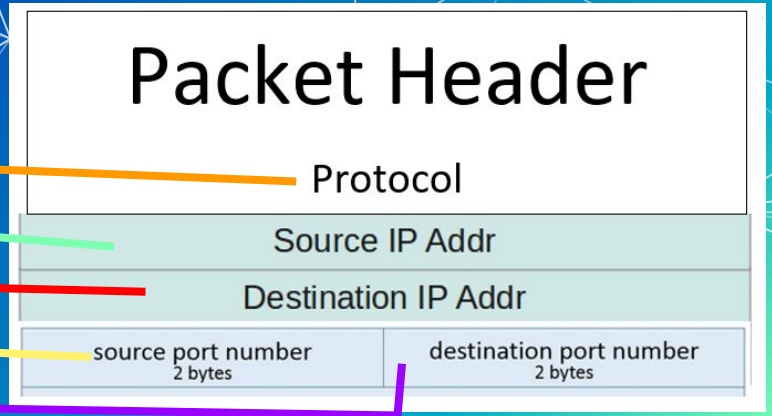


The Logic of Firewalls

Rule Hierarchy

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

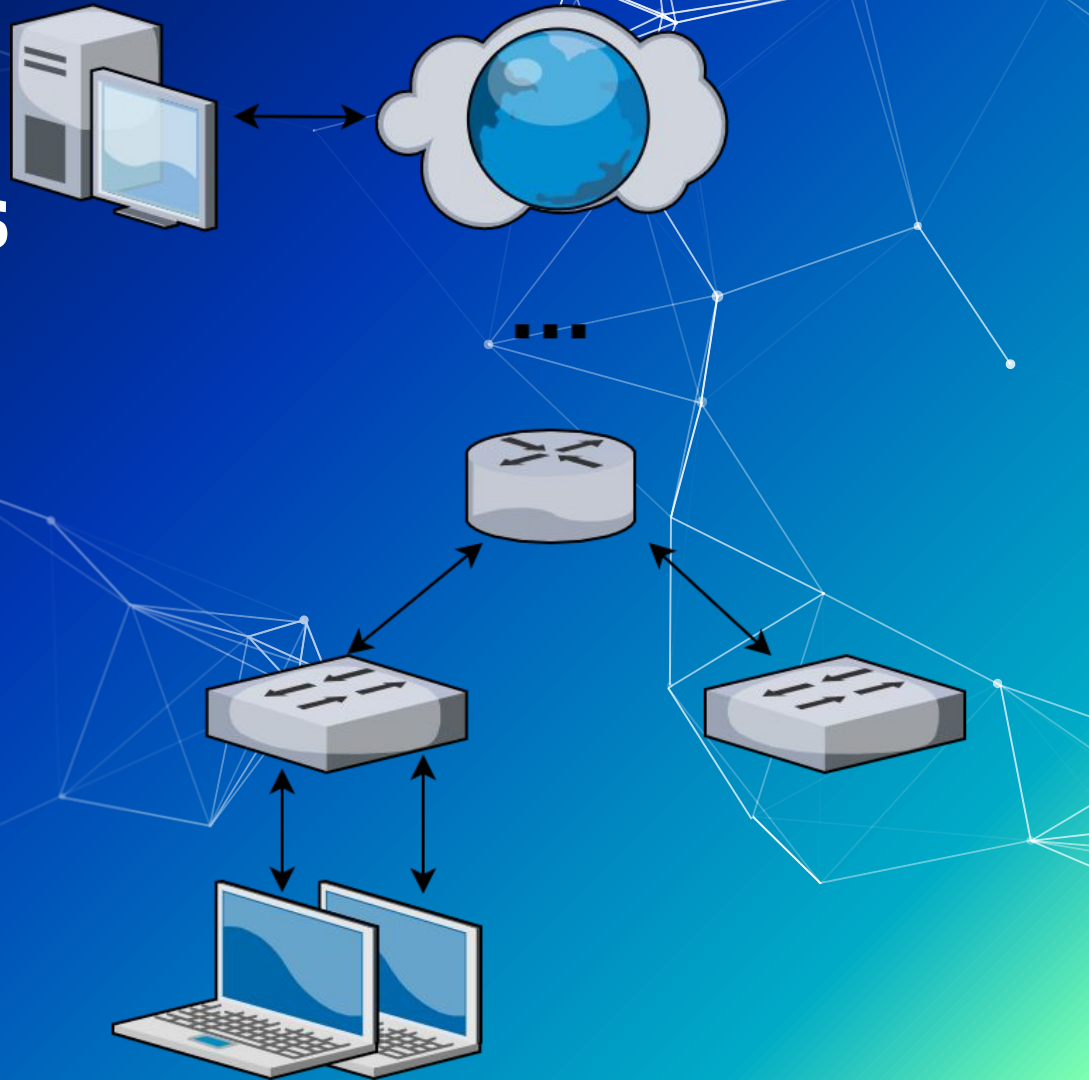
Floating WAN LAN

Rules (Drag to Change Order)

		States	Protocol	Source	Port	Destination	Port	Gateway	Queue	Schedule	Description	Actions
	✔	1 /2.30 MiB	*	*	*	LAN Address	80	*	*		Anti-Lockout Rule	
☐	✖	0 /0 B	IPv4 TCP	LAN net	*	*	443 (HTTPS)	*	none		HHTPS Traffic Block	
☐	✔	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	

How Traffic Flows

- Your Network

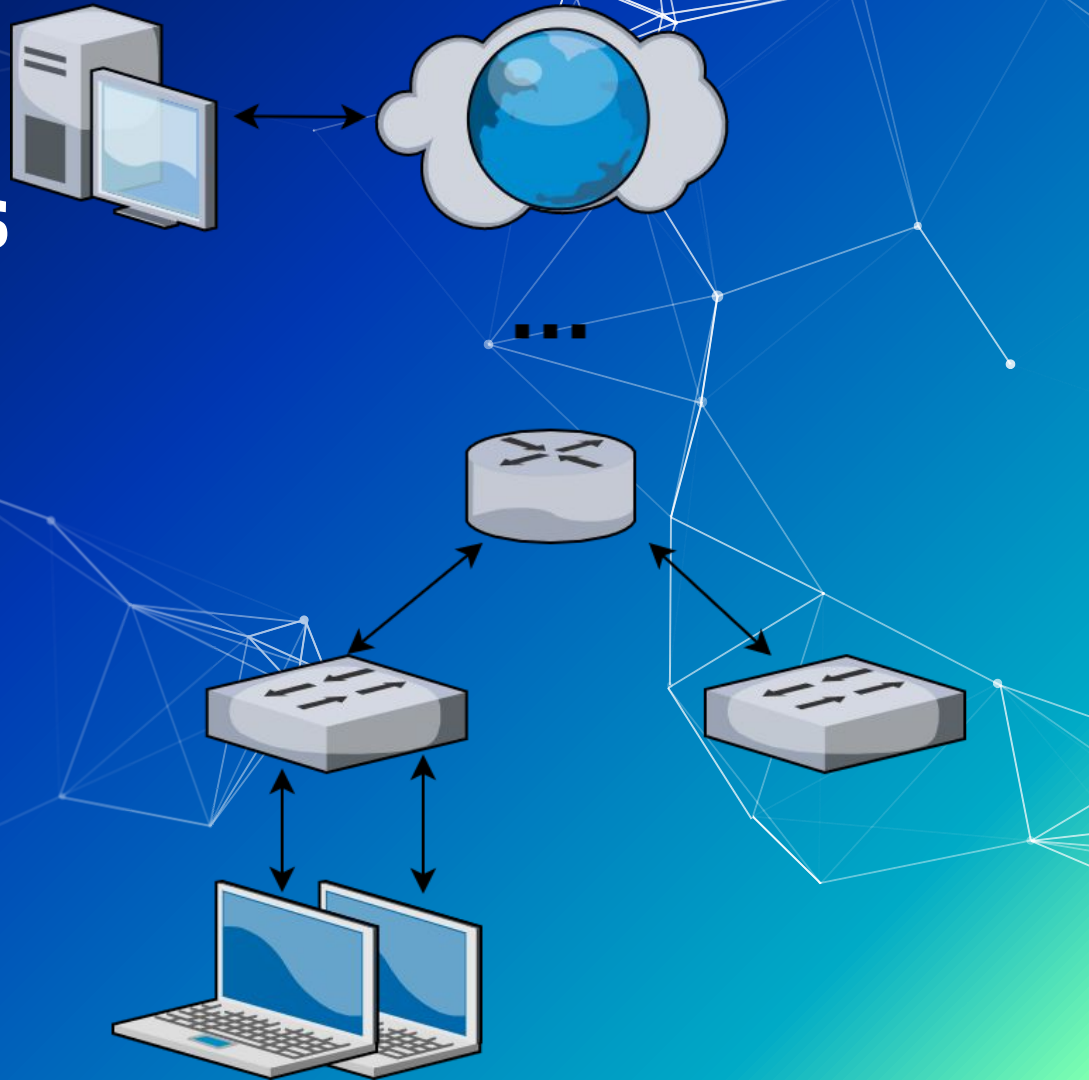


How Traffic Flows

- From LAN (AdminNet) to Web

How Traffic Flows

- Your Network



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?

Compromised Device & pfSense Hands-On

Activity – pfSense Firewall

- Prevent all ping requests from inside your LAN to anywhere on the WAN (Anywhere on internet)
  - Test by attempting to ping 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

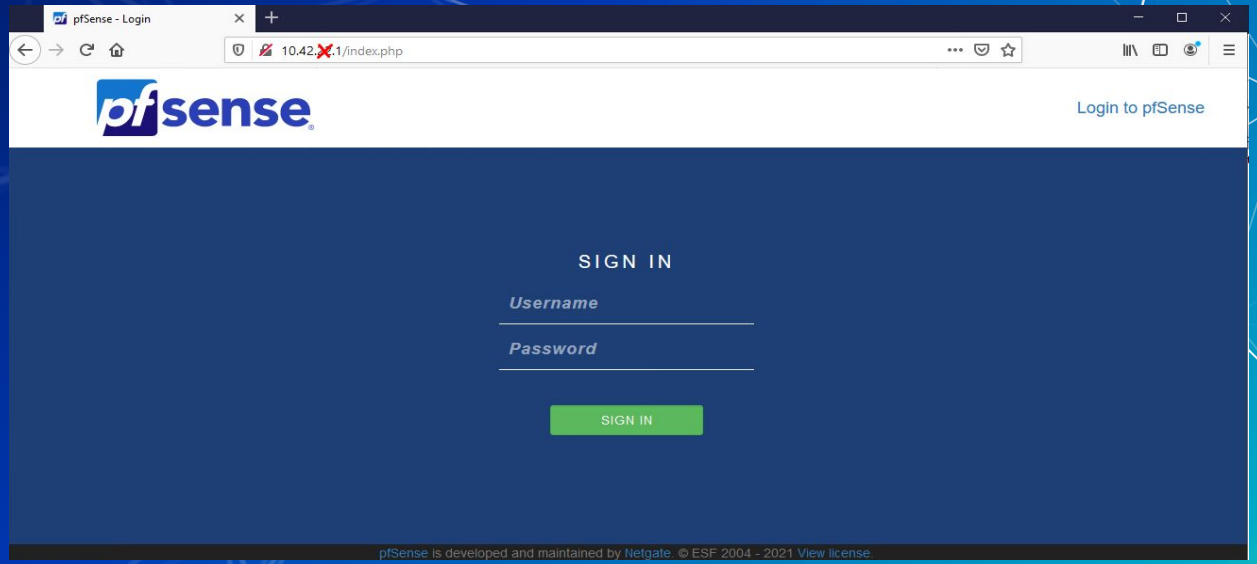
System Prep

- 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

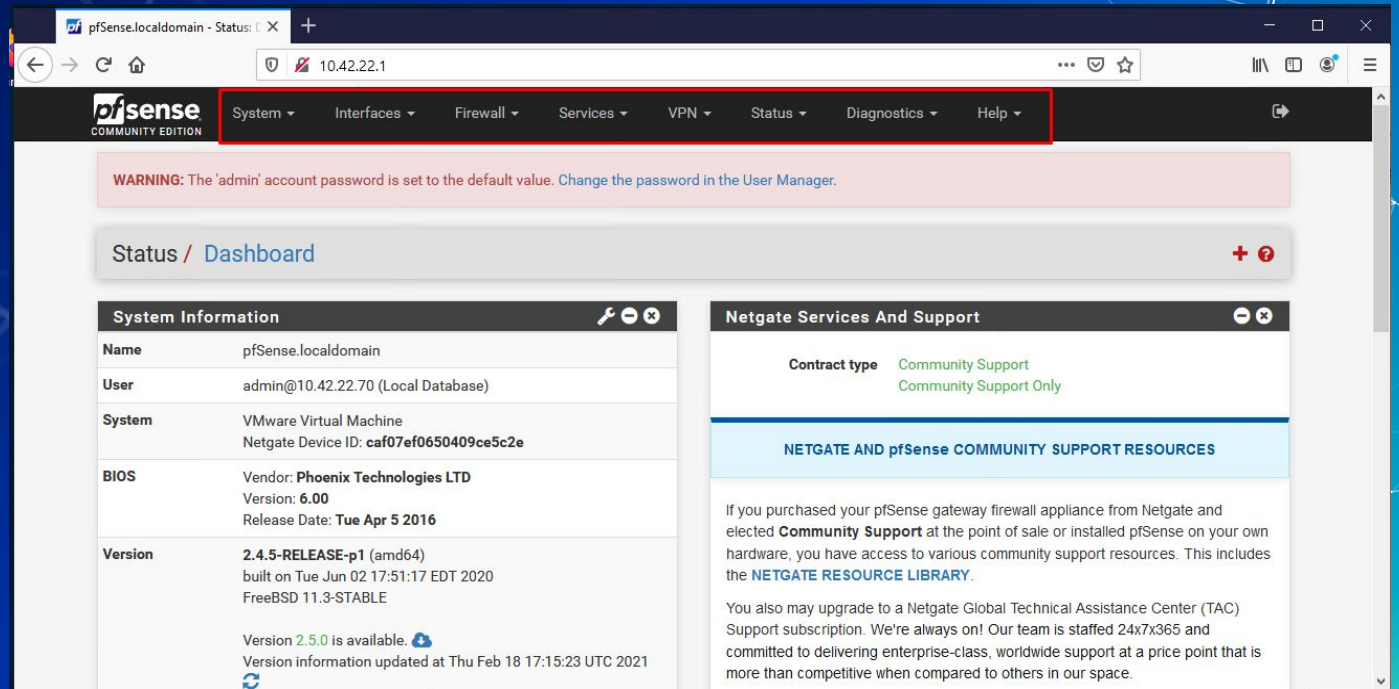
Homework Starter

- Credentials
  - Username: admin
  - Password: pfsense



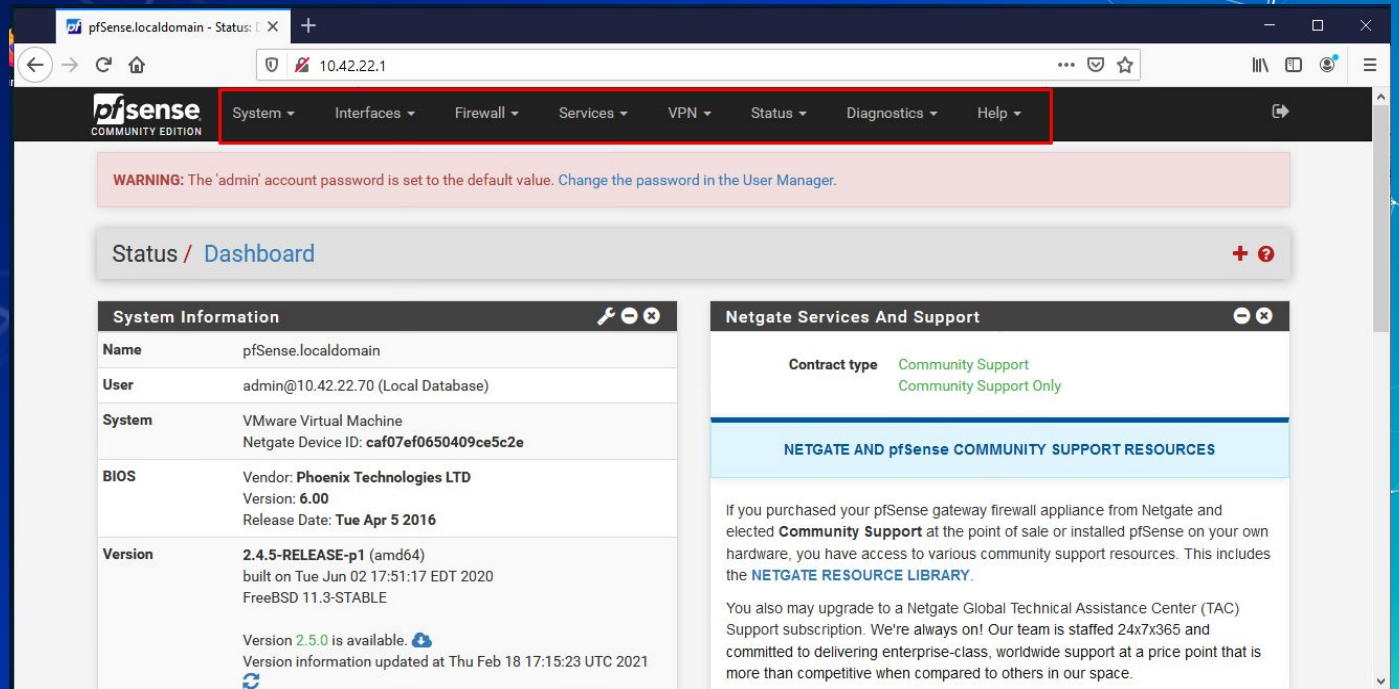
Homework Starter

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



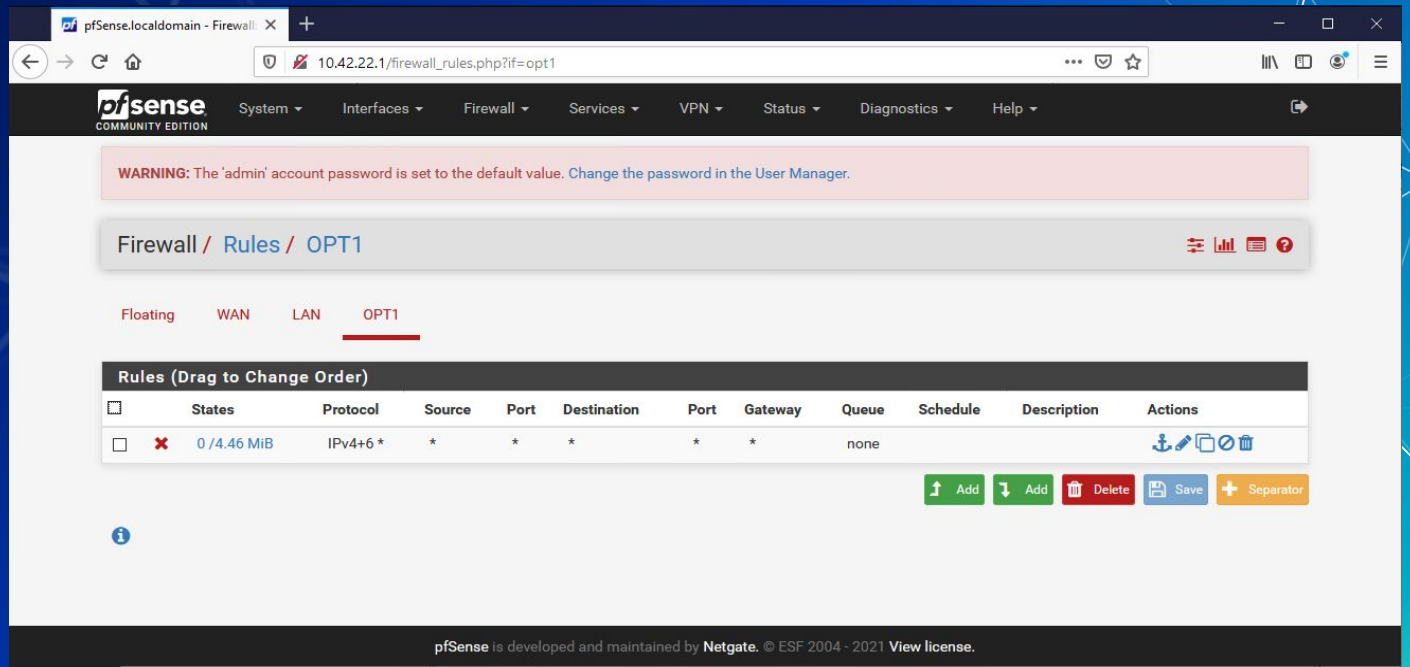
Homework Starter

- 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 add a new rule and change it, it re-enables the firewall.