 # PA4 - Subnet Addressing
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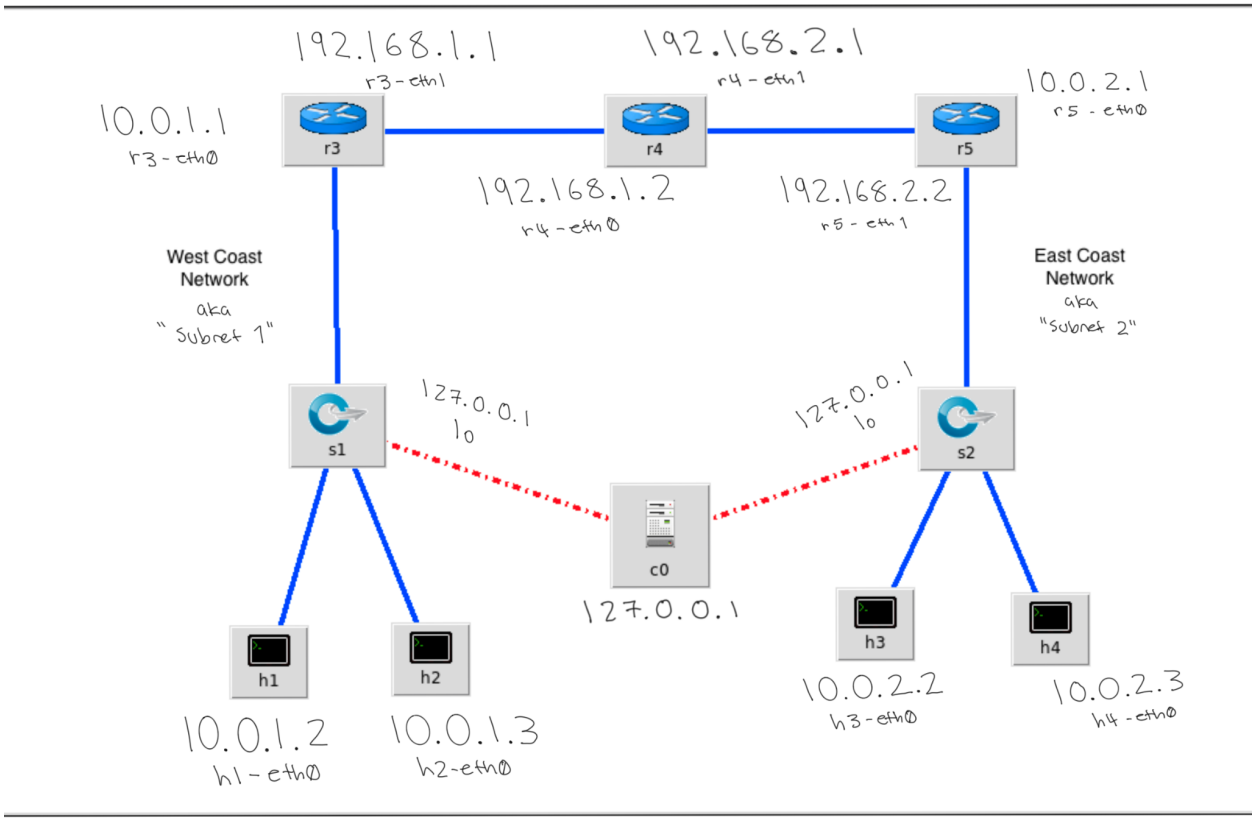
 # Network by BayTech for CST311 @ CSUMB

1. **Network Design:**



2. **Screen capture of the program that runs with no Python errors.**

```
mininet@mininet-vm:~/CST311/Final Assignment$ sudo python3 ./legacy_network.py
*** Adding Controller
*** Adding Switches
- Created S1 & S2

*** Creating Subnet 1:
- R3 H1 H2
- Establishing Links Between Devices
- Subnet Done

*** Creating Subnet 2:
- R5 H3 H4
- Establishing Links Between Devices
- Subnet Done

*** Creating "Internet":
- R4
- Establishing Links
- Establishing Routing Tables
- Routing Tables Done
- "Internet" Done

*** Starting network
*** Configuring hosts
r3 h1 h2 r5 h3 h4 r4
*** Starting controllers
*** Starting switches
*** Starting Xterms
*** Starting SSL Web Server
*** Post configure switches and hosts
*** Starting CLI:
mininet>
```

3. **Screen capture of successful *pingall* at the mininet**

```
mininet> dump
<Node r3: r3-eth0:10.0.1.1,r3-eth1:192.168.1.1 pid=4655>
<Host h1: h1-eth0:10.0.1.2 pid=4659>
<Host h2: h2-eth0:10.0.1.3 pid=4662>
<Node r5: r5-eth0:10.0.2.1,r5-eth1:192.168.2.2 pid=4685>
<Host h3: h3-eth0:10.0.2.2 pid=4699>
<Host h4: h4-eth0:10.0.2.3 pid=4705>
<Node r4: r4-eth0:192.168.1.2,r4-eth1:192.168.2.1 pid=4727>
<OVSSwitch s1: lo:127.0.0.1,s1-eth1:None,s1-eth2:None,s1-eth3:None pid=4647>
<OVSSwitch s2: lo:127.0.0.1,s2-eth1:None,s2-eth2:None,s2-eth3:None pid=4650>
<Controller c0: 127.0.0.1:6633 pid=4639>
mininet> pingall
*** Ping: testing ping reachability
r3 -> h1 h2 r5 h3 h4 r4
h1 -> r3 h2 r5 h3 h4 r4
h2 -> r3 h1 r5 h3 h4 r4
r5 -> r3 h1 h2 h3 h4 r4
h3 -> r3 h1 h2 r5 h4 r4
h4 -> r3 h1 h2 r5 h3 r4
r4 -> r3 h1 h2 r5 h3 h4
*** Results: 0% dropped (42/42 received)
mininet>
```

4. **A list of lines that were changed and why on legacy_switch.py**

These two lines were moved as a requirement of the assignment.

s2 = net.addSwitch('s2', cls=OVSKernelSwitch)

s1 = net.addSwitch('s1', cls=OVSKernelSwitch)

These lines were changed to put r3 & r5 into their correct subnets and r4 into its own subnet.

```
 26) r5 = net.addHost('r5', cls=Node, ip='0.0.0.0')
27) r5.cmd('sysctl -w net.ipv4.ip_forward=1')
30) r4 = net.addHost('r4', cls=Node, ip='0.0.0.0')
31) r4.cmd('sysctl -w net.ipv4.ip_forward=1')
32) r3 = net.addHost('r3', cls=Node, ip='0.0.0.0')
33) r3.cmd('sysctl -w net.ipv4.ip_forward=1')
```

These lines were changed so that h1/h2 and h3/h4 were put into their correct subnets.

```
36) h1 = net.addHost('h1', cls=Host, ip='10.0.0.1',
defaultRoute=None)
37) h2 = net.addHost('h2', cls=Host, ip='10.0.0.2',
defaultRoute=None)
38) h3 = net.addHost('h1', cls=Host, ip='10.0.0.3',
defaultRoute=None)
39) h4 = net.addHost('h2', cls=Host, ip='10.0.0.4',
defaultRoute=None)
```

These new lines setup the routing tables for r3-r5 and establish a link between each subnet through r4 (the "internet").

```
100) r3.cmd('route add -net 192.168.2.0/30 gw 192.168.1.2 r3-eth1')
102) r3.cmd('route add -net 10.0.2.0/24 gw 192.168.1.2 r3-eth1')
104) r5.cmd('route add -net 10.0.1.0/24 gw 192.168.2.1 r5-eth1')
106) r5.cmd('route add -net 192.168.1.0/30 gw 192.168.2.1 r5-eth1')
110) r4.cmd('route add -net 10.0.1.0/24 gw 192.168.1.1 r4-eth0')
112) r4.cmd('route add -net 10.0.2.0/24 gw 192.168.2.2 r4-eth1')
```

These lines let each xterm window popup w/ the correct chat client/server file & then also ensures each window doesn't get shutdown early by timing their launches by 1 second.

```
makeTerm(h4, title='Chat Server', term='xterm', display=None,
cmd='sudo python3 server.py')
time.sleep(1)
makeTerm(h3, title='Chat Client', term='xterm', display=None,
cmd='sudo python3 client.py')
time.sleep(1)
makeTerm(h1, title='Chat Client', term='xterm', display=None,
cmd='sudo python3 client.py')
```

Added this to enable background running of the ssl web server

```
h2.cmd('python3 ./sslserver.py &')
```

5. **Answers to these questions:**

a. What were any interesting findings and lessons learned?

An interesting finding was how much subnets affect the network. We thought that we could change the addresses 10.0.y.0 that he provided to any random number and it would work. It ended up taking many trails and errors to get the right subnet combination to get the network to work appropriatly. An interesting finding was seeing how powerful bash scripts are. A lesson we learned was how powerful bash scripts are, we have had a little experience with them to create files, folders, echo messages but this was our first experience with a complicated command. We learned how to automate certs, how to automate a network, and run a program. It took us a while to get everything to work the way we wanted, but learned new bash commands while troubleshooting.

b. Why didn't the original program forward packets between the hosts?

The original program didn't work because it didn't have the right IP addresses for matching subnets and we needed to change it to the one we were using in the network we created. The other big point is that we needed to modify the routing tables to allow the routers to send packets to each other.

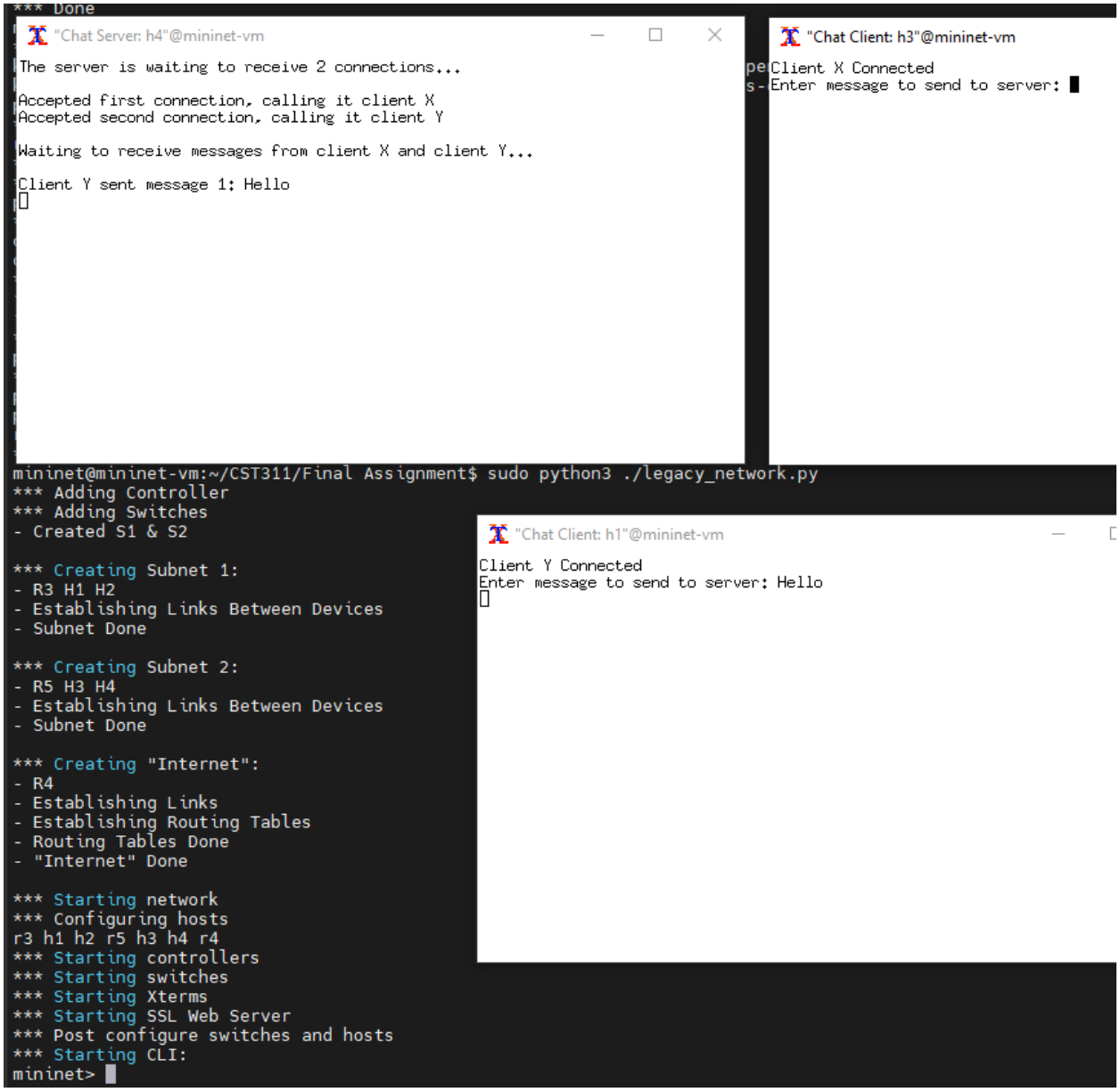
c. Is the line ' r3.cmd('sysctl -w net.ipv4.ip_forward=1') ' required?

Yes, it is necessary because it is required for forwarding packets from one subnet to another. In our case it allows us to send packets from subnet 1 to subnet 2. To be specific, R3 can ping H1 and R3 can also ping R4 and the other devices past that, but any packets originating from either subnet cannot cross R3 to the otherside. Adding that line allows for that.

d. Intentionally break your working program, e.g.: change a subnet length, IP address, or default route for a host. Explain why your change caused the network to break.

Changing the subnets will affect the program because each node may end up in a new subnet and they are unable to communicate with each other. Changing the IP address will break it because our chat/client is expecting a certain IP address to create the server. Changing the default route for a host will break if the host whole route was changed because the host will not know where to send the data to and thus be unable to connect to the network appropriately.

6. **Screen capture of a successful chat session between the two chat clients and the server.**



7. **Screen capture of the successful *wget* (or *curl*) of the web server index file.**

```
mininet> h1 ping www.webpa4.test
PING www.webpa4.test (10.0.1.3) 56(84) bytes of data.
64 bytes from www.webpa4.test (10.0.1.3): icmp_seq=1 ttl=64 time=7.90 ms
64 bytes from www.webpa4.test (10.0.1.3): icmp_seq=2 ttl=64 time=0.217 ms
64 bytes from www.webpa4.test (10.0.1.3): icmp_seq=3 ttl=64 time=0.078 ms
64 bytes from www.webpa4.test (10.0.1.3): icmp_seq=4 ttl=64 time=0.042 ms
64 bytes from www.webpa4.test (10.0.1.3): icmp_seq=5 ttl=64 time=0.044 ms
64 bytes from www.webpa4.test (10.0.1.3): icmp_seq=6 ttl=64 time=0.041 ms
64 bytes from www.webpa4.test (10.0.1.3): icmp_seq=7 ttl=64 time=0.044 ms
64 bytes from www.webpa4.test (10.0.1.3): icmp_seq=8 ttl=64 time=0.051 ms
64 bytes from www.webpa4.test (10.0.1.3): icmp_seq=9 ttl=64 time=0.042 ms
^C
--- www.webpa4.test ping statistics ---
9 packets transmitted, 9 received, 0% packet loss, time 8003ms
rtt min/avg/max/mdev = 0.041/0.940/7.908/2.464 ms
mininet> xterm h2
mininet> wget https://ww.cst311.test:4443
*** Unknown command: wget https://ww.cst311.test:4443
mininet> xterm h1
mininet> h1 wget https://www.webpa4.test:4443
--2022-06-15 18:44:56--  https://www.webpa4.test:4443/
Resolving www.webpa4.test (www.webpa4.test)... 10.0.1.3
Connecting to www.webpa4.test (www.webpa4.test)|10.0.1.3|:4443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 868 [text/html]
Saving to: 'index.html.1'

index.html.1        100%[===================>]     868  --.-KB/s    in 0s

2022-06-15 18:44:56 (2.73 MB/s) - 'index.html.1' saved [868/868]

mininet>
```

8. **Screenshot of decrypted web server certificate**

```
Certificate:
    Data:
        Version: 1 (0x0)
        Serial Number:
            ac:07:d6:54:3f:14:bd:39
    Signature Algorithm: sha256WithRSAEncryption
        Issuer: C=US, ST=CA, L=Salinas, O=SCD, OU=CST311, CN=ca.webpa4.test
        Validity
            Not Before: Jun 17 03:53:15 2022 GMT
            Not After : Jun 17 03:53:15 2023 GMT
        Subject: C=US, ST=CA, L=Salinas, O=CST311, OU=NETWORKING, CN=ca.webpa4.test
        Subject Public Key Info:
            Public Key Algorithm: rsaEncryption
                Public-Key: (2048 bit)
                Modulus:
                    00:d9:a1:22:22:15:40:47:8a:b0:7c:2f:bb:1d:80:
                    88:7f:1d:e2:36:db:c1:5a:d4:f4:3a:67:2c:14:65:
                    70:f0:8d:9b:60:ec:c6:3e:45:ec:d1:c9:0b:dd:33:
                    91:61:e1:8c:41:3f:27:a9:de:18:f0:a9:16:ea:0d:
                    51:92:11:d8:b4:43:72:cb:2e:57:d7:2b:06:9b:dc:
                    26:74:8b:a1:f1:d3:aa:ea:f0:2c:2f:ac:0d:46:9b:
                    54:91:2c:31:8f:d7:64:c7:c4:f5:ad:8b:ab:0a:98:
                    85:7e:10:a6:80:13:11:7c:7f:18:6b:97:bb:18:a2:
                    56:8d:d7:99:10:94:33:6e:f7:9d:d9:d6:96:34:e6:
                    a3:7b:f8:c5:52:d9:33:fd:b9:0b:e0:a4:b2:be:d8:
                    f1:30:66:3d:83:5c:af:10:b3:d2:af:34:13:a7:e7:
                    7a:09:5c:42:fe:f2:0a:ee:da:f2:43:71:12:36:d0:
                    39:c2:f8:5f:9f:22:4b:67:14:6a:ad:aa:be:a0:3b:
                    5e:9e:c8:88:2e:b6:79:7c:c0:d1:32:8c:e8:bc:a4:
                    c3:36:ce:93:0e:3a:15:fa:c1:dd:70:25:8f:cc:1f:
                    3d:50:72:55:fe:3a:46:3b:66:37:31:3b:99:1f:84:
                    a5:6a:e4:35:59:69:a5:34:69:30:4a:7c:9e:a8:d6:
                    29:15
                Exponent: 65537 (0x10001)
    Signature Algorithm: sha256WithRSAEncryption
         9e:4c:a0:e9:be:0a:5c:8c:35:45:34:f8:3c:15:33:79:49:af:
         bb:9d:23:e1:6d:d0:f4:8f:0b:b6:ee:3a:55:58:de:fb:f1:3c:
         81:9f:9e:8e:a2:4a:33:95:99:f1:b6:4e:00:4a:dc:47:87:90:
         43:50:12:8a:03:49:b6:ae:12:ef:23:96:69:ea:54:38:44:93:
         81:f7:79:5b:69:25:13:0a:a7:98:c1:df:39:10:ac:95:33:37:
         26:20:55:92:12:e2:b3:ac:51:0d:fd:6f:35:93:c8:44:e8:de:
         0f:9a:51:b5:f9:26:fc:ef:44:58:89:f7:ef:38:bb:74:29:28:
         c7:d0:4c:bc:15:84:0c:77:0d:e6:54:c5:fc:fb:8c:e4:84:6d:
         55:d1:72:a1:07:8c:c0:d5:52:a3:9f:27:aa:d8:67:99:78:18:
         87:91:23:19:d7:76:e6:0d:54:84:ea:9a:fc:80:33:eb:e1:5c:
         fc:37:92:65:62:01:75:9b:d5:c3:70:27:fe:91:d5:09:7f:47:
         1e:3a:75:e4:21:b3:c2:c9:13:6b:c1:52:43:87:43:bc:a3:f4:
         4e:fc:a6:f8:d8:8d:0d:7d:3c:e7:d9:81:6c:88:75:3a:47:b2:
         05:18:50:95:03:32:0e:3a:11:ec:c4:6a:76:d4:e2:94:cd:42:
         ad:44:2f:ce
```