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Part 1. Network Layer Analysis:

Part 1.1 ICMP Analysis:

Q1- As can be seen from the below screenshots when I run **"traceroute -I www.uq.edu.au"** 29 hops performed to reach the destination. The minimum TTL less than which the traceroute messages do not reach to a destination is 29. When I run **"traceroute -I -m 19 www.study.uq.edu.au" which limits max TTL to 19** it does not reach the IP address it reached before(in ss.1) as can be seen in ss2.

```
(base) sberk@Serkan-MacBook-Pro ~ % traceroute -I www.uq.edu.au
traceroute to www.uq.edu.au (130.102.184.3), 64 hops max, 72 byte packets
 1  172.21.128.3 (172.21.128.3)  5.128 ms  2.625 ms  2.825 ms
 2  10.20.30.2 (10.20.30.2)  4.524 ms  3.115 ms  3.025 ms
 3  212.175.32.141.static.ttnet.com.tr (212.175.32.141)  3.778 ms  2.759 ms  3.257 ms
 4  212.174.167.209 (212.174.167.209)  4.825 ms  4.750 ms  3.542 ms
 5  00-gayrettepe-sr14s-t2-1---00-buyukdere-t3-1.statik.turktelekom.com.tr (212.156.121.72)  4.794 ms  4.125 ms  3.680 ms
 6  41-gebze-t2-1---34-acibadem-xrs-t2-1.statik.turktelekom.com.tr (81.212.220.238)  4.521 ms  4.622 ms  5.538 ms
 7  10-balya-sr12-t4-1---10-balikesir-sr12e-t3-3.statik.turktelekom.com.tr (81.212.209.102)  4.314 ms  4.564 ms  4.596 ms
 8  301-fra-col-2---00-ebgp-gayrettepe-k.statik.turktelekom.com.tr (212.156.101.196)  53.201 ms  42.662 ms  42.646 ms
 9  213.198.83.221 (213.198.83.221)  47.533 ms  47.606 ms  47.805 ms
10  ae-8.r20.frnkge13.de.bb.gin.ntt.net (129.250.7.17)  47.217 ms  59.623 ms  48.767 ms
11  ae-0.r21.frnkge13.de.bb.gin.ntt.net (129.250.6.2)  47.896 ms  51.465 ms  48.176 ms
12  ae-12.r21.parsfr04.fr.bb.gin.ntt.net (129.250.5.27)  57.469 ms *  65.532 ms
13  * * *
14  ae-0.r25.asbnva02.us.bb.gin.ntt.net (129.250.2.36)  141.970 ms  205.170 ms  133.672 ms
15  ae-2.r25.lsanca07.us.bb.gin.ntt.net (129.250.3.189)  198.598 ms  196.359 ms  197.861 ms
16  ae-1.a04.lsanca07.us.bb.gin.ntt.net (129.250.3.81)  185.386 ms  185.622 ms  184.967 ms
17  xe-3-5-1-1.a04.lsanca07.us.ce.gin.ntt.net (204.1.253.166)  185.699 ms  202.654 ms  195.154 ms
18  et-3-0-2.pe1.alxd.nsw.aarnet.net.au (113.197.15.136)  419.512 ms  408.176 ms  331.792 ms
19  et-8-1-0.pe1.brwy.nsw.aarnet.net.au (113.197.15.152)  337.530 ms  365.371 ms  403.046 ms
20  et-0-3-0.pe1.gdpt.qld.aarnet.net.au (113.197.15.17)  348.995 ms  407.374 ms  409.275 ms
21  138.44.129.158 (138.44.129.158)  410.737 ms  409.630 ms  408.914 ms
22  fw-a-gw10.router.uq.edu.au (130.102.0.193)  410.237 ms  407.136 ms  408.605 ms
23  se10-fw-a.router.uq.edu.au (130.102.159.61)  411.546 ms  415.211 ms  405.928 ms
24  * * *
25  * * *
26  * * *
27  * * *
28  * * *
29  www.biology.uq.edu.au (130.102.184.3)  413.578 ms  439.277 ms  408.996 ms
(base) sberk@Serkan-MacBook-Pro ~ %
```

```
(base) sberk@Serkan-MacBook-Pro ~ % traceroute -I -m 19 www.uq.edu.au
traceroute to www.uq.edu.au (130.102.184.3), 19 hops max, 72 byte packets
 1  172.21.128.3 (172.21.128.3)  9.714 ms  2.315 ms  3.043 ms
 2  10.20.30.2 (10.20.30.2)  4.465 ms  3.162 ms  3.030 ms
 3  212.175.32.141.static.ttnet.com.tr (212.175.32.141)  3.649 ms  2.781 ms  3.029 ms
 4  212.174.167.209 (212.174.167.209)  5.001 ms  4.422 ms  3.920 ms
 5  00-gayrettepe-sr14s-t2-1---00-buyukdere-t3-1.statik.turktelekom.com.tr (212.156.121.72)  5.072 ms  4.340 ms  3.686 ms
 6  * * *
 7  * * *
 8  301-fra-col-2---00-ebgp-gayrettepe-k.statik.turktelekom.com.tr (212.156.101.196)  42.692 ms  42.396 ms  41.712 ms
 9  213.198.83.221 (213.198.83.221)  49.595 ms  48.023 ms  47.055 ms
10  ae-8.r20.frnkge13.de.bb.gin.ntt.net (129.250.7.17)  46.893 ms  47.491 ms  70.401 ms
11  ae-0.r21.frnkge13.de.bb.gin.ntt.net (129.250.6.2)  48.673 ms  59.718 ms  99.419 ms
12  ae-12.r21.parsfr04.fr.bb.gin.ntt.net (129.250.5.27)  63.153 ms  58.508 ms  56.883 ms
13  ae-13.r24.asbnva02.us.bb.gin.ntt.net (129.250.6.6)  142.429 ms  140.290 ms  139.637 ms
14  ae-0.r25.asbnva02.us.bb.gin.ntt.net (129.250.2.36)  133.725 ms  133.706 ms  134.181 ms
15  ae-2.r25.lsanca07.us.bb.gin.ntt.net (129.250.3.189)  304.264 ms  305.255 ms  204.106 ms
16  ae-1.a04.lsanca07.us.bb.gin.ntt.net (129.250.3.81)  188.153 ms  189.721 ms  184.956 ms
17  xe-3-5-1-1.a04.lsanca07.us.ce.gin.ntt.net (204.1.253.166)  186.237 ms  186.701 ms  190.146 ms
18  et-3-0-2.pe1.alxd.nsw.aarnet.net.au (113.197.15.136)  410.049 ms  407.115 ms  410.155 ms
19  et-8-1-0.pe1.brwy.nsw.aarnet.net.au (113.197.15.152)  410.001 ms  411.343 ms  407.106 ms
(base) sberk@Serkan-MacBook-Pro ~ %
```

```
traceroute to www.uq.edu.au (130.102.184.3), 21 hops max, 72 byte packets
 1  172.21.128.3 (172.21.128.3)  5.480 ms  3.160 ms  3.658 ms
 2  10.20.30.2 (10.20.30.2)  4.989 ms  4.066 ms  3.524 ms
 3  212.175.32.141.static.ttnet.com.tr (212.175.32.141)  4.174 ms  3.443 ms  2.863 ms
 4  212.174.167.209 (212.174.167.209)  4.208 ms  5.186 ms  4.636 ms
 5  00-gayrettepe-sr14s-t2-1---00-buyukdere-t3-1.statik.turktelekom.com.tr (212.156.121.72)  4.072 ms  4.050 ms  3.244 ms
 6  * * *
 7  * * *
 8  301-fra-col-2---00-ebgp-gayrettepe-k.statik.turktelekom.com.tr (212.156.101.196)  48.231 ms  41.421 ms  41.813 ms
 9  213.198.83.221 (213.198.83.221)  47.332 ms  47.280 ms  48.693 ms
10  ae-8.r20.frnkge13.de.bb.gin.ntt.net (129.250.7.17)  47.194 ms  46.954 ms  47.819 ms
11  ae-0.r21.frnkge13.de.bb.gin.ntt.net (129.250.6.2)  55.711 ms  49.796 ms  49.425 ms
12  ae-12.r21.parsfr04.fr.bb.gin.ntt.net (129.250.5.27)  54.645 ms  57.010 ms  53.999 ms
13  ae-13.r24.asbnva02.us.bb.gin.ntt.net (129.250.6.6)  142.129 ms  145.589 ms  142.464 ms
14  ae-0.r25.asbnva02.us.bb.gin.ntt.net (129.250.2.36)  133.410 ms  140.256 ms  133.935 ms
15  ae-2.r25.lsanca07.us.bb.gin.ntt.net (129.250.3.189)  197.232 ms  197.136 ms  199.471 ms
16  ae-1.a04.lsanca07.us.bb.gin.ntt.net (129.250.3.81)  185.639 ms  186.719 ms  185.236 ms
17  xe-3-5-1-1.a04.lsanca07.us.ce.gin.ntt.net (204.1.253.166)  185.896 ms  186.191 ms  185.355 ms
18  et-3-0-2.pe1.alxd.nsw.aarnet.net.au (113.197.15.136)  381.577 ms  332.621 ms  409.060 ms
19  et-8-1-0.pe1.brwy.nsw.aarnet.net.au (113.197.15.152)  410.229 ms  337.041 ms  379.743 ms
20  et-0-3-0.pe1.gdpt.qld.aarnet.net.au (113.197.15.17)  348.551 ms  347.150 ms  429.417 ms
21  138.44.129.158 (138.44.129.158)  410.069 ms  412.431 ms  406.006 ms
```

Q2- The default number of probes used on Macs are 3. It is 3 in my device. In the screenshots below you can see the outputs for different probes=1, 2, 4, 10. We can conclude that as number of probes increases the traceroute becomes more reliable since it will average the RTTs and if we sent only 1 packet(which mean probe=1) it will depend on immediate network conditions and other immediate things which will not be that reliable. Between different number of probes (1,2, 4, 10) the first few hops were generally was similar and consistent, less affected with the number of probes since they are initial routers, more close to us, local network in general. With multiple probes we observed more consistent results. In addition we need to keep in mind that sending more probes increases the load on the network, increases duration, and potentially affects the measurements' accuracy. All these observations can be seen in the below screenshots.

```
(base) sberk@Serkan-MacBook-Pro ~ % traceroute -I -q 1 www.uq.edu.au

traceroute to www.uq.edu.au (130.102.184.3), 64 hops max, 72 byte packets
 1  172.21.128.3 (172.21.128.3)  3.065 ms
 2  10.20.30.2 (10.20.30.2)  3.207 ms
 3  212.175.32.141.static.ttnet.com.tr (212.175.32.141)  3.316 ms
 4  212.174.167.209 (212.174.167.209)  4.393 ms
 5  00-gayrettepe-sr14s-t2-1---00-buyukdere-t3-1.statik.turktelekom.com.tr (212.156.121.72)  3.773 ms
 6  *
 7  *
 8  301-fra-col-2---00-ebgp-gayrettepe-k.statik.turktelekom.com.tr (212.156.101.196)  44.219 ms
 9  213.198.83.221 (213.198.83.221)  47.755 ms
10  ae-8.r20.frnkge13.de.bb.gin.ntt.net (129.250.7.17)  50.533 ms
11  ae-0.r21.frnkge13.de.bb.gin.ntt.net (129.250.6.2)  53.945 ms
12  ae-12.r21.parsfr04.fr.bb.gin.ntt.net (129.250.5.27)  54.061 ms
13  ae-13.r24.asbnva02.us.bb.gin.ntt.net (129.250.6.6)  142.485 ms
14  ae-0.r25.asbnva02.us.bb.gin.ntt.net (129.250.2.36)  134.105 ms
15  ae-2.r25.lsanca07.us.bb.gin.ntt.net (129.250.3.189)  200.327 ms
16  ae-1.a04.lsanca07.us.bb.gin.ntt.net (129.250.3.81)  185.555 ms
17  xe-3-5-1-1.a04.lsanca07.us.ce.gin.ntt.net (204.1.253.166)  185.561 ms
18  et-3-0-2.pe1.alxd.nsw.aarnet.net.au (113.197.15.136)  363.074 ms
19  et-8-1-0.pe1.brwy.nsw.aarnet.net.au (113.197.15.152)  408.804 ms
20  et-0-3-0.pe1.gdpt.qld.aarnet.net.au (113.197.15.17)  417.812 ms
21  138.44.129.158 (138.44.129.158)  399.314 ms
22  fw-a-gw10.router.uq.edu.au (130.102.0.193)  401.930 ms
23  se10-fw-a.router.uq.edu.au (130.102.159.61)  407.287 ms
24  *
25  *
26  *
27  *
28  *
29  www.biology.uq.edu.au (130.102.184.3)  386.595 ms
```

```
(base) sberk@Serkan-MacBook-Pro ~ % traceroute -I -q 2 www.uq.edu.au

traceroute to www.uq.edu.au (130.102.184.3), 64 hops max, 72 byte packets
 1  172.21.128.3 (172.21.128.3)  9.610 ms  2.332 ms
 2  10.20.30.2 (10.20.30.2)  3.933 ms  2.977 ms
 3  212.175.32.141.static.ttnet.com.tr (212.175.32.141)  3.496 ms  4.073 ms
 4  212.174.167.209 (212.174.167.209)  4.289 ms  3.533 ms
 5  00-gayrettepe-sr14s-t2-1---00-buyukdere-t3-1.statik.turktelekom.com.tr (212.156.121.72)  4.209 ms  3.708 ms
 6  * 41-gebze-t2-1---34-acibadem-xrs-t2-1.statik.turktelekom.com.tr (81.212.220.238)  5.308 ms
 7  10-balya-sr12-t4-1---10-balikesir-sr12e-t3-3.statik.turktelekom.com.tr (81.212.209.102)  4.510 ms  4.443 ms
 8  301-fra-col-2---00-ebgp-gayrettepe-k.statik.turktelekom.com.tr (212.156.101.196)  41.808 ms  41.728 ms
 9  213.198.83.221 (213.198.83.221)  47.257 ms  87.702 ms
10  ae-8.r20.frnkge13.de.bb.gin.ntt.net (129.250.7.17)  50.599 ms  47.231 ms
11  ae-0.r21.frnkge13.de.bb.gin.ntt.net (129.250.6.2)  51.494 ms  48.166 ms
12  * ae-12.r21.parsfr04.fr.bb.gin.ntt.net (129.250.5.27)  58.852 ms
13  ae-13.r24.asbnva02.us.bb.gin.ntt.net (129.250.6.6)  139.969 ms  141.799 ms
14  ae-0.r25.asbnva02.us.bb.gin.ntt.net (129.250.2.36)  135.159 ms  134.588 ms
15  ae-2.r25.lsanca07.us.bb.gin.ntt.net (129.250.3.189)  202.911 ms  198.648 ms
16  ae-1.a04.lsanca07.us.bb.gin.ntt.net (129.250.3.81)  186.852 ms  185.780 ms
17  xe-3-5-1-1.a04.lsanca07.us.ce.gin.ntt.net (204.1.253.166)  185.698 ms  184.980 ms
18  et-3-0-2.pe1.alxd.nsw.aarnet.net.au (113.197.15.136)  381.289 ms  406.912 ms
19  et-8-1-0.pe1.brwy.nsw.aarnet.net.au (113.197.15.152)  409.343 ms  408.445 ms
20  et-0-3-0.pe1.gdpt.qld.aarnet.net.au (113.197.15.17)  410.443 ms  410.779 ms
21  138.44.129.158 (138.44.129.158)  409.000 ms  412.214 ms
22  fw-a-gw10.router.uq.edu.au (130.102.0.193)  407.196 ms  359.312 ms
23  se10-fw-a.router.uq.edu.au (130.102.159.61)  350.920 ms  356.627 ms
24  * *
25  * *
26  * *
27  * *
28  * *
29  www.biology.uq.edu.au (130.102.184.3)  411.466 ms  355.754 ms
```

```
(base) sberk@Serkan-MacBook-Pro ~ % traceroute -I -q 4 www.uq.edu.au

traceroute to www.uq.edu.au (130.102.184.3), 64 hops max, 72 byte packets
 1  172.21.128.3 (172.21.128.3)  9.536 ms  2.843 ms  2.876 ms  3.179 ms
 2  10.20.30.2 (10.20.30.2)  3.847 ms  2.762 ms  3.825 ms  3.166 ms
 3  212.175.32.141.static.ttnet.com.tr (212.175.32.141)  3.127 ms  3.671 ms  2.530 ms  3.089 ms
 4  212.174.167.209 (212.174.167.209)  4.426 ms  9.035 ms  9.869 ms  4.038 ms
 5  00-gayrettepe-sr14s-t2-1---00-buyukdere-t3-1.statik.turktelekom.com.tr (212.156.121.72)  4.347 ms  8.810 ms  3.536 ms  4.191 ms
 6  41-gebze-t2-1---34-acibadem-xrs-t2-1.statik.turktelekom.com.tr (81.212.220.238)  4.415 ms  4.947 ms  4.274 ms  4.765 ms
 7  10-balya-sr12-t4-1---10-balikesir-sr12e-t3-3.statik.turktelekom.com.tr (81.212.209.102)  4.679 ms  3.970 ms  5.920 ms  3.817 ms
 8  301-fra-col-2---00-ebgp-gayrettepe-k.statik.turktelekom.com.tr (212.156.101.196)  42.547 ms  43.422 ms  42.223 ms  41.509 ms
 9  213.198.83.221 (213.198.83.221)  47.179 ms  47.444 ms  52.086 ms  50.259 ms
10  ae-8.r20.frnkge13.de.bb.gin.ntt.net (129.250.7.17)  47.723 ms  56.104 ms  47.892 ms  49.210 ms
11  ae-0.r21.frnkge13.de.bb.gin.ntt.net (129.250.6.2)  53.124 ms  48.609 ms  49.034 ms  54.547 ms
12  ae-12.r21.parsfr04.fr.bb.gin.ntt.net (129.250.5.27)  55.305 ms  56.139 ms  57.090 ms  53.944 ms
13  ae-13.r24.asbnva02.us.bb.gin.ntt.net (129.250.6.6)  140.708 ms  145.183 ms *  216.298 ms
14  ae-0.r25.asbnva02.us.bb.gin.ntt.net (129.250.2.36)  133.930 ms  134.374 ms  132.549 ms  132.852 ms
15  ae-2.r25.lsanca07.us.bb.gin.ntt.net (129.250.3.189)  202.610 ms  198.179 ms  292.500 ms  361.534 ms
16  ae-1.a04.lsanca07.us.bb.gin.ntt.net (129.250.3.81)  186.231 ms  185.261 ms  190.062 ms  185.617 ms
17  xe-3-5-1-1.a04.lsanca07.us.ce.gin.ntt.net (204.1.253.166)  186.194 ms  185.996 ms  185.625 ms  185.781 ms
18  et-3-0-2.pe1.alxd.nsw.aarnet.net.au (113.197.15.136)  347.435 ms  358.900 ms  409.899 ms  333.359 ms
19  et-8-1-0.pe1.brwy.nsw.aarnet.net.au (113.197.15.152)  382.262 ms  409.567 ms  336.405 ms  383.149 ms
20  et-0-3-0.pe1.gdpt.qld.aarnet.net.au (113.197.15.17)  407.109 ms  408.955 ms  409.170 ms  362.469 ms
21  138.44.129.158 (138.44.129.158)  349.155 ms  413.320 ms  347.608 ms  372.324 ms
22  fw-a-gw10.router.uq.edu.au (130.102.0.193)  407.705 ms  408.180 ms  410.142 ms  412.061 ms
23  se10-fw-a.router.uq.edu.au (130.102.159.61)  407.282 ms  409.008 ms  407.830 ms  348.533 ms
24  * * * *
25  * * * *
26  * * * *
27  * * * *
28  * * * *
29  www.biology.uq.edu.au (130.102.184.3)  355.144 ms  375.748 ms  410.843 ms  408.388 ms
```

```
(base) sberk@Serkan-MacBook-Pro ~ % traceroute -I -q 10 www.uq.edu.au

traceroute to www.uq.edu.au (130.102.184.3), 64 hops max, 72 byte packets
 1  172.21.128.3 (172.21.128.3)  3.613 ms  3.328 ms  3.117 ms  2.792 ms  3.338 ms  2.446 ms *  12.407 ms  5.372 ms  3.000 ms
 2  10.20.30.2 (10.20.30.2)  6.281 ms  4.257 ms  4.073 ms  3.401 ms  3.099 ms  3.842 ms *  6.494 ms  5.460 ms  11.239 ms
 3  212.175.32.141.static.ttnet.com.tr (212.175.32.141)  4.450 ms  3.285 ms  3.288 ms  3.972 ms  2.713 ms  2.816 ms  12.959 ms  21.146 ms  15.751 ms  17.801 ms
 4  212.174.167.209 (212.174.167.209)  7.832 ms  5.722 ms  5.393 ms  4.153 ms  4.605 ms  4.177 ms  4.226 ms  3.947 ms  4.096 ms  6.115 ms
 5  00-gayrettepe-sr14s-t2-1---00-buyukdere-t3-1.statik.turktelekom.com.tr (212.156.121.72)  4.911 ms  3.970 ms  4.204 ms  3.808 ms  3.873 ms  3.799 ms  4.687 ms  3.637 ms  4.176 ms  4.162 ms
 6  41-gebze-t2-1---34-acibadem-xrs-t2-1.statik.turktelekom.com.tr (81.212.220.238)  3.615 ms  4.778 ms  4.062 ms  4.461 ms  3.993 ms  3.702 ms  4.123 ms  4.941 ms  4.228 ms  6.137 ms
 7  10-balya-sr12-t4-1---10-balikesir-sr12e-t3-3.statik.turktelekom.com.tr (81.212.209.102)  4.562 ms  4.605 ms  4.413 ms  5.377 ms  4.132 ms  5.044 ms  4.235 ms  4.218 ms  4.668 ms  3.838 ms
 8  301-fra-col-2---00-ebgp-gayrettepe-k.statik.turktelekom.com.tr (212.156.101.196)  43.467 ms  49.611 ms  52.501 ms  42.046 ms  42.732 ms  42.114 ms  52.707 ms  41.436 ms  43.069 ms  42.558 ms
 9  213.198.83.221 (213.198.83.221)  46.773 ms  47.440 ms  47.011 ms  47.674 ms  46.637 ms  47.820 ms  47.474 ms  54.954 ms  46.660 ms  47.153 ms
10  ae-8.r20.frnkge13.de.bb.gin.ntt.net (129.250.7.17)  46.693 ms  47.045 ms  46.900 ms  46.796 ms  48.835 ms  46.222 ms  49.893 ms  47.247 ms  47.171 ms  47.093 ms
11  ae-0.r21.frnkge13.de.bb.gin.ntt.net (129.250.6.2)  54.993 ms  51.838 ms  48.290 ms  47.834 ms  48.056 ms  47.913 ms  48.439 ms  47.748 ms  51.752 ms  46.949 ms
12  * * * * * * * * * *
13  ae-13.r24.asbnva02.us.bb.gin.ntt.net (129.250.6.6)  148.483 ms  141.404 ms  140.970 ms  145.041 ms  139.915 ms  140.390 ms  140.820 ms  141.467 ms  140.826 ms  141.823 ms
14  ae-0.r25.asbnva02.us.bb.gin.ntt.net (129.250.2.36)  138.996 ms  133.492 ms  138.062 ms  140.807 ms  134.364 ms  133.575 ms  134.676 ms  135.648 ms  140.058 ms  182.138 ms
15  ae-2.r25.lsanca07.us.bb.gin.ntt.net (129.250.3.189)  198.161 ms  197.273 ms  249.527 ms  197.469 ms  198.117 ms  196.520 ms  197.003 ms  200.582 ms  196.497 ms  197.262 ms
16  ae-1.a04.lsanca07.us.bb.gin.ntt.net (129.250.3.81)  194.743 ms  186.988 ms  186.060 ms  190.314 ms  185.707 ms  186.335 ms  185.882 ms  185.134 ms  185.592 ms  185.614 ms
17  xe-3-5-1-1.a04.lsanca07.us.ce.gin.ntt.net (204.1.253.166)  186.574 ms  185.605 ms  186.005 ms  186.322 ms  185.622 ms  186.788 ms  186.249 ms  186.358 ms  185.962 ms  187.591 ms
18  et-3-0-2.pe1.alxd.nsw.aarnet.net.au (113.197.15.136)  407.883 ms  409.047 ms  410.190 ms  408.842 ms  331.661 ms  388.635 ms  411.752 ms  408.912 ms  332.921 ms  384.961 ms
19  et-8-1-0.pe1.brwy.nsw.aarnet.net.au (113.197.15.152)  407.107 ms  412.228 ms  390.249 ms  338.281 ms  337.183 ms  363.818 ms  406.494 ms  413.961 ms  405.656 ms  408.597 ms
20  et-0-3-0.pe1.gdpt.qld.aarnet.net.au (113.197.15.17)  410.697 ms  409.091 ms  408.275 ms  347.142 ms  373.597 ms  410.798 ms  405.751 ms  409.287 ms  409.295 ms  408.455 ms
21  138.44.129.158 (138.44.129.158)  411.651 ms  409.231 ms  407.960 ms  408.312 ms  348.724 ms  463.712 ms  511.945 ms  417.103 ms  349.282 ms  367.371 ms
22  fw-a-gw10.router.uq.edu.au (130.102.0.193)  410.011 ms  408.745 ms  408.426 ms  411.130 ms  408.446 ms  410.353 ms  409.171 ms  408.711 ms  409.640 ms  411.618 ms
23  se10-fw-a.router.uq.edu.au (130.102.159.61)  414.417 ms  348.787 ms  365.485 ms  405.161 ms  411.034 ms  407.970 ms  350.279 ms  349.854 ms  433.581 ms  406.360 ms
24  * * * * * * * * * *
25  * * * * * * * * * *
26  * * * * * * * * * *
27  * * * * * * * * * *
28  * * * * * * * * * *
29  www.biology.uq.edu.au (130.102.184.3)  419.076 ms  354.475 ms  436.141 ms  348.911 ms  366.399 ms  409.612 ms  410.468 ms  410.793 ms  407.443 ms  411.049 ms
(base) sberk@Serkan-MacBook-Pro ~ %
```

Q3- You can see the output of man traceroute below I used -I with traceroute to force the traceroute command to send ICMP packets instead of UDP.

```
TRACEROUTE(8)                                System Manager's Manual                                TRACEROUTE(8)

NAME
     traceroute — print the route packets take to network host

SYNOPSIS
     traceroute [-adeFISdNnrvx] [-A as_server] [-f first_ttl] [-g gateway] [-i iface] [-M first_ttl] [-m max_ttl] [-P proto] [-p port] [-q nqueries] [-s src_addr] [-t tos] [-w waittime] [-z pausemsecs] host
                [packetsize]

DESCRIPTION
     The Internet is a large and complex aggregation of network hardware, connected together by gateways.  Tracking the route one's packets follow (or finding the miscreant gateway that's discarding your
     packets) can be difficult.  traceroute utilizes the IP protocol `time to live' field and attempts to elicit an ICMP TIME_EXCEEDED response from each gateway along the path to some host.

     The only mandatory parameter is the destination host name or IP number.  The default probe datagram length is 40 bytes, but this may be increased by specifying a packet size (in bytes) after the
     destination host name.

     Other options are:

     -a      Turn on AS# lookups for each hop encountered.

     -A as_server
             Turn  on  AS#  lookups  and  use the given server instead of the default.

     -d      Enable socket level debugging.

     -D      When an ICMP response to our probe datagram is received, print the differences between the transmitted packet and the packet quoted by the ICMP response.  A key showing the location of fields
             within the transmitted packet is printed, followed by the original packet in hex, followed by the quoted packet in hex.  Bytes that are unchanged in the quoted packet are shown as underscores.
             Note, the IP checksum and the TTL of the quoted packet are not expected to match.  By default, only one probe per hop is sent with this option.

     -e      Firewall evasion mode.  Use fixed destination ports for UDP and TCP probes.  The destination port does NOT increment with each packet sent.

     -f first_ttl
             Set the initial time-to-live used in the first outgoing probe packet.

     -F      Set the "don't fragment" bit.

     -g gateway
             Specify a loose source route gateway (8 maximum).

     -i iface
             Specify a network interface to obtain the source IP address for outgoing probe packets. This is normally only useful on a multi-homed host. (See the -s flag for another way to do this.)

     -I      Use ICMP ECHO instead of UDP datagrams.  (A synonym for "-P icmp").

     -M first_ttl
             Set the initial time-to-live value used in outgoing probe packets.  The default is 1, i.e., start with the first hop.

     -m max_ttl
             Set the max time-to-live (max number of hops) used in outgoing probe packets.  The default is net.inet.ip.ttl hops (the same default used for TCP connections).

     -n      Print hop addresses numerically rather than symbolically and numerically (saves a nameserver address-to-name lookup for each gateway found on the path).

     -P proto
             Send packets of specified IP protocol. The currently supported protocols are: UDP , TCP , GRE and ICMP Other protocols may also be specified (either by name or by number), though traceroute
             does not implement any special knowledge of their packet formats. This option is useful for determining which router along a path may be blocking packets based on IP protocol number. But see
             BUGS below.

     -p port
             Protocol specific. For UDP and TCP, sets the base port number used in probes (default is 33434).  traceroute hopes that nothing is listening on UDP ports base to base+nhops-1 at the destination
             host (so an ICMP PORT_UNREACHABLE message will be returned to terminate the route tracing).  If something is listening on a port in the default range, this option can be used to pick an unused
:
```

Q4- When traffic in a network is dropped or destroyed rather than sent to its intended destination, it's referred to as a **routing blackhole**. This might happen if there is a problem with the routing data, which prevents there from being a working path to the target network. A routing blackhole is essentially a spot in the network where packets go dead since there isn't a known way for them to get there.

Even though purposeful or managed blackholes in routing are generally undesirable and signal a network issue, there are several situations in which they might be advantageous. Using a method known as "blackhole routing" or "null routing" for particular objectives is one example of this.

An way of using Routing Blackholes beneficially is DDoS mitigation. We can configure a blackhole for targeted IP adress so that we are able to direct malicious traffic to a non-existent path, preventing it to reach the destination. This technique is commonly used. We need to keep in mind that it is a temporary solution to DDoS attack since it does not give any information about underlying cause of the attack.

Part 1.2 Network Interface Analysis:

Q1- I am using Mac and as can be seen from the below screenshots ip does not work but instead there is ifconfig. I will be using ifconfig and netstat for my commands.

```
(base) sberk@Serkan-MacBook-Pro ~ % ip
zsh: command not found: ip
(base) sberk@Serkan-MacBook-Pro ~ % ifconfig
lo0: flags=8049<UP,LOOPBACK,RUNNING,MULTICAST> mtu 16384
        options=1203<RXCSUM,TXCSUM,TXSTATUS,SW_TIMESTAMP>
        inet 127.0.0.1 netmask 0xff000000
        inet6 ::1 prefixlen 128
        inet6 fe80::1%lo0 prefixlen 64 scopeid 0x1
        nd6 options=201<PERFORMNUD,DAD>
gif0: flags=8010<POINTOPOINT,MULTICAST> mtu 1280
stf0: flags=0<> mtu 1280
en5: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
        ether ac:de:48:00:11:22
        inet6 fe80::aede:48ff:fe00:1122%en5 prefixlen 64 scopeid 0x4
        nd6 options=201<PERFORMNUD,DAD>
        media: autoselect (100baseTX <full-duplex>)
        status: active
ap1: flags=8802<BROADCAST,SIMPLEX,MULTICAST> mtu 1500
        options=400<CHANNEL_IO>
        ether aa:66:5a:33:e9:a5
        media: autoselect
en0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
        options=6463<RXCSUM,TXCSUM,TSO4,TSO6,CHANNEL_IO,PARTIAL_CSUM,ZEROINVERT_CSUM>
        ether 88:66:5a:33:e9:a5
        inet6 fe80::1c76:8da6:f02d:1010%en0 prefixlen 64 secured scopeid 0x6
        inet 172.21.188.168 netmask 0xffff8000 broadcast 172.21.255.255
        nd6 options=201<PERFORMNUD,DAD>
        media: autoselect
        status: active
awdl0: flags=8843<UP,BROADCAST,RUNNING,SIMPLEX,MULTICAST> mtu 1500
        options=6463<RXCSUM,TXCSUM,TSO4,TSO6,CHANNEL_IO,PARTIAL_CSUM,ZEROINVERT_CSUM>
        ether da:df:7d:ae:c6:53
        inet6 fe80::d8df:7dff:feae:c653%awdl0 prefixlen 64 scopeid 0x7
        nd6 options=201<PERFORMNUD,DAD>
        media: autoselect
        status: active
llw0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
        options=400<CHANNEL_IO>
        ether da:df:7d:ae:c6:53
        inet6 fe80::d8df:7dff:feae:c653%llw0 prefixlen 64 scopeid 0x8
        nd6 options=201<PERFORMNUD,DAD>
        media: autoselect
        status: inactive
en1: flags=8963<UP,BROADCAST,SMART,RUNNING,PROMISC,SIMPLEX,MULTICAST> mtu 1500
        options=460<TSO4,TSO6,CHANNEL_IO>
        ether 82:21:09:25:b0:01
        media: autoselect <full-duplex>
        status: inactive
en2: flags=8963<UP,BROADCAST,SMART,RUNNING,PROMISC,SIMPLEX,MULTICAST> mtu 1500
        options=460<TSO4,TSO6,CHANNEL_IO>
        ether 82:21:09:25:b0:00
        media: autoselect <full-duplex>
        status: inactive
en3: flags=8963<UP,BROADCAST,SMART,RUNNING,PROMISC,SIMPLEX,MULTICAST> mtu 1500
        options=460<TSO4,TSO6,CHANNEL_IO>
        ether 82:21:09:25:b0:05
        media: autoselect <full-duplex>
        status: inactive
en4: flags=8963<UP,BROADCAST,SMART,RUNNING,PROMISC,SIMPLEX,MULTICAST> mtu 1500
        options=460<TSO4,TSO6,CHANNEL_IO>
```

```
llw0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
        options=400<CHANNEL_IO>
        ether da:df:7d:ae:c6:53
        inet6 fe80::d8df:7dff:feae:c653%llw0 prefixlen 64 scopeid 0x8
        nd6 options=201<PERFORMNUD,DAD>
        media: autoselect
        status: inactive
en1: flags=8963<UP,BROADCAST,SMART,RUNNING,PROMISC,SIMPLEX,MULTICAST> mtu 1500
        options=460<TSO4,TSO6,CHANNEL_IO>
        ether 82:21:09:25:b0:01
        media: autoselect <full-duplex>
        status: inactive
en2: flags=8963<UP,BROADCAST,SMART,RUNNING,PROMISC,SIMPLEX,MULTICAST> mtu 1500
        options=460<TSO4,TSO6,CHANNEL_IO>
        ether 82:21:09:25:b0:00
        media: autoselect <full-duplex>
        status: inactive
en3: flags=8963<UP,BROADCAST,SMART,RUNNING,PROMISC,SIMPLEX,MULTICAST> mtu 1500
        options=460<TSO4,TSO6,CHANNEL_IO>
        ether 82:21:09:25:b0:05
        media: autoselect <full-duplex>
        status: inactive
en4: flags=8963<UP,BROADCAST,SMART,RUNNING,PROMISC,SIMPLEX,MULTICAST> mtu 1500
        options=460<TSO4,TSO6,CHANNEL_IO>
        ether 82:21:09:25:b0:04
        media: autoselect <full-duplex>
        status: inactive
bridge0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
        options=63<RXCSUM,TXCSUM,TSO4,TSO6>
        ether 82:21:09:25:b0:01
        Configuration:
                id 0:0:0:0:0:0 priority 0 hellotime 0 fwddelay 0
                maxage 0 holdcnt 0 proto stp maxaddr 100 timeout 1200
                root id 0:0:0:0:0:0 priority 0 ifcost 0 port 0
                ipfilter disabled flags 0x0
        member: en1 flags=3<LEARNING,DISCOVER>
                ifmaxaddr 0 port 9 priority 0 path cost 0
        member: en2 flags=3<LEARNING,DISCOVER>
                ifmaxaddr 0 port 10 priority 0 path cost 0
        member: en3 flags=3<LEARNING,DISCOVER>
                ifmaxaddr 0 port 11 priority 0 path cost 0
        member: en4 flags=3<LEARNING,DISCOVER>
                ifmaxaddr 0 port 12 priority 0 path cost 0
        nd6 options=201<PERFORMNUD,DAD>
        media: <unknown type>
        status: inactive
utun0: flags=8051<UP,POINTOPOINT,RUNNING,MULTICAST> mtu 1380
        inet6 fe80::f00e:58c7:ac0:9365%utun0 prefixlen 64 scopeid 0xe
        nd6 options=201<PERFORMNUD,DAD>
utun1: flags=8051<UP,POINTOPOINT,RUNNING,MULTICAST> mtu 2000
        inet6 fe80::da05:6b24:6eff:b3fd%utun1 prefixlen 64 scopeid 0xf
        nd6 options=201<PERFORMNUD,DAD>
utun2: flags=8051<UP,POINTOPOINT,RUNNING,MULTICAST> mtu 1000
        inet6 fe80::ce81:b1c:bd2c:69e%utun2 prefixlen 64 scopeid 0x10
        nd6 options=201<PERFORMNUD,DAD>
utun3: flags=8051<UP,POINTOPOINT,RUNNING,MULTICAST> mtu 1380
        inet6 fe80::583:cf8c:742a:d3f2%utun3 prefixlen 64 scopeid 0x11
        nd6 options=201<PERFORMNUD,DAD>
```

```
IFCONFIG(8)                                System Manager's Manual                                IFCONFIG(8)

NAME
     ifconfig — configure network interface parameters

SYNOPSIS
     ifconfig [-L] [-m] [-r] interface [create] [address_family] [address [dest_address]] [parameters]
     ifconfig interface destroy
     ifconfig -a [-L] [-d] [-m] [-r] [-u] [-v] [address_family]
     ifconfig -l [-d] [-u] [address_family]
     ifconfig [-L] [-d] [-m] [-r] [-u] [-v] [-C]
     ifconfig interface vlan vlan-tag vlandev iface
     ifconfig interface -vlandev iface
     ifconfig interface bonddev iface
     ifconfig interface -bonddev iface
     ifconfig interface bondmode lacp | static
     ifconfig -X pattern [parameters]

DESCRIPTION
     The ifconfig utility is used to assign an address to a network interface and/or configure network interface parameters.

     The following options are available:

     address
             For the DARPA-Internet family, the address is either a host name present in the host name data base, hosts(5), or a DARPA Internet address expressed in the Internet standard "dot notation".

             It is also possible to use the CIDR notation (also known as the slash notation) to include the netmask.  That is, one can specify an address like 192.168.0.1/16.

             For the "inet6" family, it is also possible to specify the prefix length using the slash notation, like ::1/128.  See the prefixlen parameter below for more information.

             The link-level ("link") address is specified as a series of colon-separated hex digits.  This can be used to e.g. set a new MAC address on an ethernet interface, though the mechanism used is
             not ethernet-specific.  If the interface is already up when this option is used, it will be briefly brought down and then brought back up again in order to ensure that the receive filter in the
             underlying ethernet hardware is properly reprogrammed.

     address_family
             Specify the address family which affects interpretation of the remaining parameters.  Since an interface can receive transmissions in differing protocols with different naming schemes,
             specifying the address family is recommended.  The address or protocol families currently supported are "inet", "inet6", and "link".  The default is "inet".  "ether" and "lladdr" are synonyms
             for "link".

     dest_address
             Specify the address of the correspondent on the other end of a point to point link.

     interface
             This parameter is a string of the form "name unit", for example, "en0".

     The following parameters may be set with ifconfig:

     add     Another name for the alias parameter.  Introduced for compatibility with BSD/OS.

     alias   Establish an additional network address for this interface.  This is sometimes useful when changing network numbers, and one wishes to accept packets addressed to the old interface.  If the
             address is on the same subnet as the first network address for this interface, a non-conflicting netmask must be given.  Usually 0xffffffff is most appropriate.

     -alias  Remove the network address specified.  This would be used if you incorrectly specified an alias, or it was no longer needed.  If you have incorrectly set an NS address having the side effect of
             specifying the host portion, removing all NS addresses will allow you to respecify the host portion.

     anycast
             (Inet6 only.)  Specify that the address configured is an anycast address.  Based on the current specification, only routers may configure anycast addresses.  Anycast address will not be used as
             source address of any of outgoing IPv6 packets.

     arp     Enable the use of the Address Resolution Protocol (arp(4)) in mapping between network level addresses and link level addresses (default).  This is currently implemented for mapping between
:
```

Command 1: netstat -f inet -ix

Netstat used to display various network-related information on macOS. Unfortunately ip did not work. It gave an erro that says *"command not found".*

In this command -f flag used to specify family name. There are other alternatives such as stated in **man netstat** inet for AF_INET, inet6, for AF_INET6, unix, for AF_UNIX and vsock, for AF_VSOCK. Inet for

-f inet: This option filters the output to display only IPv4-related information.
-i: Shows the state of interfaces which have been auto-configured (interfaces statically configured into a system, but not located at boot time are not shown)
-x: Shows the state of interfaces which have been auto-configured (interfaces statically configured into a system, but not located at boot time are not shown)

```
[(base) sberk@Serkan-MacBook-Pro ~ % ip
zsh: command not found: ip
```

```
(base) sberk@Serkan-MacBook-Pro ~ % netstat -f inet -ix
Proto  Linklayer Address          Netif Expire    Refs Prbs    RSSI     LQM     NPM
0x86dd ac:de:48:33:44:55            en5 21s          1 none unknown unknown unknown
0x800  0:1c:7f:64:19:f              en0 1m30s        1 none unknown unknown unknown
0x800  18:4f:32:2f:8d:af            en0 expired      1 none unknown unknown unknown
0x800  ac:67:5d:28:a:c8             en0 2m59s        1 none unknown unknown unknown
0x800  ac:ed:5c:37:79:7c            en0 2m24s        1 none unknown unknown unknown
(base) sberk@Serkan-MacBook-Pro ~ %
```

Command 2: netstat -I en0 -w 1

-I en0: This option specifies that you want to display statistics for a specific network interface, in this case, "en0." en0 is default primary built-in Wi-Fi network interface. I detected this running ifconfig. You can see the result of the ifconfig below as well.
-w 1: refreshes output every 1 second.

```
(base) sberk@Serkan-MacBook-Pro ~ % netstat -I en0 -w 1
            input          (en0)           output
   packets  errs      bytes    packets  errs      bytes colls
        76     0      14486          2     0        432     0
        78     0       9214          0     0          0     0
       132     0      15006          2     0         84     0
       105     0      17333          0     0          0     0
```

```
      69     0      10977          3     0       1035     0
      56     0       6224          3     0       2319     0
      87     0       9463          3     0       1703     0
      70     0      10696          1     0         54     0
           input          (en0)           output
packets  errs      bytes    packets  errs      bytes colls
      71     0       8856          3     0       1714     0
      83     0      13103          3     0       1731     0
      68     0       9387          0     0          0     0
      81     0      11072          0     0          0     0
      91     0      22648         22     0      14636     0
      73     0       9954          3     0       2430     0
      59     0       7641          3     0       2125     0
      84     0      15961          5     0       1233     0
     247     0      28314          0     0          0     0
     385     0      42197          1     0         66     0
     122     0      14904          0     0          0     0
     204     0      38360          0     0          0     0
      92     0      12556          3     0        198     0
      55     0       6355          1     0         54     0
      50     0       5503          0     0          0     0
     159     0      30317          0     0          0     0
      94     0      15647          0     0          0     0
      44     0       5948          0     0          0     0
      63     0      10910          0     0          0     0
      75     0       9713          0     0          0     0
      68     0       8767          0     0          0     0
           input          (en0)           output
packets  errs      bytes    packets  errs      bytes colls
      68     0      11189         27     0      21312     0
      57     0       7147          1     0        218     0
      78     0      12035          2     0        272     0
      53     0       5806          2     0        284     0
      48     0       4912          3     0        386     0
      74     0      13910          0     0          0     0
      59     0       9556          1     0         66     0
      61     0       6743          0     0          0     0
     109     0      11690          0     0          0     0
      74     0      17230         12     0       3325     0
      63     0       6725          0     0          0     0
      79     0       7863          0     0          0     0
      52     0       5429          1     0         54     0
      93     0      14486          0     0          0     0
      69     0       8295          2     0        170     0
     109     0      18324         21     0      14558     0
      78     0      12511          0     0          0     0
      82     0      15847          7     0       4811     0
      93     0      10096          0     0          0     0
      65     0       7403          0     0          0     0
     121     0      13024          0     0          0     0
           input          (en0)           output
packets  errs      bytes    packets  errs      bytes colls
     146     0      24933         10     0       3131     0
     285     0      41410         24     0       5998     0
     171     0      25447          8     0       2450     0
     105     0      14662          3     0        261     0
     255     0      32342          0     0          0     0
     360     0      36148          0     0          0     0
     155     0      20431          0     0          0     0
     208     0      41817          0     0          0     0
```

en0 can be shown below. After running ifconfig only active was this one. en1 not active as well. So this is default for Wi-Fi connection

```
en0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
        options=6463<RXCSUM,TXCSUM,TSO4,TSO6,CHANNEL_IO,PARTIAL_CSUM,ZEROINVERT_CSUM>
        ether 88:66:5a:33:e9:a5
        inet6 fe80::1c76:8da6:f02d:1010%en0 prefixlen 64 secured scopeid 0x6
        inet 172.21.188.168 netmask 0xffff8000 broadcast 172.21.255.255
        nd6 options=201<PERFORMNUD,DAD>
        media: autoselect
        status: active
```

Command 3: ifconfig -a -v -u -m

-a: Displays information about all network interfaces, including those that are currently down.
-v: Provides more verbose output, including additional details about the network interfaces.
-u: Displays information only for interfaces that are currently up (active).
-m: Displays information about multicast groups.

You can see the screenshot of the output below.

```
(base) sberk@Serkan-MacBook-Pro ~ % ifconfig -a -v -u -m

lo0: flags=8049<UP,LOOPBACK,RUNNING,MULTICAST> mtu 16384 index 1
        eflags=12000000<ECN_DISABLE,SENDLIST>
        xflags=4<NOAUTONX>
        options=1203<RXCSUM,TXCSUM,TXSTATUS,SW_TIMESTAMP>
        capabilities=1203<RXCSUM,TXCSUM,TXSTATUS,SW_TIMESTAMP>
        inet 127.0.0.1 netmask 0xff000000
        inet6 ::1 prefixlen 128
        inet6 fe80::1%lo0 prefixlen 64 scopeid 0x1
        nd6 options=201<PERFORMNUD,DAD>
        link quality: 100 (good)
        state availability: 0 (true)
        timestamp: disabled
        qosmarking enabled: no mode: none
        low power mode: disabled
        multi layer packet logging (mpklog): disabled
        routermode4: disabled
        routermode6: disabled
en5: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500 index 4
        eflags=21000080<TXSTART,ECN_ENABLE,DIRECTLINK>
        xflags=2000<NOSHAPING>
        ether ac:de:48:00:11:22
        inet6 fe80::aede:48ff:fe00:1122%en5 prefixlen 64 scopeid 0x4
        nd6 options=201<PERFORMNUD,DAD>
        media: autoselect (100baseTX <full-duplex>)
        status: active
        supported media:
                media none
                media autoselect
                media 10baseT/UTP mediaopt full-duplex
                media 100baseTX mediaopt full-duplex
                media 1000baseT mediaopt full-duplex
                media 2500Base-T mediaopt full-duplex
        type: Ethernet
        link quality: 100 (good)
        state availability: 0 (true)
        scheduler: FQ_CODEL
        link rate: 100.00 Mbps
        qosmarking enabled: no mode: none
en0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500 index 6
        eflags=452008d0<ADV_REPORT,ACCEPT_RTADV,TXSTART,ARPLL,NOACKPRI,ECN_ENABLE,CHANNEL_DRV,FASTLN_ON>
        options=6463<RXCSUM,TXCSUM,TSO4,TSO6,CHANNEL_IO,PARTIAL_CSUM,ZEROINVERT_CSUM>
        capabilities=6463<RXCSUM,TXCSUM,TSO4,TSO6,CHANNEL_IO,PARTIAL_CSUM,ZEROINVERT_CSUM>
        ether 88:66:5a:33:e9:a5
        inet6 fe80::1c76:8da6:f02d:1010%en0 prefixlen 64 secured scopeid 0x6
```

```
en0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500 index 6
        eflags=452008d0<ADV_REPORT,ACCEPT_RTADV,TXSTART,ARPLL,NOACKPRI,ECN_ENABLE,CHANNEL_DRV,FASTLN_ON>
        options=6463<RXCSUM,TXCSUM,TSO4,TSO6,CHANNEL_IO,PARTIAL_CSUM,ZEROINVERT_CSUM>
        capabilities=6463<RXCSUM,TXCSUM,TSO4,TSO6,CHANNEL_IO,PARTIAL_CSUM,ZEROINVERT_CSUM>
        ether 88:66:5a:33:e9:a5
        inet6 fe80::1c76:8da6:f02d:1010%en0 prefixlen 64 secured scopeid 0x6
        inet 172.21.188.168 netmask 0xffff8000 broadcast 172.21.255.255
        netif: 380E0CCD-08D6-4BB7-BEB8-7B86CC6D3F1C
        flowswitch: 6FD1E5DD-34D0-4D88-BA44-426D7ECFEAD7
        nd6 options=201<PERFORMNUD,DAD>
        media: autoselect
        status: active
        supported media:
                media none
                media autoselect
        type: Wi-Fi
        agent domain:Skywalk type:NetIf flags:0xa443 desc:"Userspace Networking"
        agent domain:Skywalk type:FlowSwitch flags:0x4483 desc:"Userspace Networking"
        agent domain:WiFiManager type:CallInProgress flags:0x3d desc:"WiFi"
        link quality: 100 (good)
        state availability: 0 (true)
        scheduler: FQ_CODEL (driver managed)
        uplink rate: 185.56 Mbps [eff] / 304.20 Mbps
        downlink rate: 185.56 Mbps [eff] / 304.20 Mbps [max]
        qosmarking enabled: yes mode: none
        low power mode: disabled
        multi layer packet logging (mpklog): disabled
        routermode4: disabled
        routermode6: disabled
awdl0: flags=8843<UP,BROADCAST,RUNNING,SIMPLEX,MULTICAST> mtu 1500 index 7
        eflags=453e0080<TXSTART,LOCALNET_PRIVATE,ND6ALT,RESTRICTED_RECV,AWDL,NOACKPRI,ECN_ENABLE,CHANNEL_DRV,FASTLN_ON>
        options=6463<RXCSUM,TXCSUM,TSO4,TSO6,CHANNEL_IO,PARTIAL_CSUM,ZEROINVERT_CSUM>
        capabilities=6463<RXCSUM,TXCSUM,TSO4,TSO6,CHANNEL_IO,PARTIAL_CSUM,ZEROINVERT_CSUM>
        ether da:df:7d:ae:c6:53
        inet6 fe80::d8df:7dff:feae:c653%awdl0 prefixlen 64 scopeid 0x7
        netif: 44D45BFE-459A-463F-89E3-EBED5065B216
        flowswitch: B0C9870B-6E37-4080-BCE1-DFAFA6537807
        nd6 options=201<PERFORMNUD,DAD>
        media: autoselect
        status: active
        supported media:
                media none
                media autoselect
        type: Wi-Fi
        agent domain:Skywalk type:NetIf flags:0xa443 desc:"Userspace Networking"
        agent domain:Skywalk type:FlowSwitch flags:0x4483 desc:"Userspace Networking"
        agent domain:com.apple.wifip2pd type:AWDL flags:0x203 desc:"com.apple.wifip2pd AWDL"
        state availability: 0 (true)
        scheduler: FQ_CODEL (driver managed)
        link rate: 10.00 Mbps
        qosmarking enabled: yes mode: none
        low power mode: disabled
        multi layer packet logging (mpklog): disabled
        routermode4: disabled
        routermode6: disabled
llw0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500 index 8
        eflags=45200090<ADV_REPORT,TXSTART,NOACKPRI,ECN_ENABLE,CHANNEL_DRV,FASTLN_ON>
        xflags=400<LOWLAT>
        options=400<CHANNEL_IO>
        capabilities=400<CHANNEL_IO>
        ether da:df:7d:ae:c6:53
```

```
llw0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500 index 8
        eflags=45200090<ADV_REPORT,TXSTART,NOACKPRI,ECN_ENABLE,CHANNEL_DRV,FASTLN_ON>
        xflags=400<LOWLAT>
        options=400<CHANNEL_IO>
        capabilities=400<CHANNEL_IO>
        ether da:df:7d:ae:c6:53
        inet6 fe80::d8df:7dff:feae:c653%llw0 prefixlen 64 scopeid 0x8
        netif: 641F666D-374C-445B-9B4C-BBEB59F9FF16
        nd6 options=201<PERFORMNUD,DAD>
        media: autoselect
        status: inactive
        supported media:
                media none
                media autoselect
        type: Wi-Fi
        agent domain:Skywalk type:NetIf flags:0x4c3 desc:"Userspace Networking"
        state availability: 0 (true)
        scheduler: FQ_CODEL
        qosmarking enabled: yes mode: none
        low power mode: disabled
        multi layer packet logging (mpklog): disabled
        routermode4: disabled
        routermode6: disabled
en1: flags=8963<UP,BROADCAST,SMART,RUNNING,PROMISC,SIMPLEX,MULTICAST> mtu 1500 index 9
        eflags=41000080<TXSTART,ECN_ENABLE,FASTLN_ON>
        options=460<TSO4,TSO6,CHANNEL_IO>
        capabilities=460<TSO4,TSO6,CHANNEL_IO>
        ether 82:21:09:25:b0:01
        netif: C1D42F0B-BEB7-4490-8032-86EAB3F3882F
        media: autoselect <full-duplex>
        status: inactive
        supported media:
                media autoselect mediaopt full-duplex
        type: IP over Thunderbolt
        agent domain:Skywalk type:NetIf flags:0xa443 desc:"Userspace Networking"
        state availability: 0 (true)
        scheduler: FQ_CODEL
        qosmarking enabled: yes mode: none
        low power mode: disabled
        multi layer packet logging (mpklog): disabled
        routermode4: disabled
        routermode6: disabled
en2: flags=8963<UP,BROADCAST,SMART,RUNNING,PROMISC,SIMPLEX,MULTICAST> mtu 1500 index 10
        eflags=41000080<TXSTART,ECN_ENABLE,FASTLN_ON>
        options=460<TSO4,TSO6,CHANNEL_IO>
        capabilities=460<TSO4,TSO6,CHANNEL_IO>
        ether 82:21:09:25:b0:00
        netif: 584532BF-FDB3-4214-BAB1-DBA52A85A030
        media: autoselect <full-duplex>
        status: inactive
        supported media:
                media autoselect mediaopt full-duplex
        type: IP over Thunderbolt
        agent domain:Skywalk type:NetIf flags:0xa443 desc:"Userspace Networking"
        state availability: 0 (true)
        scheduler: FQ_CODEL
        qosmarking enabled: yes mode: none
        low power mode: disabled
        multi layer packet logging (mpklog): disabled
        routermode4: disabled
        routermode6: disabled
```

```
        routermode4: disabled
        routermode6: disabled
en3: flags=8963<UP,BROADCAST,SMART,RUNNING,PROMISC,SIMPLEX,MULTICAST> mtu 1500 index 11
        eflags=41000080<TXSTART,ECN_ENABLE,FASTLN_ON>
        options=460<TSO4,TSO6,CHANNEL_IO>
        capabilities=460<TSO4,TSO6,CHANNEL_IO>
        ether 82:21:09:25:b0:05
        netif: 97D3A38A-167E-430E-96C3-699AAED9C2C8
        media: autoselect <full-duplex>
        status: inactive
        supported media:
                media autoselect mediaopt full-duplex
        type: IP over Thunderbolt
        agent domain:Skywalk type:NetIf flags:0xa443 desc:"Userspace Networking"
        state availability: 0 (true)
        scheduler: FQ_CODEL
        qosmarking enabled: yes mode: none
        low power mode: disabled
        multi layer packet logging (mpklog): disabled
        routermode4: disabled
        routermode6: disabled
en4: flags=8963<UP,BROADCAST,SMART,RUNNING,PROMISC,SIMPLEX,MULTICAST> mtu 1500 index 12
        eflags=41000080<TXSTART,ECN_ENABLE,FASTLN_ON>
        options=460<TSO4,TSO6,CHANNEL_IO>
        capabilities=460<TSO4,TSO6,CHANNEL_IO>
        ether 82:21:09:25:b0:04
        netif: 224DF50F-09D6-4A42-BA91-EF105A2BB93C
        media: autoselect <full-duplex>
        status: inactive
        supported media:
                media autoselect mediaopt full-duplex
        type: IP over Thunderbolt
        agent domain:Skywalk type:NetIf flags:0xa443 desc:"Userspace Networking"
        state availability: 0 (true)
        scheduler: FQ_CODEL
        qosmarking enabled: yes mode: none
        low power mode: disabled
        multi layer packet logging (mpklog): disabled
        routermode4: disabled
        routermode6: disabled
bridge0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500 index 13
        eflags=41000000<ECN_ENABLE,FASTLN_ON>
        options=63<RXCSUM,TXCSUM,TSO4,TSO6>
        capabilities=63<RXCSUM,TXCSUM,TSO4,TSO6>
        ether 82:21:09:25:b0:01
        Configuration:
                id 0:0:0:0:0:0 priority 0 hellotime 0 fwddelay 0
                maxage 0 holdcnt 0 proto stp maxaddr 100 timeout 1200
                root id 0:0:0:0:0:0 priority 0 ifcost 0 port 0
                ipfilter disabled flags 0x0
        member: en1 flags=3<LEARNING,DISCOVER>
                ifmaxaddr 0 port 9 priority 0 path cost 0
                hostfilter 0 hw: 0:0:0:0:0:0 ip: 0.0.0.0
        member: en2 flags=3<LEARNING,DISCOVER>
                ifmaxaddr 0 port 10 priority 0 path cost 0
                hostfilter 0 hw: 0:0:0:0:0:0 ip: 0.0.0.0
        member: en3 flags=3<LEARNING,DISCOVER>
                ifmaxaddr 0 port 11 priority 0 path cost 0
                hostfilter 0 hw: 0:0:0:0:0:0 ip: 0.0.0.0
        member: en4 flags=3<LEARNING,DISCOVER>
                ifmaxaddr 0 port 12 priority 0 path cost 0
```

```
bridge0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500 index 13
        eflags=41000000<ECN_ENABLE,FASTLN_ON>
        options=63<RXCSUM,TXCSUM,TSO4,TSO6>
        capabilities=63<RXCSUM,TXCSUM,TSO4,TSO6>
        ether 82:21:09:25:b0:01
        Configuration:
                id 0:0:0:0:0:0 priority 0 hellotime 0 fwddelay 0
                maxage 0 holdcnt 0 proto stp maxaddr 100 timeout 1200
                root id 0:0:0:0:0:0 priority 0 ifcost 0 port 0
                ipfilter disabled flags 0x0
        member: en1 flags=3<LEARNING,DISCOVER>
                ifmaxaddr 0 port 9 priority 0 path cost 0
                hostfilter 0 hw: 0:0:0:0:0:0 ip: 0.0.0.0
        member: en2 flags=3<LEARNING,DISCOVER>
                ifmaxaddr 0 port 10 priority 0 path cost 0
                hostfilter 0 hw: 0:0:0:0:0:0 ip: 0.0.0.0
        member: en3 flags=3<LEARNING,DISCOVER>
                ifmaxaddr 0 port 11 priority 0 path cost 0
                hostfilter 0 hw: 0:0:0:0:0:0 ip: 0.0.0.0
        member: en4 flags=3<LEARNING,DISCOVER>
                ifmaxaddr 0 port 12 priority 0 path cost 0
                hostfilter 0 hw: 0:0:0:0:0:0 ip: 0.0.0.0
        nd6 options=201<PERFORMNUD,DAD>
        media: <unknown type>
        status: inactive
        supported media:
                <unknown type>
        state availability: 0 (true)
        qosmarking enabled: yes mode: none
        low power mode: disabled
        multi layer packet logging (mpklog): disabled
        routermode4: disabled
        routermode6: disabled
utun0: flags=8051<UP,POINTOPOINT,RUNNING,MULTICAST> mtu 1380 index 14
        eflags=1002080<TXSTART,NOAUTOIPV6LL,ECN_ENABLE>
        xflags=4<NOAUTONX>
        inet6 fe80::f00e:58c7:ac0:9365%utun0 prefixlen 64 scopeid 0xe
        nd6 options=201<PERFORMNUD,DAD>
        state availability: 0 (true)
        scheduler: FQ_CODEL
        qosmarking enabled: no mode: none
        low power mode: disabled
        multi layer packet logging (mpklog): disabled
        routermode4: disabled
        routermode6: disabled
utun1: flags=8051<UP,POINTOPOINT,RUNNING,MULTICAST> mtu 2000 index 15
        eflags=1002080<TXSTART,NOAUTOIPV6LL,ECN_ENABLE>
        xflags=4<NOAUTONX>
        inet6 fe80::da05:6b24:6eff:b3fd%utun1 prefixlen 64 scopeid 0xf
        nd6 options=201<PERFORMNUD,DAD>
        agent domain:ids501 type:clientchannel flags:0xc3 desc:"IDSNexusAgent ids501 : clientchannel"
        state availability: 0 (true)
        scheduler: FQ_CODEL
        qosmarking enabled: no mode: none
        low power mode: disabled
        multi layer packet logging (mpklog): disabled
        routermode4: disabled
        routermode6: disabled
utun2: flags=8051<UP,POINTOPOINT,RUNNING,MULTICAST> mtu 1000 index 16
        eflags=1002080<TXSTART,NOAUTOIPV6LL,ECN_ENABLE>
        xflags=4<NOAUTONX>
```

```
        media: <unknown type>
        status: inactive
        supported media:
                <unknown type>
        state availability: 0 (true)
        qosmarking enabled: yes mode: none
        low power mode: disabled
        multi layer packet logging (mpklog): disabled
        routermode4: disabled
        routermode6: disabled
utun0: flags=8051<UP,POINTOPOINT,RUNNING,MULTICAST> mtu 1380 index 14
        eflags=1002080<TXSTART,NOAUTOIPV6LL,ECN_ENABLE>
        xflags=4<NOAUTONX>
        inet6 fe80::f00e:58c7:ac0:9365%utun0 prefixlen 64 scopeid 0xe
        nd6 options=201<PERFORMNUD,DAD>
        state availability: 0 (true)
        scheduler: FQ_CODEL
        qosmarking enabled: no mode: none
        low power mode: disabled
        multi layer packet logging (mpklog): disabled
        routermode4: disabled
        routermode6: disabled
utun1: flags=8051<UP,POINTOPOINT,RUNNING,MULTICAST> mtu 2000 index 15
        eflags=1002080<TXSTART,NOAUTOIPV6LL,ECN_ENABLE>
        xflags=4<NOAUTONX>
        inet6 fe80::da05:6b24:6eff:b3fd%utun1 prefixlen 64 scopeid 0xf
        nd6 options=201<PERFORMNUD,DAD>
        agent domain:ids501 type:clientchannel flags:0xc3 desc:"IDSNexusAgent ids501 : clientchannel"
        state availability: 0 (true)
        scheduler: FQ_CODEL
        qosmarking enabled: no mode: none
        low power mode: disabled
        multi layer packet logging (mpklog): disabled
        routermode4: disabled
        routermode6: disabled
utun2: flags=8051<UP,POINTOPOINT,RUNNING,MULTICAST> mtu 1000 index 16
        eflags=1002080<TXSTART,NOAUTOIPV6LL,ECN_ENABLE>
        xflags=4<NOAUTONX>
        inet6 fe80::ce81:b1c:bd2c:69e%utun2 prefixlen 64 scopeid 0x10
        nd6 options=201<PERFORMNUD,DAD>
        agent domain:ids501 type:transport flags:0x4c3 desc:"IDSTransportAgent ids501 : transport"
        state availability: 0 (true)
        scheduler: FQ_CODEL
        qosmarking enabled: no mode: none
        low power mode: disabled
        multi layer packet logging (mpklog): disabled
        routermode4: disabled
        routermode6: disabled
utun3: flags=8051<UP,POINTOPOINT,RUNNING,MULTICAST> mtu 1380 index 17
        eflags=1002080<TXSTART,NOAUTOIPV6LL,ECN_ENABLE>
        xflags=4<NOAUTONX>
        inet6 fe80::583:cf8c:742a:d3f2%utun3 prefixlen 64 scopeid 0x11
        nd6 options=201<PERFORMNUD,DAD>
        state availability: 0 (true)
        scheduler: FQ_CODEL
        qosmarking enabled: no mode: none
        low power mode: disabled
        multi layer packet logging (mpklog): disabled
        routermode4: disabled
        routermode6: disabled
(base) sberk@Serkan-MacBook-Pro ~ %
```

Part 2. Understanding IP and Subnetting:

Q1- I am using Wi-Fi connection and on Macs en0 is default primary network interface. It can be seen from the below 2 screen shots my IP address is 172.21.188.168 and default gateway is (in the 3rd screenshots) 172.21.128.1.

```
(base) sberk@Serkan-MacBook-Pro ~ % ifconfig
lo0: flags=8049<UP,LOOPBACK,RUNNING,MULTICAST> mtu 16384
        options=1203<RXCSUM,TXCSUM,TXSTATUS,SW_TIMESTAMP>
        inet 127.0.0.1 netmask 0xff000000
        inet6 ::1 prefixlen 128
        inet6 fe80::1%lo0 prefixlen 64 scopeid 0x1
        nd6 options=201<PERFORMNUD,DAD>
gif0: flags=8010<POINTOPOINT,MULTICAST> mtu 1280
stf0: flags=0<> mtu 1280
en5: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
        ether ac:de:48:00:11:22
        inet6 fe80::aede:48ff:fe00:1122%en5 prefixlen 64 scopeid 0x4
        nd6 options=201<PERFORMNUD,DAD>
        media: autoselect (100baseTX <full-duplex>)
        status: active
ap1: flags=8802<BROADCAST,SIMPLEX,MULTICAST> mtu 1500
        options=400<CHANNEL_IO>
        ether aa:66:5a:33:e9:a5
        media: autoselect
en0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
        options=6463<RXCSUM,TXCSUM,TSO4,TSO6,CHANNEL_IO,PARTIAL_CSUM,ZEROINVERT_CSUM>
        ether 88:66:5a:33:e9:a5
        inet6 fe80::1c76:8da6:f02d:1010%en0 prefixlen 64 secured scopeid 0x6
        inet 172.21.188.168 netmask 0xffff8000 broadcast 172.21.255.255
        nd6 options=201<PERFORMNUD,DAD>
        media: autoselect
        status: active
awdl0: flags=8843<UP,BROADCAST,RUNNING,SIMPLEX,MULTICAST> mtu 1500
        options=6463<RXCSUM,TXCSUM,TSO4,TSO6,CHANNEL_IO,PARTIAL_CSUM,ZEROINVERT_CSUM>
        ether da:df:7d:ae:c6:53
        inet6 fe80::d8df:7dff:feae:c653%awdl0 prefixlen 64 scopeid 0x7
        nd6 options=201<PERFORMNUD,DAD>
        media: autoselect
        status: active
llw0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
        options=400<CHANNEL_IO>
        ether da:df:7d:ae:c6:53
        inet6 fe80::d8df:7dff:feae:c653%llw0 prefixlen 64 scopeid 0x8
        nd6 options=201<PERFORMNUD,DAD>
        media: autoselect
        status: inactive
en1: flags=8963<UP,BROADCAST,SMART,RUNNING,PROMISC,SIMPLEX,MULTICAST> mtu 1500
        options=460<TSO4,TSO6,CHANNEL_IO>
        ether 82:21:09:25:b0:01
        media: autoselect <full-duplex>
        status: inactive
en2: flags=8963<UP,BROADCAST,SMART,RUNNING,PROMISC,SIMPLEX,MULTICAST> mtu 1500
        options=460<TSO4,TSO6,CHANNEL_IO>
        ether 82:21:09:25:b0:00
```

```
(base) sberk@Serkan-MacBook-Pro ~ % ipconfig getifaddr en0

172.21.188.168
(base) sberk@Serkan-MacBook-Pro ~ %
```

```
(base) sberk@Serkan-MacBook-Pro ~ % netstat -nr | grep default

default            172.21.128.1       UGScg             en0
default                                fe80::%utun0                    UGcIg           utun0
default                                fe80::%utun1                    UGcIg           utun1
default                                fe80::%utun2                    UGcIg           utun2
default                                fe80::%utun3                    UGcIg           utun3
(base) sberk@Serkan-MacBook-Pro ~ %
```

Q2- A subnet mask is a 32-bit(in IPv4) number that divides IP address into network and host. It helps breaking down a larger network into smaller, more manageable segments. It is expressed using CIDR (Classless Inter-Domain Routing) notation. For example "/22" indicates that the first 22 bits are part of the network, and the remaining 32-12=10 bits are used for host addressing.

Q3- Subnet mask is 0xffff8000 as can be seen from the screenshot.
Bitmask corresponding to it is: 11111111.11111111.10000000.00000000
There are 17 leading 1's in the bitmask which means first 17 bits are part of the network and the remaining 32-17=15 bits are used for host addressing.
Subnet mask => 255.255.128.0
Subnet: 172.21.128.0/17

The network address is: 172.21.128.0

```
en0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
        options=6463<RXCSUM,TXCSUM,TSO4,TSO6,CHANNEL_IO,PARTIAL_CSUM,ZEROINVERT_CSUM>
        ether 88:66:5a:33:e9:a5
        inet6 fe80::1c76:8da6:f02d:1010%en0 prefixlen 64 secured scopeid 0x6
        inet 172.21.188.168 netmask 0xffff8000 broadcast 172.21.255.255
        nd6 options=201<PERFORMNUD,DAD>
        media: autoselect
        status: active
```

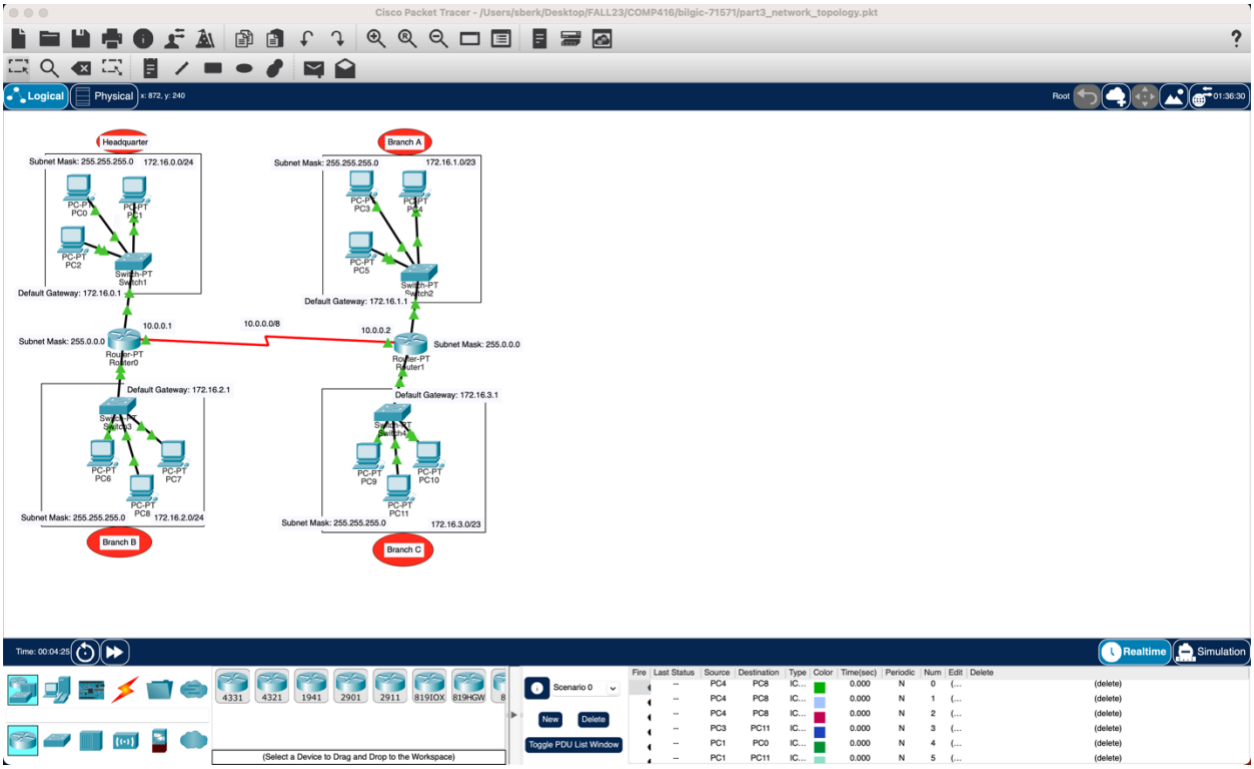
Q4- As can be seen in the screenshot **broadcast address is 172.21.255.255**. However we can also calculate from IP range which is 172.21.128.0 to 172.21.255.255. The first IP is reserved for network address and the last for broadcasting which is 172.21.255.255

```
en0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
        options=6463<RXCSUM,TXCSUM,TSO4,TSO6,CHANNEL_IO,PARTIAL_CSUM,ZEROINVERT_CSUM>
        ether 88:66:5a:33:e9:a5
        inet6 fe80::1c76:8da6:f02d:1010%en0 prefixlen 64 secured scopeid 0x6
        inet 172.21.188.168 netmask 0xffff8000 broadcast 172.21.255.255
        nd6 options=201<PERFORMNUD,DAD>
        media: autoselect
        status: active
```

Q5- Since 17 bits used for network part and remaining 15 for host part we can have up to 2^15-2 hosts connected to this subnet. -2 comes from 2 reservations first one is 172.21.128.0 for network address and the last one 172.21.255.255 for broadcasting.

Part 3. Network Layer Analysis:

Q1-



Q2-

I used Option III 172.16.0.0/20. Although I first selected Option I than I realized that option 1 has limited address space. I had to decide either I will allow 62 hosts inside branch and only 4 branches will not able to extend it if needed or will support up to 8 branches but will have at most 30 hosts inside each hosts. Option II is hard to remember, public and in our demo we give those kind of 10. 11. to routers, it is less human-readable. So I decided not to choose that one as well although it provides more flexibility and future scalability compared to other 2 options. It might be a good option for huge enterprises where there will be lots and lots of branches and lots of hosts inside branches. I thought Option III will be

enough for medium-size enterprises in the below I explained usable ranges, network, broadcast addresses.In the question 4s answer I explained how many branches and hosts it support at maximum.

Headquarter: 172.16.0.0/24
- Subnet: 172.16.0.0/24
- Subnet Mask: 255.255.255.0
- Usable IP range: 172.16.0.1 to 172.16.0.254
- Network address: 172.16.0.0
- Broadcast address: 172.16.0.255

Branch A: 172.16.1.0/24
- Subnet: 172.16.1.0/24
- Subnet Mask: 255.255.255.0
- Usable IP range: 172.16.1.1 to 172.16.1.254
- Network address: 172.16.1.0
- Broadcast address: 172.16.1.255

Branch B: 172.16.2.0/24
- Subnet: 172.16.2.0/24
- Subnet Mask: 255.255.255.0
- Usable IP range: 172.16.2.1 to 172.16.2.254
- Network address: 172.16.2.0
- Broadcast address: 172.16.2.255

Branch C: 172.16.3.0/24
- Subnet: 172.16.3.0/24
- Subnet Mask: 255.255.255.0
- Usable IP range: 172.16.3.1 to 172.16.3.254
- Network address: 172.16.3.0
- Broadcast address: 172.16.3.255

Q3- In the below screenshot you can see all my calculations.

Bit representation.
10101100.00010000.00000000.00000000

Option III: 172.16.0.0/20

I used fir - 24 bits for subnet network and last 8 bit for hosts.

$\underbrace{10101100}_{172}.\ \underbrace{00010000}_{16}.\ \overbrace{\underbrace{00000000}_{0}}^{4\text{ bit}}.\ \underbrace{00000000}_{0}$

I reserved +4 bits to support $2^4 = 16$ branches

$\underbrace{10101100.\ 00010000.\ 0000\underbrace{0000}_{4}}_{\text{first 24 bit used subnet network address}}.\ \underbrace{00000000}_{\text{those 8 bits for hosts inside the each branch}}$

those 4 bits for branches. $2^4 = 16$

it supports up to 16 branches

It supports $2^8 - 2 = 254$ hosts
1 for network address
1 for broadcasting address

So,

<u>Headquarter:</u> 172.16.0.0/24 : 10101100. 00010000. 00000000. 00000000

<u>Branch A:</u> 172.16.1.0/24 : 10101100. 00010000. 00000001. 00000000

<u>Branch B:</u> 172.16.2.0/24 : 10101100. 00010000. 00000010. 00000000

<u>Branch C:</u> 172.16.3.0/24 : 10101100. 00010000. 00000011. 00000000

If new branch added let's call it Branch D, subnet of it would be

<u>Branch D:</u> 172.16.4.0/24 : 10101100. 00010000. 00000100. 00000000

Q4-

Process	Command
Entering to the privileged EXEC mode	*enable*
Global configure mode	*configure terminal*
Configuring interface between router and switch	*interface FastEthernet0/0*
Configuring interface between routers	*interface Serial2/0*
Assigning IP adresses to an interface – between routers	*ip address 10.0.0.1 255.0.0.0*
Assigning IP adresses to an interface – between router-switch	*ip address 172.16.2.1 255.255.254.0*
Configuring routing – route/switch	*ip route 172.16.1.0 255.255.255.0 10.0.0.2*
Configuring routing – route/route	*ip route 10.0.0.0 255.0.0.0 10.0.0.1*
Deleting existing routing	*no ip route 172.16.1.0 255.255.255.0 10.0.0.2*
Enabling routing	*No shutdown*
To exit	*exit*

Equivalent IOS Commands

```
Router>enable
Router#
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#interface FastEthernet0/0
Router(config-if)#ip address 172.16.0.1 255.255.255.0
Router(config-if)#ip address 172.16.0.1 255.255.255.0
Router(config-if)#
Router(config-if)#exit
Router(config)#interface FastEthernet1/0
Router(config-if)#ip address 172.16.2.1 255.255.254.0
Router(config-if)#ip address 172.16.2.1 255.255.255.0
Router(config-if)#ip address 172.16.2.1 255.255.255.0
Router(config-if)#
Router(config-if)#exit
Router(config)#interface Serial2/0
Router(config-if)#
Router(config-if)#
```

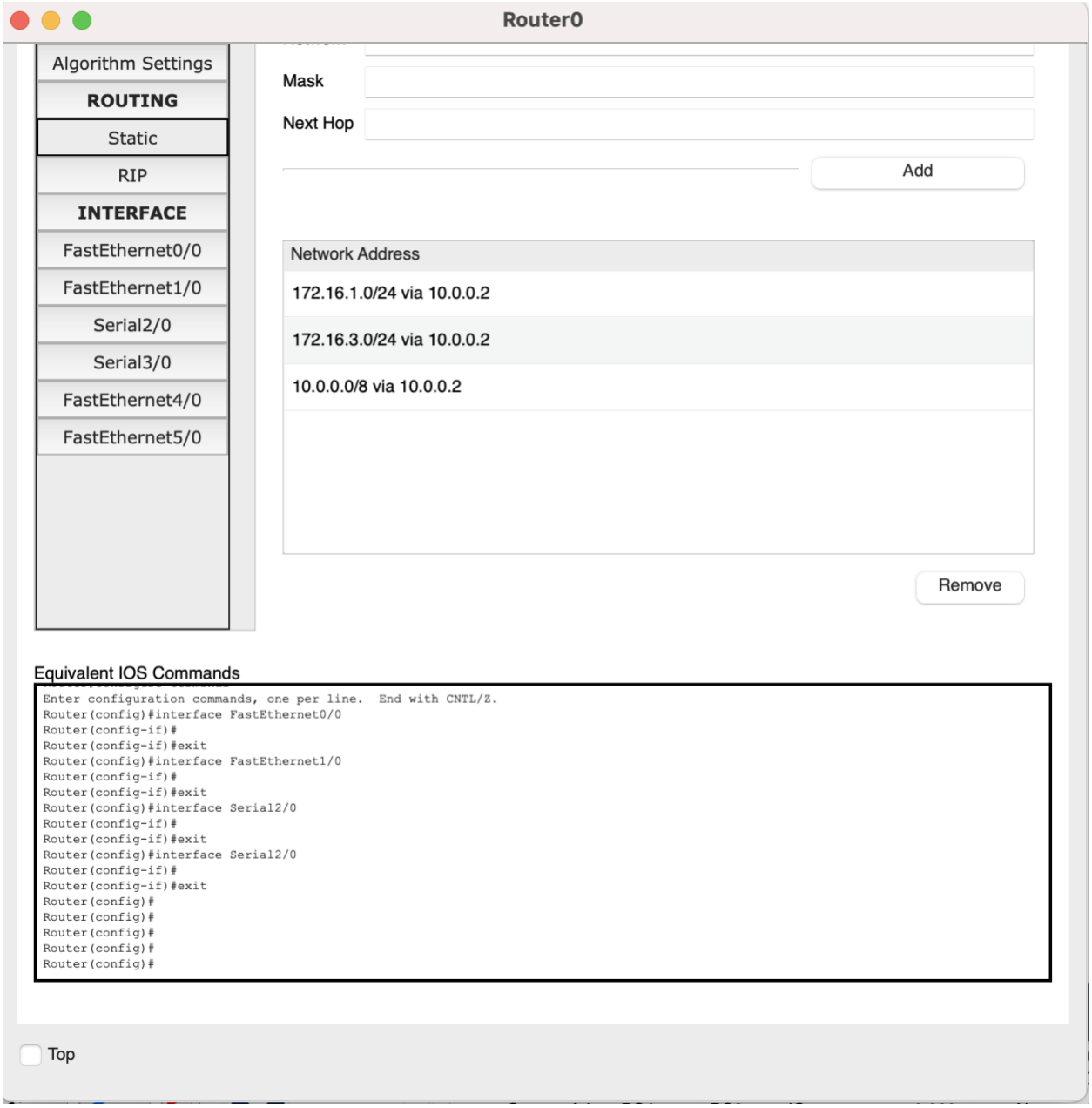
Equivalent IOS Commands

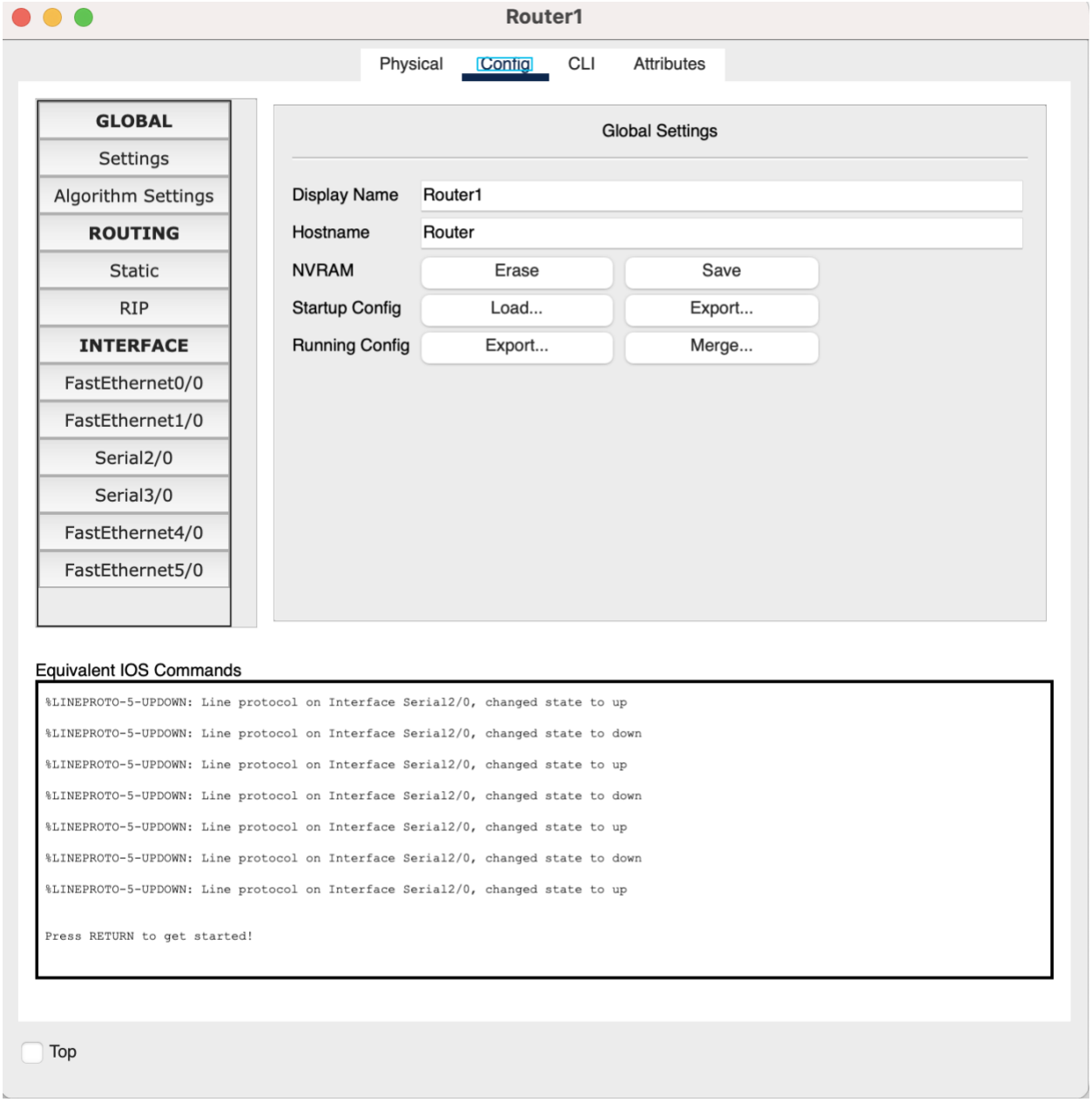
```
Router>enable
Router#
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#interface FastEthernet0/0
Router(config-if)#
Router(config-if)#exit
Router(config)#interface FastEthernet1/0
Router(config-if)#
Router(config-if)#exit
Router(config)#interface Serial2/0
Router(config-if)#
Router(config-if)#exit
Router(config)#interface Serial2/0
Router(config-if)#
Router(config-if)#exit
Router(config)#
Router(config)#
```

Q5- The command to show routing table using command line in Cisco is **show ip route.** Below you can see the screenshots of both the output after executing command and screenshot from GUI(static tab) of the router.

```
Router>show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

C    10.0.0.0/8 is directly connected, Serial2/0
     172.16.0.0/24 is subnetted, 4 subnets
C       172.16.0.0 is directly connected, FastEthernet0/0
S       172.16.1.0 [1/0] via 10.0.0.2
C       172.16.2.0 is directly connected, FastEthernet1/0
S       172.16.3.0 [1/0] via 10.0.0.2

Router>
```

```
Router>show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

C    10.0.0.0/8 is directly connected, Serial2/0
     172.16.0.0/24 is subnetted, 4 subnets
S       172.16.0.0 [1/0] via 10.0.0.1
C       172.16.1.0 is directly connected, FastEthernet0/0
S       172.16.2.0 [1/0] via 10.0.0.1
C       172.16.3.0 is directly connected, FastEthernet1/0

Router>
```


Router0
Algorithm Settings
ROUTING
Static
RIP
INTERFACE
FastEthernet0/0
FastEthernet1/0
Serial2/0
Serial3/0
FastEthernet4/0
FastEthernet5/0
Mask
Next Hop
Add
Network Address
172.16.1.0/24 via 10.0.0.2
172.16.3.0/24 via 10.0.0.2
10.0.0.0/8 via 10.0.0.2
Remove
Equivalent IOS Commands
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#interface FastEthernet0/0
Router(config-if)#
Router(config-if)#exit
Router(config)#interface FastEthernet1/0
Router(config-if)#
Router(config-if)#exit
Router(config)#interface Serial2/0
Router(config-if)#
Router(config-if)#exit
Router(config)#interface Serial2/0
Router(config-if)#
Router(config-if)#exit
Router(config)#
Router(config)#
Router(config)#
Router(config)#
Router(config)#
Top



Q6- In the below screenshots you can see both sending envelope(ss.1) and pinging different hosts between same and different subnets from the CLI(ss.2 & ss.3). Screenshot 2 shows the PC3's command prompt while the last screenshot taken from PC2's. I tried with 2 different hosts in different subnets and I sent at least 4 ping request from each. First one to the host that is in the subnet with the host that I am sending ping. And other 3 to a different hosts each within the 3 different subnets to test all of them.

Realtime Simulation

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Periodic	Num	Edit	Delete
	Successful	PC4	PC8	IC...		0.000	N	1	(...	(delete)
	Successful	PC4	PC8	IC...		0.000	N	2	(...	(delete)
	Successful	PC3	PC11	IC...		0.000	N	3	(...	(delete)
	Successful	PC1	PC0	IC...		0.000	N	4	(...	(delete)
	Successful	PC1	PC11	IC...		0.000	N	5	(...	(delete)
	Successful	PC0	PC8	IC...		0.000	N	6	(...	(delete)

Command Prompt

```
Cisco Packet Tracer PC Command Line 1.0
C:\>ping 172.16.1.3

Pinging 172.16.1.3 with 32 bytes of data:

Reply from 172.16.1.3: bytes=32 time<1ms TTL=128
Reply from 172.16.1.3: bytes=32 time<1ms TTL=128
Reply from 172.16.1.3: bytes=32 time<1ms TTL=128
Reply from 172.16.1.3: bytes=32 time<1ms TTL=128

Ping statistics for 172.16.1.3:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\>ping 172.16.3.4

Pinging 172.16.3.4 with 32 bytes of data:

Reply from 172.16.3.4: bytes=32 time<1ms TTL=127
Reply from 172.16.3.4: bytes=32 time<1ms TTL=127
Reply from 172.16.3.4: bytes=32 time<1ms TTL=127
Reply from 172.16.3.4: bytes=32 time<1ms TTL=127

Ping statistics for 172.16.3.4:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\>ping 172.16.0.2

Pinging 172.16.0.2 with 32 bytes of data:

Reply from 172.16.0.2: bytes=32 time=22ms TTL=126
Reply from 172.16.0.2: bytes=32 time=53ms TTL=126
Reply from 172.16.0.2: bytes=32 time=1ms TTL=126
Reply from 172.16.0.2: bytes=32 time=23ms TTL=126

Ping statistics for 172.16.0.2:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 1ms, Maximum = 53ms, Average = 24ms

C:\>ping 172.16.2.3

Pinging 172.16.2.3 with 32 bytes of data:

Reply from 172.16.2.3: bytes=32 time=34ms TTL=126
Reply from 172.16.2.3: bytes=32 time=1ms TTL=126
Reply from 172.16.2.3: bytes=32 time=51ms TTL=126
Reply from 172.16.2.3: bytes=32 time=37ms TTL=126

Ping statistics for 172.16.2.3:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 1ms, Maximum = 51ms, Average = 30ms

C:\>
```

Command Prompt

```
Cisco Packet Tracer PC Command Line 1.0
C:\>ping 172.16.0.2

Pinging 172.16.0.2 with 32 bytes of data:

Reply from 172.16.0.2: bytes=32 time<1ms TTL=128
Reply from 172.16.0.2: bytes=32 time<1ms TTL=128
Reply from 172.16.0.2: bytes=32 time<1ms TTL=128
Reply from 172.16.0.2: bytes=32 time<1ms TTL=128

Ping statistics for 172.16.0.2:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\>ping 172.16.1.3

Pinging 172.16.1.3 with 32 bytes of data:

Reply from 172.16.1.3: bytes=32 time=103ms TTL=126
Reply from 172.16.1.3: bytes=32 time=52ms TTL=126
Reply from 172.16.1.3: bytes=32 time=68ms TTL=126
Reply from 172.16.1.3: bytes=32 time=31ms TTL=126

Ping statistics for 172.16.1.3:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 31ms, Maximum = 103ms, Average = 63ms

C:\>ping 172.16.1.4

Pinging 172.16.1.4 with 32 bytes of data:

Reply from 172.16.1.4: bytes=32 time=34ms TTL=126
Reply from 172.16.1.4: bytes=32 time=31ms TTL=126
Reply from 172.16.1.4: bytes=32 time=40ms TTL=126
Reply from 172.16.1.4: bytes=32 time=1ms TTL=126

Ping statistics for 172.16.1.4:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 1ms, Maximum = 40ms, Average = 26ms

C:\>ping 172.16.2.3

Pinging 172.16.2.3 with 32 bytes of data:

Reply from 172.16.2.3: bytes=32 time<1ms TTL=127
Reply from 172.16.2.3: bytes=32 time<1ms TTL=127
Reply from 172.16.2.3: bytes=32 time<1ms TTL=127
Reply from 172.16.2.3: bytes=32 time<1ms TTL=127

Ping statistics for 172.16.2.3:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\>ping 172.16.3.3

Pinging 172.16.3.3 with 32 bytes of data:

Reply from 172.16.3.3: bytes=32 time=69ms TTL=126
Reply from 172.16.3.3: bytes=32 time=24ms TTL=126
Reply from 172.16.3.3: bytes=32 time=29ms TTL=126
Reply from 172.16.3.3: bytes=32 time=3ms TTL=126

Ping statistics for 172.16.3.3:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 3ms, Maximum = 69ms, Average = 31ms

C:\>ping 172.16.3.4

Pinging 172.16.3.4 with 32 bytes of data:

Reply from 172.16.3.4: bytes=32 time=47ms TTL=126
Reply from 172.16.3.4: bytes=32 time=38ms TTL=126
Reply from 172.16.3.4: bytes=32 time=39ms TTL=126
Reply from 172.16.3.4: bytes=32 time=1ms TTL=126

Ping statistics for 172.16.3.4:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 1ms, Maximum = 47ms, Average = 31ms

C:\>
```

Command Prompt

```
Cisco Packet Tracer PC Command Line 1.0
C:\>ping 172.16.1.3

Pinging 172.16.1.3 with 32 bytes of data:

Reply from 172.16.1.3: bytes=32 time<1ms TTL=128
Reply from 172.16.1.3: bytes=32 time<1ms TTL=128
Reply from 172.16.1.3: bytes=32 time<1ms TTL=128
Reply from 172.16.1.3: bytes=32 time<1ms TTL=128

Ping statistics for 172.16.1.3:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\>ping 172.16.3.4

Pinging 172.16.3.4 with 32 bytes of data:

Reply from 172.16.3.4: bytes=32 time<1ms TTL=127
Reply from 172.16.3.4: bytes=32 time<1ms TTL=127
Reply from 172.16.3.4: bytes=32 time<1ms TTL=127
Reply from 172.16.3.4: bytes=32 time<1ms TTL=127

Ping statistics for 172.16.3.4:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\>ping 172.16.0.2

Pinging 172.16.0.2 with 32 bytes of data:

Reply from 172.16.0.2: bytes=32 time=22ms TTL=126
Reply from 172.16.0.2: bytes=32 time=53ms TTL=126
Reply from 172.16.0.2: bytes=32 time=1ms TTL=126
Reply from 172.16.0.2: bytes=32 time=23ms TTL=126

Ping statistics for 172.16.0.2:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 1ms, Maximum = 53ms, Average = 24ms

C:\>ping 172.16.2.3

Pinging 172.16.2.3 with 32 bytes of data:

Reply from 172.16.2.3: bytes=32 time=34ms TTL=126
Reply from 172.16.2.3: bytes=32 time=1ms TTL=126
Reply from 172.16.2.3: bytes=32 time=51ms TTL=126
Reply from 172.16.2.3: bytes=32 time=37ms TTL=126

Ping statistics for 172.16.2.3:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 1ms, Maximum = 51ms, Average = 30ms

C:\>
```