

Routing

This lab will guide you through learning how to setup static routes to route traffic between two networks, one a shared, common network and the other a small private network shared only between your system and your neighbor. Additionally, a gateway system on the common network will also provide your systems with internet access. The last page of this handout is a network topology map. Turn-in one filled in handout per computer system by the beginning of class next week. Be sure to include the names of all team members on your lab.

The small private network connects only your system and your immediate neighbor's system (we'll call this **NET192**). The system with two NICs will act as a router, passing traffic from hosts on **NET192** to hosts on the common network **NET10**. Work in pairs of systems; the system with only one NIC will reside only on the **NET192** network, and the system with two NICs will have connections to both of the **NET10** and **NET192** networks, one network per interface. I have setup a gateway machine on **NET10** to ultimately provide your systems with internet access. Some steps are to be performed only by certain systems. Steps that are prefixed with "**NET192**" are to be performed only if your system has an interface connected to the **NET192** network (i.e. both systems). Steps that are prefixed with "**NET10**" are to be performed only if your system has an interface connected to the **NET10** network (i.e. only the router system). The "**NR**" prefix refers to steps for the non-routing system, and likewise the "**R**" prefix is for the routing machine.

Configure the System

Bring the system up single-user and perform the initial network configuration.

- Step 1. Boot your system into single user mode. To accomplish this, reboot the system, and interrupt the Red Hat splash screen at the beginning of the boot process with Control-X. Then type **linux single** at the **boot:** prompt.
- Step 2. Bring up the loopback interface. Your system should now be able to ping itself with **ping localhost**.
- Step 3. Add the entry **10.0.0.200 inet-gw** into the **/etc/hosts** table. This will allow you to refer to the instructor's gateway machine by name.

Configure the NET10 Network

Configure and bring-up the interface connected to the 10.0.0.0/24 network.

- Step 4. **NET10:** Configure your **eth0** interface as shown on the network topology map. Set your **host** part of your IP address to be the number on your computer.
- Step 5. **NET10:** Bring up the network interface (**ifup eth0**). Ping the Internet Router machine (**ping inet-gw**) to ensure connectivity. This machine will be used as your **default** route later.

Configure the NET192 Network

Configure and bring-up the interface connected to the 192.168.0.0/24 network.

- Step 6. Configure the **NET192** interface as shown on the network topology map (i.e. 192.168.routerSystemNum.hostnum). Use the computer number of the router machine as the third octet of the IP address (routerSystemNum). By convention, routers are often host 1 on a network. **R:** use 1 as your host number; **NR:** use 2 as your host number. Following this allows everyone in the lab to know how to determine the IP addresses of any system.
- Step 7. Bring up the appropriate interface connected to the **NET192** network (**ifup interface**).
- Step 8. Add entries in the **/etc/hosts** table for both your system and the other system. Tip: Use generic or relative entries such as **me192** to associate your **NET192** IP address, and **other192** should associate the IP address of the other machine on **NET192**. These relative names allow referring to either the other machine or your own machine regardless of which machine you are on at the moment.
- Step 9. Ping the machine connected on the other end of the **NET192** network to validate the network is operational (**ping other192**).

Learning the Routing Table

Use the **route** and **netstat** network utilities to examine and learn the routing table.

- Step 10. Use the **route -n** command to examine the route table. Enter your configuration in the table on the next page.
- Step 11. Now use the **netstat -rn** command and compare the output with the results entered in the table.

Destination	Gateway	Genmask	Flags	Interface

Step 12. Attempt to ping a machine *not* on your network (**NR:** ping the Internet Router machine - **inet-gw**; **R:** ping some system on the internet (cisco.com is at 198.133.219.25). You should receive the error message "*connect: Network is unreachable*" because your system does not yet know how to reach that network. Examine your route table above to be sure you understand why.

Q1. Why does the ping fail? _____

Create a Default Route

Use the route command to create a default route.

Step 13. To reach any host outside of your immediate network, there must be a route to that network. The easiest way to establish a route is by creating a **default route**. The **default route** is the route used when no other specific route exists for a particular network or host. Since one of your interfaces is connected to a network with a router, you need to specify the router's IP address as the default route. All traffic that has no other place to go will go to the routing system at that address for further routing. Set up a default route to the router on your network. **R:** your router is **inet-gw**, IP address 10.0.0.200; **NR:** your router is **other192** at IP address 192.168.routerSystemNum.1. The command below will create a default route in Linux:

```
# route add default gw router-ip-address
```

Step 14. Examine the route table again - you should see the route you just added. Fill in the table below with the new route.

Destination	Gateway	Genmask	Flags	Interface

Step 15. Once again, ping some machine *not* on your network (**NR:** ping the **inet-gw**; **R:** ping a system on the internet (cisco.com is at 198.133.219.25).

Q2. Does the **ping** succeed this time? Why? _____

Q3. If not, what is different this time compared with the previous **ping**? _____

Step 16. **NR:** Let the **ping** run continuously - if you killed it, re-run it again and let it run. Wait until the router administrator tells you to proceed.

Setting up the Router

Enabling packet forwarding on your system to act as a router.

Step 17. **NET10:** You have routes now to both the **NET10** and **NET192** networks. And host **other192** has a default route with your system acting as their router. However, their network traffic is not being forwarded! This is a security measure in UNIX. Although the routes may be setup properly, by default the system will not forward traffic. You need to tell the kernel to allow packets received on one interface to be forwarded through another interface. This is called **IP Forwarding**. Enabling **IP Forwarding** requires setting a kernel value, and using the **proc** filesystem interface is the easiest way to accomplish this. First, validate for yourself that your system is not set to forward IP traffic:

```
# cd /proc/sys/net/ipv4
# cat ip_forward
```

Q4. NET10: What is the `ip_forward` value set to? _____

Step 18. **NET10:** Now enable IP Forwarding by changing the value to 1.

```
# echo 1 > ip_forward
```

Step 19. **NET10:** You will find that the `ping` from **other192** is still not getting a response (check with the administrator of **other192** to validate this). Although traffic *is* being forwarded by your station, the router **inet-gw** does not know about your private **NET192** network. It too needs a route to your **NET192** network to allow the ICMP response (from ping) to be returned. Log into the Internet Router and examine the routing table on this machine (Login: guest; Password: see the board). Fill in the table below, excluding any **NET192** routes not your own.

Destination	Gateway	Genmask	Flags	Interface

Q5. NET10: Can the Internet Gateway machine access your **NET192** network? _____

Q6. NET10: What command can you use prove this (try it)? _____

Q7. What is the IP address of the gateway used to get your traffic out to the internet? _____

Step 20. Bribe the **inet-gw** administrator to add a route to your **NET192** network via your **NET10** interface (have your **NET192** network number and your **NET10** IP address ready). The command will be:

```
# route add -net 192.168.routerSystemNum.0/24 gw 10.0.0.routerSystemNum
```

Step 21. **NET10:** Once the route to your **NET192** network is established on **inet-gw**, ask the now-very-impatient administrator(s) of **other192** if their traffic is finally reaching **inet-gw**. Tell the administrator (s) it is OK to proceed now!

Validate Internet Access
Validate that your system now has access to the internet

Step 22. Now that you've had success in manually configuring your system to act as a router, you can bring the system up multi-user.

```
# init 3
```

Step 23. Re-enable IP forwarding by placing a 1 in `/proc/sys/net/ipv4/ip_forward` (it was disabled when the system changed run levels).

Step 24. To enable your system to use host and domain names, you need to give the system the IP address of a domain name server. The file `/etc/resolv.conf` is used to specify a DNS server to use. Edit/create this file and add the line **nameserver 153.18.8.1** to the file. Remove any other entries in the file. Try to ping some internet host using its host name (rather than its IP address).

Q8. What is the IP address of gomer.com? _____

Step 25. Start an X session using **startx** and then start a browser to surf the web. Try **telnet** to connect to one of the UNIX systems at Foothill (taipei.fhda.edu, losaltos.fhda.edu, kyoto.fhda.edu, etc.).

Network Diagnostic Tools

Gain experience using network debugging and statistics utilities

Step 26. The **netstat** command has many uses. The **-i** option shows packet statistics and other diagnostics for the various network interfaces. There are statistics for successful packet transmits and receives (TX-OK, RX-OK), and for some of the other errors that could have occurred during packet delivery (general errors, dropped frames, overruns). Run **netstat -i** and spend a few minutes interpreting these statistics.

Q9. How many packets have been transmitted over each interface? _____

Q10. How many packets have been received over each interface? _____

Step 27. Use the Linux command **watch** to repeatedly run **netstat -i** every second. Have someone ping your system, or create some network activity on another terminal. Look for changes in the packet statistics.

```
$ watch -n 1 netstat -i
```

Step 28. The **-s** option of **netstat** shows more detailed statistics.

Q11. How many ping messages were received? _____

Q12. How many were replied to? _____

Q13. NET10: How many packets were forwarded? _____

Step 29. Exit the X session.

Step 30. Run **netstat -s** and obtain the number of active TCP connections.

Q14. How many active TCP connections exist? _____

Step 31. Initiate a telnet session to one of the Foothill UNIX machines (ex. losaltos.fhda.edu, saigon.fhda.edu). On another virtual terminal, run **netstat -s** again.

Q15. How many active TCP connections now exist? _____

Step 32. Examine the ARP table with the **arp** command. Be sure you understand each entry.

Add routes to other NET192 networks

Step 33. **NET10:** Remove the default route and verify the route is gone with **netstat**. Also, try to ping some host on the internet to be sure that you cannot reach that network:

```
# route del default
# netstat -rn
```

Step 34. **NET10:** With the default route gone, neither system should be able to reach hosts on any other private 192.168.x.0/24 network. Set up a specific network route to reach hosts on another 192.168.x.0/24 network. The command below adds a route to the network 192.168.N.0/24 via a router at 10.0.0.N (which is of course on the NET10 network).

```
# route add -net 192.168.N.0/24 gw 10.0.0.N
```

Step 35. Attempt to **ping** the non-router machine on the network for which you just created a route. Use the network topology map to determine the IP address of that machine.

Q16. Did the ping succeed? Explain why or why not: _____

Adding a route to reject traffic

Add a routing table entry to reject traffic to a specific network.

Step 36. **NET10:** Restore the default route to **inet-gw**.

Step 37. **NET10:** Add a reject route to your routing table, which will prevent **NET192** traffic.

```
# route add -net 192.168.routerSystemNum.0/24 reject
```

Step 38. **NET10:** Examine the route table. Fill in the table below with the reject route, specifically noting the Flags:

Destination	Gateway	Genmask	Flags	Interface

Step 39. **NR:** Try to ping the internet gateway machine **inet-gw**. You should find that traffic is blocked by the router machine. Let the ping continue to run.

Step 40. **NET10:** Remove the reject route, using the keyword **del** instead of **add** in the command above. You should see that the ping on the **NR** machine succeeds.

Congratulations! You are now a routing expert.

