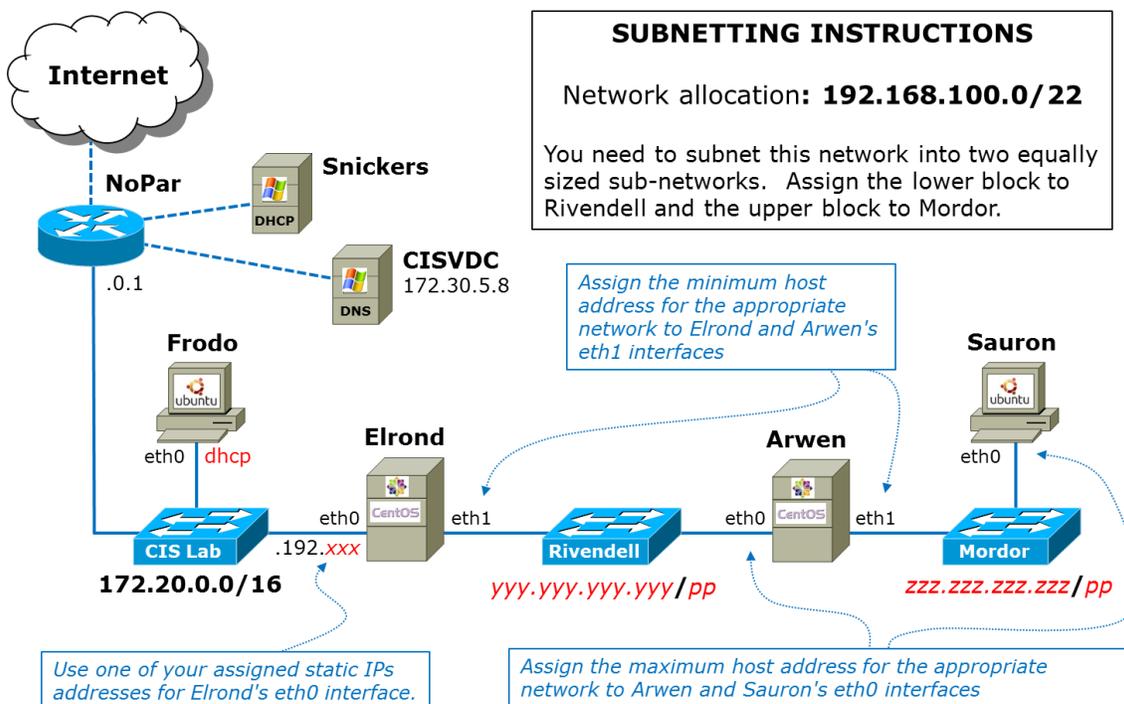# CIS 192 Linux Lab Exercise

Lab 3: Routing
Spring 2013

Lab 3: Configuring a Network Router

The purpose of this lab is to join three network segments (CIS Lab, Rivendell and Mordor) by configuring two routers between them. The three networks are shown below. You will be using four different systems: Frodo will be a client in CIS Lab. Elrond will route between the CIS Lab and Rivendell networks. Arwen will route between Rivendell and Mordor networks. Sauron is a client on the Mordor network. The goal is to obtain connectivity between Frodo in the CIS Lab and Sauron in Mordor by utilizing layer 3 routing. Success will be verified by successfully pinging from one side of the network to the other.

SUBNETTING INSTRUCTIONS

Network allocation**: 192.168.100.0/22**

You need to subnet this network into two equally sized sub-networks. Assign the lower block to Rivendell and the upper block to Mordor.

Assign the minimum host address for the appropriate network to Elrond and Arwen's eth1 interfaces

Use one of your assigned static IPs addresses for Elrond's eth0 interface.

Assign the maximum host address for the appropriate network to Arwen and Sauron's eth0 interfaces

Internet — NoPar — .0.1 — Snickers (DHCP) — CISVDC 172.30.5.8 (DNS)

Frodo — eth0 — dhcp

Elrond — eth0 — .192.*xxx* — eth1

CIS Lab **172.20.0.0/16**

Rivendell — *yyy.yyy.yyy.yyy*/*pp*

Arwen — eth0 — eth1

Mordor — *zzz.zzz.zzz.zzz*/*pp*

Sauron — eth0

Supplies
- Virtualization: VMware ESXi/vSphere (for VLab)
- Centos VMs: Elrond and Arwen
- Ubuntu VMs: Frodo and Sauron
- Virtual networks: Rivendell and Mordor

Forum
Use the forum to ask questions, collaborate, post tips and any lessons learned when you have finished. Forum is at: http://opus.cabrillo.edu/forum/

Preparation
- ☐ Revert to the "Pristine" snapshot on all four VMs.
- ☐ On Opus, make a copy of the lab03 report template file in */home/cis192/depot* in your home directory. Edit the header of this file with your own information and record all the information requested.

Make a plan
- ☐ Make your own network diagram/crib sheet that you can email to me. You can use your tool of choice (e.g. Visio, PowerPoint, etc.) or photograph/scan something you have done by hand (drawing/whiteboard).
- ☐ Do your subnetting calculations. You have been given the block of IP addresses that comprise the 192.168.100.0/22 network. You need to subnet this network into two equally sized sub-networks. Assign the lower block to Rivendell and the upper block to Mordor. Record your network addresses and prefixes on your network diagram next to the appropriate switch.
- ☐ For each subnet determine the minimum (first) and maximum (last) host addresses. Assign the minimum addresses to Elrond and Arwen's eth1 interfaces and the maximum to Arwen and Sauron's eth0 interfaces. Add these IP addresses to the interfaces on your network diagram.
- ☐ Select an IP addresses for Elrond's eth0 interface. Remember the CIS Lab network is shared so use one of your IP addresses from http://simms-teach.com/docs/cis192/Pod-Assignments-192-sp13.pdf to avoid trouble! Add this IP address to your diagram.
- ☐ Frodo uses DHCP so there is no need to configure it with static IP addresses or default gateways. After you have cabled and powered up Frodo, add the IP address it gets to your diagram.
- ☐ Decide the default gateways to configure for Elrond, Arwen and Sauron. The default gateway should be the IP address of the next-hop router on the way towards the Internet. This IP address MUST be on a network connected to the system you are configuring it on.
- ☐ Determine the static routes you will need. These static routes are required to flow traffic destined for your Rivendell and Mordor networks in the right direction (away from the Internet). Don't create any static routes that are redundant with your default gateways or point to a connected network as these are unnecessary. Record the static routes needed on your diagram.
- ☐ Think through all the **ifconfig** and **route** commands you will need to temporarily configure interfaces and routes and add them to the "crib sheet" portion of your diagram.
- ☐ Include commands you intend to use to configure the firewall and packet forwarding.
- ☐ This diagram should be no more than one page but should have everything you need to complete this lab (now or five years from now). Be as creative as you want as there is no right answer for how it should look.

❖ Record the subnetting information for the Rivendell and Mordor networks in your lab report.

Step I - Cable and configure interfaces with IP addresses
- Cable the VMs to match your diagram.
- Power on the VMs.
- Tip: layout the consoles on your screen so they align with your diagram/crib sheet.
- Use **ifconfig** to temporarily configure Elrond, Arwen and Sauron interfaces with the IP addresses and subnet masks on your diagram.
- Frodo uses DHCP so it should already be configured. Record the IP address you got on your diagram.
- Check that each system can ping its neighbor.
- Can a system ping an IP address on a network it's not connected to? No, these pings should fail until we enable packet forwarding.

Step 2 - Packet forwarding
Packet forwarding is disabled by default. For a Linux system to be a router, packet forwarding must be enabled.
- On both Elrond and Arwen, enable packet forwarding:
    echo 1 > /proc/sys/net/ipv4/ip_forward
- Do we need to configure packet forwarding on Frodo and Sauron? No, they are clients and not being used as routers.

Step 3 - Firewall
The default firewall on the CentOS systems does not allow forwarded traffic.
- On both Elrond and Arwen, use the following command to stop the firewall from blocking forwarded traffic:
    iptables -D FORWARD 1
- Do we need to do this on Frodo and Sauron? No, they are clients and not being used as routers.

Step 4 - Default gateways
In this step you will configure default gateway on Sauron, Arwen, and Elrond. Frodo uses DHCP and should already have a default route. Use default gateways to guide network traffic out toward the Internet.

Note: The default gateway selected should be the closest interface of the "next hop" router on the way towards the Internet. Only specify an interface you can ping!

- To set the default gateway on Arwen, use:
    route add default gw 192.168.*xxx*.*xxx*

Tip: A simple typo on the route command can result in a most unhelpful error message. For example, typing 192.169.*xxx.xxx* instead of 192.168.*xxx.xxx* above would get the lovely message:
"SIOCADDRT: No such process"
Just translate it to:
"That gateway is not reachable via a directly connected network -- try again"

- ☐ Using your diagram, set default gateways on Elrond and Sauron by specifying the IP address of the "next hop" router heading towards the Internet.
- ☐ Use **route -n** to verify the default gateways on each system.
- ☐ Does your default gateway on Elrond match the default gateway on Frodo which was automatically configured by the DHCP? It should.

Step 5 - Static routes
Now the real fun begins. The default routes allow us to send traffic out towards the Internet. However at this point there are no routes to guide packets toward the Rivendell and Mordor networks.

If Frodo tries to ping Sauron without static routes configured, the pings will get sent to the Internet (where they will be dropped). Same thing if Elrond tries to ping Sauron, each ping gets directed out to the Internet (because of the default route) and will never return.

If Sauron pings Frodo without static routes configured, the ping request will reach Frodo but the reply will never get back to Sauron!

Let's get those static routes configured:
- ☐ Configure a static route on Frodo that will send Rivendell destination traffic in the right direction. This would be done with:
  > **route add -net** *yyy.yyy.yyy.yyy***/***pp* **gw 172.20.192.***xxx*
  > (where *xxx* is based on your pod's unique IP address on Elrond's eth0 interface)
- ☐ Next configure a second static route on Frodo that will direct Mordor destination traffic in the right direction.
- ☐ Is it possible to replace these two static routes with a single route? Try it and if it works, give yourself a *super* pat on the back!
- ☐ Configure a static route on Elrond so that packets intended for the Mordor network will be directed in the right direction.
- ☐ Do we need a static route on Arwen to get to the Mordor network? No, it's directly connected.
- ☐ Do we need a static route on Sauron or Arwen to get to the CIS Lab network? No, that's already handled by the default gateway.
- ☐ You haven't finished this step till Frodo can ping Sauron. Don't worry about Arwen and Sauron lacking Internet access -- we will solve that in a later lab.

Tip: Test your way one system at a time till everything works. From Frodo, first ping Elrond's eth0 interface. If that works ping Elrond's eth1 interface. If that works ping Arwen's eth0 interface and

so on. Make use of **ifconfig**, **route -n**, **ping**, and even **tcpdump** to verify and understand what is going on. Ping error messages are particularly useful in pinpointing an issue.

Tip: Use the forum to collaborate. Include commands and output in your posts so others can offer help.

   ❖ On Frodo, record output from **ifconfig**, **route -n** and **ping -c3 <Sauron IP address>** commands in your lab report.
   ❖ On Elrond and Arwen, record output from **ifconfig**, **route -n** , **iptables -L** and **cat /proc/sys/net/ipv4/ip_forward** commands in your lab report.
   ❖ On Sauron, record output from **ifconfig** and **route -n** commands in your lab report.

To turn in
Check your work for completeness then submit as many times as you wish up until the due date deadline. Remember, **late work is not accepted**, so start early, plan ahead for things to go wrong and use the forum to ask questions.
   ☐ Email an electronic version of your network diagram/crib sheet to **risimms@cabrillo.edu**
   ☐ Submit your lab report on Opus using:

   cp lab03 /home/rsimms/turnin/cis192/lab03.$LOGNAME

Grading rubric (30 points)

   Lab report
        2 point for a correct submittal into the *turnin* directory
        3 points for a complete header including (name, dates, pod number, time spent)

   Network configuration
        1 points for correct static IP address on Elrond's eth0 interface (based on your pod)
        1 point for correct Mordor network description (size, broadcast address, etc.)
        2 points for correct configuration of Frodo
        2 points for correct configuration of Elrond
        2 points for correct configuration of Arwen
        2 points for correct configuration of Sauron
        5 points for successful ping from Frodo to Sauron

   Network diagram/crib sheet
        1 point for correctly emailing it to risimms@cabrillo.edu
        3 points for a correct network map (showing four VMs, lab router, and switches)
        1 point for labeling all networks (network address with prefix/mask)
        1 point for labeling all interfaces with their names and IP addresses
        1 point for labeling all VMs with hostnames
        1 point for including all default gateways
        1 point for including all static routes
        1 point for including useful commands/files

Extra Credit (5 points)

- (1 point) Update /etc/hosts on Frodo so you can ping Elrond, Arwen and Sauron by name rather than just by IP address. Include the modified /etc/hosts files in your lab report.

- (1 point) From Frodo, ping Elrond, Arwen, and Sauron and explain why the TTL value differs depending on which system is pinged. Copy the ping outputs to your lab report.

- (1 point) Configure Elrond with permanent settings for IP addresses, subnet masks, gateway, and static routes. Include contents of the following files in your lab report:
    - /etc/sysconfig/network
    - /etc/sysconfig/network-scripts/ifcfg-eth0
    - /etc/sysconfig/network-scripts/ifcfg-eth1
    - /etc/sysconfig/network-scripts/route-eth1
  Be sure to test your settings by restarting Elrond.

- (1 point) Modify the firewall permanently on Elrond to allow all packets to be forwarded. Include your /etc/sysconfig/iptables file in your lab report. Be sure to test your settings by restarting Elrond.

- (1 point) Enable packet forwarding permanently on Elrond. Include your /etc/sysctl.conf file in your lab report. Be sure to test your settings by restarting Elrond.