Purpose

- Configure Windows, Mac OS, and Linux for IPv6
- Configure Routers for native IPv6 processing
- Configure a tunnel to transport IPv6 across the IPv4 network
- Use the ping and traceroute commands in an IPv6 environment
- Perform packet capture and analysis of IPv6 packets

Before the Lab

- Review the class notes and the documents on the web site regarding the structure of IPv6 addresses. You will need to be able to analyze and interpret IPv6 addresses for the lab.

Network, Address, and Interface information is in the Pre-Lab.

Steps to Complete

1. Make sure you have the completed pre-lab table handy to look up addresses and networks.
2. Patch a hub into your assigned Buell interface.
3. Patch the Linux machine into the hub. Configure for IPv4 as usual.
4. Telnet to Buell, and configure your ethernet interface for IPv4 as usual.
5. On Buell, go back into interface config mode for your interface. To set up for IPv6, you will need to issue the commands:
   (a) `ipv6 enable`
   (b) `ipv6 address` *global-prefix* `eui-64`
   (c) Note: *global-prefix* is the IPv6 network number and prefix length (/64).
6. Exit config mode and check your interface address assignments using the command `show ipv6 interface ...`. Record the list of multicast addresses for your lab report.
7. Check your Ethernet interface in Linux and note all IPv6 addresses assigned to the interface.
8. **Do not plug the Mac in yet!** Leave the Mac configured for DHCP; *the name server is 2001:468:b02:830::5115*. Start wireshark on Linux and make sure you have a capture running. Now patch the Mac into the same hub as the Linux machine and look for router solicitation and router advertisement packets (save this packet capture). Record the IPv6 addresses assigned to the Ethernet interface on the Mac. *Note: if you need to repeat the process, unplug the Mac, wait a minute or so, then plug it back in*. You will notice that an IPv4 Zeroconf address appears on the Mac after DHCP times out.
9. Use ping6 and traceroute6 (from either Linux or the Mac) to verify connectivity to the IRG router address shown on the diagram. Record the traceroute output for your lab report.
10. While running a packet capture, test IPv6 Internet connectivity from Linux and the Mac with `ping6 www.kame.net`. In the packet captures, find the DNS lookup packets and the actual ping packets. Note the difference between the Linux and the Mac lookups. Use `traceroute6 www.kame.net` and record the path to the kame site.

11. We will now take a look at mDNS. Since each machine will respond to a locally assigned name, we need to locate these names.
    - On the Mac, go to the "Sharing" panel of System Preferences; the machine name is shown at the top. Write down the machine name; in mDNS the full name of the machine is the name you wrote down with ".local" appended to the end.
    - On Linux, type `uname -n` and note down the machine name for Linux (the full name again has ".local" appended to the end).
    - Start a packet capture (either on the Mac or on Linux).
    - On Linux, type the command `avahi-resolve -6 -n` followed by the Mac's name. Note the address(es) that are returned, and look in the packet capture for the mDNS packets.
    - On the Mac, use "`dns-sd -Q <name> AAAA`" where `<name>` is the full mDNS name of the Linux machine. This command does continuous queries, so end with `Ctrl-C`.
    - Save the packet capture.
12. To see an application of this system, start a packet capture (Mac or Linux), then on Linux, type `ssh -6` followed by the mDNS machine name for the Mac. If all is well you should be able to log into your Mac. Verify in the packet capture that you are using ssh over IPv6. If you get an error, ping the address to make sure the name can be resolved, then try the ssh command again.
13. Use the Windows machine to telnet into Davidson and set up your IPv4 Ethernet interface. Davidson has a default route to Buell, but you need to install a route on Buell to reach your Davidson interface via 132.235.201.60.
14. Patch the Student interface of the Windows machine into a switch (do not share a switch with another table), and patch the switch into your assigned Davidson interface. Configure the Student interface with an IPv4 address and a default route. The name server should be set to 132.235.201.115. *Disable the admin interface and leave it off from here on.*
15. Once your Student interface is enabled (and Admin disabled), re-open the IPv4 properties panel. Click the Advanced button and verify that there is only one IPv4 address listed (Windows tries to he helpful and sometimes adds addresses that were used in the past). If there are additional addresses, delete them, leaving only the address you just assigned. Accept the changes and double-check settings on the basic IPv4 properties panel. Verify that you have IPv4 connectivity.
16. Right-click the Student interface icon, select Properties, and look at the check box next to "Internet Protocol Version 6". If it is checked, skip to the next step. If not, click the check box, and click "OK" at the bottom of the dialog (this will start the IPv6 protocol stack). Then re-open the dialog by right-clicking on Student and selecting properties.
17. Open the properties dialog for IPv6. The protocol should be set to automatic. No need to enter a DNS server here.
18. In your command window, use"ipconfig /all"; the list will be quite long. Record the information for the "Student" interface. Then, look for an interface with a description of "Microsoft 6to4 Adapter"; jot down the formal name for that interface, it will start with "Tunnel adapter Local ...". Record the information for this interface for your report.

19. Open a second command window. Enter"netsh" in your command window. You will keep this window for netsh work; the first command window is for stuff like ping, ipconfig, etc. In netsh, enter
    - `interface ipv6` (this takes you to the IPv6 subsystem)
    - `show interface` (gets interface information)

    Match the student and the tunnel interface to the ipconfig listing, and record the interface numbers (from the first column in netsh, labeled "Idx") on your diagram.
20. Re-patch your Mac from your hub to your switch (moving it from the Buell network to the Davidson network).
21. Use ping to verify IPv6 connectivity between Windows and the Mac machine, using link-local addresses. On windows, use `ping -6 <address>%<scope>`, in this case, the scope is the number (index) of the student interface. On the Mac use `ping6 -I en0 <address>`.
22. Use `tracert -6` to find the route from windows to ns.lab.itl.ohiou.edu.
23. We will now configure the 6to4 tunnel to use Buell as the end-point. In netsh, do the following:
    - `pushd` (remember where we were)
    - `6to4` (enter the 6to4 sub-system)
    - `set relay 132.235.201.40 enabled` (change the tunnel target)
    - `popd` (return to the IPv6 sub-system)
24. Use `ipconfig /all` and record the changes in the 6to4 tunnel interface.
25. Use `route print` to record the routes in use on Windows.
26. Repeat the traceroute to ns.lab.itl.ohiou.edu and note any changes.
27. Use `ping -6` and `tracert -6` to verify connectivity from Windows to your Linux machine over IPv6. Start wireshark and record a few ping requests and replies. Examine how the 6to4 tunneling works.
28. We want the Windows machine to act as a 6to4 router to provide IPv6 connectivity for the Mac. First, lets make sure we understand the addressing (refer to your prelab). Take the IPv4 address for your windows machine and convert the 4 bytes into hex, write these as two blocks of 4 hex digits each. The 6to4 prefix for your machine should be 2002 followed by the IPv4 address as converted above. Your tunnel interface should use the IPv4 address in the lowest order bits of the address. Verify that this is the case.
29. We will now add a route on windows to a subnet constructed from the 6to4 address. 2002 and the IPv4 address make a /48 prefix, lets call that 2002:aabb:ccdd::/48 where aabb and ccdd are the IPv4 address in hex. We will give the Student interface the prefix 2002:aabb:ccdd:1::/64; in netsh type:
    - `add route 2002:aabb:ccdd:1::/64 "Student" publish=yes`
    - `show route`
30. Make sure wireshark is running on Windows so you can see the router advertisements. (You can use an ICMPv6 display filter). We will now turn on forwarding and router advertisements. In the commands below, replace `<S>` with the index number of the Student interface, and `<T>` with the index number of the 6to4 tunnel interface. In netsh, type

- `set interface <T> forwarding=enabled` (forward 6to4 in-bound packets)
- `set interface <S> forwarding=enabled advertise=enabled` (forward packets from the interface, and advertise the prefix).
- `pushd` (keep our spot).
- `6to4` (need to do some repair here).
- `set state enabled` (work-around a too-smart OS).
- `popd` (back to IPv6)

Do an `ipconfig /all` in the command window, and a `show interfaces` in netsh, and note any changes. Windows will un-helpfully renumber the interfaces at this point, so record the index numbers for the Student and 6to4 tunnel again on your diagram.

31. Display and record the ifconfig output and the routing table on the Mac. Use `traceroute6` on the Mac to trace the path to your Linux machine.
32. While running wireshark on Windows, use `ping6` from Linux to the Mac. Save this packet capture.
33. While running wireshark on Windows, browse from windows to www.lab.itl.ohiou.edu. Browse to the same site from the Mac. Save this packet capture.
34. *Graduate Students and Extra Credit*
    Issue the `show running-config` command on Buell and look for the setup of the "Tunnel2" interfaces. Record this output. Issue the `show ipv6 route` command on Buell and record the output.

Lab Report Guidelines

Each report is to be written individually, although the data for the lab can be collected during the lab with your partner/group. They should be typed/word processed and brought to class in printed form.

Lab writeups are due **in class** on the Monday following the lab. They don't generally need to be more than a few (several) pages. Officially, they need to be "long enough to answer the questions". See the web page for detailed guidelines. Each lab writeup **must** have a header on the first page that includes:

- Your name
- The lab section that you attended
- Your affiliation (CS ugrad, CS grad, ITS ugrad, MCTP grad)
- Your lab partner's name
- Your lab partner's affiliation

Things you must include

- The patch panel worksheet
- The signed pre-lab.

Your report must answer these questions:

1. List all addresses and multicast groups associated with you interface on Buell.
2. List all addresses for the eth1 interface on Linux.
3. List all addresses for the en0 interface on the Mac while connected to Buell.
4. Show the complete routing table (IPv4 and IPv6) on Linux
5. Show the traceroute6 from either Linux or Mac (while connected to Buell) to the IRG router.
6. Show the IPv6 traceroute from Linux to www.kame.net.
7. Show packet summaries for the following packets:
   (a) Show one router solicitation and one router advertisement packet exchanged between the Mac and Buell.
   (b) Show the DNS query and reply packet resolving the address for www.kame.net.
   (c) Show one mDNS query and the corresponding reply exchanged between Linux and the Mac.
   (d) Show one IPv6 SSH packet exchanged between the Mac and Linux.
8. For the traceroute from windows to ns.lab.itl.ohiou.edu:
   (a) Show the Windows 6to4 tunnel interface detail before 6to4 routing has been pointed at Buell.
   (b) Show the Windows 6to4 tunnel interface detail when 6to4 goes through Buell, and explain the difference to the previous table.

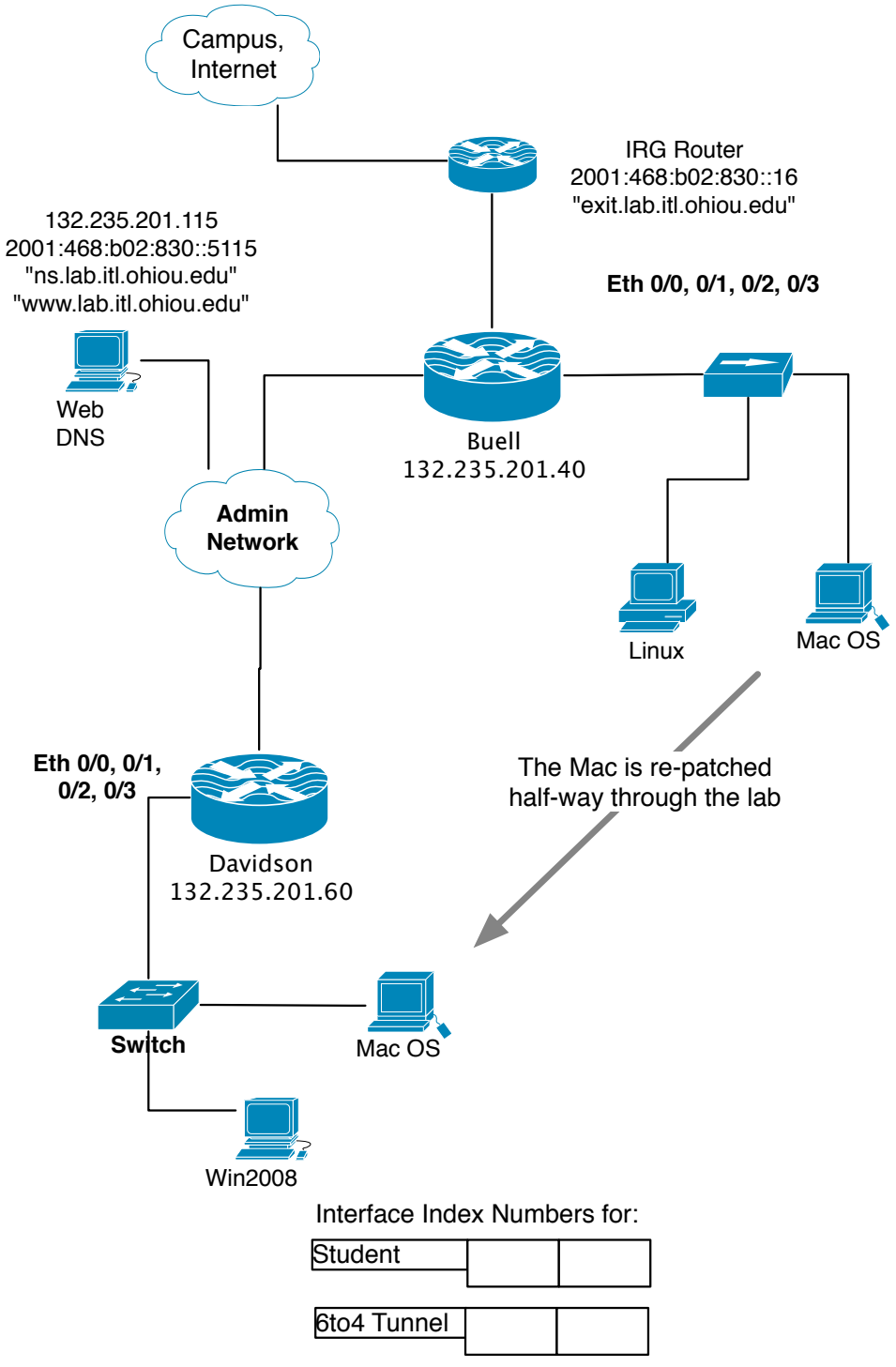
(c) Show both traceroutes and explain their differences from the information in the previous two questions

9. Show one ping packet from Windows to Linux (expand the full packet); list all protocol layers present and explain why this is a "tunnel" packet.
10. Once the Mac is connected to the Windows network and 6to4 tunneling works for the Mac, show all addresses assigned to the en0 interface and the routing table on the Mac.
11. Select a ping request from the Mac to Linux as captured on Windows. Note that the packet appears twice, once as a pure IPv6 packet, and once as a tunneled packet. For these two packets:
    (a) Show the Ethernet type field value in the tunneled packet.
    (b) Show the Ethernet type field value in the pure IPv6 packet.
    (c) Show the IPv4 protocol field value in the tunneled packet.
    (d) Show the IPv6 next header field value in both packets.
12. Show the DNS query and reply when
    (a) Windows resolves www.lab.itl.ohiou.edu
    (b) The Mac resolves www.lab.itl.ohiou.edu
13. Explain the difference in DNS lookup packets between Windows and the Mac.
14. Show two packet summaries which prove that www.lab.itl.ohiou.edu is being retrieved via IPv6.
15. *Graduate Student Question:*
    (a) Explain the tunnel2 interface on Buell. You will need to look up and explain each Cisco command you found in the tunnel interface portion of the configuration.
    (b) Explain each of the IPv6 routes in Buell's routing table.

## Pre-Lab

Fill in the required information below.

| | Table 1 | Table 2 | Table 3 | Table 4 |
|---|---|---|---|---|
| Ethernet Interface on Buell (IPv6) | 0/0 | 0/1 | 0/2 | 0/3 |
| IPv6 Global Prefix on Buell | 2001:468:b02:0838::/64 | 2001:468:b02:0839::/64 | 2001:468:b02:083a::/64 | 2001:468:b02:083b::/64 |
| IPv4 Network on Buell | 132.235.201.144 /29 | 132.235.201.176 /29 | 132.235.201.208 /29 | 132.235.201.240 /29 |
| Buell IPv4 Address | | | | |
| Netmask | | | | |
| Linux IPv4 Address | | | | |
| Ethernet Interface on Davidson (IPv4) | 0/0 | 0/1 | 0/2 | 0/3 |
| IPv4 Network on Davidson | 132.235.201.128 /28 | 132.235.201.160 /28 | 132.235.201.192 /28 | 132.235.201.224 /28 |
| Davidson IPv4 Address | | | | |
| Netmask | | | | |
| Windows IPv4 Address | | | | |
| 6to4 Network Prefix | | | | |


Campus,
Internet
IRG Router
2001:468:b02:830::16
"exit.lab.itl.ohiou.edu"
132.235.201.115
2001:468:b02:830::5115
"ns.lab.itl.ohiou.edu"
"www.lab.itl.ohiou.edu"
Eth 0/0, 0/1, 0/2, 0/3
Web
DNS
Buell
132.235.201.40
Admin
Network
Linux
Mac OS
Eth 0/0, 0/1,
0/2, 0/3
The Mac is re-patched
half-way through the lab
Davidson
132.235.201.60
Switch
Mac OS
Win2008
Interface Index Numbers for:
Student
6to4 Tunnel