IPv6 Host OS Student Lab Guide

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Shared Lab Environment Setup:

See Diagram and Tables for IPv4 and IPv6 addresses for each host OS and router setup. This lab utilizes the EVE-NG Community Edition software running in Google Cloud Platform. You will access your lab via the public IPv4 address listed in the table listed in the Lab Walk Through section.

EVE-NG Community Edition

Eve-ng:
Username: admin

Password: IPv6demo

Console Type select: Html5 console

Linux: CentOS and Ubuntu

CentOS:
Username: root

Password: Test123

Ubuntu:
Username: root

Password: eve

Windows:

Windows 2022 Server:
Username: administrator

Password: Test123

Windows 10:
Username: administrator

Password: eve

Router: Vyos

Vyos:
Username: vyos

Password: vyos

Lab Rules:

Only log into your assigned student lab environment. Logging into any other lab without permission of that student or the instructor is NOT allowed.

Note: If you intentionally destroy or make inoperable a student lab, lab privileges will be revoked for the duration of the training and no refund for the course will be provided.

You can reboot or reload the Linux servers and clients in your assigned student lab.

You can reboot or reload the Windows servers and clients in your assigned student lab.

The router is used to connect all the hosts, if that is shutdown or reloaded your lab hosts will NOT have network connectivity to each other nor will much of the IPv6 lab work be possible. It is not recommended that you reload or shutdown the router. There are also some lab scenarios where the servers are being used for services (such as DNS or DHCPv6) and shutting down those servers will result in lose of functionality. It is up to the good judgement of the student to determine if a server or client system should be reloaded if not explicitly told to do so by the lab guide or the instructor.

Windows Server 2022 will need to have DNS and DHCPv6 built out. Powershell is provided to build out these resources for the lab. The lab recommends using “example.com”, “microsoft.com”, and “msftncsi.com” in DNS along with some simple AAAA records. Installing IIS on Windows so we can test web and DNS from the remote client to show IPv6 access to the resources.

Useful comparison of IPv6 support in operating systems:

The following is a summary of OS support. Unfortunately, there is not a list being maintained that is current around features and functions within the OS for things like RFC 6724 support and other more nuanced issues.

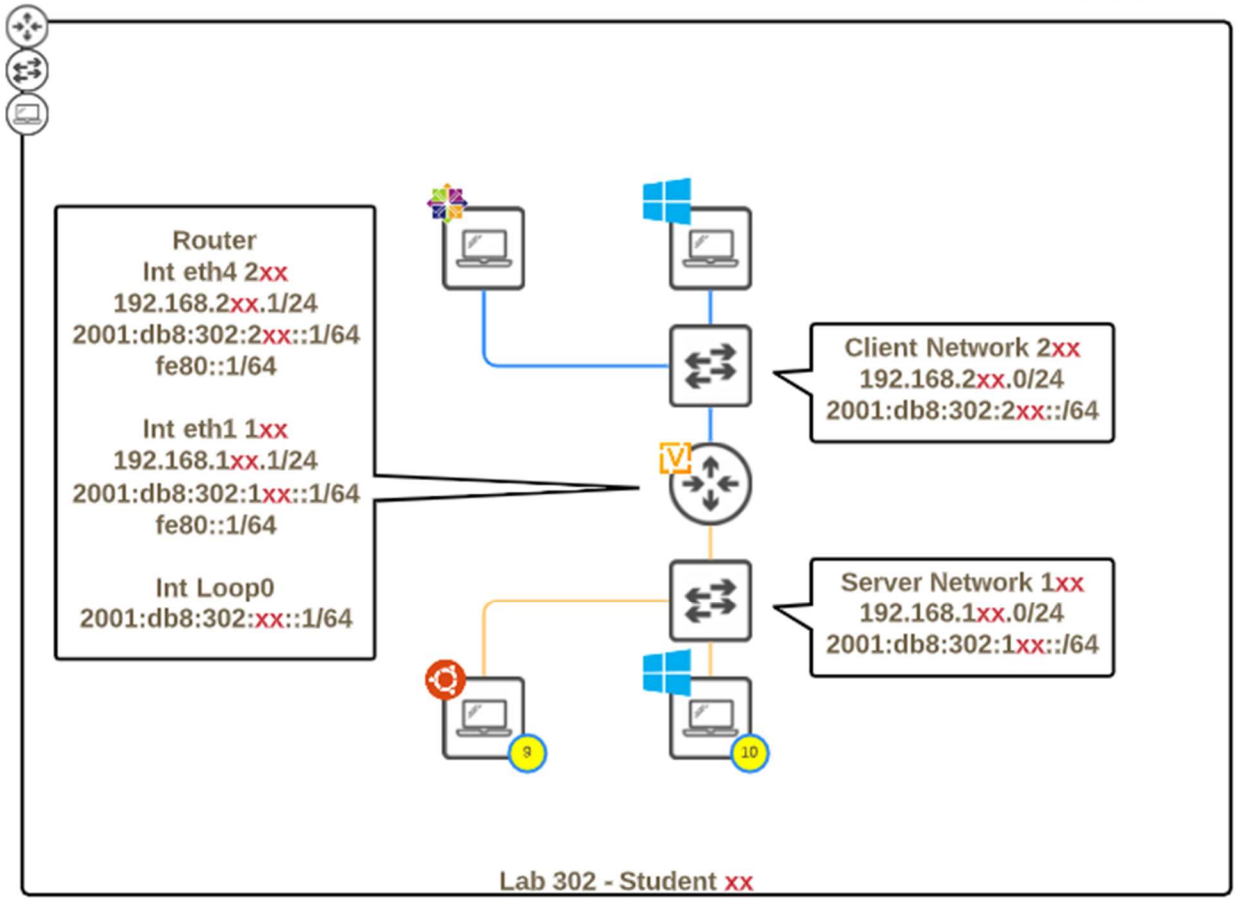
https://en.wikipedia.org/wiki/Comparison_of_IPv6_support_in_operating_systems

Lab Diagrams and Tables

The following lab diagrams and tables are for the Host OS Student Lab environment. The goal of the lab is the demonstrate how specific OS's behave with different IPv6 configurations. Specifically, SLAAC and DHCPv6 along with manual or static IPv6 address configurations. The goal is NOT to provide expertise in the specific OS. Students will need their own laptop with a modern browser and wired/wireless Internet to access the virtual environment.

Overview:

The following diagram is an overview of the lab.



The lab has virtual OS's running on two separate networks. The 101 network is for Servers and 201 network is for Clients. Your student ID number will be the same throughout the duration of this course unless your lab environment has specific issues in which case you may be assigned a new student number.

The lab has a Vyos router that routes between VLAN 101 and VLAN 201 and will also run the Routing Advertisements (RAs) and help provide other network functions. Each student lab has assigned VLANs for that lab environment.

Each Vyos router has specific IPv4 and IPv6 addresses assigned as follows:

Student ID	VLAN ID	IPv4	IPv4 DG	IPv6	Notes
01	101	192.168.101.0/24	192.168.101.1	2001:db8:302:101::/64	
01	201	192.168.201.0/24	192.168.201.1	2001:db8:302:201::/64	

The student Vyos routers are NOT connected to each other for this lab. The lab is NOT connected to the IPv6 Internet. Because all the student environments are isolated from each other, this lab will simply use the same Network ID of 01 for all the labs. The lab is able to connect to the IPv4 Internet for software updates, downloads and installs as needed.

Lab Walk Through

The following is a brief walk through of the lab environment used for this hands-on lab (HOL) self-paced learning.

Logging into the lab environment

This lab is run in Google Cloud Platform (GCP) and uses EVE-NG to run the actual lab environment. EVE-NG is a well-known virtual and lab simulation environment that is often used for networking lab and validation. To access the GCP EVE-NG environment please use the following table for the public IP address, URL, username, and password to gain access to the lab using a regular Internet browser. We recommend Chrome but Firefox, Safari and Microsoft Edge should all work. The EVE-NG VM's will be turn off (shutdown) when the lab is not in use outside of class hours unless specific arrangements are made with the instructor. The browser will list the site as "Not secure" as the site is simply port 80 (http). It is safe to ignore the warnings as these labs are temporary in nature and will be deleted once the class is completed.

Student	Public IP	URL	Username	Password
01	35.192.149.20	http://34.71.249.230/	admin	IPv6demo
02	34.139.141.99	http://34.139.141.99/	admin	IPv6demo
03	34.139.211.66	http:// 34.139.211.66/	admin	IPv6demo
04	34.71.42.171	http:// 34.71.42.171/	admin	IPv6demo
05	34.152.52.241	http:// 34.152.52.241/	admin	IPv6demo
06	35.203.83.152	http:// 35.203.83.152/	admin	IPv6demo
07	34.127.58.43	http:// 34.127.58.43/	admin	IPv6demo
08	35.185.200.39	http:// 35.185.200.39/	admin	IPv6demo
09	34.125.25.160	http:// 34.125.25.160/	admin	IPv6demo
10	34.125.70.152	http:// 34.125.70.152/	admin	IPv6demo
~~11~~	~~34.86.246.208~~	~~http://-34.86.246.208/~~	~~admin~~	~~IPv6demo~~
~~12~~	~~34.85.243.81~~	~~http://-34.85.243.81/~~	~~admin~~	~~IPv6demo~~
13	34.130.8.78	http:// 34.130.8.78/	admin	IPv6demo
14	34.130.235.177	http:// 34.130.235.177/	admin	IPv6demo
15	35.246.72.235	http:// 35.246.72.235/	admin	IPv6demo
16	35.246.84.43	http:// 35.246.84.43/	admin	IPv6demo
17	34.159.200.60	http:// 34.159.200.60/	admin	IPv6demo
18	34.159.145.197	http:// 34.159.145.197/	admin	IPv6demo
19	34.141.203.214	http:// 34.141.203.214/	admin	IPv6demo
20	34.90.67.26	http:// 34.90.67.26/	admin	IPv6demo
21	34.65.80.22	http:// 34.65.80.22/	admin	IPv6demo
~~22~~	~~34.65.92.8~~	~~http://-34.65.92.8/~~	~~admin~~	~~IPv6demo~~

The EVE-NG environment will have a lab listed as HBT-302 and that is the lab to utilize for this HOL guide.

EVE-NG utilized Apache Guacamole for console and remote access of lab resources that are running in the lab. The HTML5 console is limited in some capabilities. Cut and Paste is

one of those that can be a challenge. Apache Guacamole does have a way to pass text from the browser to the local client. You use the following keyboard combinations to bring up the Apache Guacamole menu.

Windows: Ctrl+Alt+Shift

Mac: Ctrl+Command+Shift

Once you put the text into the provided window it is available in the remote console or system to paste. Most of the lab you will be typing in commands so that you develop some associated recall for commands and their functions but there may be times when bulk cut and copy may be useful. This is where the Apache Guacamole menu can be helpful. This menu also provides the option for a keyboard. You will need this to issue a Ctrl+Alt+Del to the Windows Server virtual machines. You can then turn off the on-screen keyboard to enter the password and log into the server (make sure to unclick the Ctrl and Alt keys).

Lab Summary

The labs are designed to teach IPv6 impacts on an OS, not to teach specific application configuration and use. There will be some situations where configuration and set up of an application is required but only for the purposed of using that service in the lab itself. The goals are to understand the differences of how the OS will behave with IPv6 enabled. Both for dual-stack and for IPv6-only situations. The lab topics are:

Lab 1 - Common commands

Lab 2 - Setup and configuration of IPv6

Lab 3 - Address allocation methods

Lab 4- IPv6 behavior

Lab 5 - IPv6 in the data center

Lab 6 - Address and formatting issues

Lab 7 - RA flags and impacts

Lab 8 - General considerations - Open Lab

The initial scripts for the lab routers and the steps to make changes to the router are all in the associated lab router files. These are available via GitHub and should be available at:

https://github.com/hexabuild/hbt302

The file names are structured and start with the course number (hbt-302) and then the lab plus a reference number (lab)<#> followed by the device (rtr, linux, windows) and then the use (initial build, steps, commands). For example, lab 1 router steps would be the file name:

hbt-302-lab1-rtr-steps.txt

The labs reference the file name you need to use for getting the lab initially set up. It will have the file name for the lab steps (for that specific lab) and any reference files (if needed).

The lab sections below describe the goals and objectives for the lab itself and things to consider as you are going through the lab steps. The goal of the labs is not to provide all the answers written out and explained but to require the student to do some critical thinking. There will be cases with the answer is NOT given in the lab guides and you might be required to use some of the reference links, your favorite search engine or even the vendor product documentation to figure out the answer. This is by design. There are plenty of websites that have the information about IPv6 available out there (some good, some not) and focus of the labs is to allow practice in seeing the behavior of host operating systems with IPv6. Often your final IPv6 configuration will be different than what is done in the lab, the goal is to give you enough experience to understand how to tackle deploying and operating your systems to support and work with dual-stack and IPv6-only.

Lab 1 – Host OS Common Commands

Goals and Objectives:

The following lab is to become familiar with host OS commands for IPv6 and how IPv6 information is presented so that you can understand the configuration of the host. Many of the base commands for each operating system are like those used for IPv4 but have slight differences that may impact scripts, automation, monitoring and operating the system. The goals are to know how to use the commands, what syntax may change and finally how to use the output.

This lab requires a basic SLAAC configuration on the Vyos router to allow the Windows and Linux clients to get basic IPv6 information (via an RA). An RDNSS configuration will provide a DNS resolver. The lab is NOT connected to the IPv6 Internet (by design) so there will not be any working name resolution using IPv6 to external resources.

Steps:

1. Do the initial setup file steps to get the lab environment set up properly.
2. Use the reference files for Linux and Windows to try out some of the common commands you will need to know to administer and operate hosts with IPv6 setups

Things to consider:

1. Make sure to understand HOW the commands expect IPv6 and IPv4 addresses are to be represented
2. Note when switches/flags are used in some commands to get the desired behavior
3. Note when some commands are entirely different for IPv6

Initial setup file (this is already loaded as a startup file in EVE-NG, you shouldn't need to do anything to get the Vyos router up and running):

hbt-302-lab1-rtr-init.txt

Reference files:

hbt-302-lab-linux-commands.txt

hbt-302-lab-mac-commands.txt

hbt-302-lab-windows-commands.txt

Useful external reference links:

http://www.teachmeipv6.com/IPv6-Essentials-Reference-Sheet.pdf - Jeff Carrell

https://en.wikipedia.org/wiki/Comparison_of_IPv6_support_in_operating_systems - Wikipedia

https://github.com/buraglio/broken-v6only - Nick Buraglio (new project that Nick is looking for help on contributions - so consider submitting)

Lab 2 – Setup and Configuration

Goals and Objectives:

The following lab is to build on the basic configuration from lab 1 and walk-through specific configuration settings. Go through the following steps:

1. SLAAC and LLA Default Gateway Next Hop.
2. Setting up the OS for manual IPv6 configuration of addresses for servers
3. Setting up the OS for manual DNS configuration for servers
4. Set up the Windows server (with PowerShell or GUI or both) to enable and configure DHCPv6 and DNS - prep for Lab 3
5. Confirming that IPv6 is enabled (and preferred)
6. Resetting interfaces or restarting IPv6 on an interface
7. Show default route (link-local next hop and Global Unicast)
8. Change the OS back to RA listening/aware
9. Change OS back to dynamic DNS listening
10. Describe what is going on with IPv4 on the host and if there are any impacts on IPv6

Things to consider:

1. What information do you NEED to set up a manual IPv6 configuration on a server?
2. Is there an easy way to determine the default gateway?
3. Why is it important to be able to force IPv6-only testing versus just using the defaults?
4. What impact does the RA values have on the host OS?

Initial setup file:

none

Lab steps file:

hbt-302-lab2-linux-steps.txt

hbt-302-lab2-windows-steps.txt

Reference files:

hbt-302-lab-linux-commands.txt

hbt-302-lab-mac-commands.txt

hbt-302-lab-windows-commands.txt

Useful external reference links:

https://docs.microsoft.com/en-us/powershell/module/dhcpserver/?view=windowsserver2019-ps

https://docs.microsoft.com/en-us/powershell/module/dnsserver/?view=windowsserver2019-ps

https://wiki.ubuntu.com/DHCPv6

http://www.cu.ipv6tf.org/pdf/dns_v6.pdf

https://access.redhat.com/solutions/5488011

Lab 3 – Address Allocation Methods

Goals and Objectives:

The following lab is to walk through the different methods of address allocation and to understand what the host OS is doing based on the values provided via the RA or DHCPv6. The lab will start with SLAAC initially and then switch the router to DHCPv6.

Steps:

1. Do lab initial setup
2. Use Vyos scripts to change the router from SLAAC to DHCPv6 (Flag combinations)
3. Once the DHCPv6 relay and listener interfaces are set up, check the host OS to see what they have configured and why.
4. Reload the OS or down/up the interface and check the host OS
5. Use reference file commands to determine SLAAC settings and DHCPv6 settings
6. What is interesting about a new DHCPv6 prefix scope?
7. What is interesting about a new SLAAC prefix on the Vyos router?
8. Test to internal web server - what interface address is being used?
9. How do you determine if the host is doing DHCPv6 or SLAAC?
10. Test to the web server to determine what is going on?
11. Does it matter what dual-stack setup and GUA, ULA or LLA is used?

Initial setup file:

none

Lab steps file:

hbt-302-lab3-rtr-steps.txt

hbt-302-lab3-linux-steps.txt

hbt-302-lab3-windows-steps.txt

Reference files:

hbt-302-lab-linux-commands.txt

hbt-302-lab-mac-commands.txt

hbt-302-lab-windows-commands.txt

Lab 4 – IPv6 Behavior

Goals and Objectives:

The following lab is to review in more detail the specific IPv6 behavior identified in lab 3. There will be several combinations of IPv4, IPv6 and different IPv6 address types used in the lab. The goal is to become familiar with the impacts of some combinations on the OS.

Steps:

1. Do lab initial setup (if needed)
2. Run through DHCPv6 and SLAAC combinations - IPv6-only
3. Run through dual-stack combinations - set up IPv4 on Vyos
4. Which address type is used for what purpose?
5. What impacts do some combinations have on the OS?
6. How is duplicate address detection functioning?
7. What impact does duplicate LLA have on routers? On the OS?
8. How does the IPv4 and IPv6 routing table look different?
9. How is happy eyeballs impacting behavior?
10. Do transition technologies have any impact?

Initial setup file:

none

Lab steps file:

hbt-302-lab4-rtr-steps.txt

Reference files:

hbt-302-lab-linux-commands.txt

hbt-302-lab-mac-commands.txt

hbt-302-lab-windows-commands.txt

Lab 5 – IPv6 in the Data Center

Goals and Objectives:

IPv6 in the Data Center has some differences in terms of how you want it to operate. You likely will NOT want RAs coming from the Vyos router.

Steps:

1. Do lab initial setup (if needed)
2. Turn off DHCPv6 and SLAAC combinations and the RA
3. Manually configure the host with a static IPv6 address
4. Manually set up the default gateway
5. Test connectivity to the Vyos router
6. Is there a better way to set up the default gateway on the Vyos and the host?
7. Why do you not want RAs?

Initial setup file:

none

Lab steps file:

hbt-302-lab5-rtr-steps.txt

Reference files:

hbt-302-lab-linux-commands.txt

hbt-302-lab-mac-commands.txt

hbt-302-lab-windows-commands.txt

Lab 6 – Address and Formatting Issues

Goals and Objectives:

This lab is to allow time on the OS to determine syntax and format differences in terms of how IPv6 is represented in command line and in applications. Just try out a variety of command line syntax with different IPv6 and IPv4 addresses.

Initial setup file:

none

Lab steps file:

none

Reference files:

hbt-302-lab-linux-commands.txt

hbt-302-lab-mac-commands.txt

hbt-302-lab-windows-commands.txt

Lab 7 – RA Flags and Impacts

Goals and Objectives:

The combinations for RA flag settings can have different impacts on the host OS. Try adding additional prefixes to the Vyos router and different flag settings.

Initial setup file:

none

Lab steps file:

hbt-302-lab7-rtr-steps.txt

Reference files:

hbt-302-lab-linux-commands.txt

hbt-302-lab-mac-commands.txt

hbt-302-lab-windows-commands.txt

Lab 8 – General Considerations - Open Lab

Goals and Objectives:

Open lab time to work through general considerations that the student might have in their environment that they want to test or work through.

Initial setup file:

none

Lab steps file:

none

Reference files:

hbt-302-lab-linux-commands.txt

hbt-302-lab-mac-commands.txt

hbt-302-lab-windows-commands.txt

Prefix Policy Table Reference Information

Windows 10+ and Server 2016+ default Prefix Policy Table values:

Prefix	Precedence	Label
3ffe::/16	1	12
fec0::/10	1	11
::/96	1	3
fc00::/7	3	13
2001::/32	5	5
2002::/16	30	2
::ffff:0:0/96	35	4
::/0	40	1
::1/128	50	0

Linux default Prefix Policy Table “label” values:

```
#label ::1/128       0
#label ::/0          1
#label 2002::/16     2
#label ::/96         3
#label ::ffff:0:0/96 4
#label fec0::/10     5
#label fc00::/7      6
#label 2001:0::/32   7
```