





Build Your Own IPv6 Learning Lab - for FREE






Build Your Own IPv6 Learning Lab - for FREE

Jeffrey L Carrell
Networking & Big Data
Instructor/Course Developer
Hewlett Packard Enterprise
(the day job, this presentation is not part of that)
jeff.carrell@teachmeipv6.com
@JeffCarrell_v6



Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell

1



Building your own IPv6 learning lab

- Virtual technology options
- What our IPv6 lab may look like
- IPv6 basics
- IPv6 in Wireshark
- IPv6 resources

Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell

2

Build Your Own IPv6 Learning Lab - for FREE



What is this presentation about?

- It is about building a no-cost * virtual lab environment specifically targeted to gain experience on IPv6

* assumes you have a computer with at least a dual-core processor, 8G RAM, 250G storage, less than 8yrs old (depends on CPU), and it must support VT-x or AMD-V (nested virtualization).

More CPU/memory capability available will provide for a better experience

** if only 8GB RAM, probably limited to Linux clients only
[no Windows clients recommended in less than 16GB RAM of host RAM available]

Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell

3



Building your own lab

- Can be with equipment
 - Cost, space, power, heat, noise
- Can be with virtual systems
 - Some free resources, some cost (optional)
- Subscription labs
 - Cost, access, duration

Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell

4

Build Your Own IPv6 Learning Lab - for FREE



Virtual lab system - options

- VMware Player/Workstation/Fusion/ESXi
- Oracle VM VirtualBox
- GNS3, EVE-NG, Dynamips, QEMU
- Cisco Modeling Labs
- Biggest issue, getting legal licenses for devices. Some vendors charge, some don't...

Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell

5



Virtual lab system - Type 2 Hypervisors

- VMware Personal Desktop
 - Workstation Player (free)
 - not as flexible
 - Workstation Pro (\$)
 - Fusion Pro for MAC (\$)
- Oracle VM VirtualBox (free)

Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell

6

Build Your Own IPv6 Learning Lab - for FREE



Virtual lab system – Emulators

- GNS3 (free)
 - Graphical Network Simulator-3
- EVE-NG (free/\$)
 - Emulated Virtual Environment Next Generation
- Cisco Modeling Labs - Personal (\$)
 - fka VIRL

Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell

7



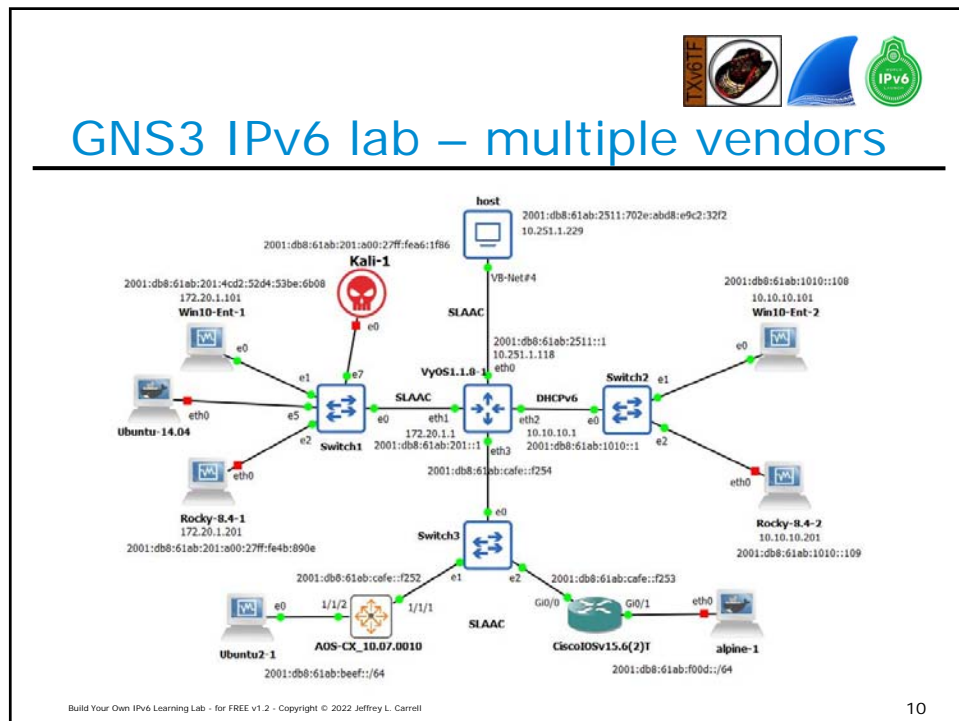
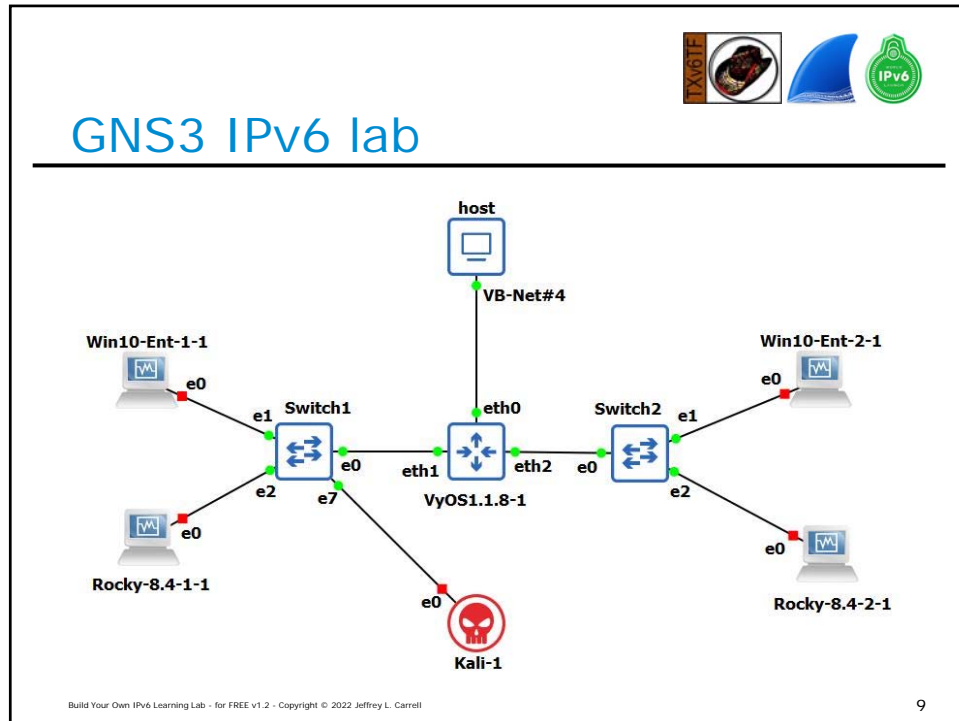
IPv6 virtual lab system

- Your computer
- VirtualBox (free)
- GNS3 (free)
- VyOS (free, older version)
- Windows client (free, timed eval)
- Linux client (free)

Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell

8

Build Your Own IPv6 Learning Lab - for FREE



The diagram illustrates a network topology for an IPv6 Learning Lab, divided into Physical Devices and Virtual Devices.

Physical Devices:

- Cisco-3850-1:** A physical switch with interface `gi0/21` (IP: `2001::db8:61ab:2511::7254`) connected to **Switch3** via interface `e2`.
- host_laptop:** A physical laptop with interface `VMnet15` connected to **Switch3** via interface `e1`.

Virtual Devices:


- Win10-Ent-1-1:** A virtual Windows 10 Enterprise laptop connected to **Switch1** via interface `e0`.
- Rocky-8.4-1-1:** A virtual Rocky Linux 8.4 laptop connected to **Switch1** via interface `e0`.
- Ubuntu-1:** A virtual Ubuntu laptop connected to **Switch1** via interface `eth0`.
- alpine-1-1:** A virtual Alpine Linux laptop connected to **Switch1** via interface `eth0`.
- Switch1:** A virtual switch connected to **Switch3** via interface `e1` and **SLAAC** via interface `e0`.
- Switch3:** A virtual switch connected to **Cisco-3850-1** via interface `e2` and **SLAAC** via interface `e0`.
- SLAAC:** A virtual switch connected to **Switch3** via interface `e0` and **Switch2** via interface `eth1` (IP: `2001::db8:61ab:2011::1`).
- Switch2:** A virtual switch connected to **SLAAC** via interface `eth1` and **DHCPv6** via interface `eth0` (IP: `2001::db8:61ab:1010::1`).
- DHCPv6:** A virtual switch connected to **Switch2** via interface `eth0`.
- Switch2:** A virtual switch connected to **DHCPv6** via interface `eth0`.
- VyOS1.8-1:** A virtual switch connected to **SLAAC** via interface `eth0` (IP: `2001::db8:61ab:2511::1`) and **Switch2** via interface `eth2` (IP: `2001::db8:61ab:1010::1`).

11

Address Type	IPv4	IPv6
Default Route	0.0.0.0/0	::/0
Unspecified	0.0.0.0/32	::/128
Loopback	127.0.0.1/8	::1/128
Multicast	224.0.0.0/4	ff00::/8
Link-Local	169.254.0.0/16	fe80::/10
Global Unicast	All others	2000::/3
Unique Local	10.0.0.0/8 172.16.0.0/12 192.168.0.0/16	fc00::/7 * use fd00::/8
Documentation	192.0.2.0/24 198.51.100.0/24 203.0.113.0/24	2001:db8::/32

12

Build Your Own IPv6 Learning Lab - for FREE



IPv6 default for subnet

- Based on the default definition an IPv6 address is logically divided into two parts: a 64-bit network prefix and a 64-bit interface identifier (IID)
- Therefore, the default subnet size is /64
- 2001:0db8:1010:61ab:f005:ba11:00da:11a5/64

64bits for Network Identifier


64bits for Interface Identifier

Prefix Length

- A single /64 network yields 18 billion-billion possible addresses

Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell

13



Interface ID from MAC address

Company ID Manufacturer Data

00 19 71 64 3F 00

IEEE 48-Bit MAC Address

00 19 71 FF FE 64 3F 00

Expand to EUI-64
(IEEE Extended Unique ID)

00000000

00000010

7th bit inverted – Local/Global bit

02 19 71 FF FE 64 3F 00

Invert the Local/Global Bit

0219:71ff:fe64:3f00

Modified EUI-64
Interface ID

Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell

14

Build Your Own IPv6 Learning Lab - for FREE



Interface ID from Random Number

- RFC 4941 - Privacy Extensions for Stateless Address Autoconfiguration in IPv6
- Initial IID is derived based on mathematical computation to create a "random 64bit number" and appended to prefix to create a GUA
- An additional but different 64bit number is computed, appended to prefix, and tagged "temporary" for a 2nd GUA
- Temporary GUA should be re-computed on a frequent basis
- Temporary GUA is used as primary address for communications, as it is considered "more secure"

Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell

15






IPv6 autoconfiguration options

Address Autoconfiguration Method	ICMPv6 RA (Type 134) Flags M Flag O Flag		ICMPv6 RA (Type 134) ICMPv6 Option Prefix Info A Flag L Flag		Prefix Derived from	Interface ID Derived from	Other Configuration Options	# of IPv6 Addr
Link-Local (always configured)	N/A	N/A	N/A	N/A	Internal (fe80::)	M-EUI-64 or Privacy	Manual	1
Manual	Off	Off	Off	On	Manual	Manual	Manual	2 (LL, Manual)
SLAAC	Off	Off	On	On	RA	M-EUI-64 or Privacy	Manual	3 (LL, IPv6, IPv6 temp)
Stateful (DHCPv6)	On	N/R	Off	On	DHCPv6	DHCPv6	DHCPv6	2 (LL, DHCPv6)
Stateless DHCPv6	Off	On	On	On	RA	M-EUI-64 or Privacy	DHCPv6	3 (LL, IPv6, IPv6 temp)
Combination Stateless & DHCPv6	On	N/R	On	On	RA and DHCPv6	M-EUI-64 or Privacy and DHCPv6	DHCPv6	4 (LL, IPv6, IPv6 temp, DHCPv6)

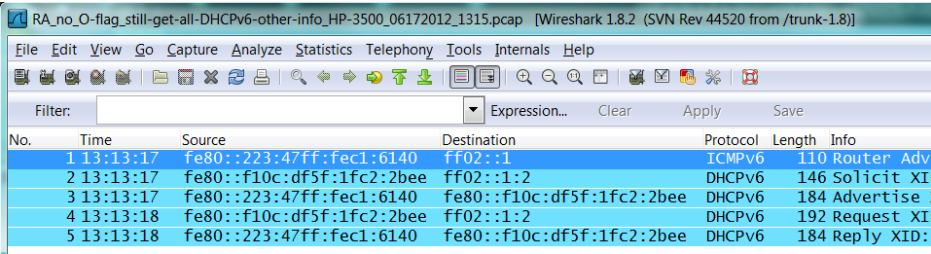
Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell

16

Build Your Own IPv6 Learning Lab - for FREE



IPv6 Stateful (DHCPv6) process






No.	Time	Source	Destination	Protocol	Length	Info
1	13:13:17	fe80::223:47ff:fec1:6140	ff02::1	ICMPv6	110	Router Adv
2	13:13:17	fe80::f10c:df5f:1fc2:2bee	ff02::1:2	DHCPv6	146	Solicit XI
3	13:13:17	fe80::223:47ff:fec1:6140	fe80::f10c:df5f:1fc2:2bee	DHCPv6	184	Advertise
4	13:13:18	fe80::f10c:df5f:1fc2:2bee	ff02::1:2	DHCPv6	192	Request XI
5	13:13:18	fe80::223:47ff:fec1:6140	fe80::f10c:df5f:1fc2:2bee	DHCPv6	184	Reply XI

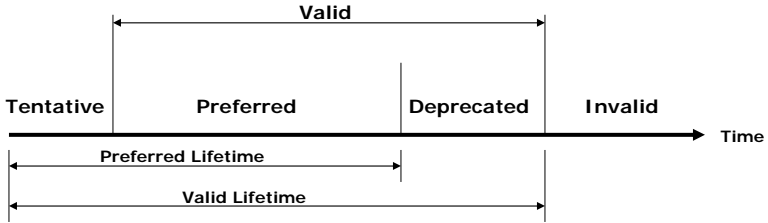
- DHCPv6Solicit = DHCPDiscover (IPv4)
- DHCPv6Advertise = DHCPOffer (IPv4)
- DHCPv6Request = DHCPRequest (IPv4)
- DHCPv6Reply = DHCPAck (IPv4)

Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell

17



States of an IPv6 address (timers)



The diagram illustrates the lifecycle of an IPv6 address. It starts in the **Tentative** state. Once verified, it moves to the **Preferred** state. After a period, it becomes **Deprecated**, and finally **Invalid**. The **Preferred Lifetime** timer starts at the beginning of the Preferred state. The **Valid Lifetime** timer starts at the beginning of the Preferred state and ends at the beginning of the Invalid state.

- Tentative – address is in process of verification for uniqueness and is not yet available for regular communications
- Valid – address is valid for use in communication based on Preferred and Deprecated status
- Preferred – address is usable for all communications
- Deprecated – address can still be used for existing sessions, but not for new sessions
- Invalid – an address is no longer available for sending or receiving

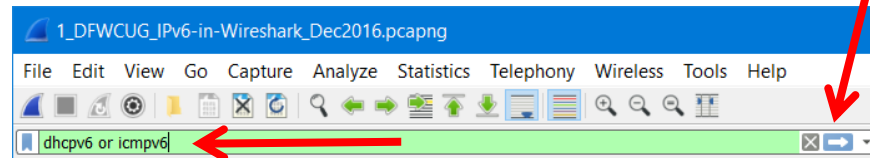
Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell

18

Build Your Own IPv6 Learning Lab - for FREE

Using Wireshark to view IPv6 pkts

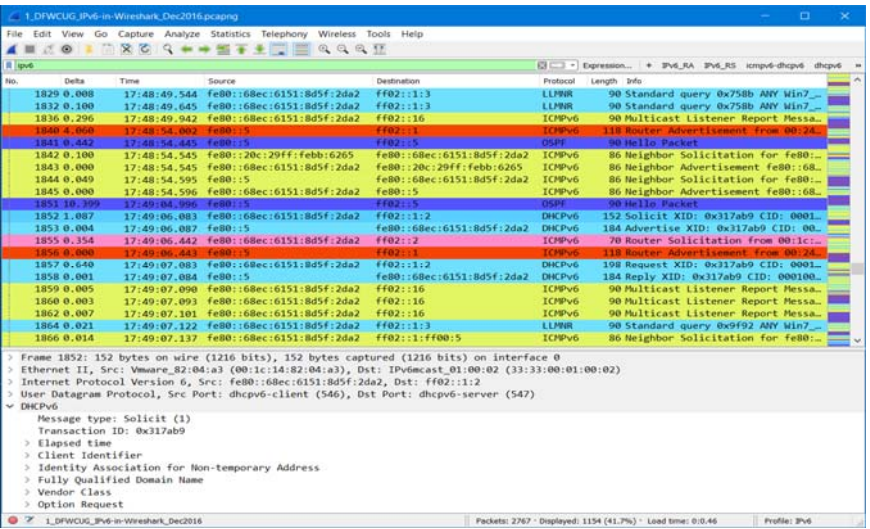
- IPv6 display filter families
 - ipv6
 - icmpv6
 - dhcpv6
- IPv6 related display filters:
 - <http://www.wireshark.org/docs/dfref/i/ipv6.html>



Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell

19


Jeff's IPv6 Wireshark



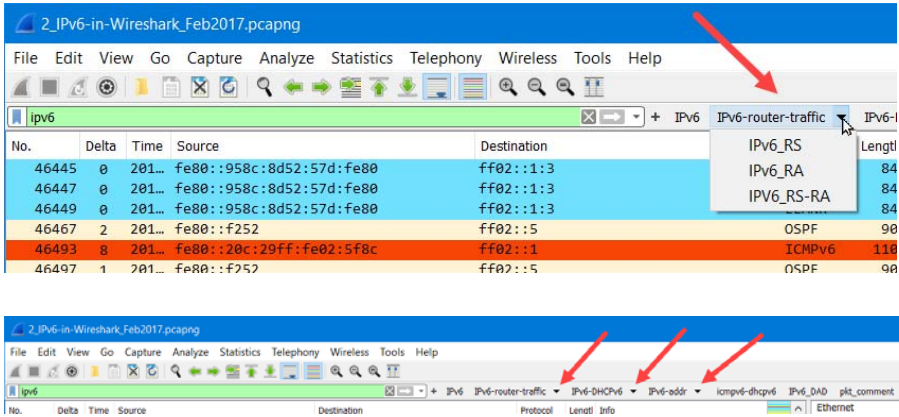
Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell

20

Build Your Own IPv6 Learning Lab - for FREE




Nested display filter buttons

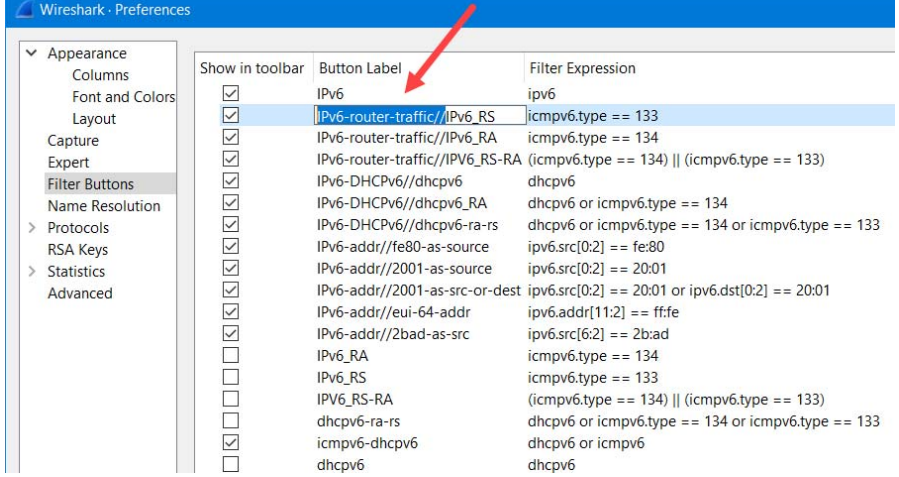


Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell

21



Nested display filter buttons



Show in toolbar	Button Label	Filter Expression
<input checked="" type="checkbox"/>	IPv6	ipv6
<input checked="" type="checkbox"/>	IPv6-router-traffic/IPv6_RS	icmpv6.type == 133
<input checked="" type="checkbox"/>	IPv6-router-traffic/IPv6_RA	icmpv6.type == 134
<input checked="" type="checkbox"/>	IPv6-router-traffic/IPv6_RS-RA	(icmpv6.type == 134) (icmpv6.type == 133)
<input checked="" type="checkbox"/>	IPv6-DHCPv6/dhcpv6	dhcpv6
<input checked="" type="checkbox"/>	IPv6-DHCPv6/dhcpv6_RA	dhcpv6 or icmpv6.type == 134
<input checked="" type="checkbox"/>	IPv6-DHCPv6/dhcpv6-ra-rs	dhcpv6 or icmpv6.type == 134 or icmpv6.type == 133
<input checked="" type="checkbox"/>	IPv6-addr/fe80-as-source	ipv6.src[0:2] == fe:80
<input checked="" type="checkbox"/>	IPv6-addr/2001-as-source	ipv6.src[0:2] == 20:01
<input checked="" type="checkbox"/>	IPv6-addr/2001-as-src-or-dest	ipv6.src[0:2] == 20:01 or ipv6.dst[0:2] == 20:01
<input checked="" type="checkbox"/>	IPv6-addr/eui-64-addr	ipv6.addr[11:2] == ff:fe
<input checked="" type="checkbox"/>	IPv6-addr/2bad-as-src	ipv6.src[6:2] == 2b:ad
<input type="checkbox"/>	IPv6_RA	icmpv6.type == 134
<input type="checkbox"/>	IPv6_RS	icmpv6.type == 133
<input type="checkbox"/>	IPv6_RS-RA	(icmpv6.type == 134) (icmpv6.type == 133)
<input type="checkbox"/>	dhcpv6-ra-rs	dhcpv6 or icmpv6.type == 134 or icmpv6.type == 133
<input type="checkbox"/>	icmpv6-dhcpv6	dhcpv6 or icmpv6
<input type="checkbox"/>	dhcpv6	dhcpv6

Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell

22

The screenshot displays the Wireshark 2.10.4 interface. The top menu bar includes File, Edit, View, Go, Capture, Analyze, Statistics, Telephony, Wireless, Tools, and Help. The main packet list on the left shows a single packet of type 'ICMPv6 Echo (ping)' from 192.168.1.100 to 192.168.1.1. The packet details pane on the right shows the 'Internet Control Message Protocol' section, indicating it is a 'Type 0 (ping)' packet. The packet bytes pane on the right shows the raw data of the packet.

<http://teachmeipv6.com/IPv6-Essentials-Reference-Sheet.pdf>

[illegible]

24

Build Your Own IPv6 Learning Lab - for FREE



Resources



Networking

Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell



CISCO

SECURITY

IPv6 Security

Information assurance for the next-generation Internet Protocol

Scott Hogg, CCIE® No. 5133
Eric Vyncke

ciscopress.com

25



Resources



3RD EDITION

PRACTICAL PACKET ANALYSIS

USING WIRESHARK TO SOLVE REAL-WORLD NETWORK PROBLEMS

CHRIS SANDERS

Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell



Wireshark® Network Analysis

The Official Wireshark Certified Network Analyst Study Guide

Second Edition


Laura Chappell

- Learn **insider tips and tricks** to spot the cause of lousy network performance
- Discover **basic through advanced Wireshark techniques** to quickly identify evidence of discovery processes and breached hosts
- Analyze real world case studies to see how network problems have been solved by IT professionals (just like YOU!)

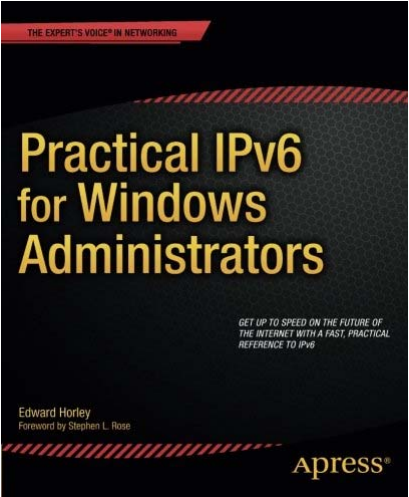
Foreword by
Gerald Combs
Creator of Wireshark

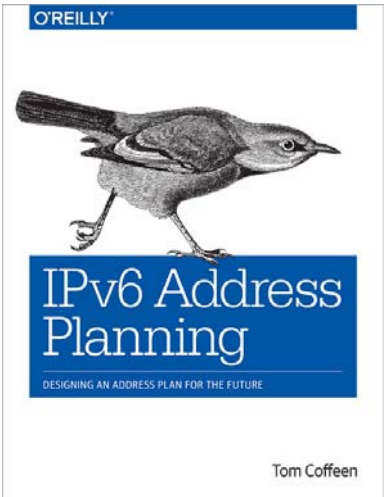
26

Build Your Own IPv6 Learning Lab - for FREE




Resources



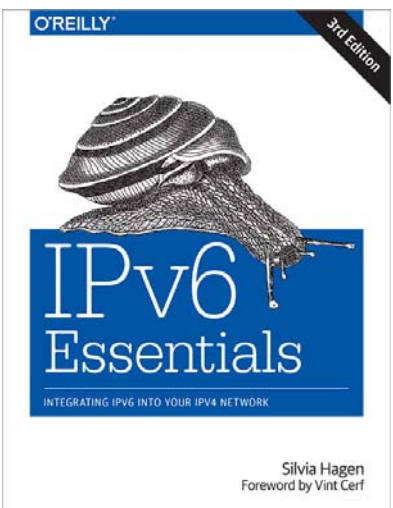


Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell

27



Resources



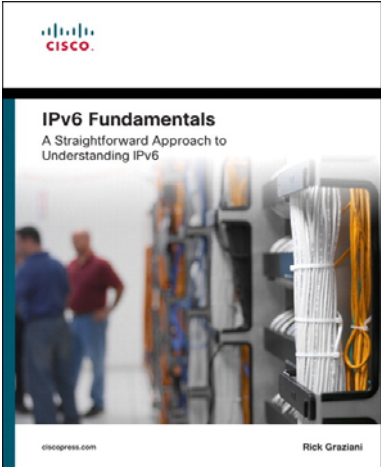
Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell

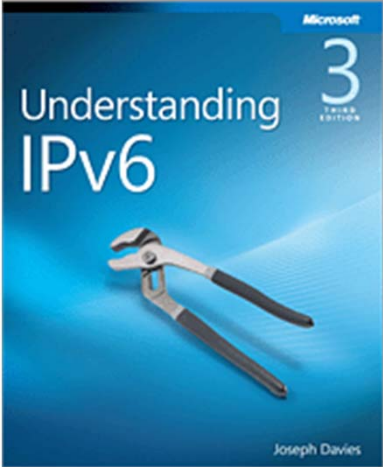
28

Build Your Own IPv6 Learning Lab - for FREE



Resources





Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell

29



Thank You for Attending!

jeff.carrell@teachmeipv6.com

@JeffCarrell_v6

Build Your Own IPv6 Learning Lab - for FREE v1.2 - Copyright © 2022 Jeffrey L. Carrell

30