IPv6 Core Functionality

Jeffrey L Carrell

Hewlett Packard Enterprise

Networking & Big Data Instructor/Course Developer

jeff.carrell@teachmeipv6.com

Twitter: @JeffCarrell_v6

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IPv6 Core Functionality

- IPv6 Introduction
- IPv6 Address Architecture
- IPv6 Header
- ICMPv6 and IPv6 Neighbor Discovery Protocol
- IPv6 Address Autoconfiguration
- IPv6 in Wireshark

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IPv6: Trivia

- In modern day operating systems, is IPv6 an enabled protocol?   **YES!**

- Generally, will an IPv6 enabled interface have more than one IPv6 address assigned to it?   **YES!**

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IPv6 Brief History

- Fall 1992 – IPv4 addresses will run out someday

- Oct 1993 – DHCP – RFC 1531 – easier IPv4 address management

- Dec 1993 – IPng – RFC 1550 – basic specification for next version IP

- May 1994 – NAT – RFC 1631 – temporary solution before IPng available

- Dec 1995 – RFC 1883 – Basic specifications of IPv6

- Feb 1996 – RFC 1918 – Private Iv4 addresses

- Dec 1998 – RFC 2460 – Full IPv6 defined

- May 2005 – RFC 3927 – APIPA (IPv4)

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IPv6 Basics

Comparing IPv4 & IPv6 Addresses

- IPv4 addresses 2^{32} = 4,294,967,296

- IPv6 addresses 2^{128} =
  340,282,366,920,938,463,463,374,607,431,768,211,456
  - which is 340 undecillion
    - 340 trillion trillion trillion
  - 79,228,162,514,264,337,593,543,950,336 times more v6 addresses than v4

- If IP addresses weighed one gram each:
  - IPv4 = half the Empire State Building
  - IPv6 = 56 billion earths

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Comparing IPv4 and IPv6 headers

Version	IHL	Type of Service	Total Length	
Identification			Flags	Fragment Offset
Time to Live		Protocol	Header Checksum	
Source Address				
Destination Address				
Options			Padding	

Version	Traffic Class	Flow Label	
Payload Length		Next header	Hop Limit
Source Address			
Destination Address			

- Field names kept from IPv4 to IPv6
- Field names and position changed in IPv6
- New field in IPv6
- Fields not kept in IPv6

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IPv6 Basics

What is an IPv6 Address?

- IPv6 addresses are very different than IPv4 addresses in the size, numbering system, and delimiter between the numbers
  - 128bit -vs- 32bit
  - colon-hexadecimal -vs- dotted-decimal
  - colon and double colon -vs- period (or "dot" for the real geeks)

Valid IPv6 addresses are comprised of hexadecimal numbers (0-9 & a-f), with colons separating groups of four numbers, with a total of eight groups

(each group is known as "quibble" or "**hextet**")
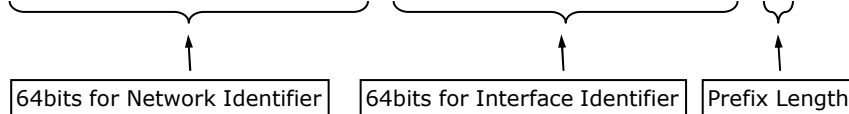
- 2001:0db8:1010:61ab:f005:ba11:00da:11a5

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

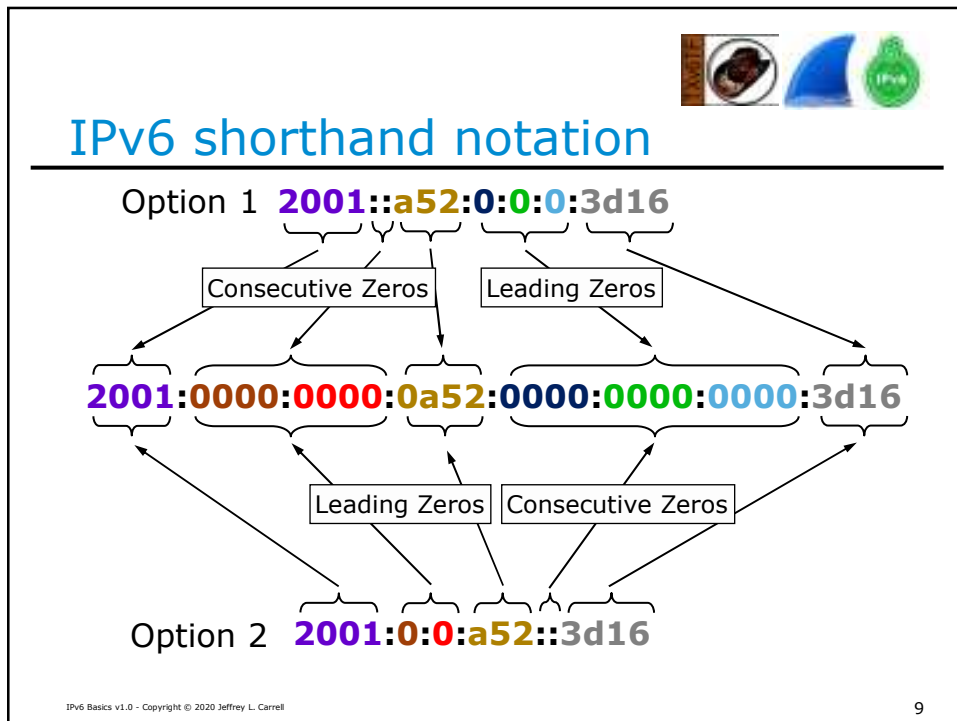- 2001:0db8:1010:61ab:f005:ba11:00da:11a5/64

| 64bits for Network Identifier | 64bits for Interface Identifier | Prefix Length |

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

IPv6 Basics

IPv6 shorthand notation

Option 1 **2001::a52:0:0:3d16**

Consecutive Zeros   Leading Zeros

2001:0000:0000:0a52:0000:0000:0000:3d16

Leading Zeros   Consecutive Zeros

Option 2 **2001:0:0:a52::3d16**

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Incorrect shorthand notation

2001:0000:0000:0a52:0000:0000:0000:3d16

Consecutive Zeros   Consecutive Zeros

Leading Zeros

NOT A VALID IPv6 Address

2001::a52::3d16

How many bits are represented by each ":"?

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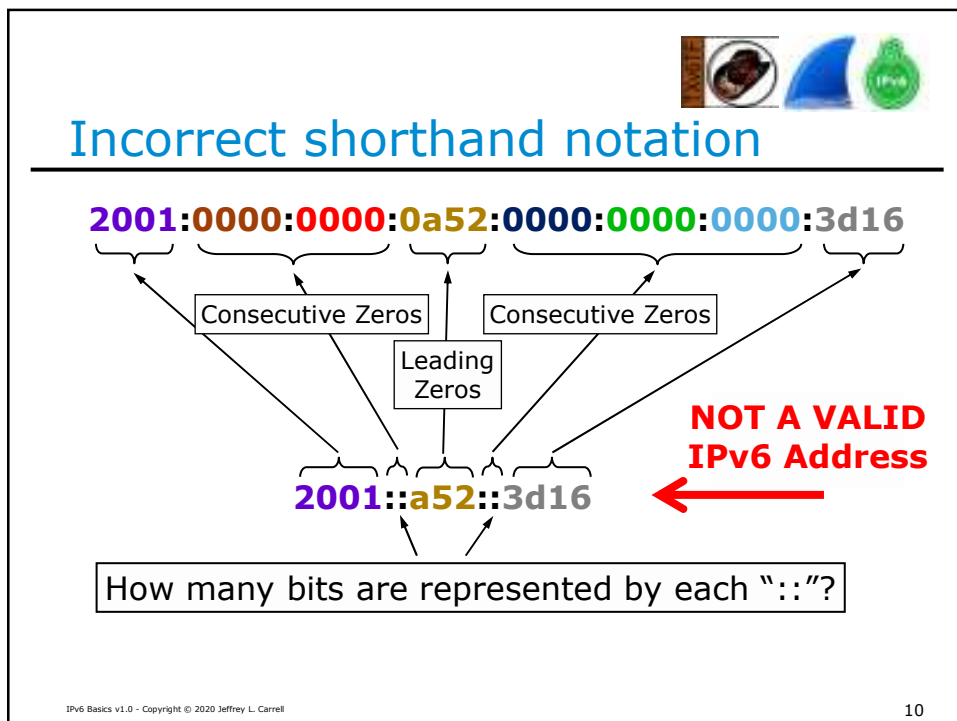
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IPv6 Basics

Address types

Address Type	IPv4	IPv6
Unicast - One-to-one communication	Yes	Yes
Broadcast - One-to-many communication local	Yes	No
Multicast - One-to-many communication local/remote	Yes	Yes
Anycast - One-to-many communication nearest	Yes	Yes

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Address scopes

Address Scope	IPv4	IPv6
Link-Local - Not routable	Yes (is temp, APIPA)	Yes
Global Unicast - Routable to Internet	Aka public	Yes
Unique Local - Routable only within domain	Aka private RFC 1918	RFC 4193

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IPv6 Basics

IPv4/IPv6 special addresses

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
Documentation	192.0.2.0/24 198.51.100.0/24 203.0.113.0/24	2001:db8::/32

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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)

0xFFFE inserted

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
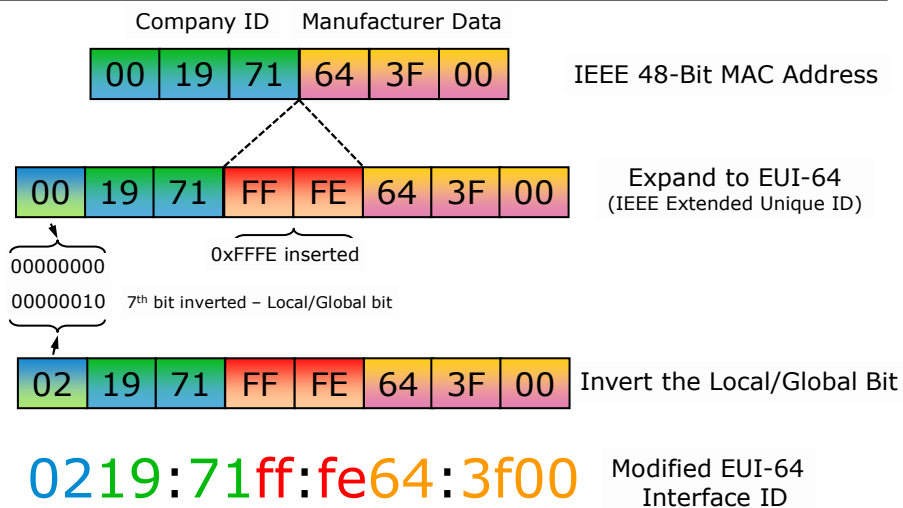
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IPv6 Basics

Interface ID from Random Number

- RFC4941 - 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"

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Lifetime states of an IPv6 address
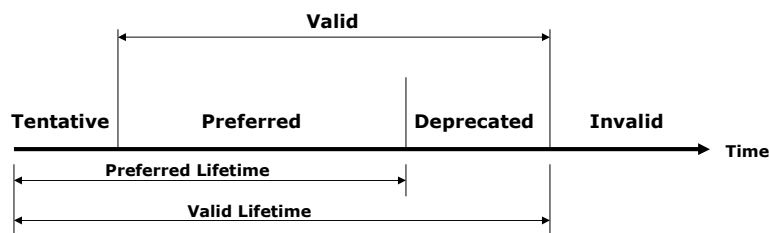
- Tentative – address is in process of verification for uniqueness and is not yet available for regular communications
- Valid – address is valid for use in communication based on Preferred and Deprecated status
- Preferred – address is usable for all communications
- Deprecated – address can still be used for existing sessions, but not for new sessions
- Invalid – an address is no longer available for sending or receiving

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Comparing IPv4 & IPv6 Neighbor Discovery Protocols

IPv4	IPv6
ARP Request	Neighbor Solicitation
ARP Reply	Neighbor Advertisement
Router Solicitation	Router Solicitation
Router Advertisement	Router Advertisement
Gratuitous ARP	Duplicate Address Detection
ARP Cache	Neighbor Cache

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IPv6 Neighbor Discovery Protocol

- Neighbor Discovery Protocol (NDP) is defined in RFC 4861
- NDP provides the following basic IPv6 functions per node
  - Discover what link they are one
  - Learn link prefix addresses
  - Discover the on-link router
  - Discover on-link neighbors
  - Keep track of active neighbors

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NDP ICMPv6 message types

- ICMPv6 type 133 - Router Solicitation (RS)
- ICMPv6 type 134 - Router Advertisement (RA)
- ICMPv6 type 135 - Neighbor Solicitation (NS)
- ICMPv6 type 136 - Neighbor Advertisement (NA)

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IPv6 autoconfiguration options

Address Autoconfiguration Method	ICMPv6 RA (Type 134) Flags		ICMPv6 RA (Type 134) ICMPv6 Option Prefix Info		Prefix Derived from	Interface ID Derived from	Other Configuration Options	# of IPv6 Addr
	M Flag	O Flag	A Flag	L Flag				
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)
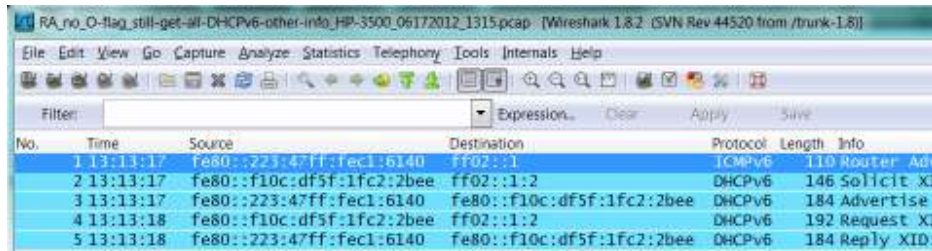
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IPv6 Stateful (DHCPv6) process

RA_no_O-flag_still-get-all-DHCPv6-other-info_HP-3500_06172012_1315.pcap [Wireshark 1.8.2 (SVN Rev 44520 from /trunk-1.8)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: ▼ Expression...   Clear   Apply   Save

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 XID:

- DHCPv6**S**olicit   =   DHCP**D**iscover (IPv4)
- DHCPv6**A**dvertise = DHCP**O**ffer (IPv4)
- DHCPv6**R**equest = DHCP**R**equest (IPv4)
- DHCPv6**R**eply   =   DHCP**A**ck (IPv4)

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Key difference in DHCP/DHCPv6

- Default gateway
  - DHCP – configurable Router option in scope
  - DHCPv6 – no configurable Router option in scope
    (possible future, but no client OS support yet)

- An IPv6 node derives its default gateway from the router's Link-Local address when the L flag is set in the Prefix information field of an RA
    (! not from the network prefix !)

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IPv6 Basics

Duplicate Address Detection (DAD)

- When a node initially assigns an IPv6 address to its interface, it must check whether the selected address is unique
- If unique, the address is configured on interface

- To verify uniqueness, the node sends a multicast Neighbor Solicitation message with the:
  - dest MAC of 33:33:<last 32bits of IPv6 mcast addr>
  - dest IPv6 addr of ff02::1:ff<last 24bits of proposed IPv6 addr>
  - source IPv6 of "::" (IPv6 unspecified addr)

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IPv4 & IPv6 Routing protocols

IPv4	IPv6
Static Route	Static Route
RIP v1/v2	RIPng
OSPFv2	OSPFv3
EIGRP	EIGRP for IPv6
IS-IS	IS-IS for IPv6
BGP4	MP-BGP

❖ Routing protocols generally run separate: "Ships in the Night"

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IPv6 Basics

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

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Using Wireshark to view IPv6 pkts
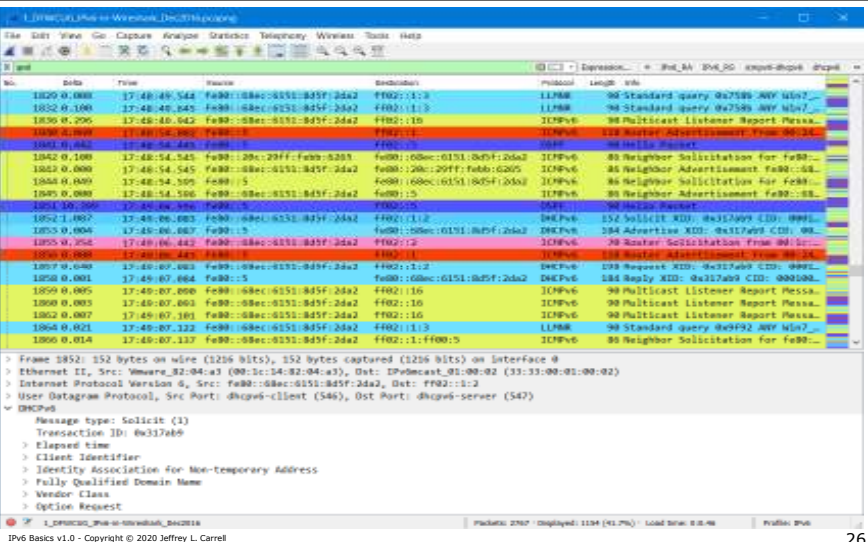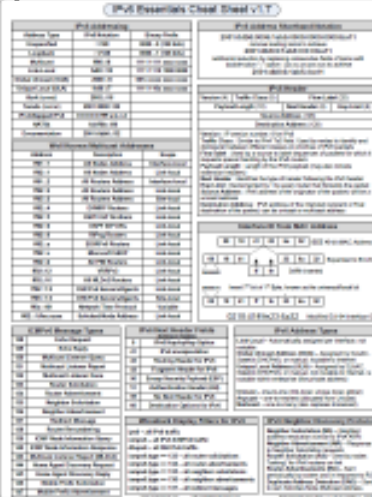
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IPv6 Essentials Cheat Sheet

http://teachmeipv6.com/IPv6-Essentials-Cheat-Sheet.pdf

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Thank You for Attending!

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- Twitter: @JeffCarrell_v6

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Resources

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Resources

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Resources

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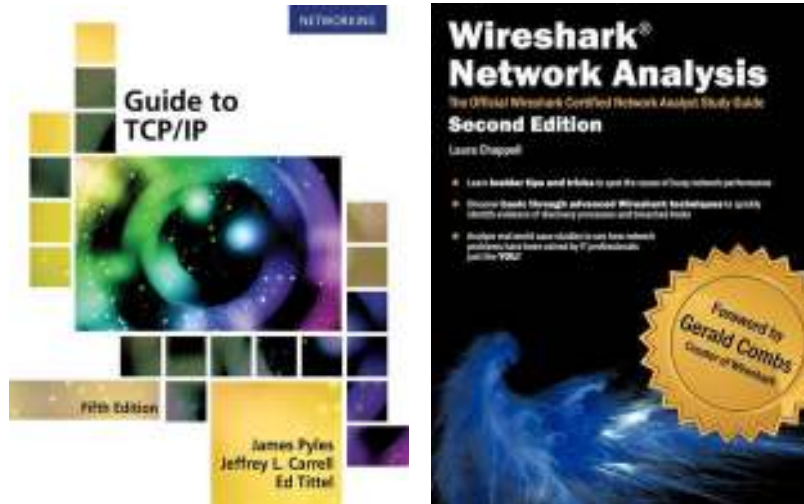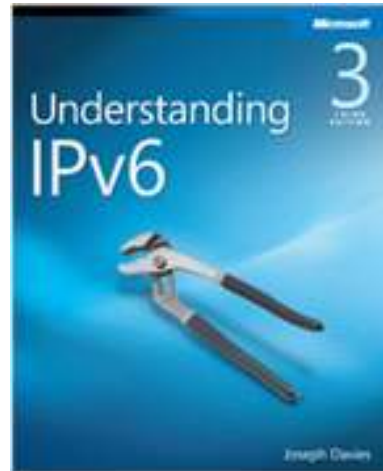
Resources
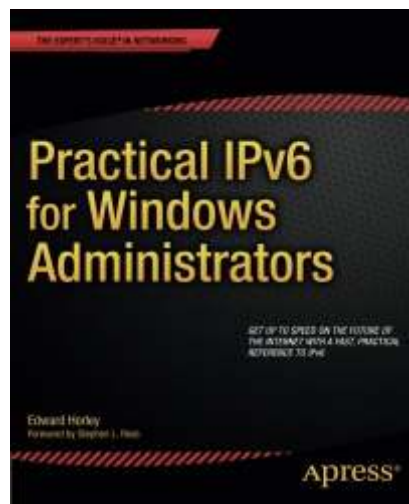
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IPv6 Basics

IPv6 notation in URL
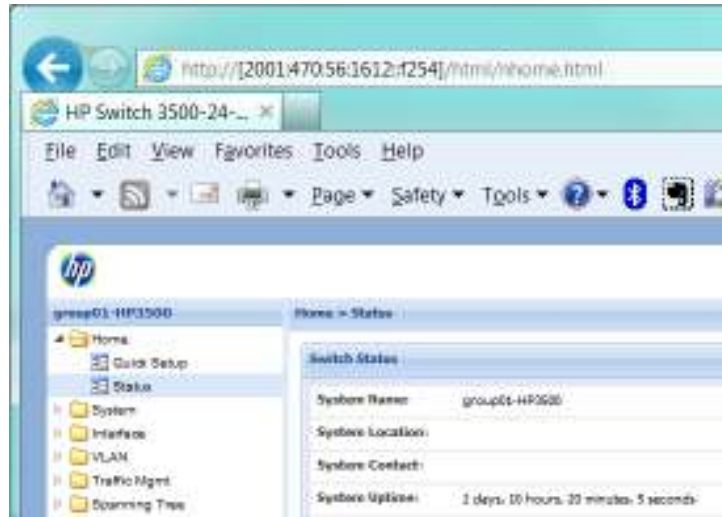
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IPv6 Browser add-ons

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IPv6 Basics

Telnet/SSH over IPv6
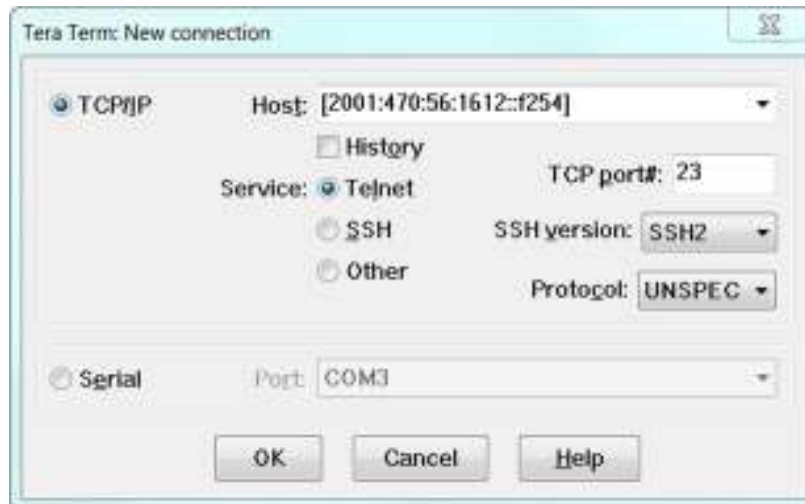
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TFTP over IPv6

```
group05-NetIron#copy running-config tftp ipv6
  2001:470:ba04:1652::102 group05.cfg
```

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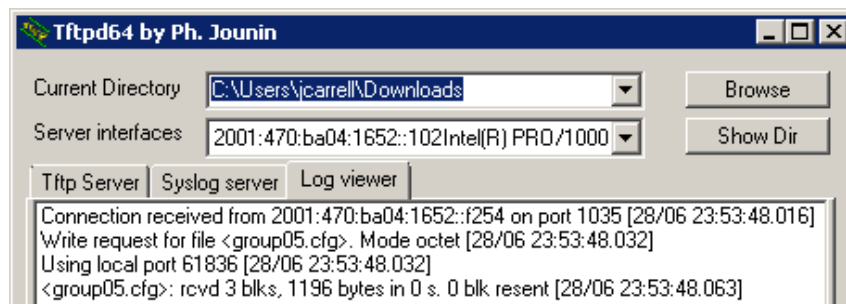
RDP over IPv6

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IPv6 and DNS

- Bind forward and reverse resolution

; 4to6labs.com Dumped
<snip>
www.4to6labs.com.   3600   IN   AAAA   2607:f2f8:a6d0:0:0:0:0:2

; 0.0.0.0.0.d.6.a.8.f.2.f.7.0.6.2.ip6.arpa Dumped ;
  2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.d.6.a.8.f.2.f.7.0.6.2.ip6.arpa.
  86400 IN PTR www.4to6labs.com.

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