https://github.com/jeffcarrell/IPv6-for-the-IPv4-Brain
--- get the trace file and other files too!

IPv6 for the IPv4 Brain

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IPv6 Basics

- IPv6 Introduction
- IPv6 Address Architecture
- IPv6 Header
- ICMPv6 and IPv6 Neighbor Discovery Protocol
- IPv6 Address Autoconfiguration
- IPv6 Support for Network Applications
- IPv6 in Wireshark

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!**

IPv6: Trivia

- How many IPv6 GUA addresses can a network interface have that are in the same network? **Up to 4!**
- How many IPv6 GUA addresses can a network interface have that are in different networks? **Almost infinite!**
- Can the IPv6 Link-Local address be the same address for all network interfaces in a host? **YES!**

IPv6: Trivia

- How does an IPv6 enabled host derive its default gateway? **Via the RA!**
- Does DHCPv6 have a configurable option to provide an IPv6 default gateway? **NO!**
- Does an IPv6 host use its LL or GUA address to communicate to its default gateway? **LL!**

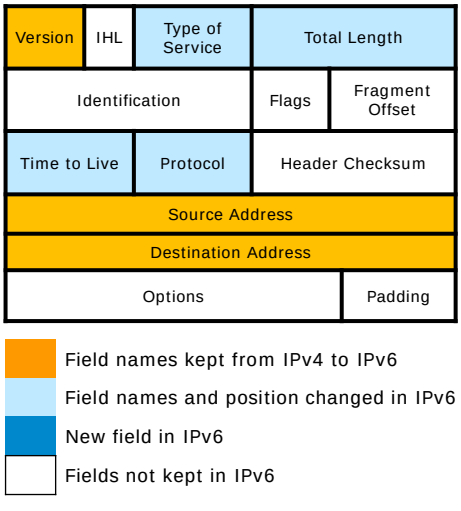
IPv6 Brief History

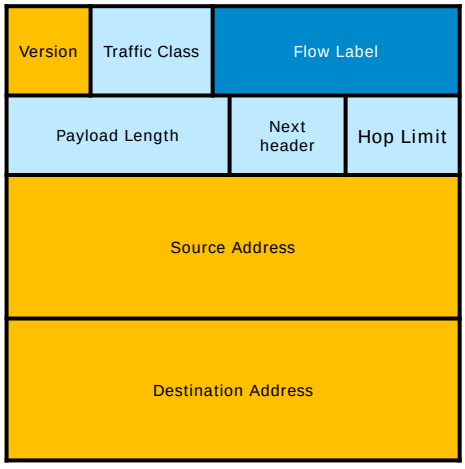
- Fall 1992 – IPv4 addresses will run out someday
- Oct 1993 – DHCP – RFC 1531 – easier IPv4 address management
- Dec 1993 – IPng – RFC 1550 – basic specification for next version IP
- May 1994 – NAT – RFC 1631 – temporary solution before IPng available
- Dec 1995 – RFC 1883 – Basic specifications of IPv6
- Feb 1996 – RFC 1918 – Private Iv4 addresses
- Dec 1998 – RFC 2460 – Full IPv6 defined
- May 2005 – RFC 3927 – APIPA (IPv4)

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

Comparing IPv4 and IPv6 headers





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

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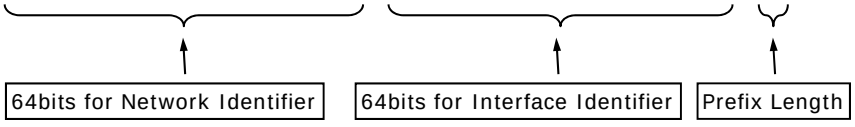
IPv6 default for subnet

- 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



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

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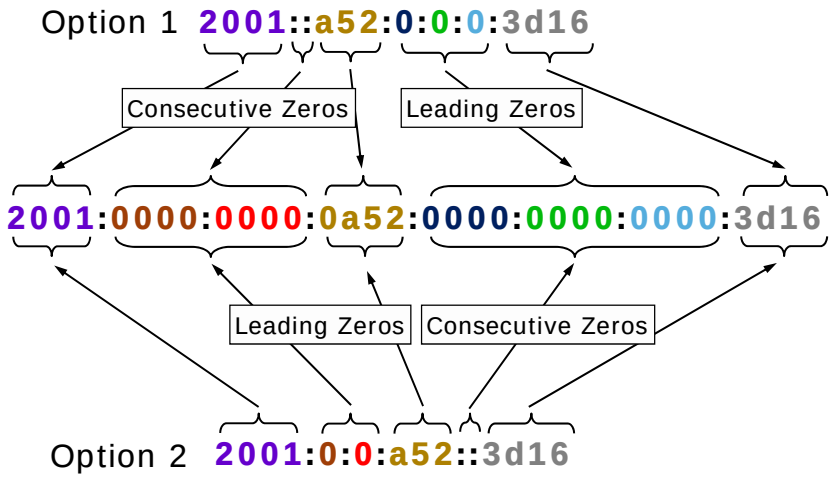
IPv6 shorthand notation



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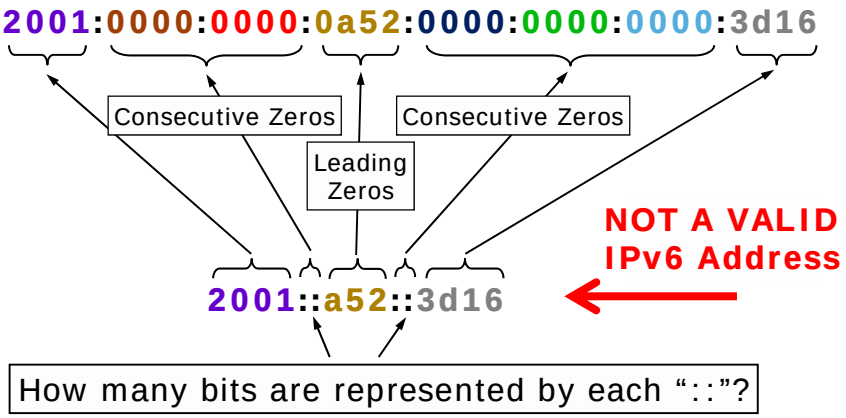
Incorrect shorthand notation



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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

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

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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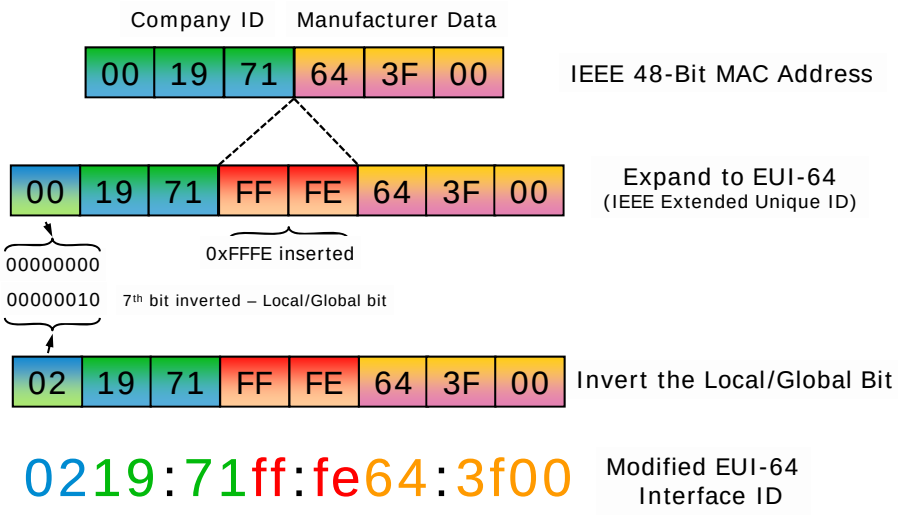
Interface ID from MAC address



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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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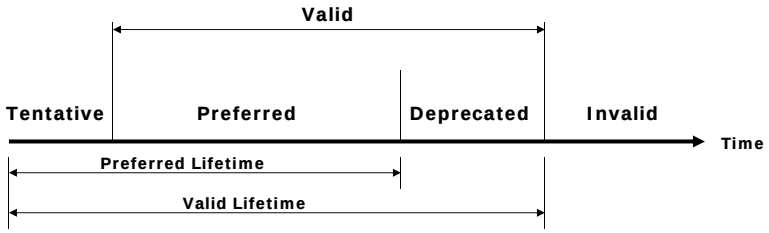
Lifetime states of an IPv6 address



- 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

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

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)

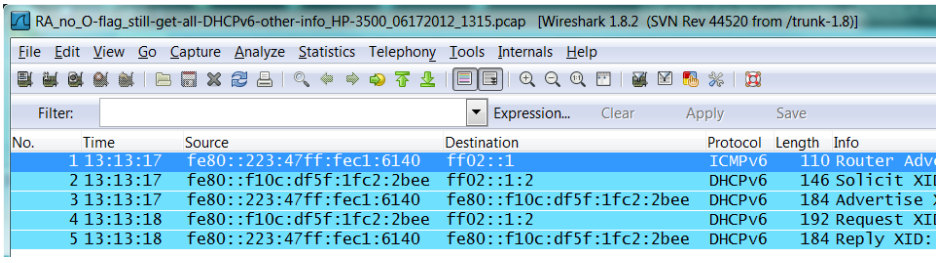
Duplicate Address Detection (DAD)

- 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)

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)

IPv6 Stateful (DHCPv6) process



- 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)

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)

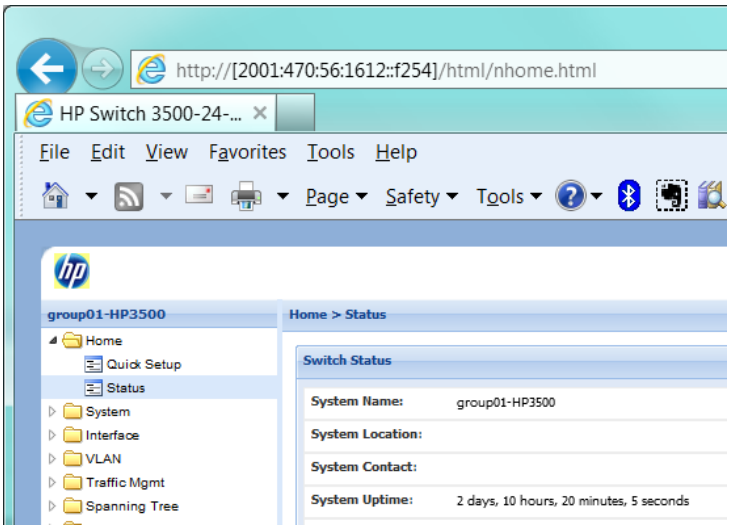
- An IPv6 node derives its default gateway from the router's Link-Local address when the L flag is set in the Prefix information field of an RA
  (! not from the network prefix !)

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"

IPv6 notation in URL



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IPv6 Browser add-ons

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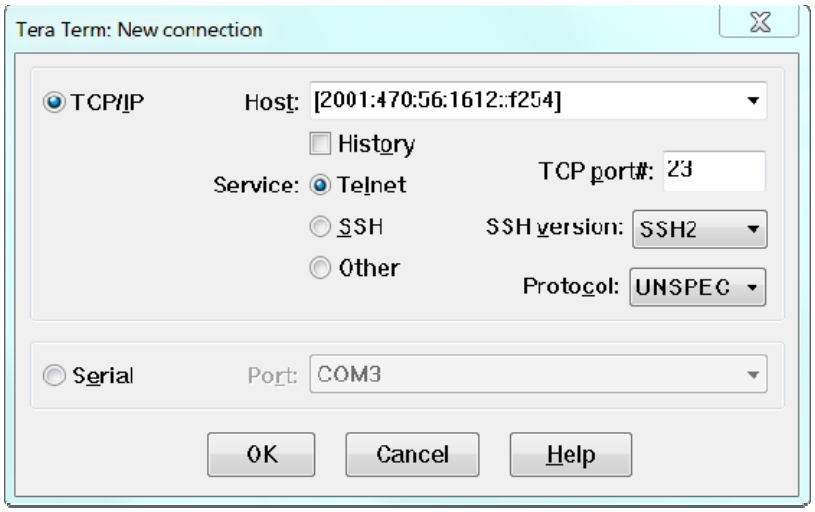
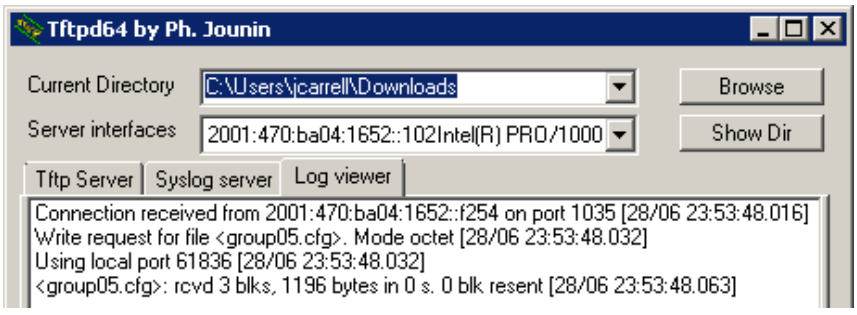
Telnet/SSH over IPv6

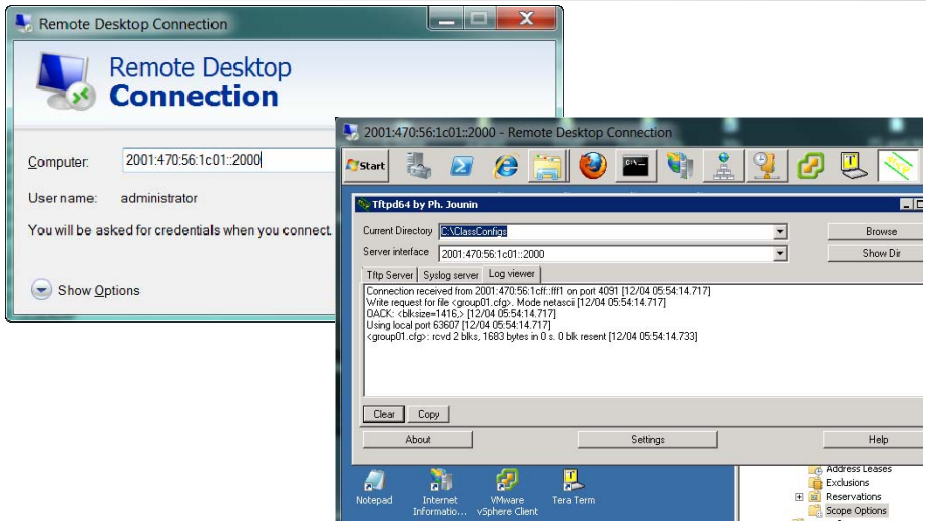


TFTP over IPv6

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



RDP over IPv6



IPv6 and DNS

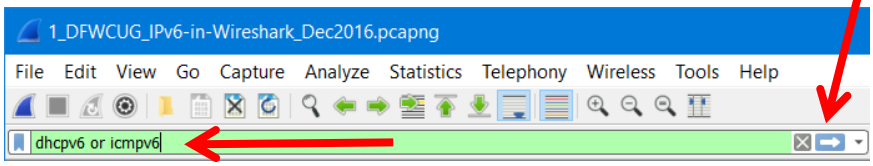
- Bind forward and reverse resolution

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

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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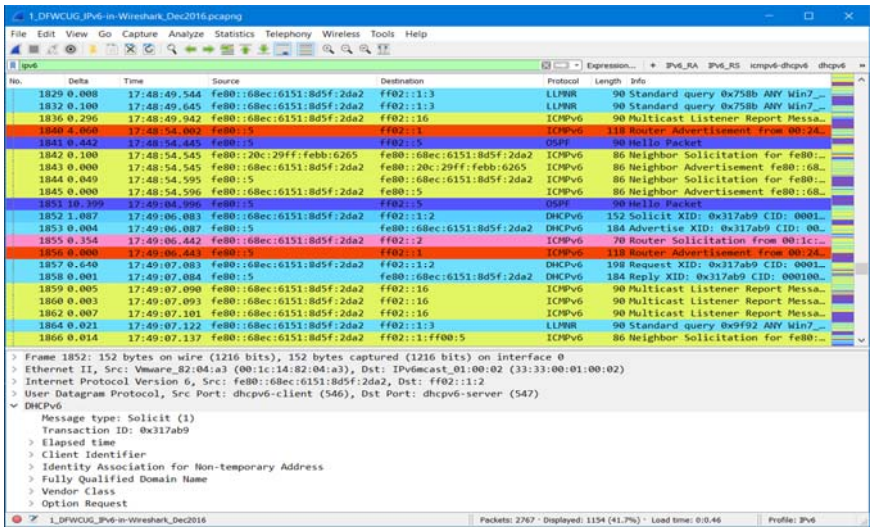
Using Wireshark to view IPv6 pkts



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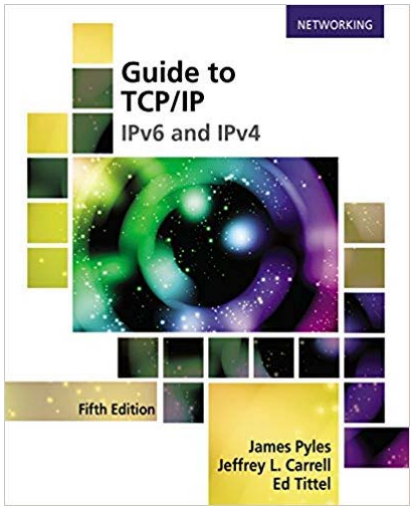
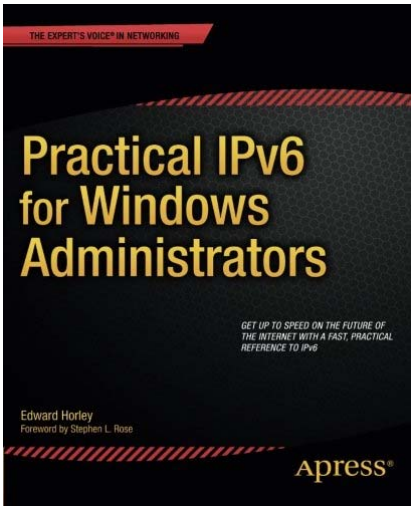
IPv6 Essentials Cheat Sheet

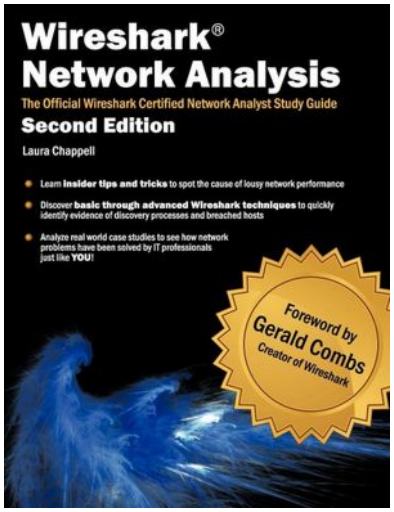
http://teachmeipv6.com/IPv6-Essentials-Cheat-Sheet.pdf

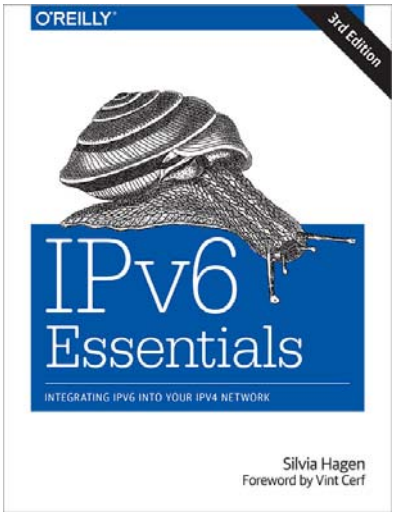
Resources





Resources





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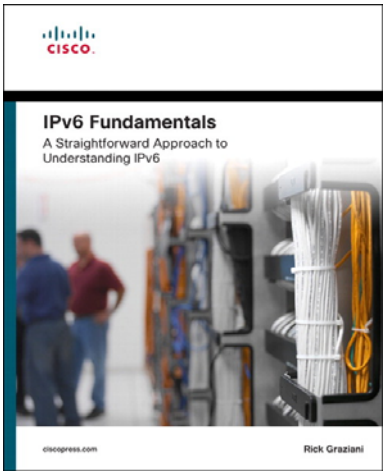
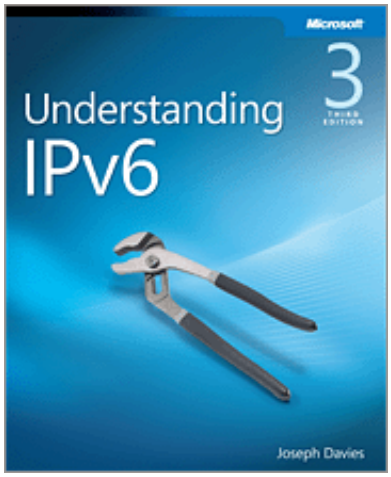
Resources





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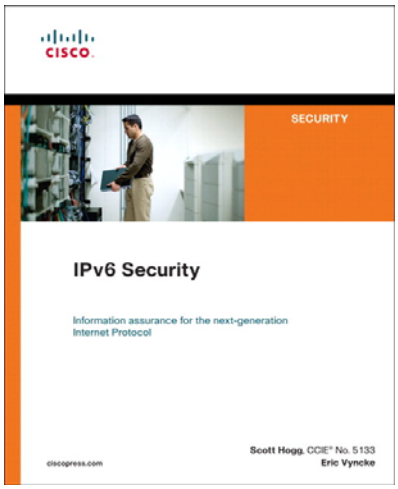
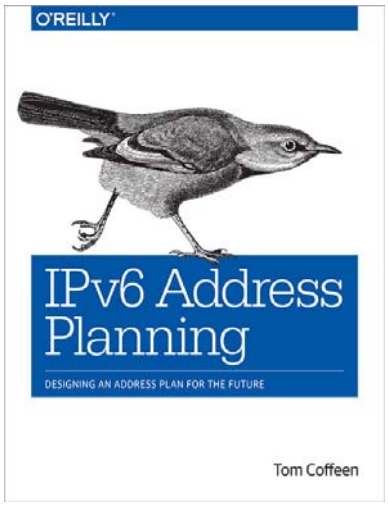
Resources





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Thank You for Attending!

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