IPv6 for IPv4 users

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Welcome!

- Bill Stearns
  - Active Countermeasures
- Prerequisites
  - Helpful if you're familiar with IPv4

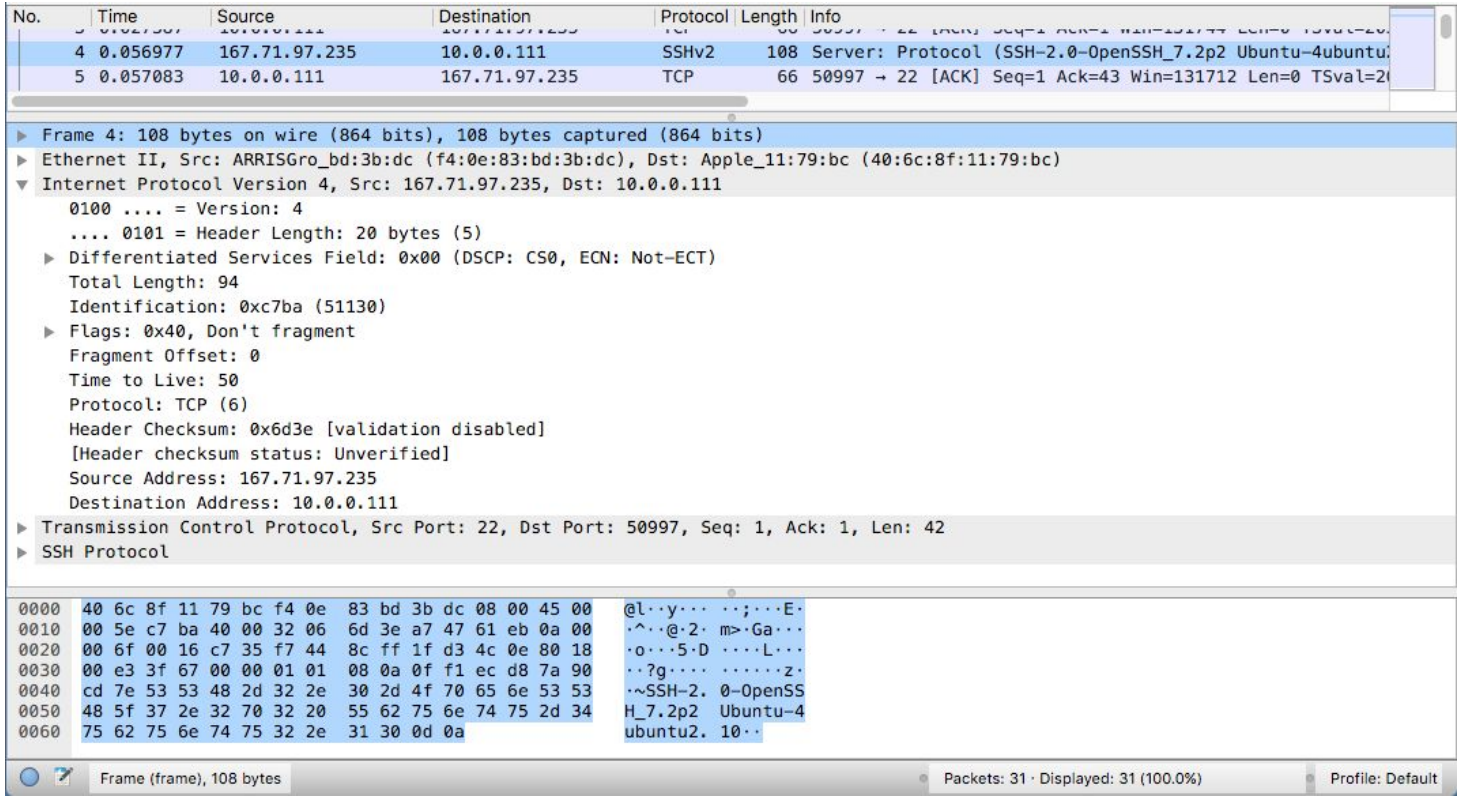
What we'll cover

- IPv6
  - How it compares to IPv4
  - Addresses
  - Multicast
  - OS/App support

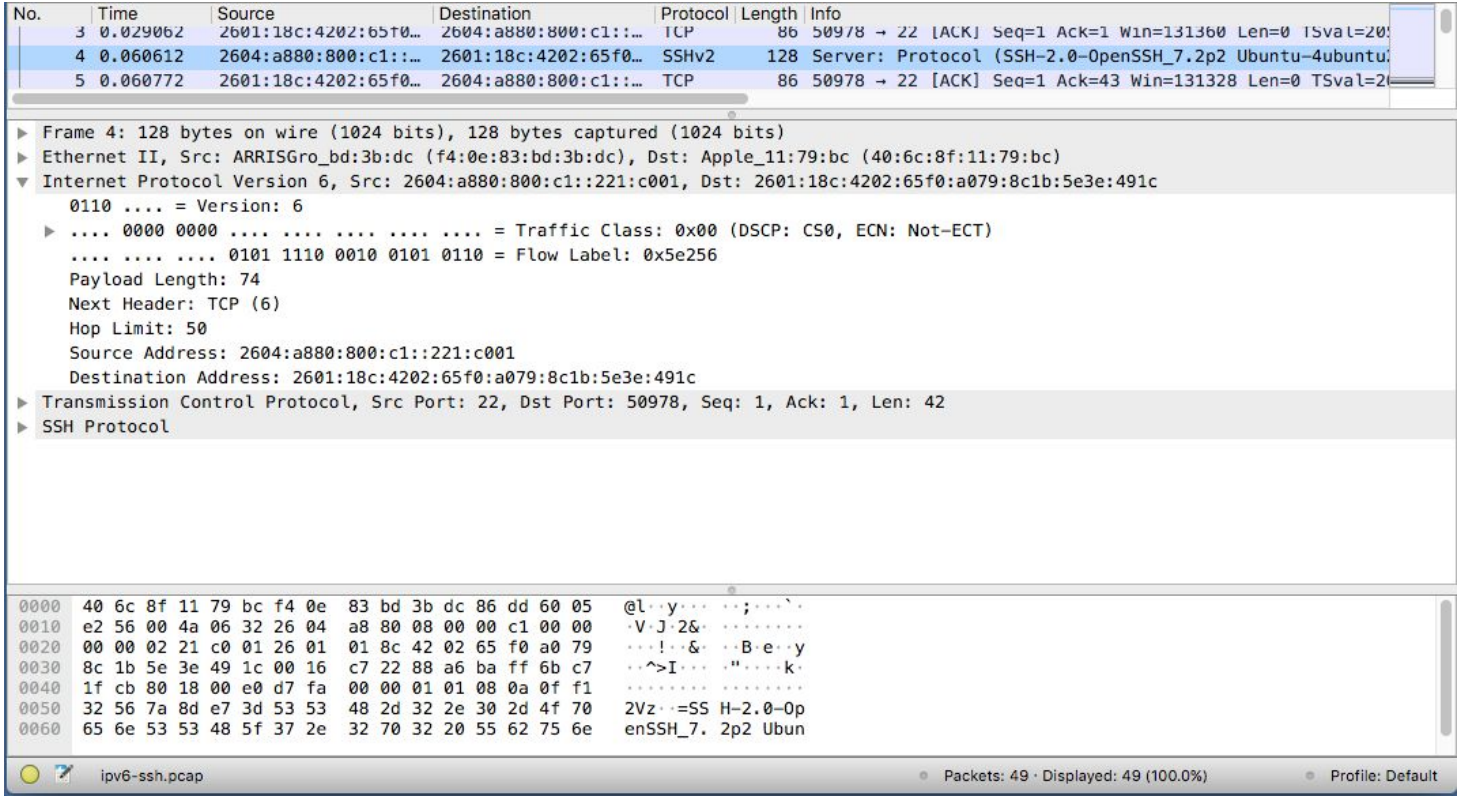
Addresses

- 128 bits = 16 bytes = 32 hex characters
  - (IPv4: 32 bits = 4 bytes = 8 hex characters)
  - Colons instead of periods
  - fe80::da7f:fd91:ee44:5297
  - Umm, "::"?
    - Replaces single longest block of all 0's
    - = fe80:0000:0000:0000:da7f:fd91:ee44:5297
  - Can leave off leading 0's
    - = fe80:0:0:0:da7f:fd91:ee44:5297

Wireshark IPv4 SSH- packet



Wireshark IPv6 SSH- packet



TCP? UDP? ICMP?

- TCP
  - Same layer as IPv4
- UDP
  - Same layer as IPv4
- ICMP
  - Different types and codes

Ports

- Colon gets confusing, so
  - http://[fe80::da7f:fd91:ee44:5297]:80
  - Easier to use hostname:
  - http://www.example.com:80
-

Private/reserved addresses

- IPv4
  - 10.x.y.z, 192.168.y.z, 172.16.y.z-172.31.y.z
- IPv6
  - fe80::/112
- Loopback
  - IPv4 127.0.0.1 -> IPv6 ::1
- Unspecified
  - IPv4 0.0.0.0 -> IPv6 ::

Can I have both?

- Absolutely!
  - A single network interface can have multiple IPv4 and multiple IPv6 addresses
  - Almost always have an fe80:.... address to start
  - If an IPv6 router shows up, will locally create a global IPv6

Ifconfig eth0 (and lo)

```
lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1

eth0      Link encap:Ethernet  HWaddr  5a:42:63:68:45:7f
          inet addr:167.71.106.69  Bcast:167.71.111.255  Mask:255.255.240.0
          inet6 addr: 2604:a880:800:c1::221:b001/64 Scope:Global
          inet6 addr: fe80:: 5842:63ff:fe68:457f/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
```

ip addr show dev eth0 (and lo)

```
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever

2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group
default qlen 1000
    link/ether 5a:42:63:68:45:7f brd ff:ff:ff:ff:ff:ff
    inet 167.71.106.69/20 brd 167.71.111.255 scope global eth0
       valid_lft forever preferred_lft forever
    inet 10.17.0.17/16 brd 10.17.255.255 scope global eth0
       valid_lft forever preferred_lft forever
    inet6 2604:a880:800:c1::221:b001/64  scope global
       valid_lft forever preferred_lft forever
    inet6 fe80::5842:63ff:fe68:457f/64  scope link
       valid_lft forever preferred_lft forever
```

Types of addresses

- Run ifconfig
  - ::1 Scope:Host
    - Localhost, assigned to lo
  - fe80:... Scope:Link
    - Only communicates on this network segment
  - (other) Scope:Global
    - Used to talk with the rest of the world
- Also: "ip addr"
- If you only have fe80's, no Internet

IPv6 allocations

- Regional Internet Registry: /12 (~10^34 *) to /23 (~10^32)
  - Local IR: /19 (10^33) to /32 (10^29)
- ISP: /32 (10^29)
- Customer: /48 (10^24) to /56 (10^22)
  - Internal networks: /64 (10^19) or smaller

* Approximate # of IPv6 addresses in each

https://en.wikipedia.org/wiki/IPv6_address#General_allocation

Broadcast/multicast

- IPv4
  - 255.255.255.255
  - *Net.work*.255.255 (Network + all 1's)
  - 224.x.y.z-239.x.y.z Multicast
- IPv6
  - No broadcast
  - Multicast
    - FF00::/8
    - FF02:0:0:0:0:0:0:1 All Nodes Address
    - FF02:0:0:0:0:0:0:2 All Routers Address...
    - See reference

Where do I get an address?

- IPv4
  - DHCP server (or manually assigned)
- IPv6
  - Router advertisement
  - Interface creates its own address
  - DHCPV6?

NAT/address sharing?

- IPv4
  - Yes
- IPv6
  - No

Is it live?

- Ping google public DNS address
- IPv4

```
ping -c 3 8.8.8.8
```

- IPv6

```
ping6 -c 3 2001:4860:4860::8888
```

Can I mix?

- IPv4 talking to IPv6
  - No, but
  - Can use IPv6 to "::IP.v4.add.ress"
  - ::8.8.8.8 = 0:0:0:0:0:0:8.8.8.8
  - Still technically IPv6
- Use a proxy in between

Application support

- Very strong now
  - Hard to find apps that can't use IPv6
  - Code level: listen on "::", can accept both IPv4 and IPv6 connections
- Occasionally parallel tools
  - ping/ping6
  - traceroute/traceroute6
- DOD mandated IPv6

Listening on IPv6 with python

https://github.com/activecm/save_json_stream/blob/main/save_json_stream.py

```
def create_server(listening_port, max_connections):
        """Create the initial listening server socket."""

        try:
                server_h = socket.socket(socket.AF_INET6, socket.SOCK_STREAM)           #We try to open an IPv6 listener (which also accepts IPv4).  If this fails
        except OSError:
                server_h = socket.socket(socket.AF_INET, socket.SOCK_STREAM)            #...we retry with IPv4 only.

        try:
                server_h.setsockopt(socket.SOL_SOCKET, socket.SO_REUSEADDR, 1)
                server_h.bind(('', int(listening_port)))
                server_h.listen(max_connections)
        except PermissionError:
                fail('Unable to listen on port ' + str(listening_port))
        Debug('Listening on TCP port ' + str(listening_port), True)

        sel_objs.register(server_h, selectors.EVENT_READ, handle_accept)
```

Capturing packets

- Packet capture tools can save both
  - Pcap format supports both
- Some?/Many?/Most? have IPv6 decoders
- Tell the difference?
  - First 4 bits after the physical header
    - "Version" field in both IPv4 and IPv6
    - 0x4 = 4 for IPv4
    - 0x6 = 6 for IPv6
    - (5 was experimental: https://en.wikipedia.org/wiki/Internet_Stream_Protocol)
  - Wireshark displays

IPv4 and IPv6: which is used?

- Linux prefers IPv6 now
  - Try IPv6 first, then fall back to IPv4
- Windows (>= Vista) prefers IPv6
  - To change:
  - https://docs.microsoft.com/en-us/troubleshoot/windows-server/networking/configure-ipv6-in-windows
- MacOS (prefers IPv6 if A + AAAA returned)
  - To disable IPv6:
  - https://choibles.com/revert-mac-to-ipv4/

Packets

- BPFs
  - IPv4: use 'ip'
  - IPv6: use 'ip6'
- https://www.networkacademy.io/ccna/ipv6/ipv4-vs-ipv6
- TCP and UDP headers
  - No change between IPv4 and IPv6
- ICMP vs ICMPv6
- Bare Ipv6 header
  - Additional stuff moved to other headers

Firewall/IDS/IPS/Network monitor

- Totally separate for IPv4 and IPv6
  - Need to implement both!

DNS

- IPv4
  - A records: hostname->IPv4 address
  - PTR records: IPv4 address-> hostname
- IPv6
  - AAAA records: hostname->IPv6 address
  - PTR records: IPv6 address-> hostname

Hostname for an IP address

- IPv4

```
dig +short -x 8.8.4.4
Dns.google.
```

  - 4.4.8.8.in-addr.arpa. 86400 IN PTR dns.google.

- IPv6

```
dig +short -x 2001:4860:4860::8844
Dns.google.
```

  - 4.4.8.8.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.6.8.4.0.6.8.4.1.0.0.2.ip6.arpa. 86400 IN PTR dns.google.

Mac address: privacy

- IPv6 EUI-64
  - Obsoleted
- 6 byte mac address ("11:22:33:44:55:66")
- -> 8byte value, with ff:fe in the middle
  - 1122:33ff:fe44:5566
  - **And** invert bit 7 from the left:
  - 1**3**22:33ff:fe44:5566
- Can tell who made the NIC from address
- Replaced by hash

References

- Google DNS
  - https://developers.google.com/speed/public-dns/docs/using
- EUI-64
  - https://packetlife.net/blog/2008/aug/04/eui-64-ipv6/
  - -> https://www.rfc-editor.org/in-notes/rfc4941.txt
- IPv6 Multicast addresses
  - https://www.iana.org/assignments/ipv6-multicast-addresses/ipv6-multicast-addresses.xhtml
- https://en.wikipedia.org/wiki/Comparison_of_IPv6_support_in_operating_systems

More references

- https://ipv6int.net/systems/
- https://www.activecountermeasures.com/malware-of-the-day-ipv6-address-aliasing/
- https://en.wikipedia.org/wiki/IPv6_address
-

Next Fireside Friday

- 3/28's presentation
  - Packet crafting!
  - Please install ncat and hping3
    - RPM-based systems

```
sudo yum -y install nmap-ncat hping3
```

    - Deb-based systems

```
sudo apt -y install ncat hping3
```

- Only if above are not available
  - Alternate names:
  - nmap-ncat, netcat

Questions?

- ...