

How to Try IPv6 @Home

Yordan Sutanto
Network Engineer
Schlumberger
YSutanto@slb.com

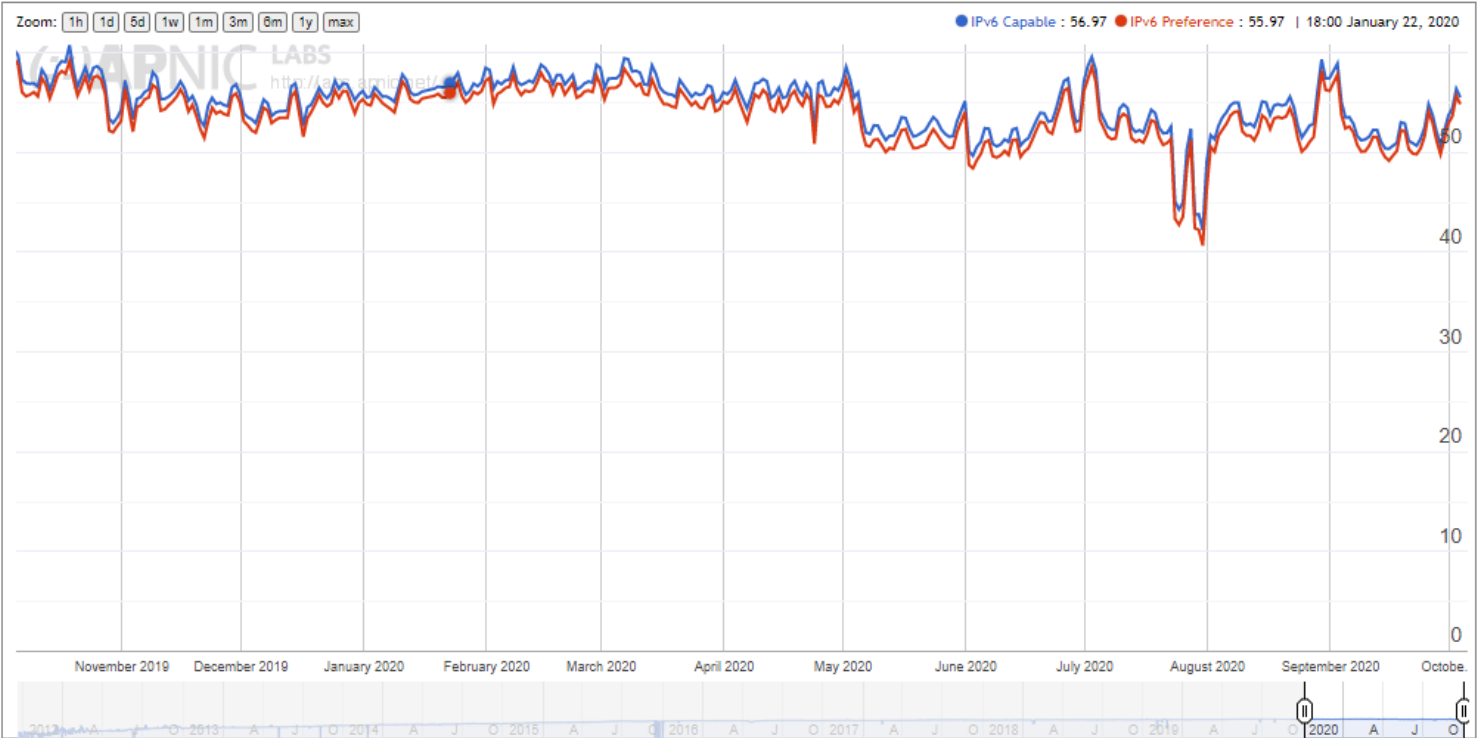
NANOG 80, Oct 19-21, 2020



<https://ipv6.he.net/certification/>

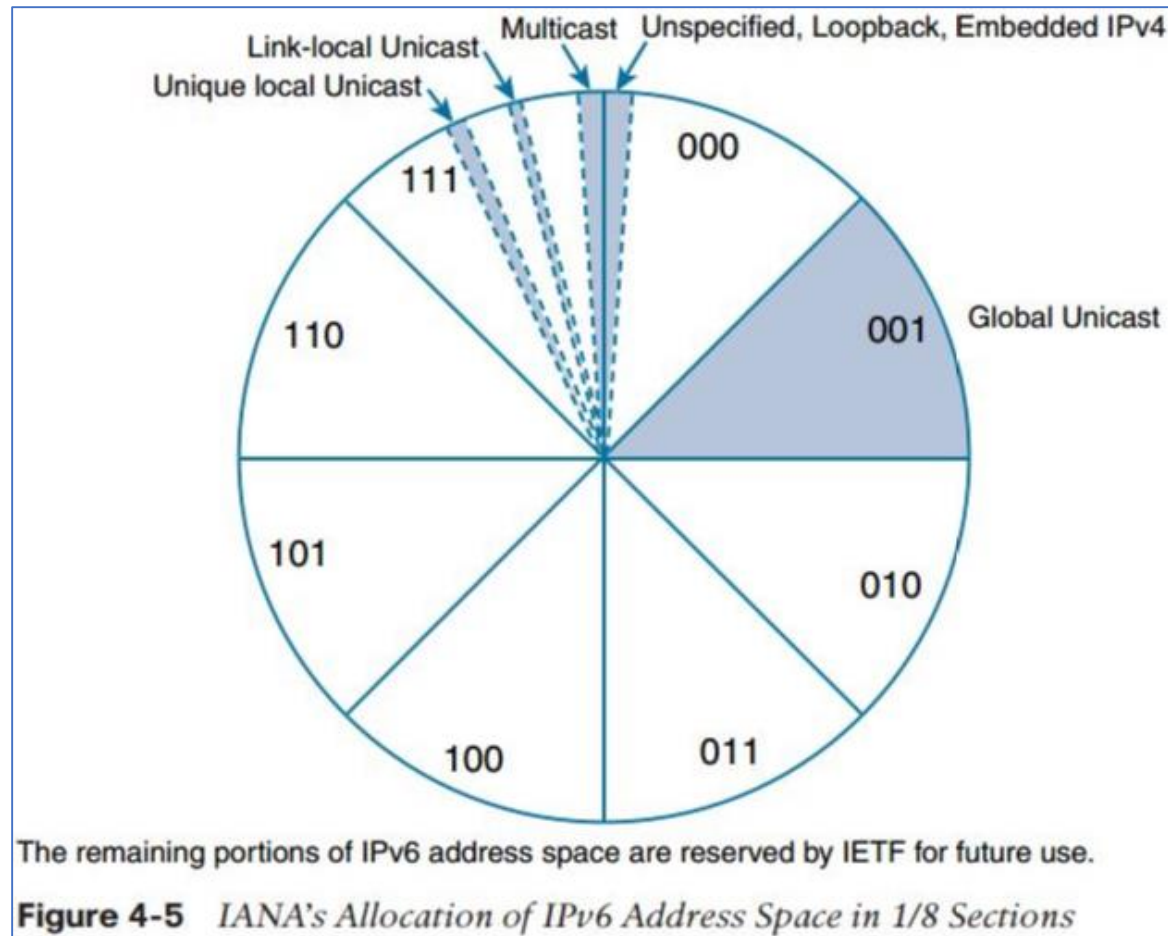
The Problem – When Should We Start?

Use of IPv6 for United States of America (US)



Last 1 year from October 5, 2020
Image from <https://stats.labs.apnic.net/ipv6/US>

Basic Concepts (1): IPv6 Address Space in 1/8 Sections



Basic Concepts (1): IPv6 Address Space in 1/8 Sections

No	N1	N2	N3	Leading Bits	1st Hex	IPv6 Address	Range of 1st Hex	Allocation	Fraction of Space
1				000x	0	0000::/3	0000 - 1fff		1/8
	1			0000 0000	00	0000::/8	0000 - 00ff	unspecified, loopback, IPv4 embedded	1/256
	2			0000 0001 - 0001 ffff	01		0100 - 1fff	--reserved by IETF--	remaining 1/8
2				001x	2	2000::/3	2000 - 3fff	Global unicast	1/8
						2002::/16		6to4 tunneling	
3				010x	4	4000::/3	4000 - 5fff	--reserved by IETF--	1/8
4				011x	6	6000::/3	6000 - 7fff	--reserved by IETF--	1/8
						64:ff9b::/96		NAT64 well-known prefix (WKP)	
5				100x	8	8000::/3	8000 - 9fff	--reserved by IETF--	1/8
6				101x	a	a000::/3	a000 - bfff	--reserved by IETF--	1/8
7				110x	c	c000::/3	c000 - dfff	--reserved by IETF--	1/8
8				111x	e	e000::/3	e000 - ffff		1/8
	1			1110 x	e	e000::/4	e000 - efff	'--reserved by IETF--	1/16
	2			1111 0x	f0	f000::/5	f000 - f7ff	'--reserved by IETF--	1/32
	3			1111 10x	f8	f800::/6	f800 - fbff	--reserved by IETF--	1/64
	4			1111 110x	fc	fc00::/7	fc00 - fdff	Unique local unicast	1/128
		1		1111 1100 x	fc	fc00::/8	fc00 - fcff	--reserved by IETF--	
		2		1111 1101 x	fd	fd00::/8	fd00 - fdff	locally assigned	
	5			1111 1110 0x	fe0	fe00::/9	fe00 - fe7f	--reserved by IETF--	1/512
	6			1111 1110 10x	fe8	fe80::/10	fe80 - febf	Link-local unicast	1/1024
	7			1111 1110 11x	fec	fec0::/10	fec0 - feff	--reserved by IETF--	1/1024
	8			1111 1111 x	ff	ff00::/8	ff00 - ffff	Multicast	1/256

Basic Concepts (2): DHCPv6 with Prefix Delegation Option

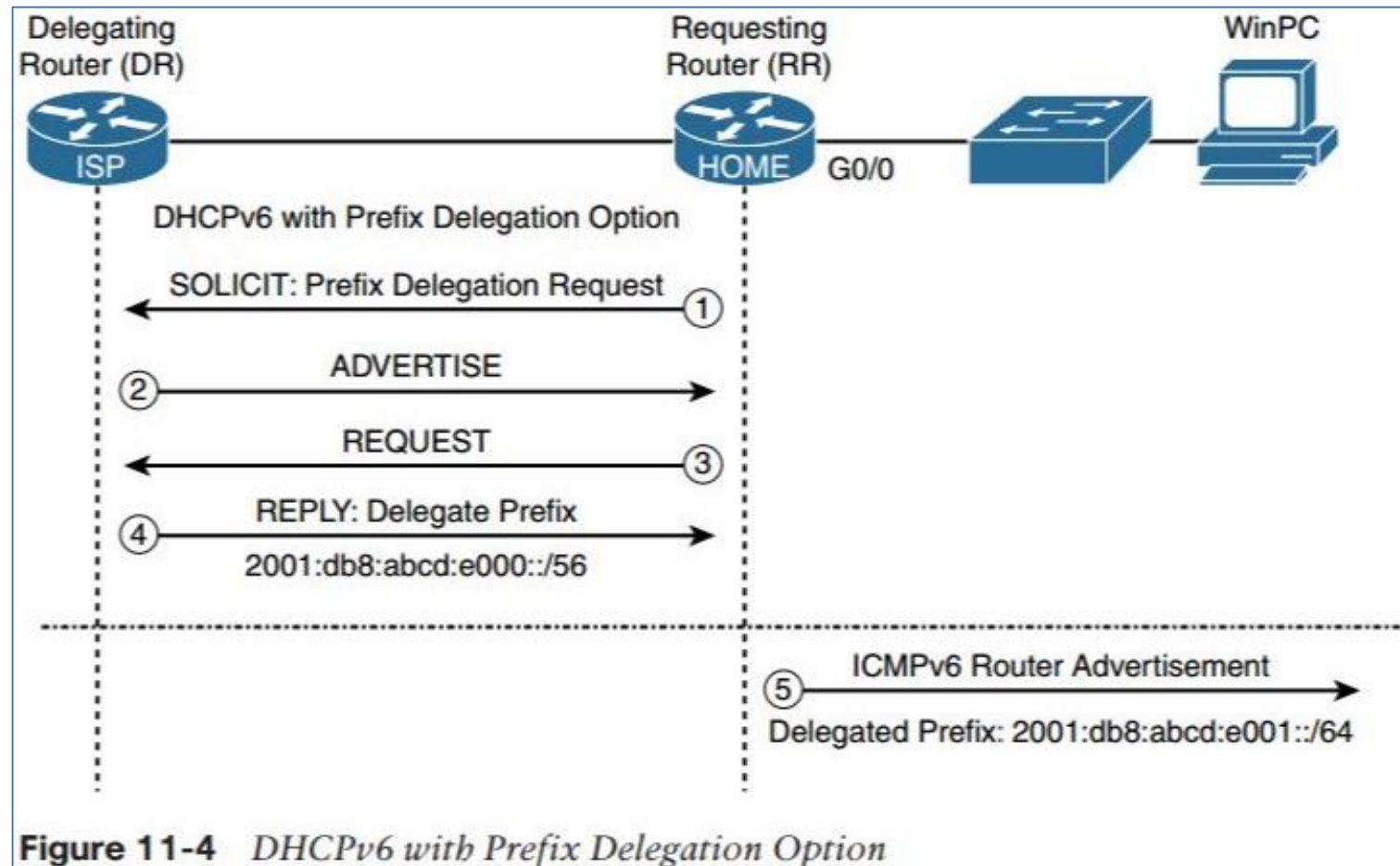
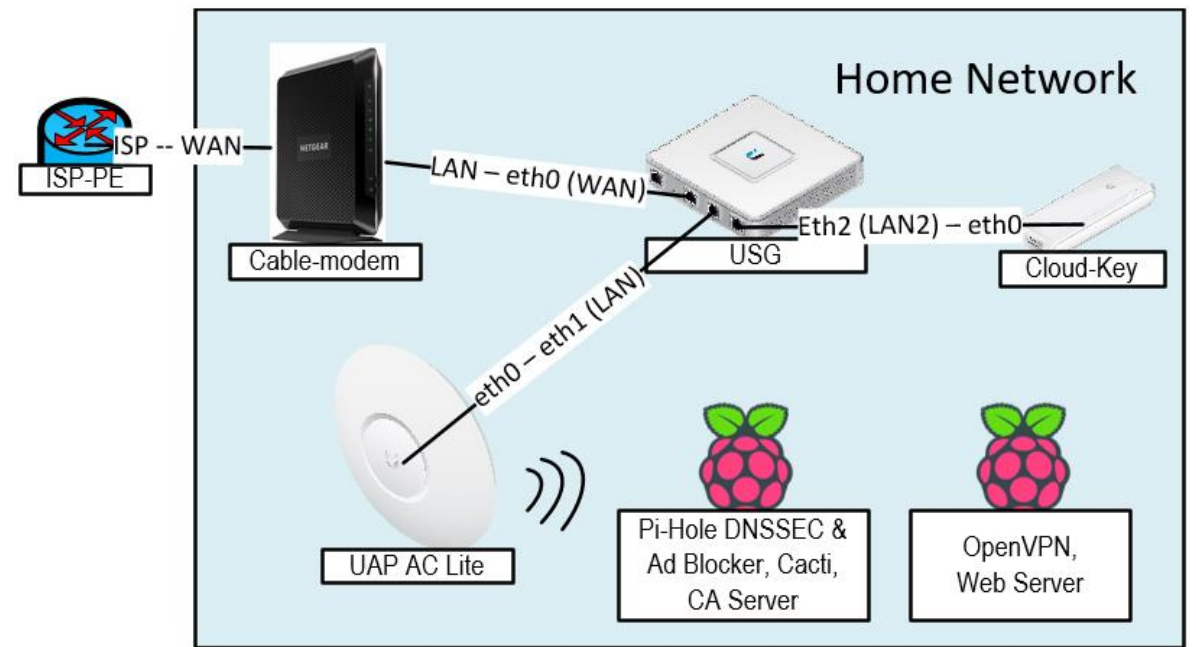


Figure 11-4 *DHCPv6 with Prefix Delegation Option*

My Solution: Ubiquiti (USG, CK, AP) + 2 Raspberry Pi + LastPass

No	Device	Price (amazon, etc)
1	Ubiquiti UniFi Security Gateway (USG), for <100 Mbps internet.	US\$ 126
2	Ubiquiti UniFi Cloud Key Controller (UC-CK).	US\$ 94
3	Ubiquiti UniFi Ap-AC Lite - Wireless Access Point - 802.11 B/A/G/n/AC (UAP AC LITE US), White.	US\$ 89
4	2x CanaKit Raspberry Pi 3 B+ (B Plus) with Premium Clear Case and 2.5A Power Supply + 32GB MicroSD card.	US\$ 135
5	Annual LastPass Family password manager plan.	US\$ 48
6	Annual Google Domain name.	US\$ 12
	Total	US\$ 504 (tax excl.)
7	Optional 1: Ubiquiti UniFi Dream Machine Pro (Built-in Controller, 8 Port Gigabit Switch, 2x 10G SFP+), for 1 Gbps internet. #1,2 above and #8 below not required.	US\$ 379
8	Optional 2: TP-Link TL-SG108E (8 Port Gigabit, Easy Smart Managed Switch).	US\$ 30

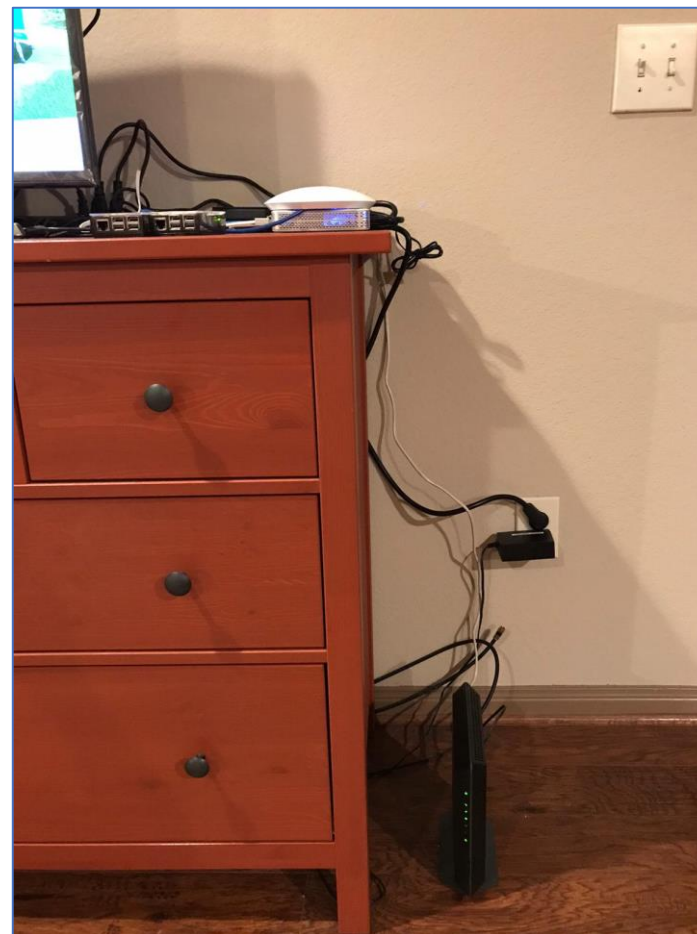


Important keywords:

- Affordable (to my household budget),
- Reliable,
- Easy to maintain.

The Look..

I have a space constraint in my apartment, so I'm using the space on top of my drawer, right beside my smart TV..



What The 2 Raspberry Pi Do

Installed apps in the internal-facing RPi 1:

Pi-Hole (on lighttpd)
Cacti (on apache)
EasyRSA CA Server
Fail2Ban

Installed apps in the internet-facing RPi 2:

OpenVPN Server
Web Server (on apache)
Let's Encrypt
UFW (Uncomplicated FW)
Fail2Ban

The single webpage in RPi 2 can be accessed using below URLs:

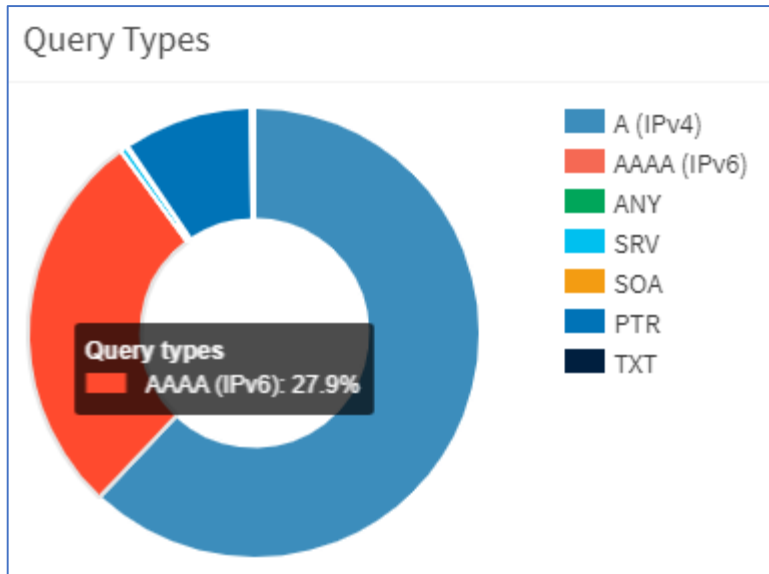
http://ipv4.yordan12.com
http://ipv6.yordan12.com
https://ipv4.yordan12.com
https://ipv6.yordan12.com
www.yordan12.com (v4 & v6)
yordan12.com (v4 & v6)

Fun fact, to check any website security header score, go to:

<https://securityheaders.com/>
<https://observatory.mozilla.org/>

1. Pi-Hole DNS Server & Ad Blocker

A Pi-Hole Home DNS Server with DNSSEC and Ad Blocker capability.



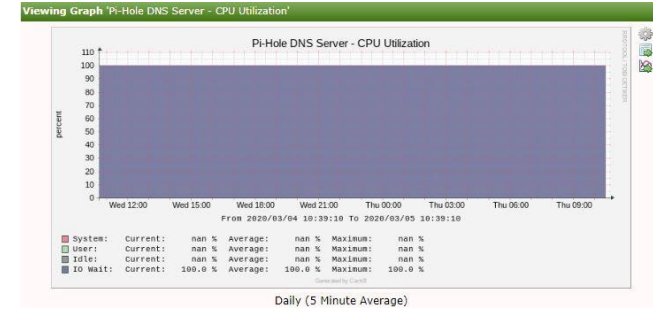
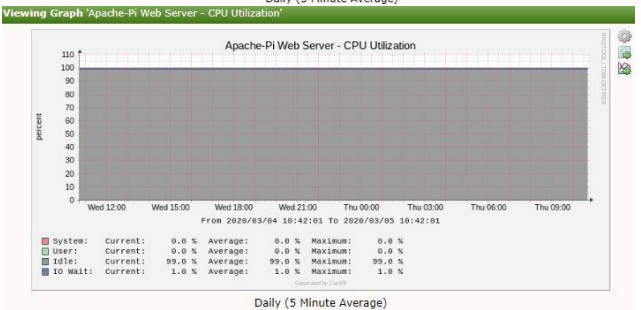
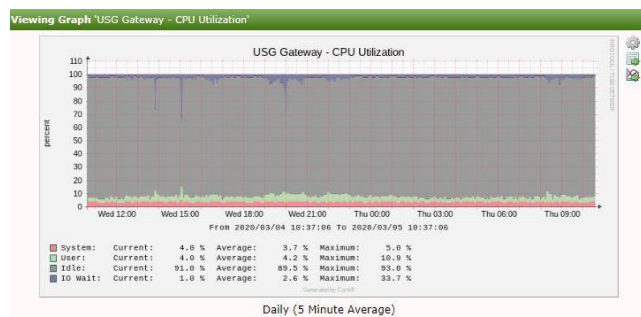
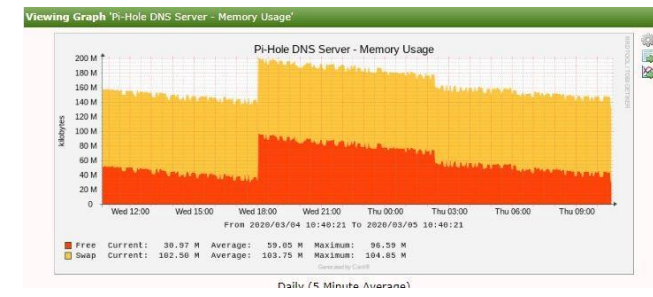
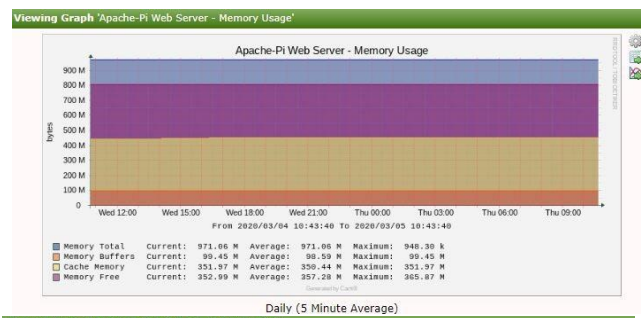
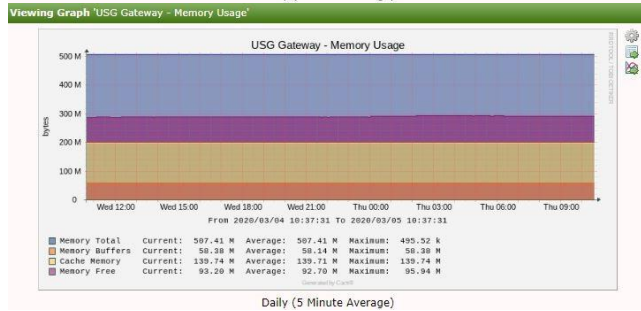
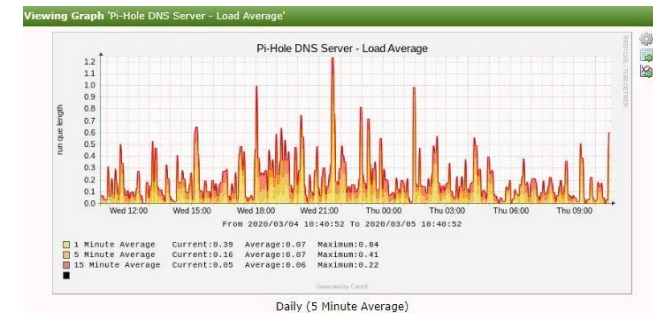
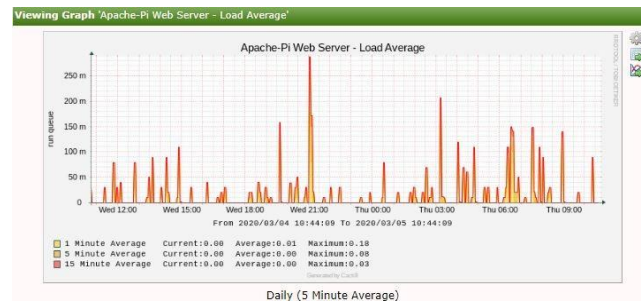
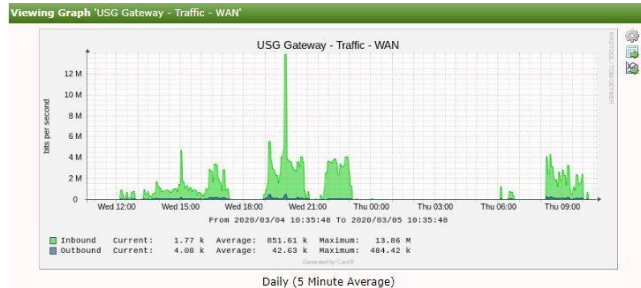
Time	Type	Domain	Client	Status	Reply	Action
2020-10-05 13:27:35	AAAA	edge.stream-smarttv-samsung-act ive.xcr.comcast.net	192.168.4.100	OK (forwarded)	IP (37.2ms)	Blacklist
2020-10-05 13:27:31	AAAA	me.apple-dns.net	2601:2c7:4500:4151:3d9a:d846:774a:bbbc	OK (forwarded)	IP (36.7ms)	Blacklist
2020-10-05 13:27:28	AAAA	alternate.tokopedia.link	2601:2c7:4500:4151:3d9a:d846:774a:bbbc	OK (cached)	NODATA (0.4ms)	Blacklist
2020-10-05 13:27:02	AAAA	qr.api.gopay.money	2601:2c7:4500:4151:3d9a:d846:774a:bbbc	OK (forwarded)	NODATA (52.2ms)	Blacklist
2020-10-05 13:26:53	AAAA	www.gojek.link	2601:2c7:4500:4151:3d9a:d846:774a:bbbc	OK (forwarded)	NODATA (41.7ms)	Blacklist
2020-10-05 13:26:53	AAAA	test-tokopedia.link	2601:2c7:4500:4151:3d9a:d846:774a:bbbc	OK (forwarded)	NODATA (108.9ms)	Blacklist
2020-10-05 13:26:53	AAAA	alternate.test-tokopedia.link	2601:2c7:4500:4151:3d9a:d846:774a:bbbc	OK (forwarded)	NODATA (85.9ms)	Blacklist
2020-10-05 13:26:43	AAAA	trk.tokopedia.email	████████████████████iphone	OK (forwarded)	SERVFAIL	Blacklist
2020-10-05 13:26:43	AAAA	trk.tokopedia.email	2601:2c7:4500:4151:3d9a:d846:774a:bbbc	OK (forwarded)	N/A	Blacklist
2020-10-05 13:26:42	AAAA	staging.tokopedia.com	2601:2c7:4500:4151:3d9a:d846:774a:bbbc	OK (cached)	SERVFAIL (0.4ms)	Blacklist

Showing 1 to 10 of 5,287 entries

Previous **1** 2 3 4 5 ... 529 Next

2. Cacti Network Monitoring Server

A Cacti network graphing server to monitor my home network devices (CPU, memory, traffic, disk space, etc).



IPv6 At Home with DHCPv6 Prefix Delegation

```
yordan12@ubnt:~$ show ipv6 route
Codes: K - kernel route, C - connected, S - static, R - RIPng, O - OSPFv3,
       I - ISIS, B - BGP, * - FIB route.

K>* ::/0 via fe80::201:5cff:fe9e:7446, eth0
C>* ::1/128 is directly connected, lo
C>* 2001:558:6022:97:d449:5ad3:e50e:a70e/128 is directly connected, eth0
C>* 2601:2c3:8580:flb1::/64 is directly connected, eth1
C * fe80::/64 is directly connected, eth0
C * fe80::/64 is directly connected, eth1
C>* fe80::/64 is directly connected, eth2
yordan12@ubnt:~$
```

```
yordan12@ubnt:~$ show interfaces
Codes: S - State, L - Link, u - Up, D - Down, A - Admin Down
Interface      IP Address          S/L  Description
-----
eth0           73.32.136.102/23    u/u  WAN
              2001:558:6022:97:d449:5ad3:e50e:a70e/128
eth1           192.168.1.1/24      u/u  LAN
              2601:2c3:8580:flb1:7683:c2ff:fed2:ae29/64
eth2           192.168.2.1/24      u/u  LAN2
lo             127.0.0.1/8         u/u
              ::1/128
yordan12@ubnt:~$
```

```
yordan12@ubnt:~$ ping6 google.com
PING google.com(dfw25s17-in-x0e.1e100.net) 56 data bytes
64 bytes from dfw25s17-in-x0e.1e100.net: icmp_seq=1 ttl=55 time=13.2 ms
64 bytes from dfw25s17-in-x0e.1e100.net: icmp_seq=2 ttl=55 time=13.5 ms
64 bytes from dfw25s17-in-x0e.1e100.net: icmp_seq=3 ttl=55 time=13.1 ms
64 bytes from dfw25s17-in-x0e.1e100.net: icmp_seq=4 ttl=55 time=13.6 ms
^C
--- google.com ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3003ms
rtt min/avg/max/mdev = 13.165/13.406/13.680/0.205 ms
yordan12@ubnt:~$
```

```
yordan12@ubnt:~$ show ipv6 neighbors | match REACHABLE
fe80::48e:3309:28ee:bl3b dev eth1 lladdr d0:81:7a:7f:52:3c REACHABLE
2601:2c3:8580:flb1:8811:62fe:500f:1373 dev eth1 lladdr dc:a2:66:4b:bf:05 REACHABLE
2601:2c3:8580:flb1:18c4:e073:4c34:4df6 dev eth1 lladdr d0:81:7a:7f:52:3c REACHABLE
fe80::201:5cff:fe9e:7446 dev eth0 lladdr 00:01:5c:9e:74:46 router REACHABLE
yordan12@ubnt:~$
```

"In residential networks, Comcast/Xfinity allows the user to ask for a maximum of 16 x /64 prefixes or /60."

<https://networkjutsu.com/how-to-configure-edgerouter-lite-part-two/>

IPv6 Verification

```
Wireless LAN adapter Wi-Fi:

Connection-specific DNS Suffix . : localdomain
IPv6 Address. . . . . : 2601:2c3:8580:f1b1:1408:23e0:9357:65c8
IPv6 Address. . . . . : fd00::7cc
Temporary IPv6 Address. . . . . : 2601:2c3:8580:f1b1:8811:62fe:500f:1373
Link-local IPv6 Address . . . . . : fe80::1408:23e0:9357:65c8%16
IPv4 Address. . . . . : 192.168.1.12
Subnet Mask . . . . . : 255.255.255.0
Default Gateway . . . . . : fe80::7683:c2ff:fed2:ae29%16
                            192.168.1.1
```

```
C:\Users\Sylvia>tracert -6 facebook.com

Tracing route to facebook.com [2a03:2880:f134:183:face:b00c:0:25de]
over a maximum of 30 hops:

  0  16 ms    2 ms     2 ms  2601:2c3:8580:f1b1:7683:c2ff:fed2:ae29
  1  15 ms    13 ms    11 ms  2001:558:4081:97::1
  2  14 ms    10 ms    11 ms  ae-252-1222-rur02.grant.tx.houston.comcast.net [2001:558:2c2:8041::1]
  3  26 ms    18 ms    12 ms  ae-37-ar01.bearcreek.tx.houston.comcast.net [2001:558:2c0:bf::1]
  4  *        *        *      Request timed out.
  5  *        *        24 ms  be-12441-pe01.1950stemmons.tx.ibone.comcast.net [2001:558:0:f673::2]
  6  20 ms    17 ms    31 ms  2001:559::133e
  7  18 ms    19 ms    16 ms  po102.psw02.dfw5.tfbnw.net [2620:0:1cff:dead:bef0::25f]
  8  19 ms    25 ms    22 ms  po2.msw1am.02.dfw5.tfbnw.net [2a03:2880:f034:ffff::24d]
  9  20 ms    18 ms    17 ms  edge-star-mini6-shv-02-dfw5.facebook.com [2a03:2880:f134:183:face:b00c:0:25de]

Trace complete.
```

The screenshot shows a mobile application interface for a Traceroute. At the top, the status bar shows AT&T, signal strength, Wi-Fi, time 23:18, and 48% battery. The app title is "Traceroute". Below the title is a search bar containing "google.com". There are two buttons for "Protocol": "IPv4" and "IPv6", with "IPv6" selected. A "Cycles" control shows "1" with minus and plus buttons. The traceroute results are displayed in a list format:

- HOP 1: 2601:2c3:8580:f1b1:7683:c2ff:fed2:ae29 (7.86ms 12.01ms 1.63ms)
- HOP 2: 2001:558:4081:97::1 (11.35ms 12.86ms 14.03ms)
- HOP 3: ae-252-1221-rur01.grant.tx.houston.comca... (12.46ms 16.66ms 36.44ms)
- HOP 4: 2001:558:2c0:10c::2 (11.25ms 10.93ms 10.28ms)
- HOP 5: ae-37-ar01.bearcreek.tx.houston.comcast... (26.40ms 14.11ms 27.45ms)

IPv6 GUA Is Preferred Over IPv4

Using the USG, we can briefly spy on our home network devices.

`sudo tcpdump -npi eth1 'ether dst d0:81:7a:7f:52:3c or ether src d0:81:7a:7f:52:3c' -w /home/yordan12/cap.pcapng`

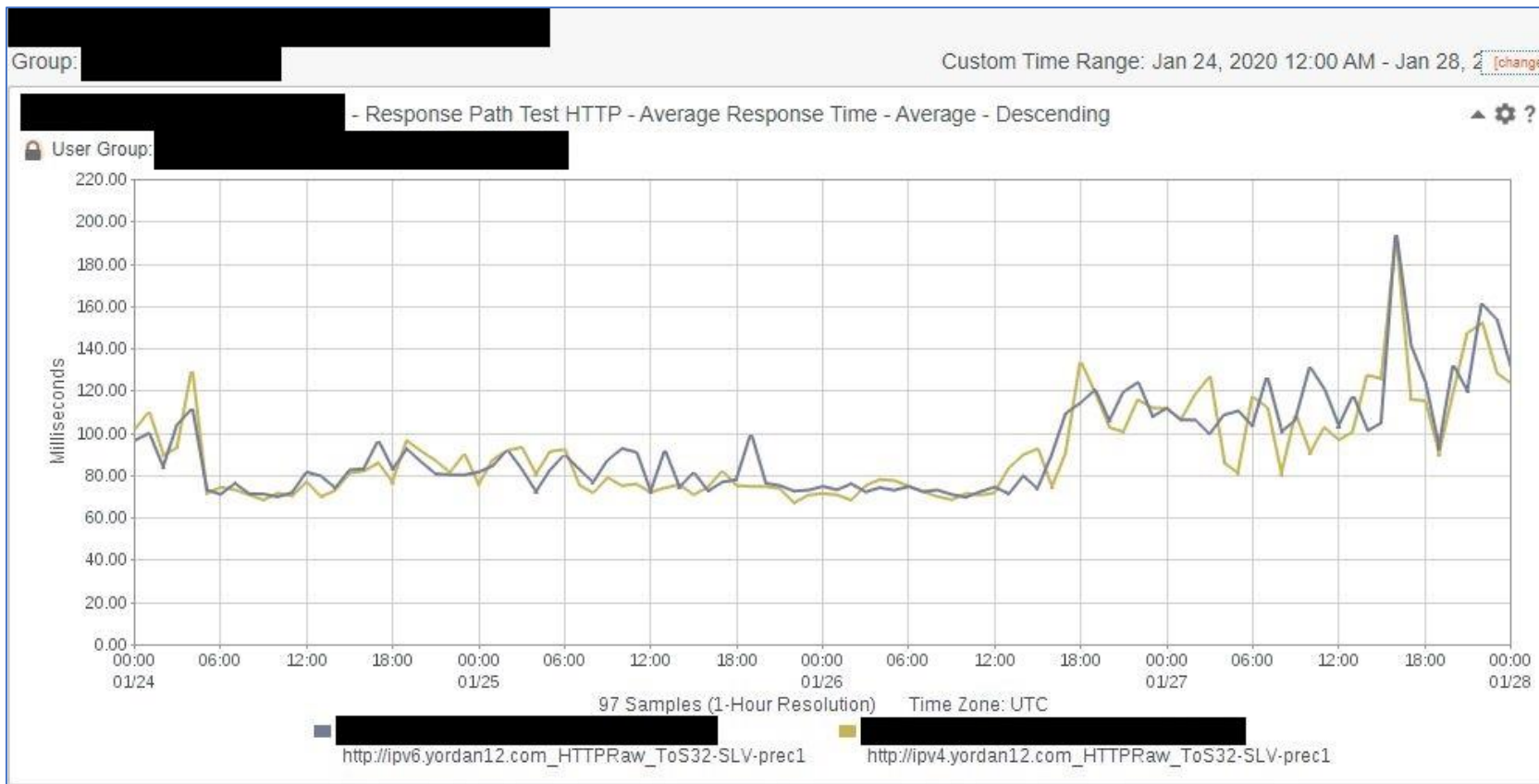
Below shows Facebook App traffic from an iPhone.

Ethernet · 3	IPv4 · 5	IPv6 · 10	TCP · 20	UDP · 35									
Address A	Address B		Packets	Bytes	Packets A → B	Bytes A → B	Packets B → A	Bytes B → A	Rel Start	Duration	Bits/s A → B	Bits/s B → A	
2001:559:800c:1902:face:b00c:0:358e	2601:2c3:8580:f1b1:80f9:bc7d:21f0:38ae		15,282	12 M	7,983	11 M	7,299	654 k	7.296183	5.4303	16 M	964 k	
2001:559:800c:1902:face:b00c:0:a7	2601:2c3:8580:f1b1:80f9:bc7d:21f0:38ae		5,428	4198 k	2,871	3959 k	2,557	238 k	1.972821	8.1781	3873 k	232 k	
2001:559:800c:1903:face:b00c:0:358e	2601:2c3:8580:f1b1:80f9:bc7d:21f0:38ae		3,028	2428 k	1,615	2301 k	1,413	127 k	7.296595	3.1414	5860 k	325 k	
2001:559:800c:1903:face:b00c:0:a7	2601:2c3:8580:f1b1:80f9:bc7d:21f0:38ae		2,152	1599 k	1,163	1503 k	989	96 k	1.972274	8.1522	1475 k	94 k	
2601:2c3:8580:f1b1:80f9:bc7d:21f0:38ae	2a03:2880:f034:112:face:b00c:0:2		1,021	796 k	328	127 k	693	669 k	1.404122	11.9942	84 k	446 k	
2601:2c3:8580:f1b1:80f9:bc7d:21f0:38ae	2a03:2880:f134:183:face:b00c:0:25de		76	30 k	40	20 k	36	9286	1.404432	8.9839	18 k	8269	
fe80::48e:3309:28ee:b13b	fe80::7683:c2ff:fed2:ae29		73	8954	38	4039	35	4915	1.388156	8.9859	3595	4375	
2601:2c3:8580:f1b1:80f9:bc7d:21f0:38ae	2a03:2880:f034:10b:face:b00c:0:8e		63	9672	33	5410	30	4262	2.659205	10.7496	4026	3171	
2601:2c3:8580:f1b1:80f9:bc7d:21f0:38ae	2a03:2880:f034:11a:face:b00c:0:3		47	15 k	23	4059	24	11 k	7.392566	2.7019	12 k	34 k	
fe80::48e:3309:28ee:b13b	ff02::fb		1	94	1	94	0	0	12.777591	0.0000	—	—	

Ethernet · 3	IPv4 · 5	IPv6 · 10	TCP · 20	UDP · 35								
Address A	Address B	Packets	Bytes	Packets A → B	Bytes A → B	Packets B → A	Bytes B → A	Rel Start	Duration	Bits/s A → B	Bits/s B → A	
31.13.93.19	192.168.1.10	37	5553	15	2400	22	3153	1.358061	0.3468	55 k	72 k	
192.168.1.10	216.58.194.134	33	7990	19	2509	14	5481	13.399010	0.1769	113 k	247 k	
17.154.67.26	192.168.1.10	29	11 k	13	7105	16	4460	4.920394	0.3376	168 k	105 k	
31.13.93.35	192.168.1.10	24	3558	10	1600	14	1958	1.541107	0.0768	166 k	203 k	
192.168.1.10	224.0.0.251	1	74	1	74	0	0	12.777368	0.0000	—	—	

IPv6 Performance = IPv4 Performance

We now have an evidence that IPv6 web performance is similar to IPv4.



Conclusion

1. In terms of HTTP IPSLA performance, IPv6 is similar to IPv4.
2. It would be cool if all internet providers in North America can provide IPv6 with no additional cost, like Comcast and AT&T.
3. Adding security features at home can be a reasonable justification to purchase the required devices.
4. A little bit of fun and a lot of learning.

Thank You!



Image from free-icon-rainbow.com

DIY Tutorial for this project can be found in:
<https://gitlab.com/yordan12/usg>

Feel free to leave any comments or feedback here:
ysutanto@slb.com / yordan12@gmail.com