

# Despliegue IPv6

Lo aprendido en 6 años



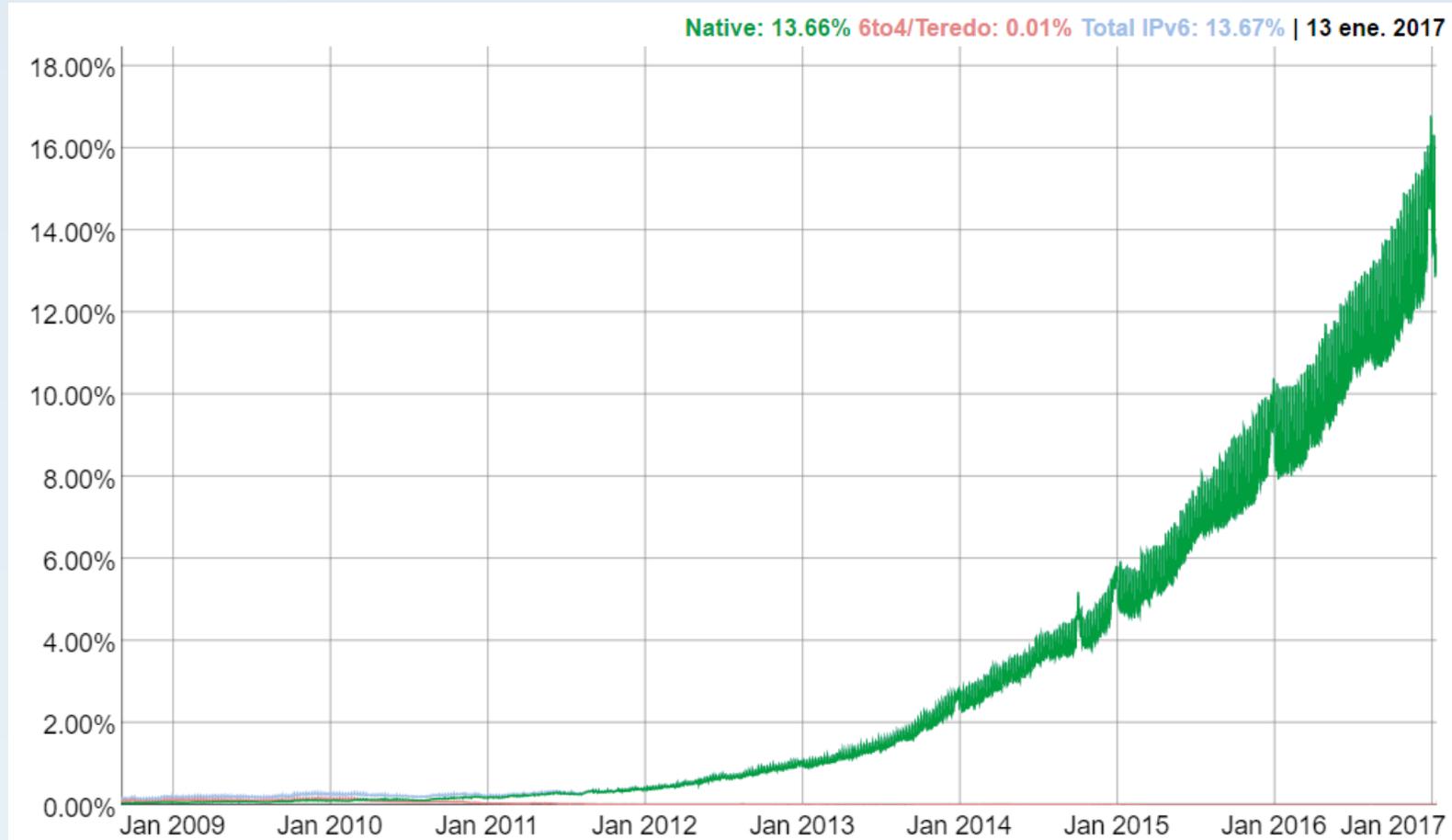
- Historia
- Motivación
- Antes de empezar
- Primeros pasos
- Implementando IPv6 en todo
- Preguntas

2800:640:cf:22:c95c:7a48:e1c3:35b2

- IPv6 nació en 1996 (RFC 1883)
- Para 1998 la IETF lo definió como el sucesor de IPv4 (RFC 2460)
- En febrero 2011 IANA entregó los últimos 5 bloques /8
- El 8 de junio del 2011 fue el World IPv6 Day
- El 6 de junio del 2012 fue el World IPv6 Launch Day



## Breve historia



## Adopción Global de IPv6 – Visto desde Google

<https://www.google.com/intl/en/ipv6/statistics.html>

- Crecimiento exponencial de la Internet
- Seguridad
- Desempeño
- Simplicidad de diseño

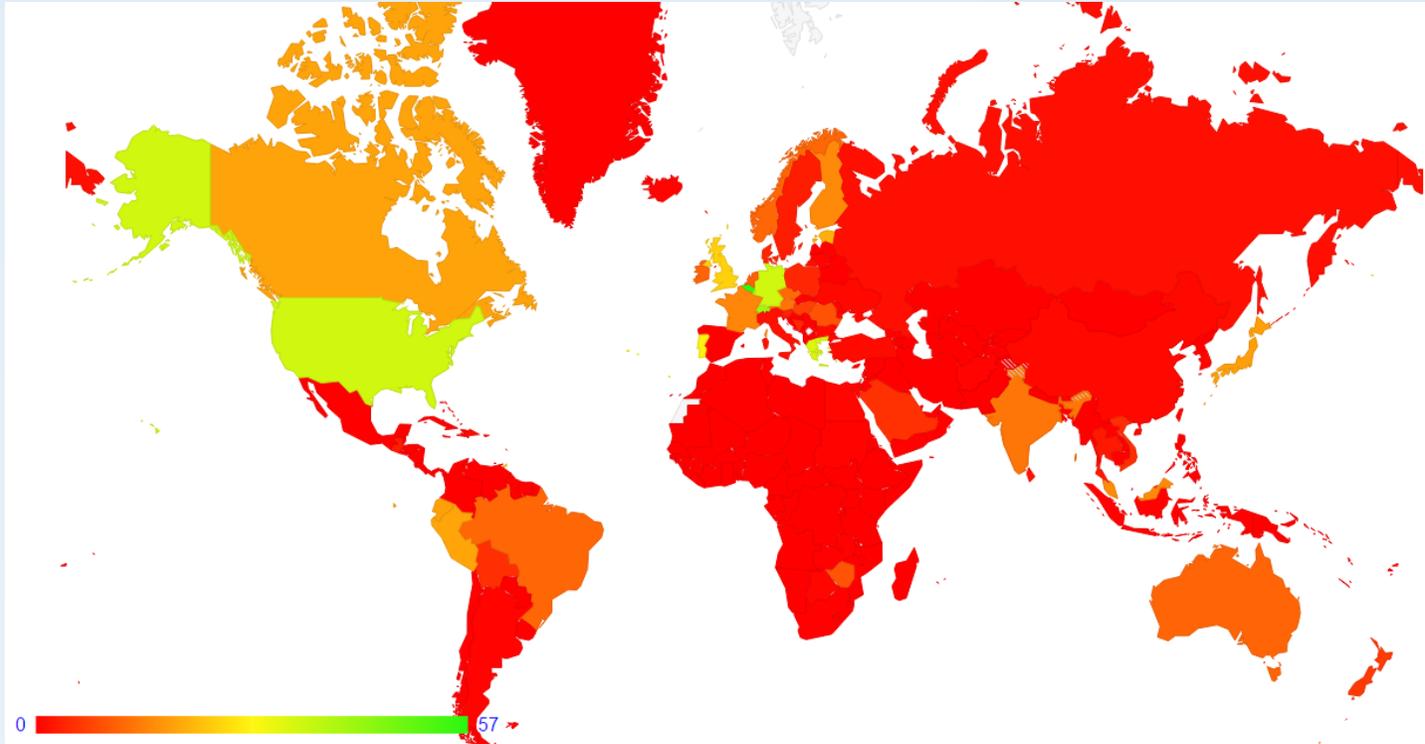
Motivación



Guatemala	0.25%
Panamá	0.08%
México	0.05%
Honduras	0.03%
Costa Rica	0.02%
El Salvador	0.01%
Nicaragua	0.01%
Belice	0.00%

## Motivación

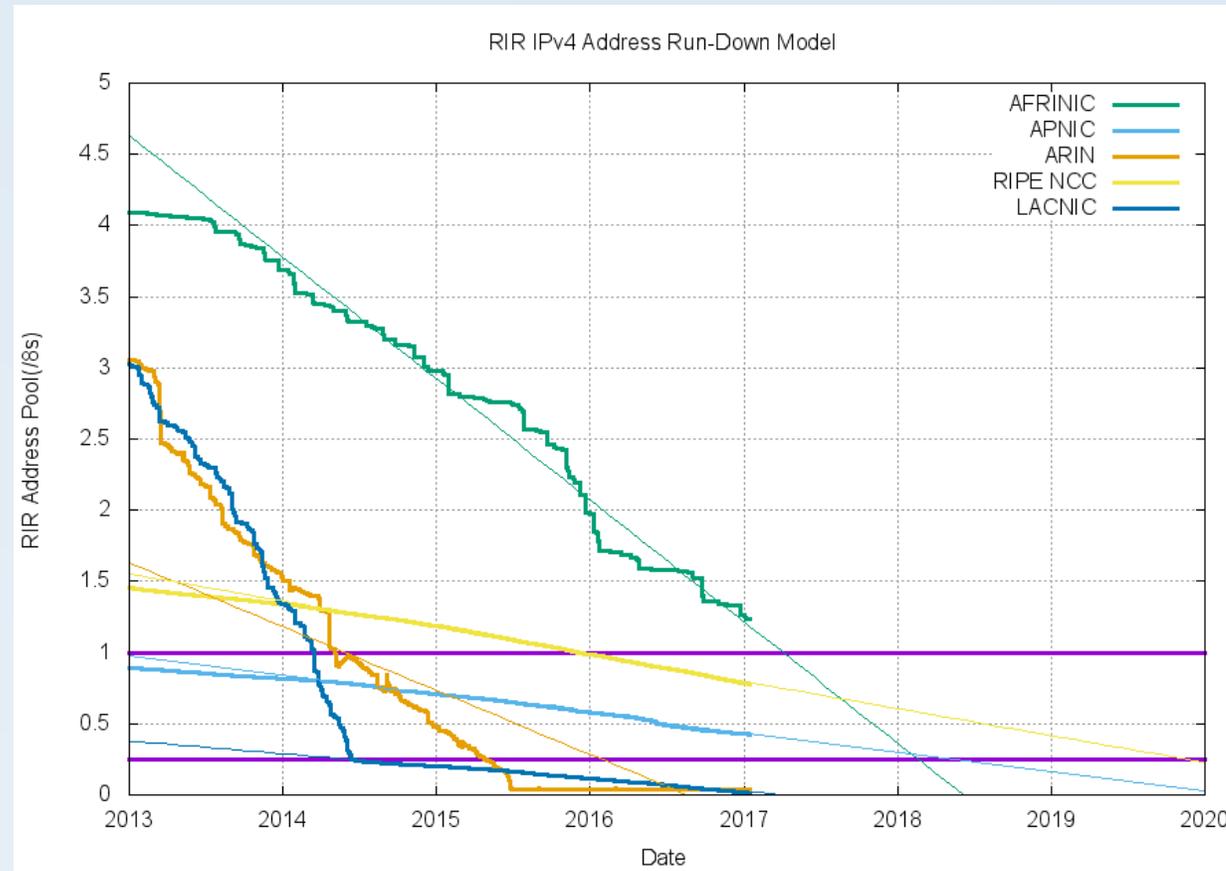
Adopción en Centro América



1. Bélgica 53.6%
2. Suiza 35.9%
3. USA 33.8%
4. Alemania 30.7%
5. Grecia 27.9%
6. Luxemburgo 26.9%
7. Portugal 22.9%
8. Inglaterra 22.0%
9. Perú 18.5%
10. Ecuador 18.1%
16. Trinidad & T 13.5%
18. Brasil 10.9%

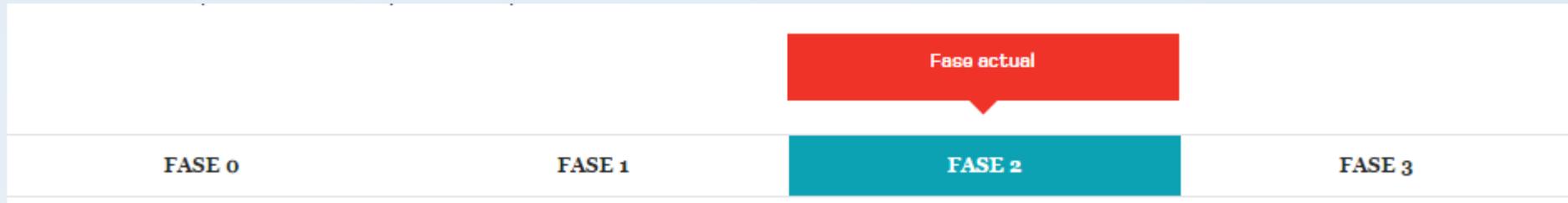
# Motivación

Adopción en el mundo



# Motivación

Agotamiento del pool de direcciones IPv4



- El 10 de Junio de 2.014 se ha activado la fase 2
- solo se podrá asignar bloques desde un prefijo /24 hasta un /22, pudiendo recibir un bloque adicional cada 6 meses

## Motivación

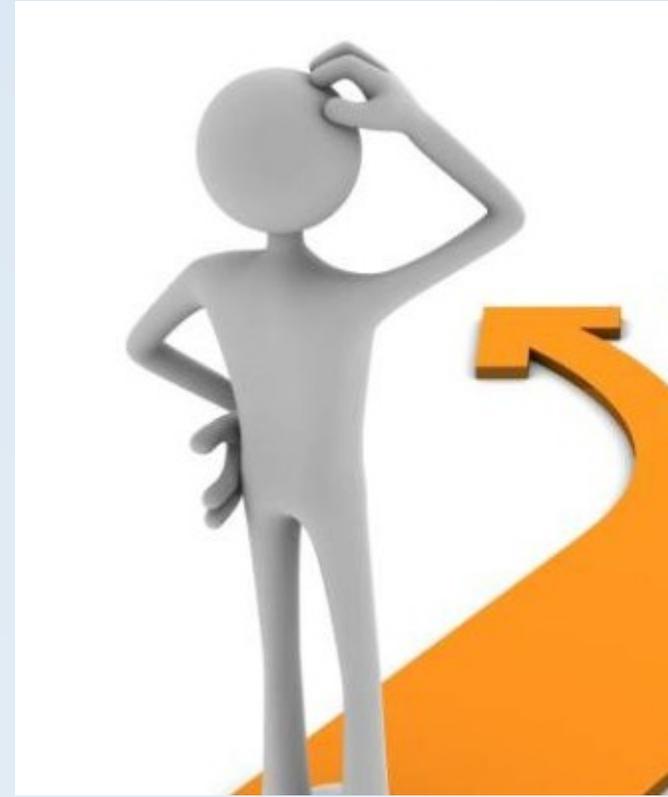


- El 20 de Marzo de 2.017 se espera entrar en la última fase, la 3
- solo se podrá asignar bloques desde un prefijo /24 hasta un /22, a nuevos miembros

Motivación



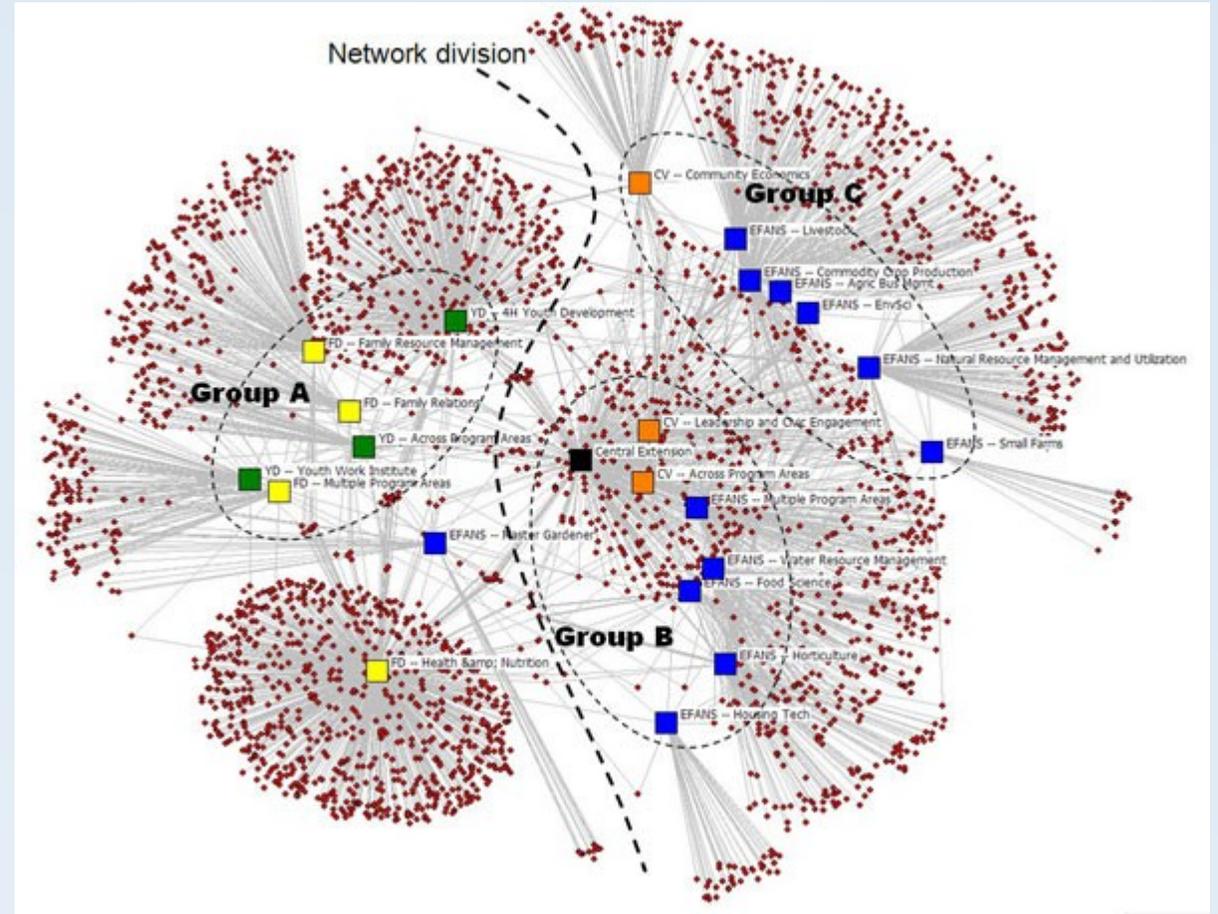
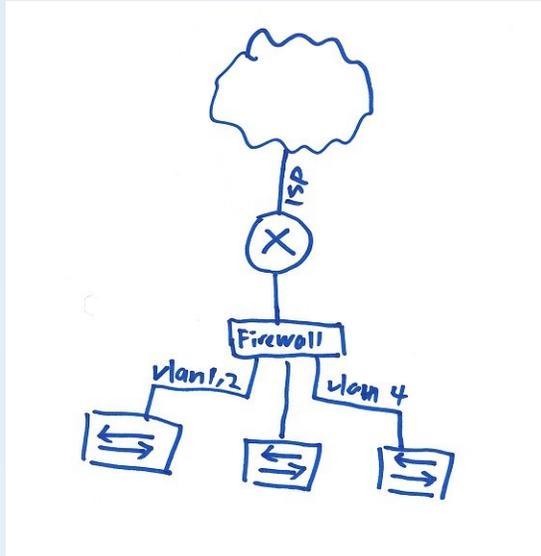
Antes de empezar



- Recursos a solicitar y a quien
- Compatibilidad del Hardware
- Esquema lógico
- Update del Software
- Entrenamiento del personal

## Antes de empezar

Detalles del plan



# Antes de empezar

La estructura de la red determina el camino a seguir y los recursos a solicitar

- Dual stack (Doble pila)
- 6to4
- 6RD
- Teredo

## Antes de empezar

Opciones de despliegue



En febrero del 2011 configuramos un túnel con HE

LACNIC nos asigna la red 2800:640::/32

La anunciamos usando BGP vía el túnel de HE

## Primeros Pasos

IPv6 – Hello World

Optamos por usar Dual Stack

OSPFv3 para la distribución interna

Link local (FE80::/10) para la comunicación entre routers

Solo un IPv6 global por equipo (preferiblemente en la loopback)

Un /64 por sitio

## Primeros Pasos

Distribución interna

Nomenclatura fácil de entender

Redes /48 para cada función en la red

Red "BackBone"

2800:640:bb::/48

Access Point 2 en sitio 3

2800:640:bb:3::a2

Red "Cliente Final"

2800:640:cf::/48

Cliente 37

2800:640:cf:37::1

## Primeros Pasos

Plan de direccionamiento

Stateless Address Autoconfiguration (SLAAC)

RA habilitado solo en un equipo de Backbone por sitio

RA habilitado y DHCPv6 en las antenas cliente en la interface Ether1

## Primeros Pasos

SLAAC - Router Advertisement

BGP												
Instances VRFs Peers Networks Aggregates VPN4 Routes Advertisements												
Name	Instance	Remote Address	Remote AS	M...	R...	TTL	Remote ID	Uptime	Prefix Co...	State		
BGPm4	default	129.82.138.6	6447	yes	no	default	129.82.138.6	1d 22:35:20		established		
BGPmon4	default	184.106.199.193	65179	yes	no	default	184.106.199.193	1d 22:36:16		established		
BGPmon6	default	2001:470:1f10:847::2	65179	yes	no	default	184.106.199.193	1d 22:36:59		established		
Quagga_v4	default	200.59.21.6	262149	no	no	default	200.59.21.6	4d 04:03:26	2	established		
Quagga_v6	default	2800:640:d:1::6	262149	no	no	default	200.59.21.6	4d 04:04:59	1	established		
Radar_v4	default	178.248.237.29	197068	yes	yes	default	178.248.237.29	3d 21:52:52		established		
crix_v4	default	200.59.17.42	262149	no	no	default	200.59.17.17	4d 04:05:40	974	established		
crix_v6	default	2800:640:ee:101::2	262149	no	no	default	200.59.17.17	4d 04:05:35	40	established		
gnd_v4	default	200.59.17.43	262149	no	no	default	200.59.17.18	4d 03:57:11	578364	established		
gnd_v6	default	2800:640:ee:101::3	262149	no	no	default	200.59.17.18	4d 03:57:09	35226	established		
he	default	2001:470:13:81::1	6939	no	no	default	216.66.70.2	1d 22:36:55	34200	established		
tigo_v4	default	186.176.7.73	20299	no	no	default	186.32.0.89	1d 22:25:48	617096	established		
tigo_v6	default	2800:860:face:24::1	20299	no	no	default	186.32.0.89	1d 22:25:54	35341	established		

13 items

# Primeros Pasos

Sesiones BGP

BGP Peer <he>

General Advanced Status

Address Families:  ip  ipv6  l2vpn  vpn4  l2vpn-cisco

Update Source: 2001:470:13:81::2

Cisco VPLS NLRI Length Format: auto bits

# Primeros Pasos

Peer BGP

	Address	From Pool	Interface	Advertise	
G	2800:640:bb:3::a7/64		ether1	no	
DL	fe80::4e5e:cff:fe8a:f464/64		ether1	no	
DL	fe80::4e5e:cff:fe8a:f465/64		wlan1	no	

3 items

# Primeros Pasos

Asignación de IPs v6 Access Point

OSPFv3

Interfaces Instances Areas Area Ranges Virtual Links Neighbors NBMA Neighbors LSA Routes AS Border Routers OSPFv3 Routers

+ - ✓ ✕ ⌵ Find

Area	Interface	Cost	Priority	Network Type	Instance	Neig...	State
backbone	ether1	5	1	default	default	11	dr other
backbone	wlan1	20	1	default	default	3	designated router

2 items

# Primeros Pasos

Configuración OSPF v3

# Primeros Pasos

Tabla de ruteo IPv6

IPv6 Route List				
				
	Dst. Address	/	Gateway	Distance
DAo	▶ ::/0		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2000::/3		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2001:470:13:81::/64		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2001:13d8:a800::4/126		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2607f238:2::1		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2800:640:d:1::/64		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2800:640:f:1000::/64		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2800:640:f:1111::/64		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2800:640:f:2000::/64		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2800:640:f:2222::/64		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2800:640:f:6666::/64		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2800:640:bb:1::/64		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2800:640:bb:2::/64		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAC	▶ 2800:640:bb:3::/64		ether1 reachable	0
DAo	▶ 2800:640:bb:4::/64		fe80::4e5e:cff fe63:4b44%ether1 reachable	110
DAo	▶ 2800:640:bb:5::/64		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2800:640:bb:6::/64		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2800:640:bb:7::/64		fe80::4e5e:cff fe63:4b44%ether1 reachable	110
DAo	▶ 2800:640:bb:8::/64		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2800:640:bb:9::/64		fe80::4e5e:cff fe63:4b44%ether1 reachable	110
DAo	▶ 2800:640:bb:10::/64		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2800:640:bb:11::/64		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2800:640:bb:12::/64		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2800:640:bb:13::/64		fe80::4e5e:cff fe8d:223c%ether1 reachable	110
DAo	▶ 2800:640:bb:14::/64		fe80::4e5e:cff fe8d:223c%ether1 reachable	110
DAo	▶ 2800:640:bb:15::/64		fe80::4e5e:cff fe8d:223c%ether1 reachable	110
DAo	▶ 2800:640:bb:16::/64		fe80::4e5e:cff fe8d:223c%ether1 reachable	110
DAo	▶ 2800:640:bb:20::/64		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2800:640:bb:21::/64		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2800:640:bb:22::/64		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2800:640:bb:23::/64		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2800:640:cf:1::/64		fe80::4e5e:cff fe80:52ba%wlan1 reachable	110
DAo	▶ 2800:640:cf:2::/64		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2800:640:cf:3::/64		fe80::e68d:8cff fe61:57c7%wlan1 reachable	110
DAo	▶ 2800:640:cf:6::/64		fe80::4e5e:cff fe63:4b44%ether1 reachable	110
DAo	▶ 2800:640:cf:7::/64		fe80::4e5e:cff fe63:4b44%ether1 reachable	110
DAo	▶ 2800:640:cf:8::/64		fe80::4e5e:cff fe63:4b44%ether1 reachable	110
DAo	▶ 2800:640:cf:9::/64		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110
DAo	▶ 2800:640:cf:10::/64		fe80::4e5e:cff fe8d:223c%ether1 reachable	110
DAo	▶ 2800:640:cf:11::/64		fe80::4e5e:cff fe8f:8fb0%ether1 reachable	110

	Address	From Pool	Interface	Advertise	
G	2800:640:cf:1::1/64		ether1	yes	
DL	fe80::4e5e:cff:fe80:52b9/64		ether1	no	
DL	fe80::4e5e:cff:fe80:52ba/64		wlan1	no	

3 items

# Primeros Pasos

Configuración IPs v6 cliente

OSPFv3

Interfaces Instances Areas Area Ranges Virtual Links Neighbors NBMA Neighbors LSA Routes AS Border Routers OSPFv3 Routers

+ - ✓ ✕ ⏏ Find

Area	Interface	Cost	Priority	Network Type	Instance	Neig...	State
backbone	wlan1	20	1	default	default	3	dr other

1 item

# Primeros Pasos

OSPFv3 Cliente

```
PS C:\Users\jorge> ipconfig
```

```
Configuración IP de Windows
```

```
Adaptador de Ethernet Ethernet 2:
```

```
Sufijo DNS específico para la conexión. . . :  
Dirección IPv6 . . . . . : 2800:640:cf:1:f5b0:bd38:f98e:dab2  
Dirección IPv6 temporal. . . . . : 2800:640:cf:1:a1da:3192:1727:9bb5  
Vínculo: dirección IPv6 local. . . : fe80::f5b0:bd38:f98e:dab2%16  
Dirección IPv4. . . . . : 192.168.11.83  
Máscara de subred . . . . . : 255.255.255.0  
Puerta de enlace predeterminada . . . . . : fe80::4e5e:cff:fe80:52b9%16  
192.168.11.1
```

## Primeros Pasos

IPv6 stateless autoconfiguration

```
PS C:\Users\jorge> tracert www.google.com
```

```
Traza a la dirección www.google.com [2607:f8b0:4008:807::2004]  
sobre un máximo de 30 saltos:
```

```
 1  <1 ms    <1 ms    <1 ms    ether1.mikrotik-casa-jorge.fratec.net [2800:640:cf:1::1]  
 2  11 ms    9 ms     3 ms     ether1.mikrotik-ap-sm7.fratec.net [2800:640:bb:3::a7]  
 3   8 ms    5 ms    10 ms    ether1.mikrotik-bb-sm1.fratec.net [2800:640:bb:3::b1]  
 4  15 ms    9 ms    14 ms    ether1.mikrotik-bb-noc-2.fratec.net [2800:640:bb:1::b2]  
 5  18 ms   17 ms   21 ms    ether3.mikrotik-bb-zeus.fratec.net [2800:640:bb:1::1]  
 6  15 ms   16 ms   27 ms    sfp-sfpplus1.mikrotik-bb-router-gnd1.fratec.net [2800:640:ee:101::3]  
 7  29 ms   55 ms   38 ms    2803:1300::e:c:0:2  
 8  16 ms   16 ms   12 ms    2803:1300::e:0:103:1  
 9  18 ms   36 ms   19 ms    2607:f438:0:3502:190:242:134:95  
10  46 ms   44 ms   35 ms    2607:f438:0:1:63:245:107:189  
11  57 ms   70 ms   71 ms    2607:f438:0:1:63:245:107:126  
12  54 ms   58 ms   53 ms    2607:f438:0:1002:63:245:6:182  
13  68 ms   75 ms   61 ms    2001:4860::1:0:245c  
14  60 ms   56 ms   92 ms    2001:4860:0:1::f5  
15  54 ms   90 ms   76 ms    mia07s25-in-x04.1e100.net [2607:f8b0:4008:807::2004]
```

```
Traza completa.
```

## Primeros Pasos

Traceroute

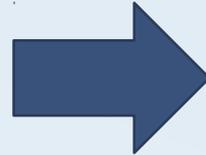
Otros equipos (routers) en la red

Red "Cliente Final DHCP"

2800:640:cfd::/48

Cliente 37

2800:640:cfd:370::/60



2800:640:cfd:370::/64

2800:640:cfd:371::/64

...

2800:640:cfd:37f::/64

## Primeros Pasos

DHCPv6

IPv6 Pool

Pools Used Prefixes

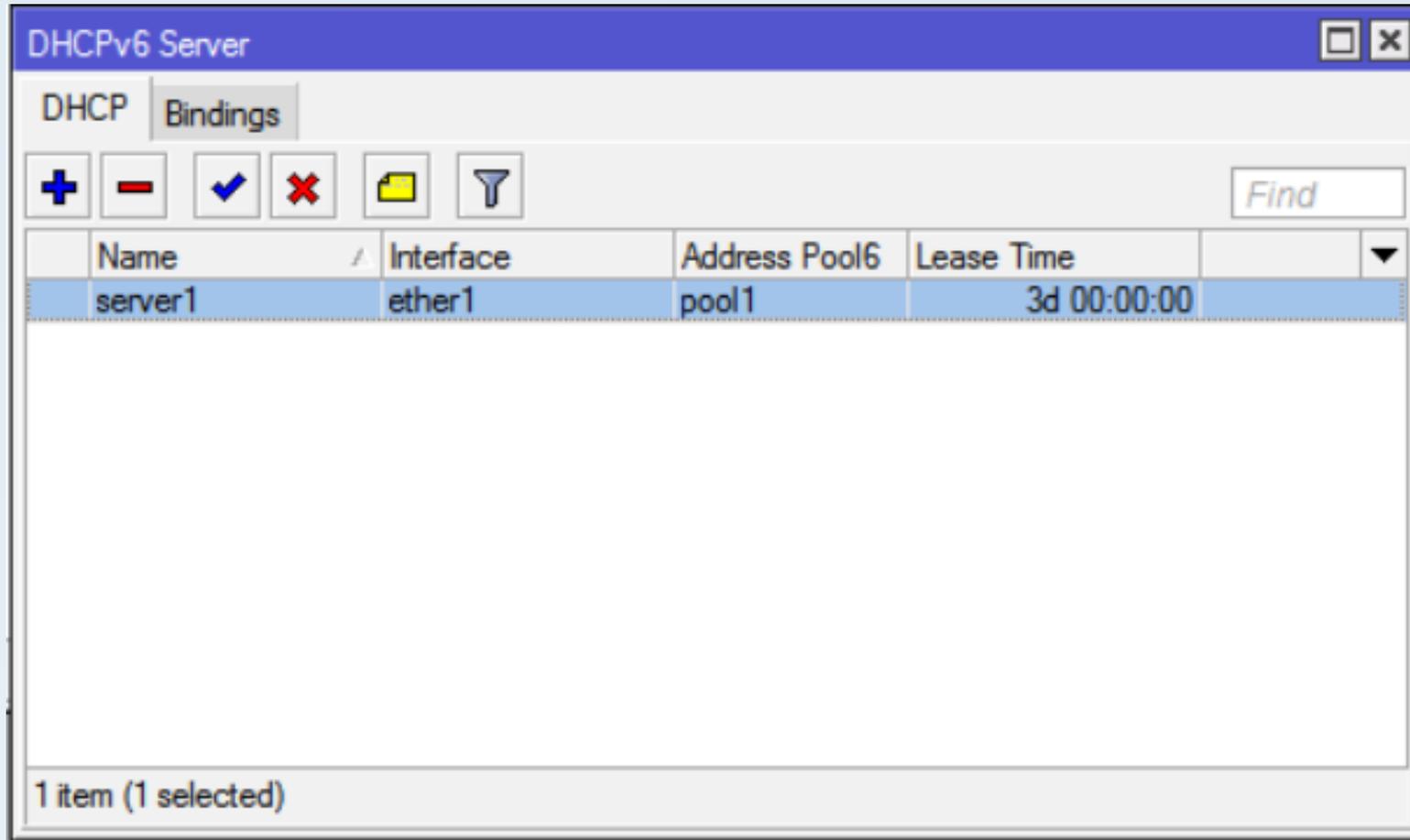
+ - Filter Find

Name	Prefix	Prefix Length	Expire Time	
pool1	2800:640:cfd:10::/60	64		

1 item

# Primeros Pasos

DHCPv6 - Pool



# Primeros Pasos

DHCPv6

DHCPv6 Server

DHCP Bindings

+ - ✓ ✗ [Icon] [Icon] Find

	Address	DUID	IAID	Server	Expire Time	Status	
D	2800:640:cf0:10::/64	0xc0562746c0c7	658948296	server1	2d 23:59:53	bound	▼

1 item

# Primeros Pasos

DHCPv6

```
PS C:\Users\jorge> ipconfig

Configuración IP de Windows

Adaptador de Ethernet Ethernet 2:

    Estado de los medios. . . . . : medios desconectados
    Sufijo DNS específico para la conexión. . . . . :

Adaptador de LAN inalámbrica Conexión de área local* 1:

    Estado de los medios. . . . . : medios desconectados
    Sufijo DNS específico para la conexión. . . . . :

Adaptador de LAN inalámbrica Wi-Fi:

    Sufijo DNS específico para la conexión. . . . . :
    Dirección IPv6 . . . . . : 2800:640:cfb:10:215b:d1b7:4044:5088
    Dirección IPv6 . . . . . : fd04:4c25:6de0:0:215b:d1b7:4044:5088
    Dirección IPv6 temporal. . . . . : 2800:640:cfb:10:f552:3bbf:465c:a577
    Dirección IPv6 temporal. . . . . : fd04:4c25:6de0:0:f552:3bbf:465c:a577
    Vínculo: dirección IPv6 local. . . . . : fe80::215b:d1b7:4044:5088%13
    Dirección IPv4. . . . . : 192.168.1.119
    Máscara de subred . . . . . : 255.255.255.0
    Puerta de enlace predeterminada . . . . . : fe80::c256:27ff:fe46:c0c7%13
                                                    192.168.1.1
```

# Primeros Pasos

IPv6 stateless autoconfiguration

```

PS C:\Users\jorge> tracert www.google.com

Traza a la dirección www.google.com [2607:f8b0:4008:807::2004]
sobre un máximo de 30 saltos:

  1      8 ms      1 ms      8 ms  2800:640:cf:10:c256:27ff:fe46:c0c7
  2     14 ms     14 ms     9 ms  ether1.mikrotik-casa-jorge.fratec.net [2800:640:cf:1::1]
  3     55 ms     27 ms     27 ms ether1.mikrotik-ap-sm7.fratec.net [2800:640:bb:3::a7]
  4     18 ms     17 ms     17 ms ether1.mikrotik-bb-sm1.fratec.net [2800:640:bb:3::b1]
  5     28 ms     17 ms     28 ms ether1.mikrotik-bb-noc-2.fratec.net [2800:640:bb:1::b2]
  6     43 ms     45 ms     55 ms ether3.mikrotik-bb-zeus.fratec.net [2800:640:bb:1::1]
  7     27 ms     27 ms     27 ms sfp-sfpplus1.mikrotik-bb-router-gnd1.fratec.net [2800:640:ee:101::3]
  8     29 ms     67 ms     37 ms 2803:1300::e:c:0:2
  9     29 ms     37 ms     37 ms 2803:1300::e:0:103:1
 10     30 ms     36 ms     28 ms 2607:f438:0:3502:190:242:134:95
 11     50 ms     47 ms     35 ms 2607:f438:0:1:63:245:106:167
 12     74 ms     77 ms    107 ms 2607:f438:0:1:63:245:107:126
 13     72 ms     78 ms     67 ms 2607:f438:0:1002:63:245:6:182
 14     75 ms     77 ms     74 ms 2001:4860::1:0:245c
 15     81 ms     83 ms     97 ms 2001:4860:0:1::f5
 16     70 ms    107 ms     84 ms mia07s25-in-x04.1e100.net [2607:f8b0:4008:807::2004]

Traza completa.

```

# Primeros Pasos

Traceroute

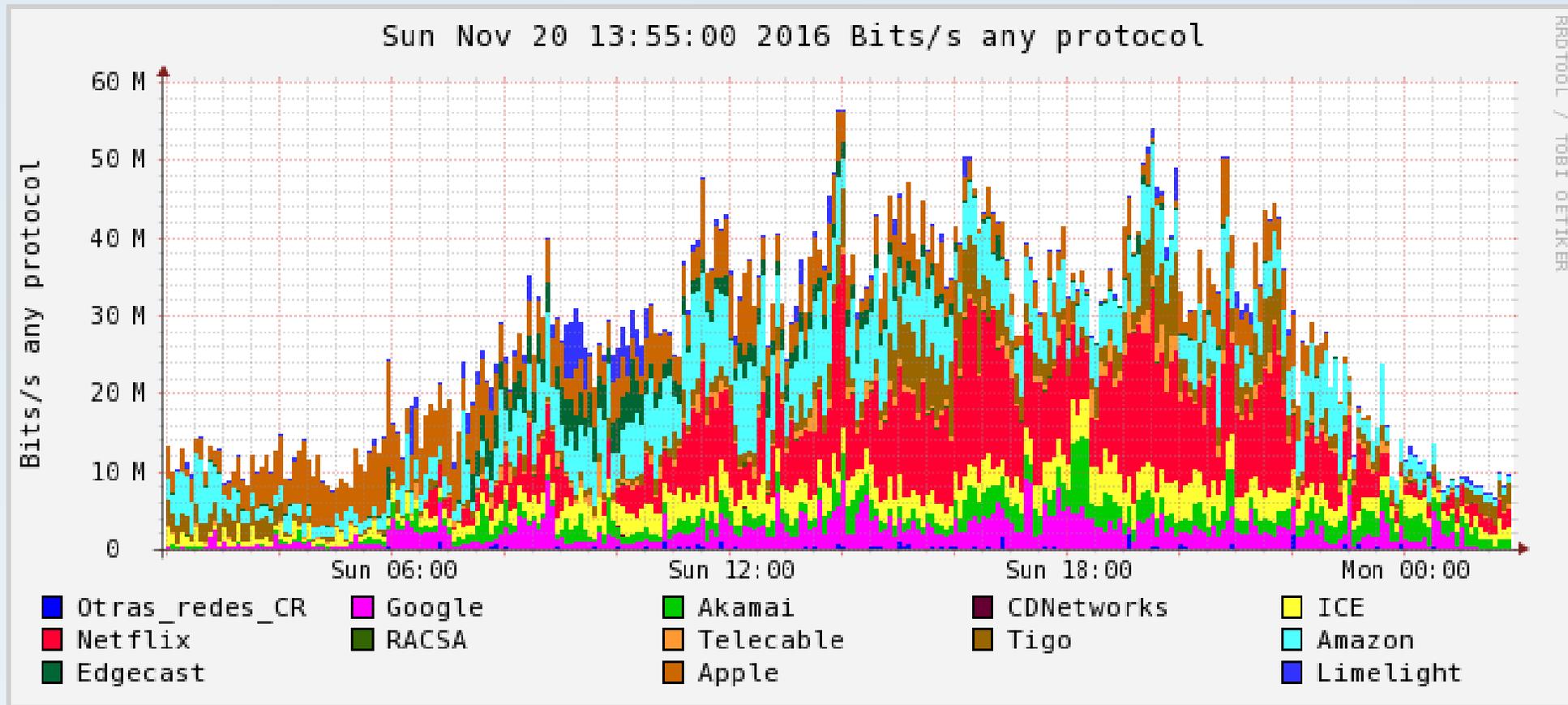
```
/ipv6 firewall address-list
add address=2800:640:cf::/48 list=valid
add address=2800:640:cf::/48 list=valid
/ipv6 firewall filter
add action=drop chain=forward in-interface=ether1 src-address-list=!valid
```

## Primeros Pasos

Firewall – IETF BCP 38

## Implementando IPv6 en todo

VPN, DNS, Correo, Páginas Web, etc.



## Implementando IPv6 en todo

Monitoreo – Herramientas como NFSen ocupan netflow v9 para desplegar IPv6

Top 20 flows ordered by flows:

Date flow start	Duration	Proto	Src IP Addr:Port		Dst IP Addr:Port	Packets	Bytes	Flows
2016-11-21 16:52:23.040	1707.860	TCP	2801:1d:a001:1::d.443	->	2800:640:cf:57:3100:2f67:e201:7377.54450	22695	28.9 M	78
2016-11-21 16:52:23.000	1707.870	TCP	2800:640:cf:57:3100:2f67:e201:7377.54450	->	2801:1d:a001:1::d.443	12215	958264	78
2016-11-21 16:46:10.680	2319.310	UDP	2801:1d:a001:1::c.443	->	2800:640:cf:18:c4ca:306b:2cfb:6fcc.53776	68802	95.9 M	55
2016-11-21 16:46:10.680	2319.310	UDP	2800:640:cf:18:c4ca:306b:2cfb:6fcc.53776	->	2801:1d:a001:1::c.443	36143	3.4 M	54
2016-11-21 15:51:42.720	1688.990	UDP	2801:1d:a001:1::d.443	->	2800:640:cf:18:89f:e64:4b2c:c7b2.48030	32854	44.6 M	50
2016-11-21 15:51:42.700	1688.980	UDP	2800:640:cf:18:89f:e64:4b2c:c7b2.48030	->	2801:1d:a001:1::d.443	17041	1.7 M	50
2016-11-21 16:03:49.260	3097.500	UDP	2801:1d:a001:1::c.443	->	2800:640:cf:d:440:e4dd:8368:391a:14fb.14600	56724	78.2 M	49
2016-11-21 16:03:49.260	3097.470	UDP	2800:640:cf:d:440:e4dd:8368:391a:14fb.14600	->	2801:1d:a001:1::c.443	29105	2.8 M	49
2016-11-21 15:46:43.060	6177.540	UDP	2800:640:cf:64:d4e0:5dc6:cd42:4d95.27428	->	2801:1d:a001:1::d.443	239753	21.8 M	40
2016-11-21 15:46:43.100	6177.500	UDP	2801:1d:a001:1::d.443	->	2800:640:cf:64:d4e0:5dc6:cd42:4d95.27428	474759	658.5 M	40
2016-11-21 16:39:32.490	1191.410	UDP	2801:1d:a001:1::d.443	->	2800:640:cf:70:cc8a:f977:61bd:423d.52815	25013	33.7 M	36
2016-11-21 16:39:32.480	1191.820	UDP	2800:640:cf:70:cc8a:f977:61bd:423d.52815	->	2801:1d:a001:1::d.443	12622	1.2 M	35
2016-11-21 15:32:49.850	1056.810	UDP	2801:1d:a001:1::d.443	->	2800:640:cf:18:89f:e64:4b2c:c7b2.24439	23733	32.9 M	30
2016-11-21 15:32:49.830	1056.820	UDP	2800:640:cf:18:89f:e64:4b2c:c7b2.24439	->	2801:1d:a001:1::d.443	12659	1.2 M	30
2016-11-21 15:44:02.880	1132.050	TCP	2801:1d:a001:1::d.443	->	2800:640:cf:1:5cf:ea95:5070:fb44.61395	7944	10.1 M	27
2016-11-21 15:44:02.840	1132.070	TCP	2800:640:cf:1:5cf:ea95:5070:fb44.61395	->	2801:1d:a001:1::d.443	5219	532524	27
2016-11-21 15:44:28.210	556.550	TCP	2801:1d:a001:1::c.443	->	2800:640:cf:57:6dfd:7d46:8263:164f.51653	17591	22.5 M	19
2016-11-21 15:44:28.180	556.560	TCP	2800:640:cf:57:6dfd:7d46:8263:164f.51653	->	2801:1d:a001:1::c.443	14893	980920	19
2016-11-21 16:03:48.780	3073.790	Frag6	2800:640:cf:d:440:e4dd:8368:391a:14fb.0	->	2801:1d:a001:1::c.0	47	8178	17
2016-11-21 16:46:22.560	325.540	TCP	2801:1d:a001:1::d.443	->	2800:640:cf:57:3100:2f67:e201:7377.54413	4015	5.1 M	13

Summary: total flows: 3369, total bytes: 2.6 G, total packets: 2.9 M, avg bps: 3.0 M, avg pps: 412, avg bpp: 908

Time window: 2016-11-21 15:06:22 - 2016-11-21 17:29:43

Total flows processed: 2932398, Blocks skipped: 0, Bytes read: 176354532

Sys: 0.290s flows/second: 10078527.6 Wall: 0.288s flows/second: 10151377.6

## Implementando IPv6 en todo

Monitoreo – Herramientas como NfSen ocupan netflow v9 para desplegar IPv6

Mantener los mismos nombres para los registros A (IPv4) y AAAA (IPv6)

No usar menos de /64 aunque sean 2 equipos

Asignar redes /48 /56 o /60 a los clientes de manera estática

No filtrar ICMP

Preferir Router Advertisement sobre DHCP

DNS gestionable por el cliente final

BCP38

Implementando IPv6 en todo

Buenas prácticas



Preguntas?