



Lesson from the Field Implementing IPv6 in Tonga

(Tonga) TCC IPv6 Project



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Introduction

Acknowledge (Help and Support)

- TCC Management Commitment and Support
- ISIF & APNIC Foundation
- Project Team
- Everyone Else

About TCC (My Employer)

- One in 3 , Telecom , ISP, Enterprise
- Fixed and Mobile Service Voice and Data
- Acquire single /32 ~2009
- Proof of Concept

1. Target Audience

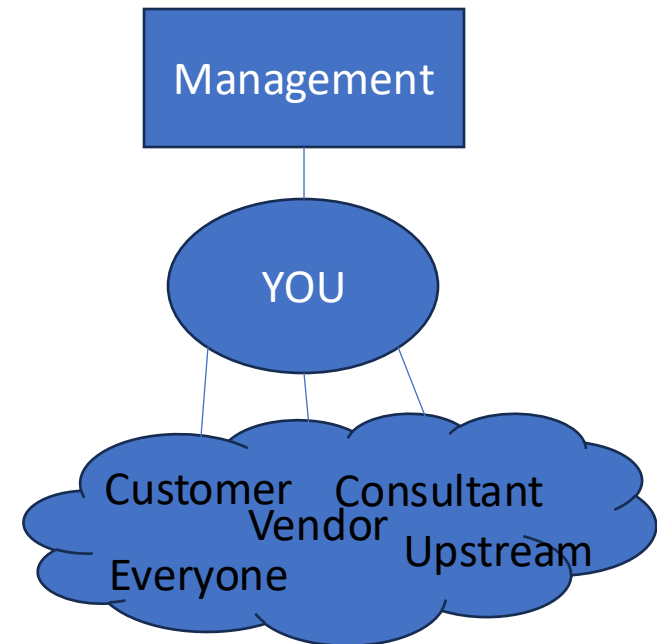
2. IPv6 Deployment Qualification ?

Who is a Network He/She ?

- Fixed
- Cellular

IPv6 in Network Layer

If you know well IPv4 now



Why Deploy IPv6 ?

Motivations		
	Fixed	Cellular
Curious/Learning	👍 You Can	😞 You can't
Management	🙄 Don't Care	😞 Not Sure
Customer/Stakeholder	🙄 Don't Care	🙄 Don't Care
Vendor	🙄 Don't Care	😄 Bring it On
Cost (Capex) Eliminate NAT44		✅

When will Reolink support ipv6 for their NVRs and cameras? I run an FTP server in AWS and they just announced they will begin charging a fee for public ipv4 addresses in 2024. With ipv4 addresses becoming more scarce, it's only a matter of time before this becomes either not possible or too expensive. I see this question asked basically yearly for the last few years with no response.

Fixed Deployments

- APNIC 46 in New Caledonia 2018
- No Capex (Network Is Ready) ~2019
- 10 year Gap , No Motivation Management , Network and Subscriber
 - ADSL , FTTH and Direct Fiber
 - Curiosity , Why Not, Start Deploy
 - No formal Project Team
- Works our Way Downstream (Dual Stack All the Way to Subscriber CPE)
 - Upstream
 - Intl Gateway Fiji
 - 1st IPv6 Request
 - Dual Stack 2 Upstream Upstream
 - ISP Core
 - Border Router , PE Core (MPLS VPN)
 - Dual Stack DNS Resolver
 - Gateway and Access
 - BRAS PPPoE Dual Stack
 - MSAN and LAN Switches readily Support both 0x86DD and 0x0800
 - CPE
 - ADSL CPE and FTTH Support Dual Stack but not Cellular CPE we use.

Fixed Deployments

What's its look like

1.0 Border Router Upstream

Upstream P-T-P

- ip address
- ipv6 address

Upstream eBGP

- Global Neighbour Config
- Adress-family ipv4
- Address-family ipv6

2.0 Border Router Downstream

- 2 OSPF Version over MPLS VPN Public VRF to PE Router
 - v2 for IPv4
 - v3 for IPv6
- 2 OSPF Version over MPLS VPN Public VRF to BNG
 - Repeate the same
- No LDP Support back then
 - 6VPE to carry IPv6 over IPv4

3.0 Access Network

- All MSAN's , Switches readily support L2 IPv6 Frame

4.0 CPE

- All ADSL, FTTH and DSL Router shipped with Dual Stack
- We just need to enable it manually ☹ !!
 - Door to Door

Fixed Deployments

CPE IPv6 Support

- ADSL/VDSL Fleet (DS)
 - ADSL
 - VDSL
 - FTTH
- Enterprise CPE (DS and IPv6 only)
 - Wifi Routers
 - Linux/Window Server
- 4G CPE ☹️ !!! No IPv6 At all
 - Pocket Wifi
 - 4G Modem
 - Measureable Amount of Traffic Remain IPv4
 - Must Slowly Replace these Fleet (3 ~ 4 yrs)

TP-Link IPv6 Ready

User Application Requirement

Actualizado04-18-2019 01:28:13 AM

👁 159474

TP-Link is ready for IPv6

As one of the most competitive providers of networking products, we at TP-Link have carried through our plan to improve our routers by ensuring compliance with IPv6 (please check the support list to see which products are compatible now).

TP-Link has been and will continue to provide more high quality products supporting IPv6.

Cellular Deployment (Primary Focus)

Funded Projects

- ISIF through APNIC Foudation
- Apply for Grant in early 2022 and granted late same year
- Focus on TCC Cellular Network Brand (Ucall) (IPv6 Enabled Now 😊)
 - Welcome to Tonga 😊 with your Compatible Device
 - IPv6 Connections on TCC Network.
 - If you would bring IoT's .

Cellular Deployment (Evolution of Cellular Network in Tonga)

- 1998 (Tonga Telecommunication Commission (TTC))
- AMPS (Advance Mobile Phone System)
- 1G
- Voice only
- Postpaid
- 1 site
- 24 voice channels
- 2000, TTC merge with Tonga Cable and Wireless Ltd to form TCC.
 - 2001, introduce 2G technology (Alcatel)
 - Voice + SMS
 - 2002, Prepaid services.
 - Expand coverage (3 sites).
 - 10K subscribers
 - 2002, further expand coverage in **Tongatapu**
 - 2003, extend coverage to **Vava'u** and **Ha'apai**
 - 2005, introduce roaming (voice only)
 - MMS (Multimedia Messaging Service)
 - Reach 25K subscribers (around 2007)

Cellular Deployment

Year	Services	Approx Cust No	Remark	NAT 44
~2010	2.5G,3G,20 sites Voice+MMS+SMS+Data	~30k sub		ASA Device 300k con
~2014	4G (4site)	30k < More		ASA Device 500k con
~2019	48 sites, 4G+, 48 sites	70k >	Outer Island	☹ ASA Exhausted ☹ Need Costly Solution
2020 Upgrade ~70 k USD (FTD 2130) On Paper 5.4 Gbps Throuthput 😊 !! Yaaaayyyy 10 more yrs before another upgrade				
~2022	3G,4G,4G+	80k <	95 % Coverage Include all outer Island	☹ FTD Exhausted @ 4Gbps Traffic Profile Consider Another Upgrade 140k USD 😊 IPv6
2023				IPv4 Redirect to CGNAT IPv6

Cellular Deployment

Internal Audit

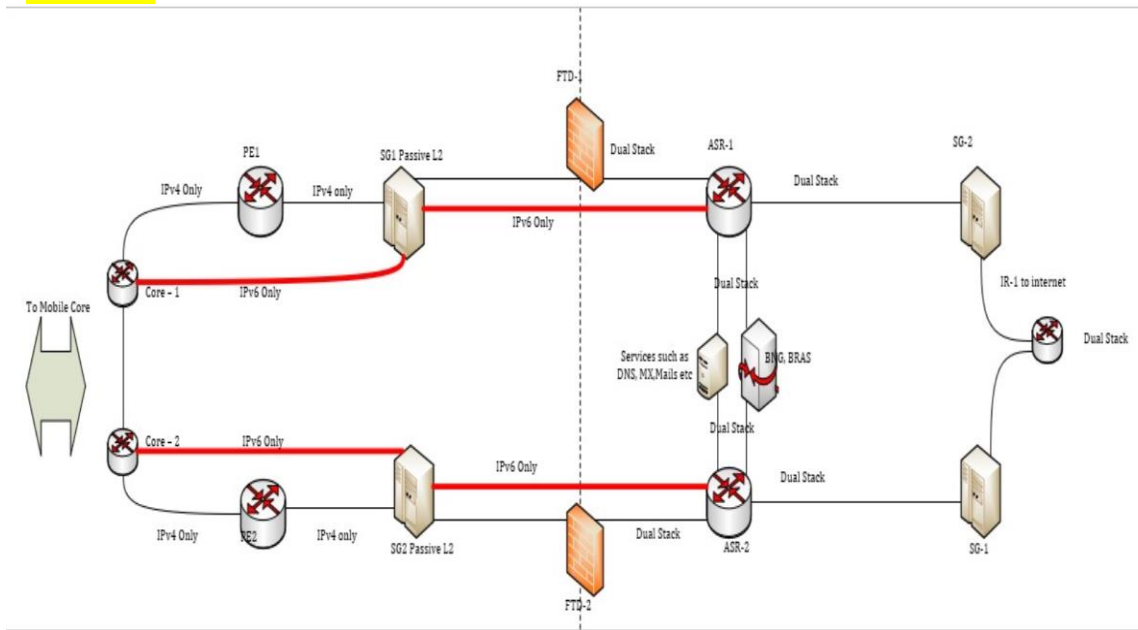
- Network Audit – Different Network Segment
- What Change – Physically and Logically
- Consider Transition Technology
 - Dual Stack
 - 464xlat
- Consider Consultant Services
 - IPv6 Deployments
 - Mobile Core
- Purchased Item (License or Hardware)
- Its beneficial if a single Team Managed All (IP Network)

Cellular Deployment

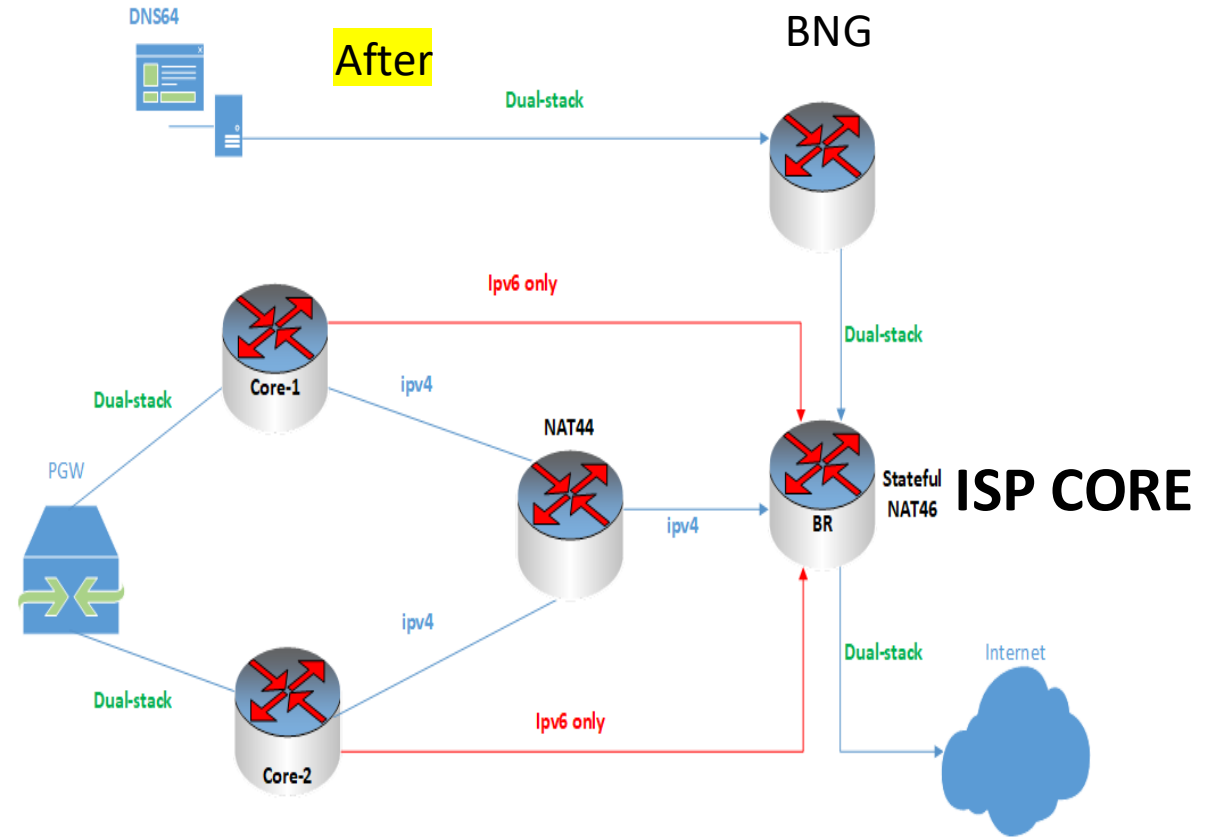
Audit Result

- Redirect Traffic from the FW to a Dedicate NAT44 router
- Create Direct IPv6 only Link from Mobile Core to Border Router

Before

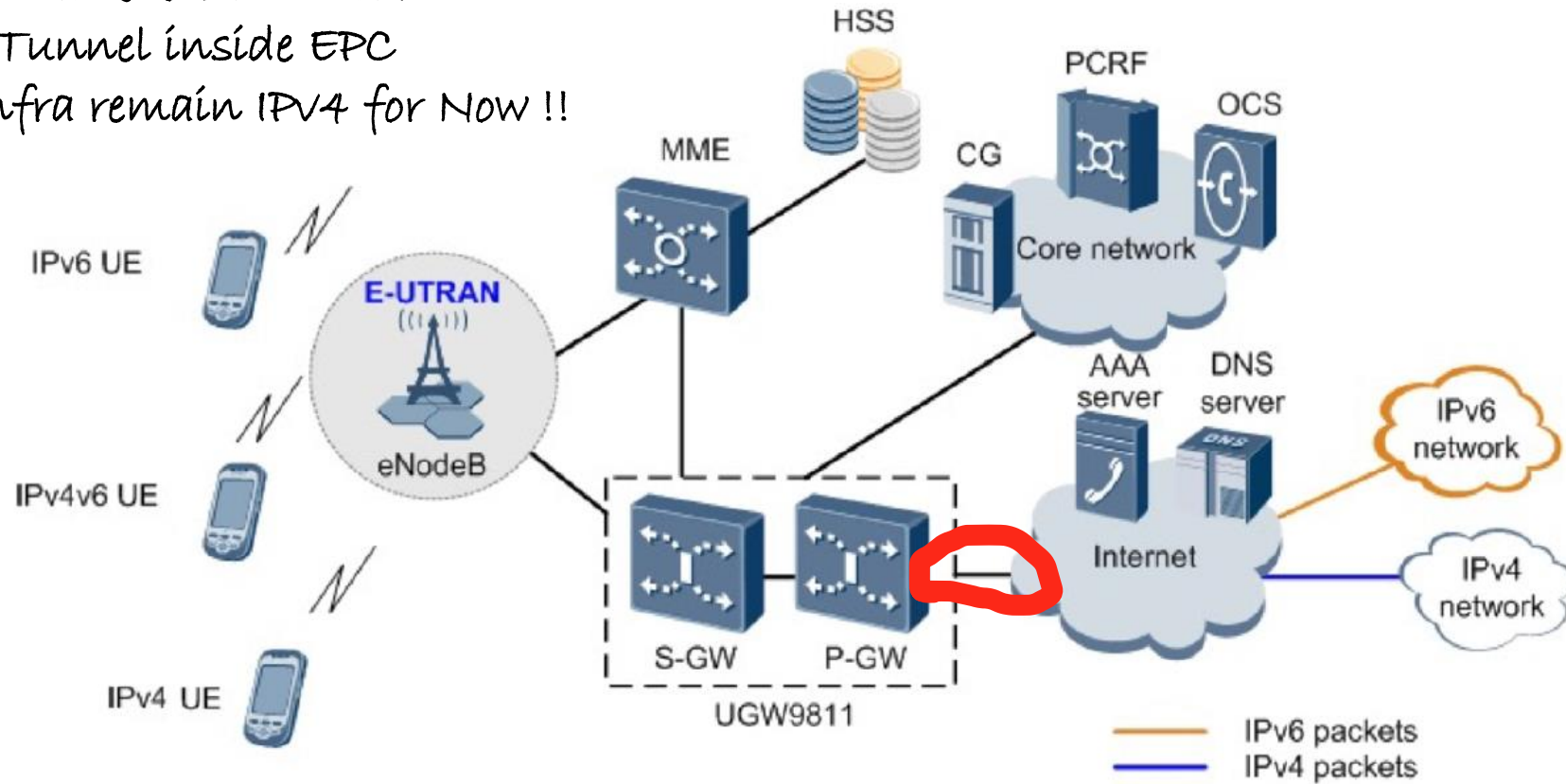


After



Cellular Deployment

- Single APN
- Dual Stack to PE in RED
- GTP Tunnel inside EPC
- All infra remain IPv4 for Now !!



Mobile Core

Cellular Deployment

Parent Prefix (single /32)	1 X /36 (Mobile Core)
IPv4v6 Test APN	1 X /48
IPv6Only – Test APN	1 X /48 (464XLAT)
Live APN's (2 x IPv4v6)	1 X /47 ~70k sub

Note : Mobile Core ability to provide whatever UE request IPv4,IPv4v6 or IPv6.

A single /64 per Single PDP Context with two IP address

- Single Stack / Single PDP Context/Bearers
- Dual Stack / Single Context/Bearer with 2 Address

```
Access type = lu
NSAPI = 5
Activation initiator = Activation initiated by MS
Ti = 0
APN NI in use = TESTIPV6
APN OI in use = MNC001.MCC539.GPRS
PDN type in use = IPv4v6
IPv4 address in use = 10.20.23.169
IPv6 address in use = 2400:6400:C000:2:539:101:36:8099
```

Cellular Deployment

Summary Steps for Production Deployment of Ucall APN's

#	Step	nodes	Service impacts	Comments
1	Change live APN for Handsets to support dual stack	GGSN/PGW	none	Consider the prefix for UE
2	Change live APN for Modems to support dual stack	GGSN/PGW	none	Consider the prefix for Modems
3	Provision test users on both APNs to test	n/a	none	Tests carried out to verify
4	Provision all live users to support dual stack	HLR/HSS	All bearers/PDP Reset	After this step, most users will still be on IPv4 as they are all set to request only IPv4, However there were group of User their UE already in IPv6 enable mode
5	Start migration of UE configuration	n/a	n/a	Team to advise users to change to IPv6 or IPv4v6 as required

What we can Control from the Network side (HRL/HSS)

- Network Provide as UE Request (IPv4only , IPv4v6 or IPv6 only)
 - Androids is clear cos User is able to do the Change

iPhones IPv6 Only Hack

- Compatible iPhones (iPhone 11 and later) Default Request DS
 - we can provide single IPv6 only address instead of two.

Challenge for this , we have no visibility beyond the IP address 🙅

- *Match IP to MSSIDN*
 - *Easily Assign IPv6only to DS iPhones* ✅
 - *No CLATd Tether Devices cannot Access Literals IPv4* ❌

Cellular Deployment

Expectations Adoption Rate	Actual Adoption Rate	Remarks
80% <	~ < 13 – 14 % Androids 1. IPv6 Only Device 2. IPv4v6 APN Set	1. Require Manual Change for Androids APN Settings 2. All iOS Device is IPv6 Disabled 3. All 4G Modems and 4G PocketWifi is not support IPv6

Statistics

2018 – Fix Deployment

Friday 16th August 2024 – per Country in Oceania

CC	Country	IPv6 Capable	IPv6 Preferred	Samples	Weight	Weighted Samples
AU	Australia, Australia and New Zealand, Oceania	43.23%	39.65%	8,233,196	0.48	3,935,227
NZ	New Zealand, Australia and New Zealand, Oceania	31.84%	26.90%	1,856,704	0.43	796,339
TO	Tonga, Polynesia, Oceania	28.32%	27.75%	14,207	0.57	8,088
FJ	Fiji, Melanesia, Oceania	27.33%	26.40%	134,209	0.67	89,572
PG	Papua New Guinea, Melanesia, Oceania	20.45%	19.58%	118,629	1.89	223,837
NC	New Caledonia, Melanesia, Oceania	4.97%	4.10%	39,727	1.16	46,153
FM	Micronesia (Federated States of), Micronesia, Oceania	2.65%	2.48%	12,057	3.11	37,494

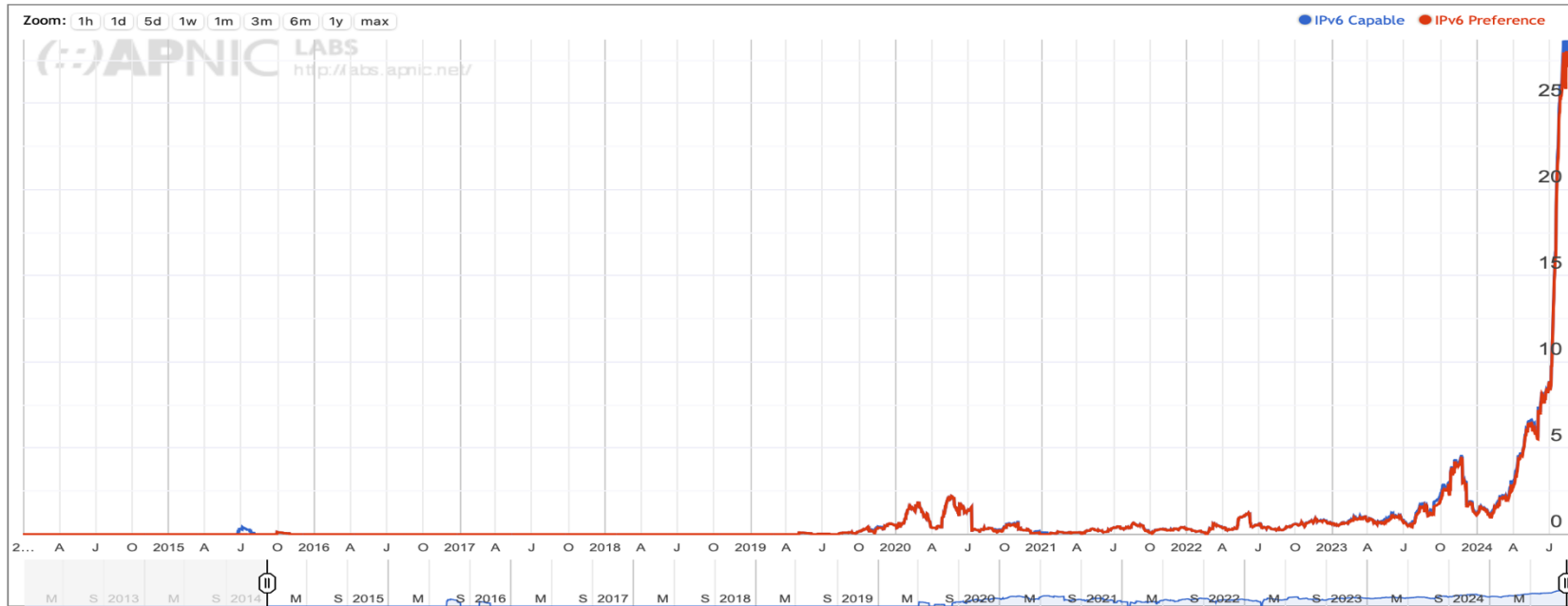
Statistics

Code	SubRegion	IPv6 Capable	IPv6 Preferred	Samples	Weight	Weighted Samples
QS	Polynesia, Oceania	3.02%	2.93%	74,929	0.96	71,806

ASN	AS Name	IPv6 Capable	IPv6 Preferred	Samples
AS38201	KALIANET-PUBLIC-AS-AP Tonga Communications Internet Network	47.97%	47.03%	8,363
AS38198	DIGICELNET-TO Digicel Tonga Ltd	0.10%	0.07%	4,073
AS132831	EZINET-AS-AP EziNET Limited	0.00%	0.00%	1,749
AS14593	SPACEX-STARLINK	0.00%	0.00%	13
AS135409	KBSPL-AS-AP Kacific Broadband Satellites Pte Ltd	0.00%	0.00%	8
AS13335	CLOUDFLARENET	0.00%	0.00%	1
AS13335	CLOUDFLARENET	0	0	1
AS14593	SPACEX-STARLINK	0	0	13
AS135409	KBSPL-AS-AP Kacific Broadband Satellites Pte Ltd	0	0	8

Statistics

Use of IPv6 for Tonga (TO)

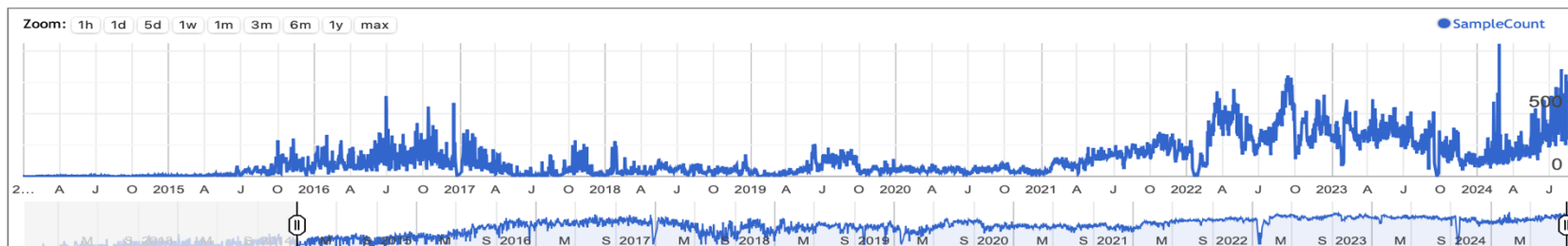


Fluctuates

- Most iOS 17.4 have Updates

Continuation Growth

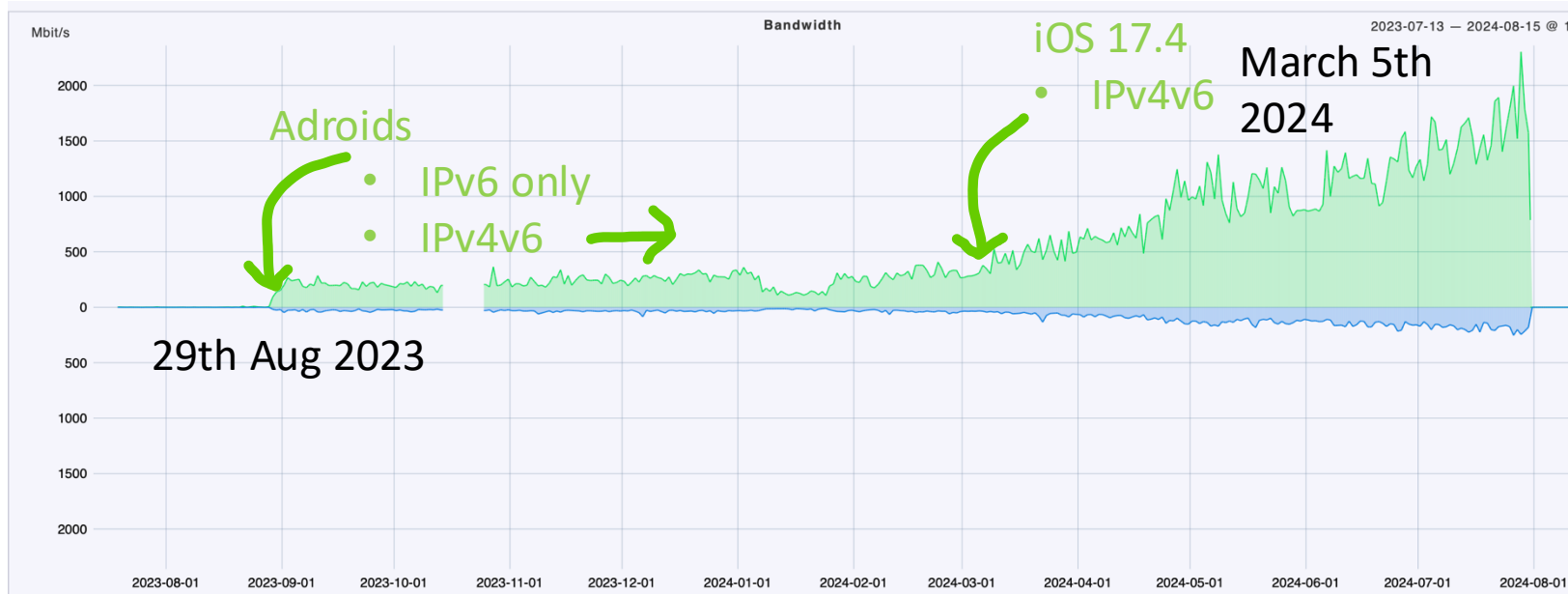
- Gradual Deploy/Replace 4G IPv6 enable CPE
- Older iOS Replace
- Automatic/Manual Change Androids APN Settings.
- Enterprises/Organizations



Statistics

New Direct IPv6 only Inter from Mobile Core Router to Border Router

IP Traffic

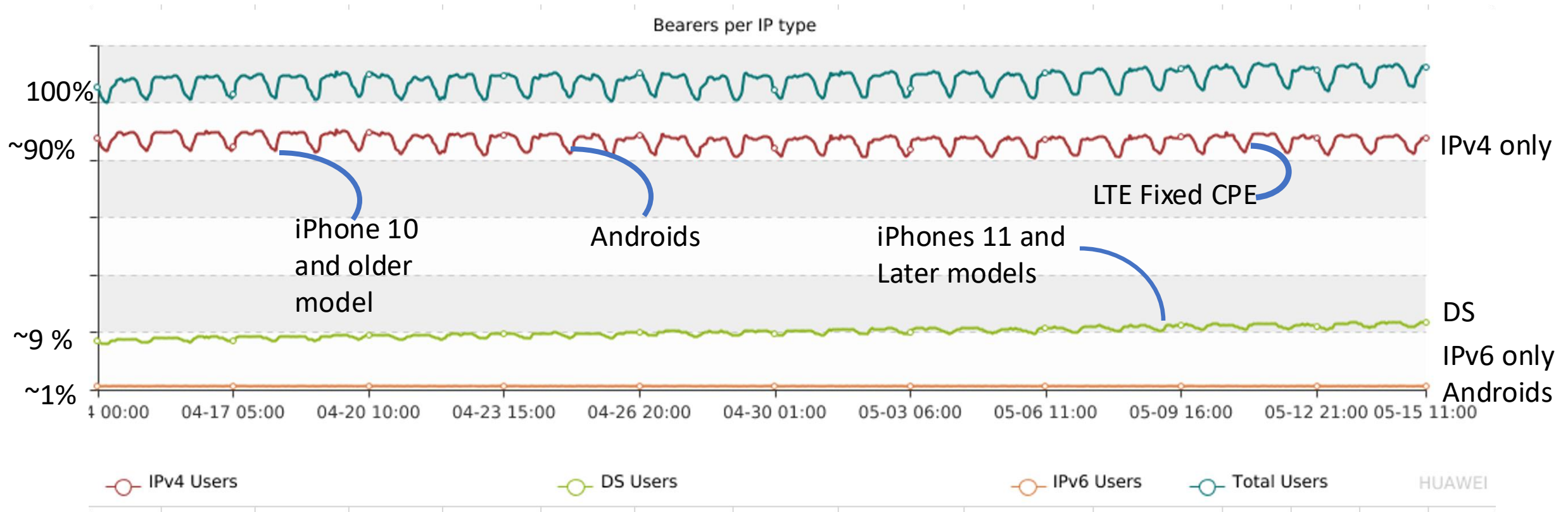


IPv6 Only Interface

Statistics – Mobile PGW

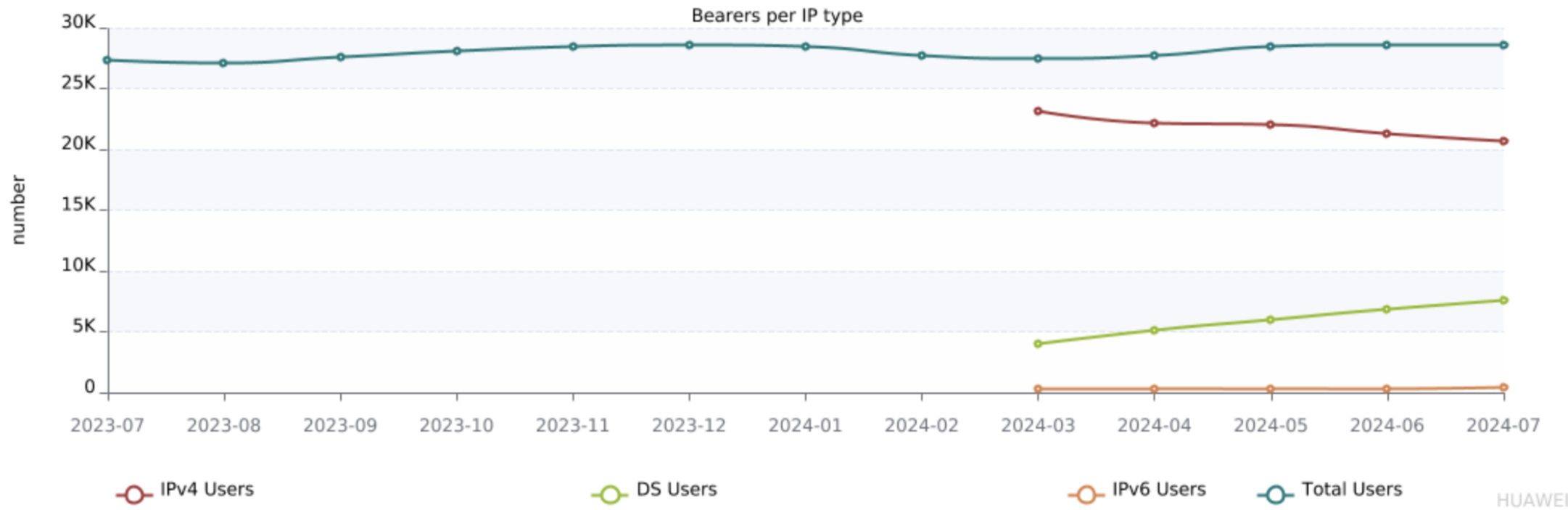
Mobile Core Statistics

- Online Users Only
- Active but Offline is not Included in this stats



Statistics – Mobile PGW

Promising Forecast :



👉 Total 13 Records

HUAWEI

Lesson Learned - Can and Cannot

What a Small Operator cannot Do

- Treat our Subscriber with utmost respect
 - We can't force them
 - Network Deployment Done, Change will take time
 - Incompatible iOS Devices
 - Androids
 - Not Required to Teach them about IPv6 (They are not interested)
 - However pick a few (Enterprises)
- No Outages in Transitions
 - Avoid Negative Feedback
 - Public
 - Management too.
- Be nice to Vendor 😊
 - Just follow their Directions
 - We Request This and That and they said nope 😞
 - It's their thing and they do not care, esp if you are that small.

Lesson Learned – The Apple Case

Please contact Apple from the Start !!!

- **Planning Phase**

Unforeseen Circumstances

- 134 days to established the proper Comm with Apple engineers
 - Border Drop two Major Sending IPv4 SMTP in APAC.
 - Receive Email Intermittently
 - They use .0 IPv4 Addresses
 - Specifically Allow that on our ACL
 - Establish Email Comm 11th September 2023

Expectations	What we get
Subscriber Choice (IPv4, IPv4v6 or IPv6 Only (Like Androids))	Nope , Sorry 😞
IPv6 only with CLATd	Nope , Sorry 😞 Only DS
iPhones Support Sooner	6 months (Release 17.4) March 6th 2024

Lesson Learned – What you Can Do

What a Network Operator can Do

Asked for Clarification/Help from those before Us

- Others have done it, You can also
- Send an email to
- Call someone
- Be Patience !.
- Looking in the Regoin
 - Vodafone (Fiji & PNG) 2024 Deployments
 - Email Send with no Reply just keep looking
 - On Youtube I find
 - Jio Reliance India (No Response)
 - T-Mobile (Youtube Contact)
 - His Response Chaang my View

Change will come !!

From: "Byrne, Cameron" <Cameron.Byrne@T-Mobile.com>
Date: Friday, 19 April 2024 at 10:37 AM
To: Maile Halatuituia <maile.halatuituia@tcc.to>
Subject: Re: IPv6 Deployment in Tonga

we managed it so that new handsets we sell are set to IPv6-only. Old handset just go away over time with ipv4.

Old handsets remained on ipv4, this allows for a steady transition over time as new handset go to market.

For apple, you may want to find a different person at apple to help you. It is unfortunate they are unwilling to help you get to ipv6-only.

TCC IPv6 Future

Now to ~ 5 years

- Achieve ~60 - 70 % of the 80k or more Subscriber to be IPv6
 - Gradually Replace Fix 4G CPE
 - Old iOS Device Replace with IPv6 Support Devices
 - Majority of Androids APN Settings Changed (Heavily rely on User Manual Change) – ***Impractical !!***
 - Options To Accelerate
 - OTA Updates (Similar to Apple iPhones)
 - Native SIM's (IPv4 only)
 - HTTP Enabled JAVA SIM's (IPv4v6)
 - Handsets Sytems Setting Override

TCC IPv6 Future

Now to ~ 5 years

- Public Wifi SSID (within 1yr timeline)
 - Support NAT64 (Wifi Gateway)
 - Dual SSID (IPv4v6 & IPv6 only)
- New Modernization Project for our EPC
 - Current Mobile Core Infra is purely IPv4
 - Vendor confirmed IPv6 will be configured in the new infrastructure 😊 !!
 - Prep for Service Expand such as VoLTE
 - Future 5G Proof
- **Primarily Focus on Individual Subscriber**
 - **Enterprise Networks Later**
 - **Starting with our own Enterprise Network**
 - <https://msrc.microsoft.com/update-guide/vulnerability/CVE-2024-38063>
 - Systems are not affected if IPv6 is disabled on the target machine.
 - **Then expand to Every TCC Subscriber**
 - **Phase 2 Objectives for second Phase IPv6 Grant Fund**

Thanks you for your time

Question Now !

If not

Email : maile.halaituituia@tcc.to