IPv6 Single Stack Now or Later? -The ultimate carrier conundrum

APRICOT 2015 - March 2015

IT'S HOW WE CONNECT

INTRODUCTION

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Introduction

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Telstra

Telstra is Australia's leading telecommunications and information services company, offering a full range of communications services and competing in all telecommunications markets.

In Australia we provide 16.4 million mobile services, 7.4 million fixed voice services and 3 million retail fixed data services.

We believe the more connected people are, the more opportunities they have. That's why we help create a brilliant connected future for everyone, everyday.

As Australia's leading telecommunications and information services company, Telstra is proud to be helping our customers improve the ways in which they live and work through connection.

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Agenda

1. Introduction
2. Why IPv6 for Mobile Networks?
3. Current IPv4 Mobile Network Architectures
4. Transition Methods – Dual Stack vs Single Stack
5. The Dual-Stack dilemma
6. The End Now : IPv6 Single Stack
7. The Blissful Ignorance of Illusion
8. "All hope is lost" – "There is another"
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WHY IPv6 IN MOBILE NETWORKS?

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Why IPv6 in Mobile Networks?

Drivers for IPv6 in Mobiles

- Depleted IPv4 allocations from APNIC
- Sustained Growth in mobile data traffic volumes
- Growth in the number of devices per person
- New devices are session hungry, consuming multiple IPs and ports
- Projected uptake of Sensor-Networks using 6LoWPAN and Machine to Machine (M2M) communications as well as the Internet of Things which uses IPv6 only
- IPv4 Public address depletion: Most operators started to deploy NAT44 very early on either on Internet gateways or dedicated devices.

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Why IPv6 in Mobile Networks?

- IPv4 Private address depletion: APN IP Address pools. Reuse subnets if/where possible.
- Offload the NAT44 Architecture and avoid complications and costs associated with development of NAT444 – more bandaid!
- VoLTE/IMS

Remember –

The use of IPv6 services should be invisible to the end-user.

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CURRENT IPv4 MOBILE NETWORK ARCHITECTURES

Wireless Internet Access
Quick 3GPP terminology refresher

SGSN/MME – Provides Signaling information

GGSN/EPG – Gateway to IP environment. Allocates IP addresses to UEs via PDP requests.

IBR – Internet Border Router

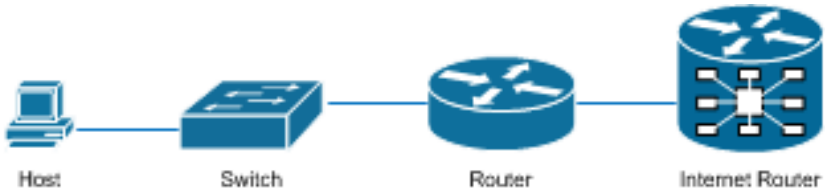
UE – User Equipment (Handset)

HLR – Home Location Register

APN – Access Point Name (VLAN). Can have local and real. Think of it as an SVI (Logical VLAN) or a real VLAN

PDP – Packet Data Protocol (IP / Mobile No / Tunnel information to GGSN/SGSN

Pref64::/n – an IPv6 prefix used for IPV6 address synthesis (RFC6416). Typically, n=96.



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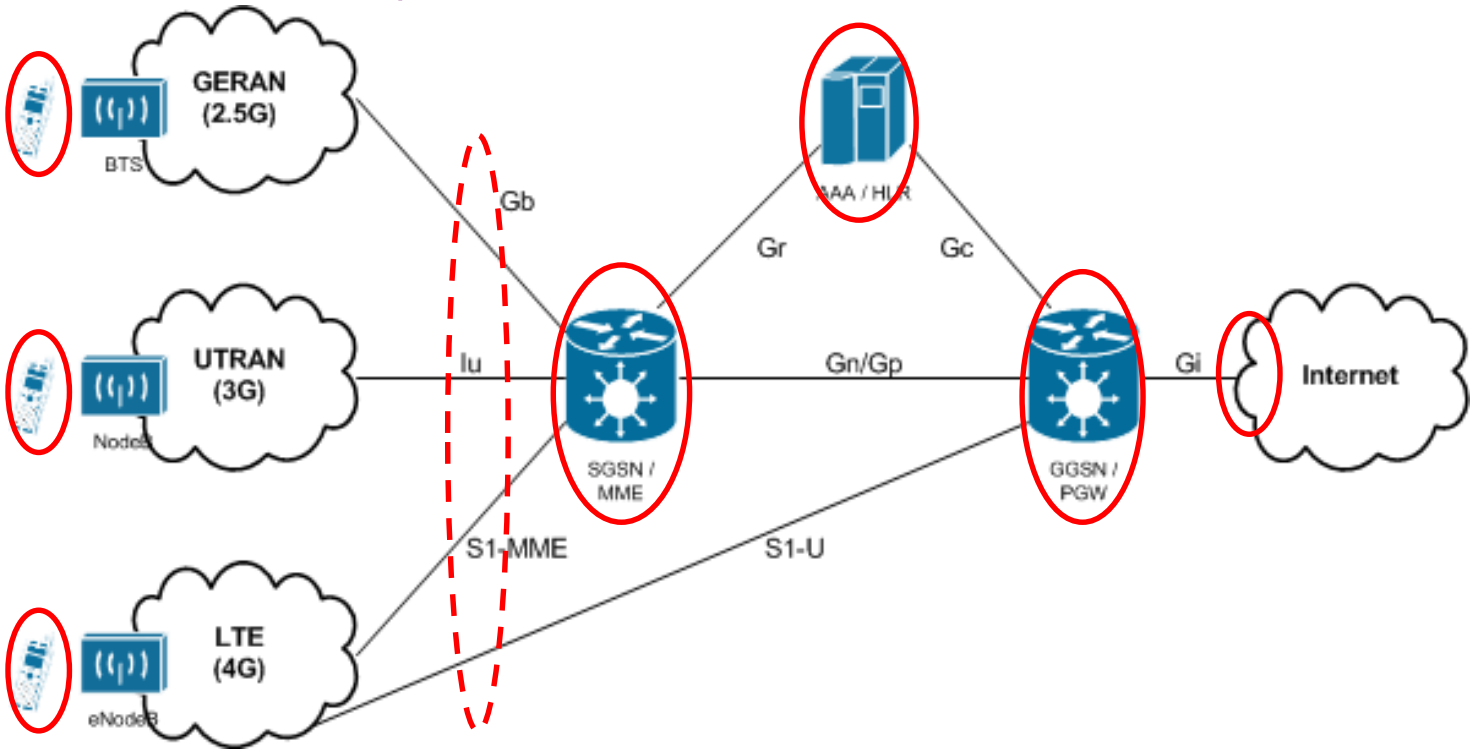
Wireless Internet Access
Basic IPv6 requirements



Dual-Stack / Native IPv6 UE
Backhaul – IPv6 optional
SGSN – IPv6 PDP aware
HLR – Full IPv6 support
Radius AAA – Full IPv6 support

DNS – Full IPv6 support
GGSN – Full IPv6 support
MPLS Core – 6PE/6VPE
Large Scale NAT – NAT44 and NAT64

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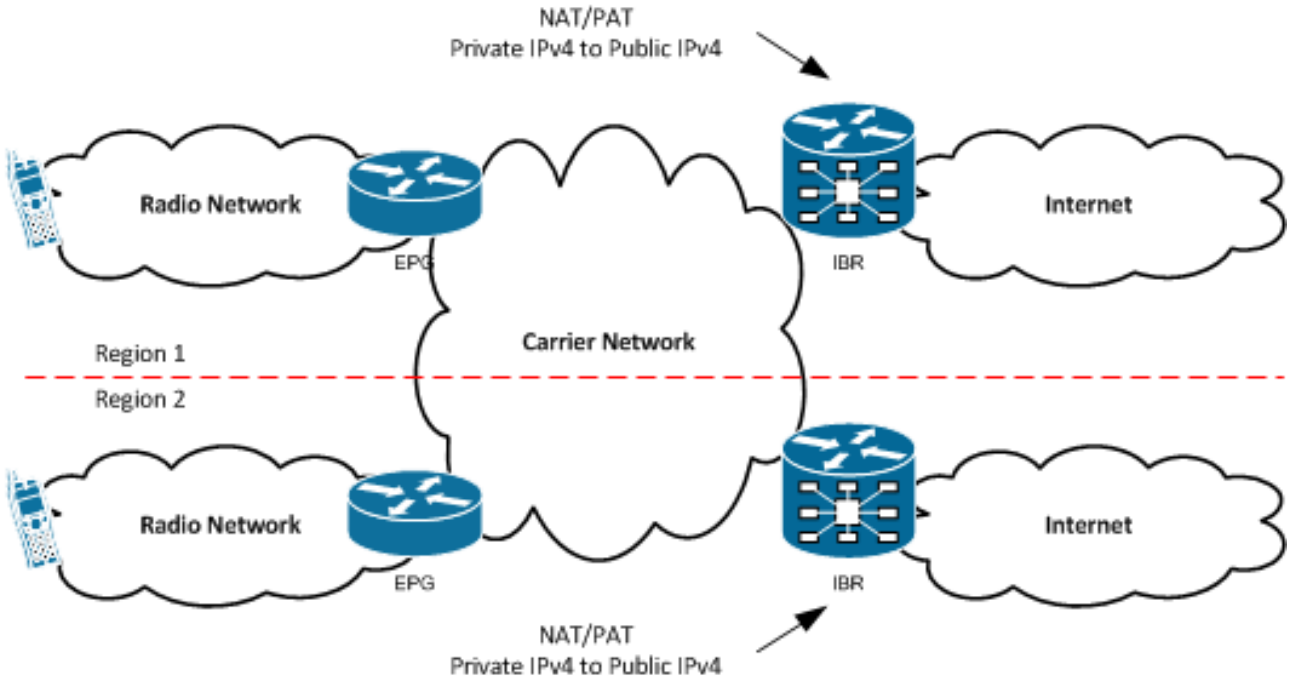
Current IPv4 Implementation
Centralised CGN



- RFC1918 IPv4 Private Address space used for UE assignment for each APN.
- CGN performs NAT/PAT 44

  PAT substantially reduces Public and Private IPv4 address demand, but does not prevent IPv4 address depletion.

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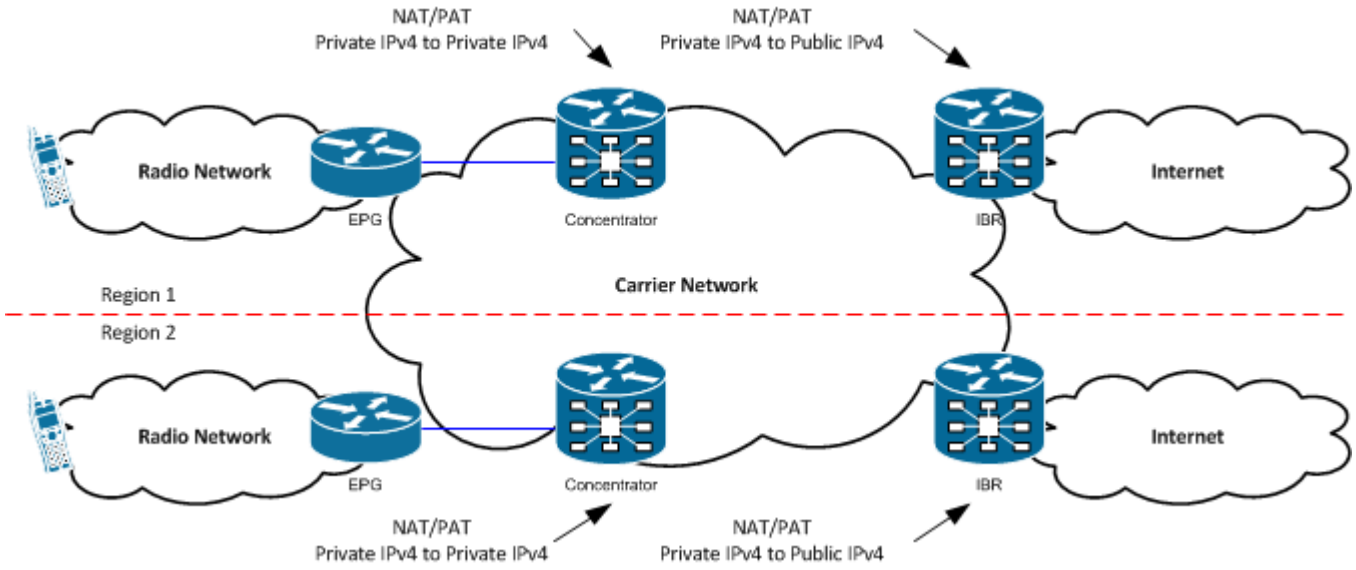
Current IPv4 Implementation
Centralised CGN

NAT444

- Possible but don't forget that you will need new ALG development due to the double translation
- Investigations and Troubleshooting becomes extremely difficult
- Compliance with regulatory obligations will require the development of complex solutions
- Scalability and Reliability becomes major issues
- Why spend on preventing the inevitable? Spend and invest wisely on long-term solutions



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TRANSITION METHODS

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Transition Methods
Terminology Refresher

NAT64 (RFC6146)

- Stateful Translation of IPv6 addresses to allow IPv6 only clients to contact IPv4 servers.

DNS64 (RFC6147)

- DNS64 is a mechanism for synthesizing AAAA records from A records. It is usually used with an IPv6/IPv4 translator for communication between an IPv6 only client and an IPv4 only server.

464XLAT (RFC6877)

- Provides limited IPv4 connectivity across an IPv6 only network by combining RFC 6146 in the core, and Stateless protocol translation (RFC 6145) at the edge. No encapsulation is required.
- http://tools.ietf.org/html/rfc6877
- https://conference.apnic.net/data/37/464xlat-apricot-2014_1393236641.pdf

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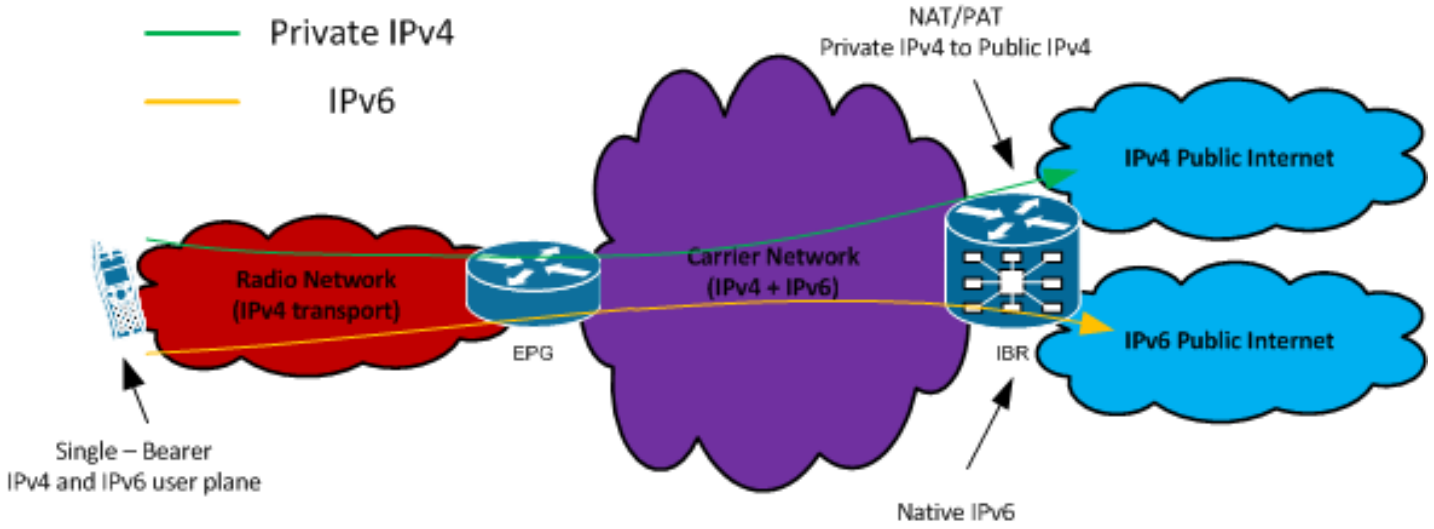
Transition Method 1
Enabling IPv6 dual-stack



No NAT64/DNS64 or 464XLAT required

Run a single PDP context / bearer Dual-Stack implementation to reduce licensing costs if you want to do Dual-Stack

IP Network Core is enabled with Dual-Stack

Introduce customers onto IPv6 quickly with minimal risk

Most existing applications on handsets work perfectly fine

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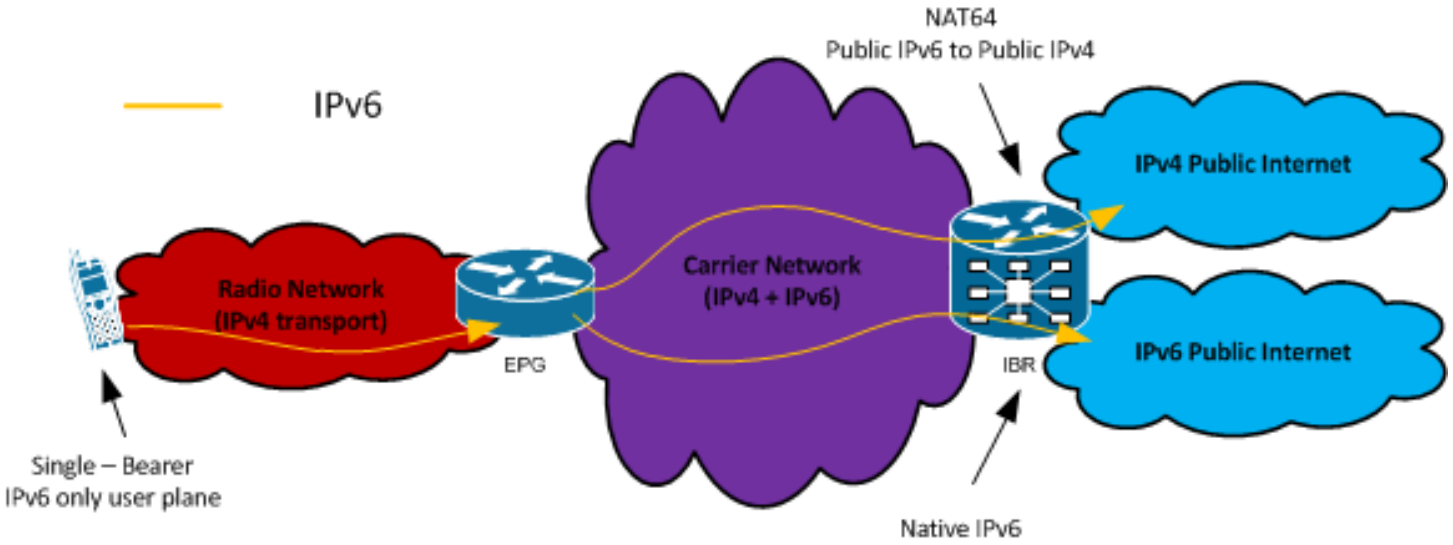
Transition Method 2
Enabling IPv6 single Stack



Stateful NAT64 replaces NAT44 for IPv4 destined traffic.

IP Network Core is enabled with Dual-Stack

A DNS64 MUST be in the path for Single Stack IPv6 to function to IPv4 only websites (464XLAT will not activate unless it is an IPv4 literal or non-protocol agnostic application)

UE requires 464XLAT or similar due to many IPv4 only applications still out there. Requires UEs to support 464XLAT

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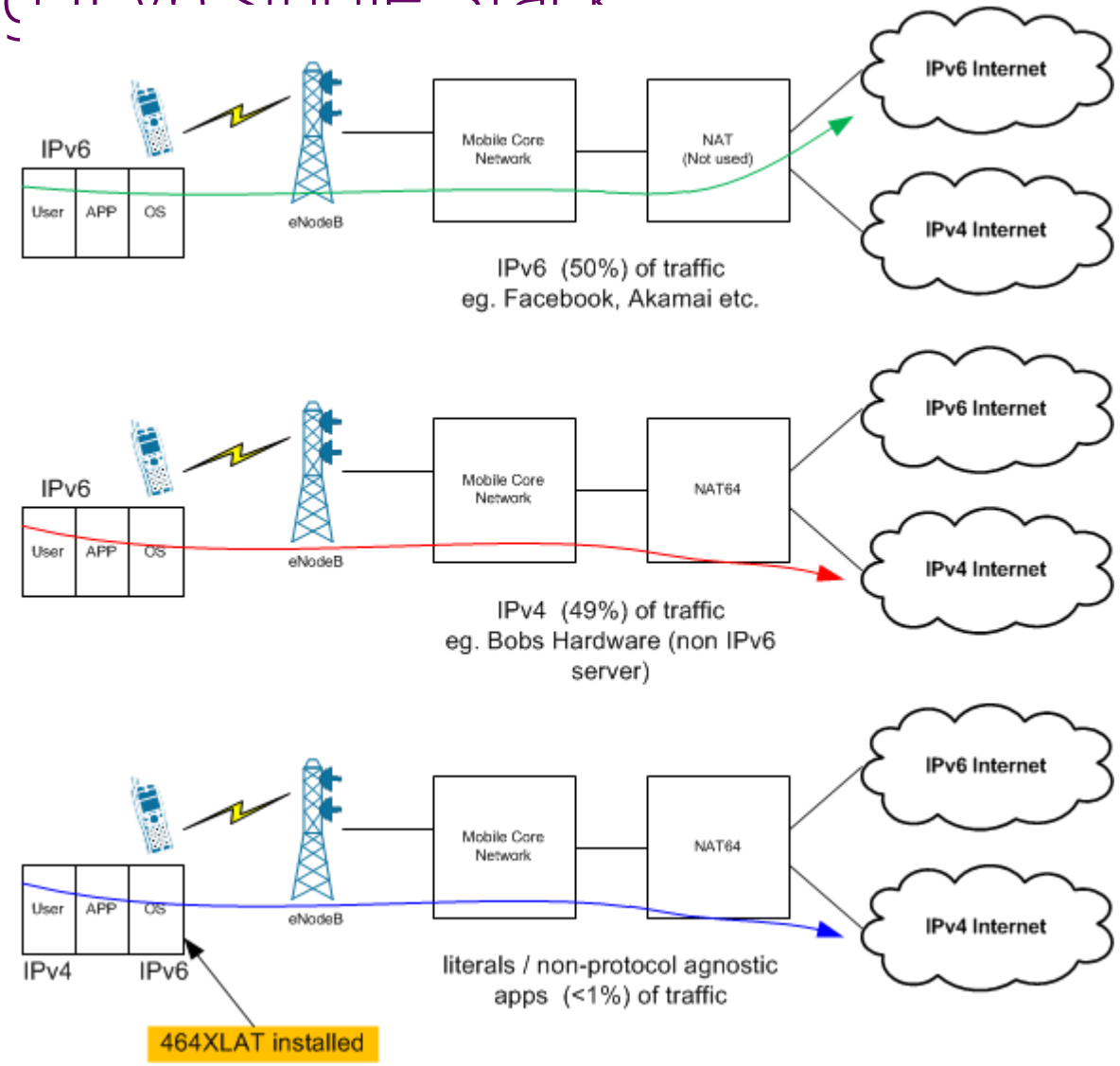
Transition Method 2
Enabling IPv6 single Stack



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THE DUAL-STACK DILEMMA

The Dual-Stack Dilemma

Dual-Stack IPv4v6

PROS:

- 100% IPv4/IPv6 content access
- Ease of migration
- May be cheaper for your organization to quickly get users onto IPv6
- Users may use IPv6 native straight away to most popular sites
- Provides production IPv6 experience with customers while still having the reliability and completeness of IPv4 implementations available during IPv6 introduction.

CONS:

- Does not solve IPv4 depletion problem – you are still using IPv4 addresses whether it is public or private addresses!
- If you do not have translation systems in the network, what is your end strategy for native IPv6? Implementing Dual-Stack with no strategy to move to Single-Stack IPv6 will end up costing your organization more in the long term.

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The Dual-Stack Dilemma

It gets worse:

- Authentication and other services may be inadvertently impacted due to 2 addresses being issued to the same user
- Troubleshooting for users become harder as there are 2 protocols to contend with
- How do you introduce a Single-Stack service into a Dual-Stack environment without affecting existing users? You may inadvertently translate them unnecessarily
- There is no DHCP-PD or DHCPv6 yet on some devices. How do you allocate a valid useable IPv6 GUA to a tethered device?
- If UEs are configured with IPv4v6 and a single APN and the equipment is sold to the customer, how do you change them to Single Stack without user intervention, without significant changes to the Packet Core network equipment and without affecting existing customers on the same APN?
- Issues with International Roaming for pre-3GPP release 8 networks. Customers will be black-holed.

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THE END NOW:
IPv6 SINGLE STACK

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The End Now: IPv6 Single Stack

Single Stack IPv6

PROS:

- No usage of IPv4 private address, and translated to IPv4 public only when required
- Native IPv6 traffic flows to major sites with no translation required
- Simplified traffic flow

CONS:

- Each device must support 464XLAT. There are still some issues where literals and domain names are not resolved properly using DNS64.
- More complex migration strategy with no guarantees everything will work day 1
- More complex network architecture with NAT64 required
- Associated NAT64 ALGs may not be fully supported.

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THE BLISSFUL IGNORANCE OF ILLUSION

The Blissful ignorance of illusion

There are advantages and disadvantages with both solutions.

But either one by itself will not meet your business and customer needs in the long-term future.

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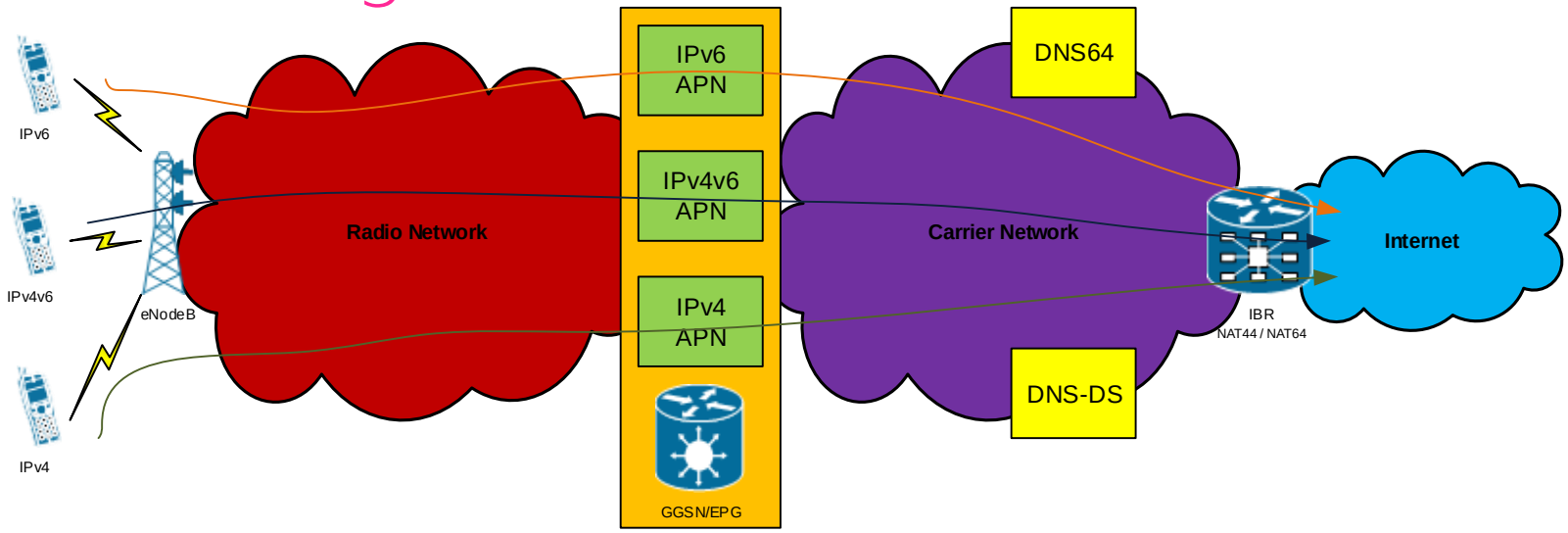
The Blissful ignorance of illusion



Create multiple real APNs that supports IPv4, IPv6, and IPv4v6 individually

1. You must run separate APNs for each protocol type. This will create operational and engineering complexity and does not allow for simplification of the network in the long-term. However you may have finer control of the network as a result.

   a) Multiple APNs however cause havoc on your Device provisioning teams. You will prefer a common APN and setting across all UEs.

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The Blissful ignorance of illusion

2. BYOD is a major issue. Users may receive a default setting, but can easily modify the APN settings. Custom APN settings that are not standard will cause issues with these users.

   a) What if you have a DS-only APN and your user inserts a SS-only device onto your DS-only APN unknowingly?

   b) What if you have a SS-only APN (with IPv6 only) and your user changes the PDP to IPv4v6 and expects IPv4?

3. Applications that do not understand IPv6 will fail with SS IPv6. In some instances 464XLAT will fix it. But if not, then the user must fall back to IPv4 or IPv4v6. There is a possibility they will select DS and not IPv4 only. If this is the case, then the same issue as 2b) will occur.

4. Devices are usually preconfigured with the appropriate APN settings. If not all APN settings are present, users have no way to default back to IPv4.

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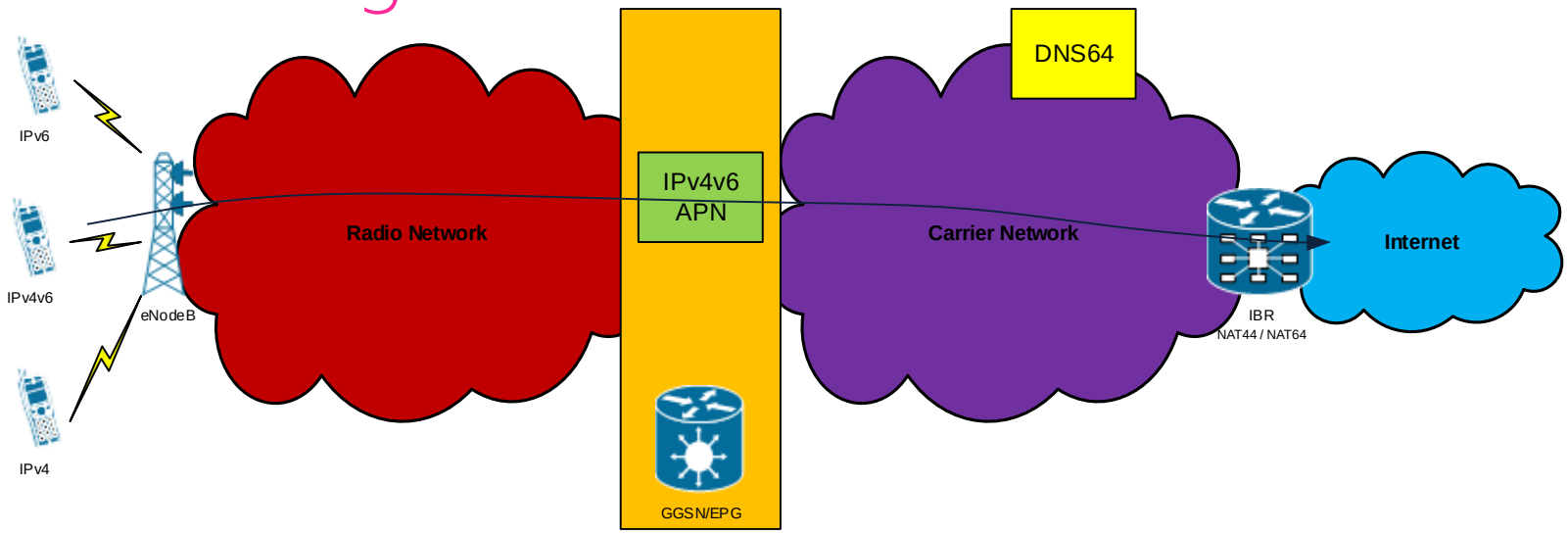
The Blissful ignorance of illusion



Create a single APN that supports both DS and SS

1. You must run the PDP as Dual-Stack unless you have another method to simultaneously allow IPv4 and IPv6 SS UEs on the same APN.

   a) This also means you will have no control of what protocol your user is accessing your network with. You must support all 3 options in your network

2. DS users may experience inefficiencies due to DNS64 in the path from unnecessary NAT64 translations. Because of this, users who are on SS who switch to DS may not have any resolution until they switch to IPv4 SS.

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The Blissful ignorance of illusion

So Close……

Create a single Logical APN that supports both DS and SS on separate real APNs

1. Huge Advantage. Separate Real APNs means separate DNS name servers so DNS64 is no longer an issue.
2. The same problems as Single APN before but what control mechanism do you have to determine which real APN your user should go to? There are not many options in the default APN optional fields; except for Username
   a) Bad long-term as the field can be used for other purposes in the future
   b) You will have a whole deployment of handsets with the username set for a purpose that the field was not designed for
   c) BYOD users will need to know the APN settings. If the username is not known, then they will configure it incorrectly and attach to the wrong real APN!

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…. ALL HOPE IS LOST

THERE IS ANOTHER….

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Is this the best option?

Create a single real APN that supports both DS and SS and use faux IPv6 DNS resolver addresses

DNS configuration

-DNS has IPv4 and IPv6 interface addresses

-An inbound filter will direct a DNS request to a particular logical partition based on the below filter rules.

-IPv4 logical partition is normal IPv4, except add ‘match destination’ as its own IPv4 interface address.

-IPv6 logical partition is enabled with DNS64, and add ‘match destination’ as its own IPv6 interface address

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Is this the best option?

GGSN configuration

-IPv4 DNS name server as per before

-IPv6 primary DNS name server: ::ffff:1.2.3.4 (use a 'faux' IPv6 address to point to IPv4)

-IPv6 secondary DNS name server: 2001:a:c:d::8/64 (Real IPv6 address)

In this configuration, UEs will receive either both IPv4 name servers for IPv4 SS, all 4 name servers for IPv4v6, and both IPv6 name servers for IPv6 SS.

DS UEs will accept the primary IPv6 DNS name server as it is resolvable for IPv4.

SS UEs will attempt and fail to reach the primary IPv6 DNS name server, and then retry with secondary.

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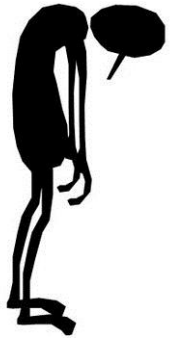
Is this the best option?

Surely this is the best solution!

…. Alas its not.



What if your IPv6 primary name server fails?

What if your IPv6 secondary name server fails?

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THE PAINFUL TRUTH OF REALITY

The Painful Truth of Reality

There are 4 carriers in the world that have deployed IPv6 into their production wireless environments:

SP1	SP2 / SP3	SP4
Dual-Stack	SS+NAT64+DNS64+CLAT	SS/DS+NAT64+DNS-HD+CLAT

1. Every carrier will have a unique set of circumstances that dictates which transition method they will use. There is no standard way of doing this.
2. You must determine which is the best method for your network.

In any method, remember to ensure you have a long-term strategy for the eventual deployment of native Single Stack IPv6!

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The Painful Truth of Reality

Wait wait wait….

NAT64+DNS-HD?

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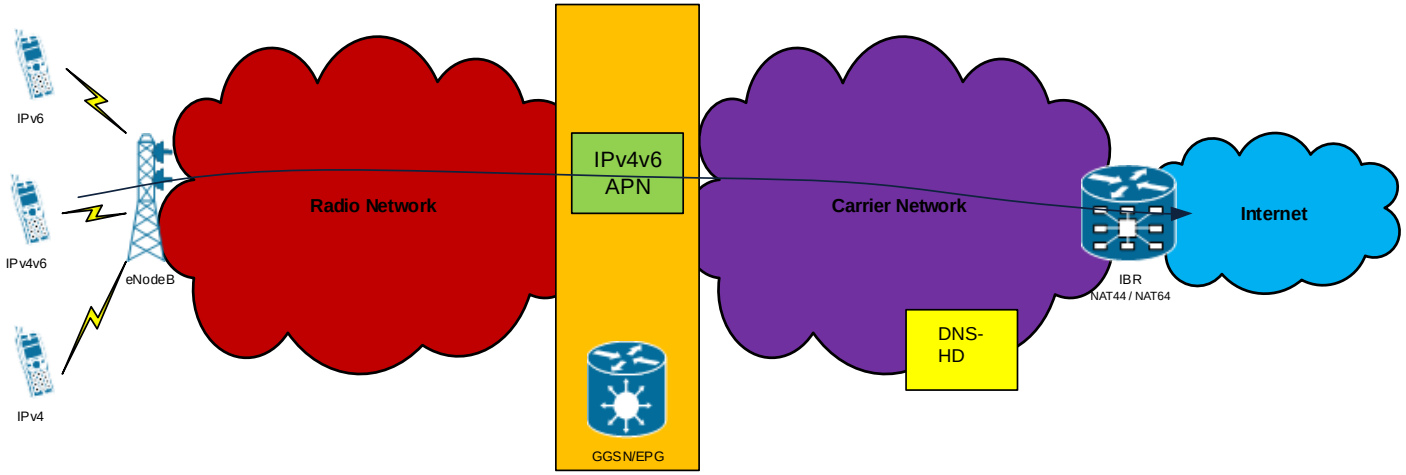
The Final Countdown



Create a single real APN that supports both DS and SS and use RFC7050

DNS configuration

-IPv6 logical partition processes AAAA requests normally (DNS64 is not enabled), and add 'match destination' as its own IPv6 interface address

-'bind' to the Well-known Names: ipv4.google.com and ipv4only.arpa and point to your own Authoritive Name Server

- In your ANS, manually map the IPv4 translated address to a AAAA entry to any Pref64::/n

- In the DNS response to the UE, the UE shall use that Pref64::/n for both local synthesis and for detecting synthesis done by the DNS64 server on the network.

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The Final Countdown

GGSN configuration

-IPv4 and IPv6 DNS name servers use real IPs.

In this configuration, UEs will receive either both IPv4 name servers for IPv4 SS, all 4 name servers for IPv4v6, and both IPv6 name servers for IPv6 SS.

DNS Redundancy is maintained!

It does also mean the UE needs to support RFC7050 as well as RFC6877

The Final Configuration:

SS/DS UEs + NAT64 + DNS-HD + 464XLAT

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The Painful Truth of Reality

But in a Wireless Carrier environment, the APN configuration is defined by the GGSN

The primary goal of RFC7050 is to enable UEs to perform local IPv6 synthesis and potentially avoid NAT64 in a Dual-Stack deployment. It is considered an 'extension' to DNS64 (RFC6147).

Given we are looking at a single APN configured to support IPv4 SS, IPv6 SS, and IPv4v6 DS, there is a relatively simple fix on the GGSN:

If a UE sends a PDP request to the GGSN, the GGSN should respond with the APN configuration required. If the GGSN detects the PDP requested is IPv6 only, then send it the real IPv6 address for DNS64. If the PDP requested is IPv4v6 only, then send the real IPv6 address for DNS-HD with no DNS64.

Modifications to UEs often takes months and lots of effort to convince manufacturers to add new features. This is the same for Packet Core equipment. But which stays in the network more permanently and requires less interaction with multiple vendors?

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IT'S ALL ABOUT THE CUSTOMER

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Its all about the Customer

Find a solution to meet the following goals:

1. We know IPv6 does not work with everything – make it the least painful for the customer if they need to fall back to Dual-Stack or IPv4 only
2. Make the solution work for the long-term goals of the business – a path to native IPv6 and removing the need for private IPv4 addressing. Public IPv4 is needed but will slowly reduce over time.
3. Ensure vendors understand the importance of supporting RFC6877, RFC7050, and IPv6 in general for their software and application development. This is crucial for the transition phase to IPv6 native.
4. Ensure the customers are well informed and have avenues to find answers easily during the transition. The worst situation is defaulting everyone back to IPv4 because something is broken or misunderstood!!

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STATUS UPDATES

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Status Updates

1. Android 4.4.x+ is recommended for all IPv6 launches. These are the most stable OS at the moment and large improvements to solve MTU and 464XLAT related issues.

2. Questions with WM8.1 why 464XLAT is only on the IPv4v6 PDP and not on the IPv6 only PDP.

3. NAT64 ALGs may have some issues sorting out 464XLAT related source addresses. Check and test thoroughly with your vendors!

4. There are more innovative ways to create DNS-HD. You need to think carefully about the logical flow of the DNS request to make it work.

5. Tethering is a big issue. Please attend the APIPv6TF meeting Wednesday 4/3 at 4pm Room 501 for further information.

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….. JUST 1 MORE THING

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IPv6 International Roaming

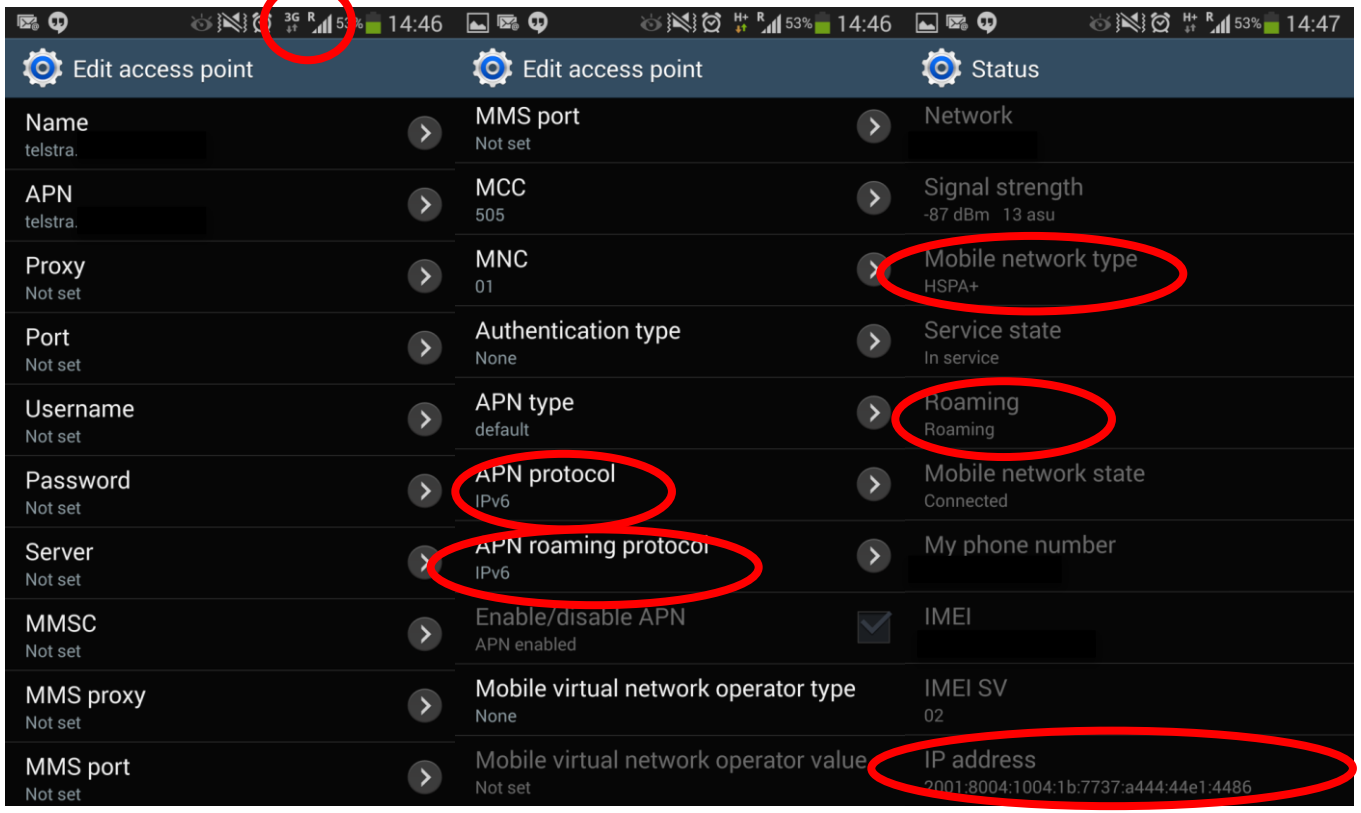
IPv6 International Roaming works

- We need more carriers to support IPv6 and support 3GPP R9+
- IPv4v6 not recognized by older SGSNs so customer connections will fail
- Recommendation to set all APN roaming configurations to IPv4 only until the situation improves in the global carrier industry.

Telstra LTE sim card

APN roaming protocol = IPv6

GGSN PDP setting = IPv6



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LTE and VoLTE International Roaming

– The following will be some of the challenges the Carrier community needs to overcome together as we move down this road of enabling IPv6:

  - PCRF interworking over S9 interface
  - VoLTE IPv6 International Roaming

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IN CONCLUSION

Conclusion

1. Every carrier will have a unique set of circumstances that dictates which transition method they will use. There is no standard way of doing this.

2. You must determine which is the best method for your network.

3. Avoid NAT444 if possible. Any investment should be placed into long-term solutions which transitions you more quickly to IPv6. NAT/PAT are suitable in the short-term however.

4. Dual-Stack is required in most circumstances but you can run certain services with IPv6 Single-Stack today. Why not find a solution to do both simultaneously? You can do IPv6 Single Stack Now!

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Q&A

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