IPV6 Transition for Mobile Operators

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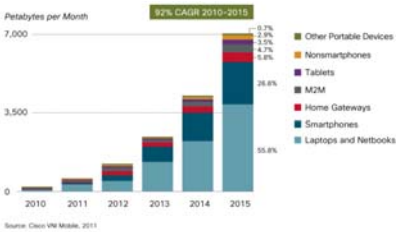
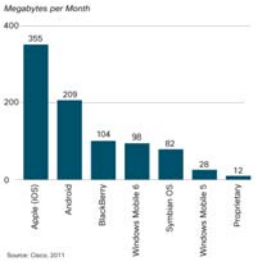
Agenda

- **Motivation**:
  Towards IPv6
- **Architecture Review**:
  IPv6 in Mobile Architectures: GSM/UMTS/LTE
- **The Transition**:
  IPv4 Preservation,
  Dual-Stack IPv4-IPv6 Co-Existence,
  IPv6-only Mobile Hosts

Mobile Operators – Why IPv6?

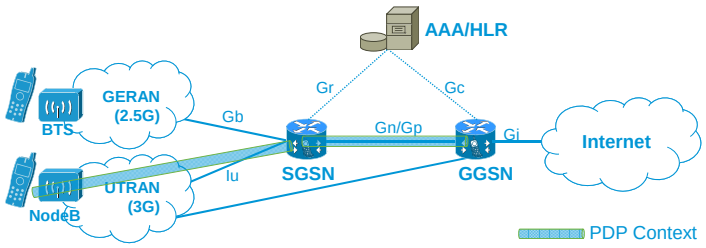
- Current Situation
  - Massive growth of number of mobile data traffic **and** number of mobile end-points
  - IPv4 run out: Most Operators started to deploy NA(P)T44 (on gateway or dedicated devices)
- Drivers for IPv6
  - Key: Off-load NAT44 Infrastructure
  - Provider-hosted IPv6 only services (VoIP/IMS)
  - Sensor-Networks/Machine 2 Machine communication





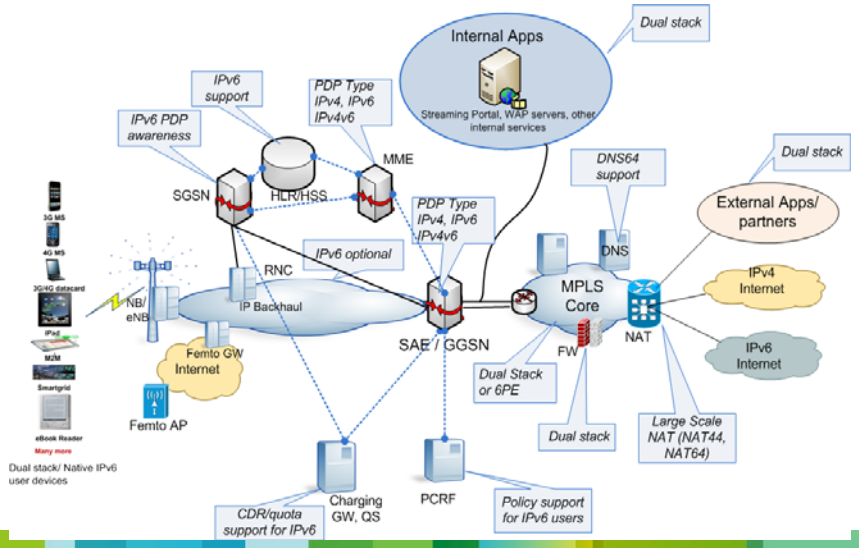
IPv6 in Mobile Architectures

Mobile 3G Internet Access
GPRS/UMTS



- PDP Contexts / Bearer
  - IPv4 only: UE – GGSN link is “IPv4 only”
  - IPv6 only: UE – GGSN link is “IPv6 only”
  - IPv4v6 (>= Rel. **9**): UE – GGSN link transports IPv4 and IPv6 (and has /64 prefix and IPv4 address configured)

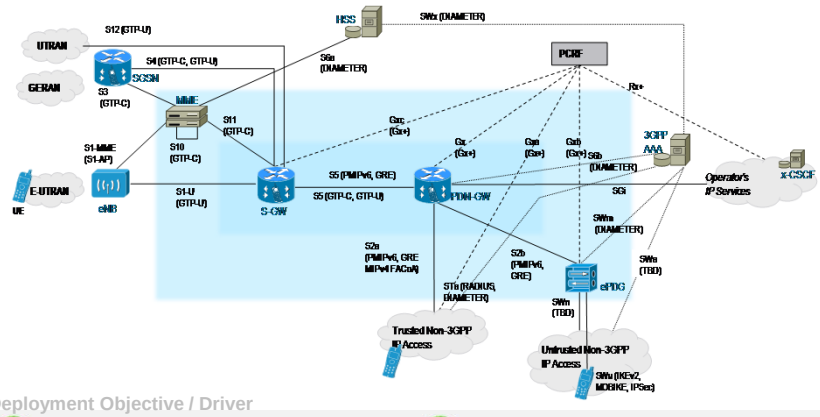
IPv6 “Touch Points” in 3G Networks
Summary



IPv6 in EPS (LTE/EPC) Architecture

3GPP EPS Architecture

IPv6 Deployment Domains



Initial Deployment Objective / Driver

1. Enable IPv6 customer applications
   - IPv6 for user plane interfaces
   - IPv6 related attributes for control plane interfaces
   - IPv6 related attributes for policy/charging/control interfaces
2. Enable IPv6 transport
   - IPv6 Home-PLMN
   - IPv6 Visted-PLMN
   - IPv6 Interconnect-PLMN

Note: Protocol choice analysis in TR 29.803

EPS Bearer Types

- IPv4 only bearer
  The link is “IPv4 only”: One IPv4 Address
- IPv6 only bearer
  The link is “IPv6 only”:
  One /64 prefix per bearer;
  One IPv6 Address on UE

Dual Stack results in 2 EPC Bearers (i.e. **two** interfaces on PGW); Can be supported within the same APN

- IPv4v6 bearer (since Rel-8)
  The link is “dual-stack”: The bearer is configured with both IPv4 address and one /64 prefix.
  v4v6 bearer type is the default in Rel-8 and beyond
  If v4v6 bearer establishment fails and only a single stack bearer is enabled for UE, UE “should” try to establish separate PDN connection for missing stack

Dual Stack results in 1 EPC Bearers (i.e. **one** interface on PGW)

3GPP Release-8 and Release-9 Networks and IPv6

Access Network	Core	Release	IPv4-bearer	IPv6-bearer	IPv4v6-bearer
2G/3G	GPRS (SGSN/GGSN)	< Rel-9	yes	yes	**no**
2G/3G	GPRS (SGSN/GGSN)	>= Rel-9	yes	yes	yes
2G/3G	EPC (PDN-GW via S4 Release-8 SGSN)	>=Rel-8	yes	yes	yes
LTE/ E-UTRAN	EPC	>=Rel-8	yes	yes	yes

Transport Network Aspects

- Clear user- and transport-plane separation in 3GPP:
  Transport and User-plane be migrated to IPv6 independently
- IPv4 and IPv6 Transport available for both GTP and PMIPv6
  - GTP – since R99
  - PMIPv6 – since Rel-8 (introduction of PMIPv6 into 3GPP architecture)
- Roaming Networks
  - Roaming networks (IPX, GRX) are distinct networks (separated from the Internet)
  - Inter-PLMN networks are all IPv4 **only** (see GSMA.IR.34)

Summary of Enabling Features for IPv6
Gateway Focused

Enable IPv6 customer applications

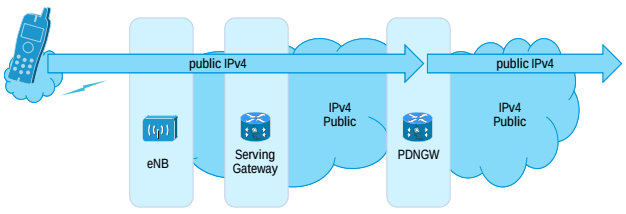
- IPv6 PDP Context support
- Protocols/Encapsulation
  - GTP-U (v6 over v4/v6)
  - IPsec (incl. IPsec for GTP-C/GTP-U)
- Addressing
  - ICMPv6, ND, SLAAC, Stateless-DHCPv6
  - Prefix allocation w/ priotity from
    - Local-pool, Radius, DHCP
  - Mobile-specific parameterization (29.061, clause 11.2.1.3.4)
- Control Protocols
  - v6 AVPs in Gx, Gy, Rf
  - v6 AVPs/VSAs for S6b
  - v6 IE in GTP‘
  - v6 IE in GTP-C
  - v6 LI – SNMP, UDP, FTP
- Session Services
  - Per APN & interface redirect, ...
- Security

Enable IPv6 Transport for Access Network

- Control Protocols
  - Gx, Gy, Rf over v6
  - S6b over v6
  - GTP‘ over v6
  - GTP-C over v6
  - SNMPv6, FTPv6, UDP for LI
  - SNMPv6
- IPv6 routing/forwarding infrastructure
  - IPv4/v6 concurrent support on interfaces
  - IPv6 IGPs
  - IPv6 VPN – 6PE/6vPE
- Security

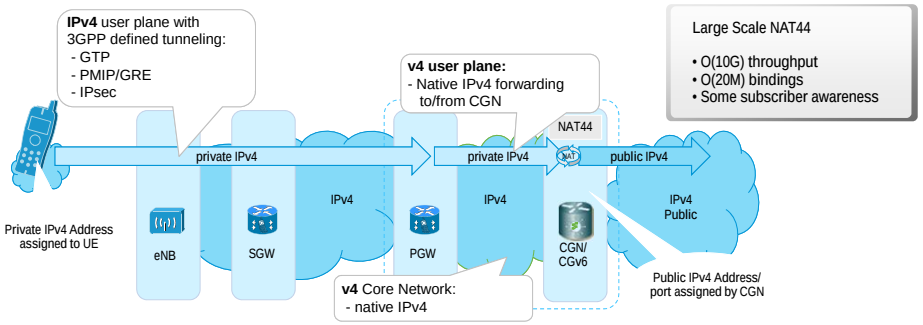
Transition Solutions

In the Beginning
Public IPv4 Deployment



- Public IPv4 addresses used in Transport Network
- Public IPv4 addresses used on Handset for Service access
- Declining Adoption
  - <30% of all carriers offer public IPv4 addresses to their subscribers

Now: Preserve Public IPv4 via NAT44
Central Large Scale NAT44

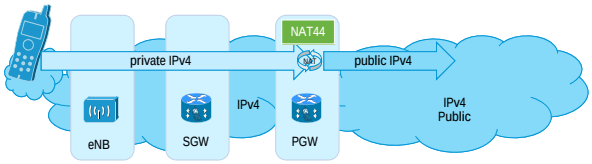


- Limited IPv4 life extension
  - SP operates non overlapping private address space
  - UE obtains a IPv4 address from the private SP address space
  - CGN/CGv6 performs NAT(P)44 with high scalability
  - Many UEs are serviced by fewer Public IP-Address on LSN
    - Dynamically reuses available pool of Public IP-address/port bindings

Evolution of current NAT solutions
- ~70% of all mobile operators leverage NAT44
- Current deployments implement NAT44 on Enterprise-Class Firewalls:
  - scale & throughput challenges

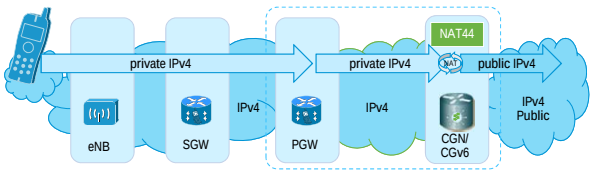
Considerations on NAT
Where to Place the NAT Function?

Option 1: NAT on Gateway (Distributed)



Key Benefits:
- Subscriber aware NAT
  - per subscriber control
  - per subscriber accounting
- Large Scale (further enhanced by distribution)
- Highly available (incl. geo-redundancy)

Option 2: NAT on Router (Centralized)

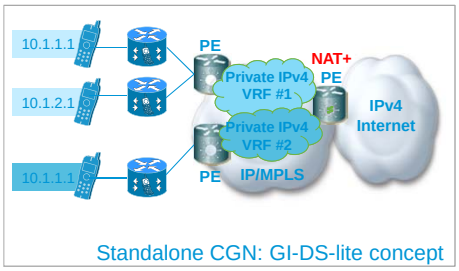


Key Benefits:
- Integrated NAT for multiple administrative domains (operational separation)
- Large Scale
- Overlapping private IPv4 domains (e.g. w/ VPNs)

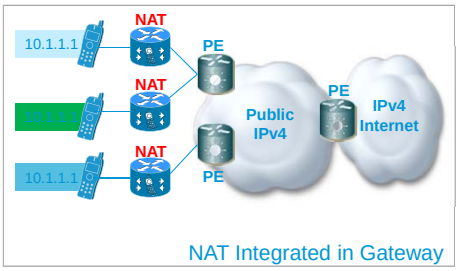
Considerations: Where to place NAT?
Summary

Consideration	NAT on Gateway (i.e. ASR 5000)	NAT on Core Router (i.e. CRS w/ CGSE)
Scale	> 120M bindings > 1M/sec binding setups	~240M bindings (CRS-16) > 1M/sec binding setups
NAT Control	Per-Subscriber; Per System	Per System
NAT Binding Accounting	Per-Subscriber; Bulk	Bulk
High-Availability	1:1 Intrabox HA 1:1 Interbox HA	1:1 Intra-box hot standby (Future: 1:1 Interbox HA)
Convergence (FMC)	NAT specific to gateway & business operation	NAT solution can cover multiple segments
Public IPv4 Address Management	Distributed	Centralized
Solution for Private IPv4 Exhaust	Network Partitioning: Per-Gateway local address pools	Network Partitioning: - Per VPN local addresses Future: GI-DS-lite

Public & Private IPv4 Exhaust
Overlapping private IPv4 addresses / Large Deployments



Standalone CGN: GI-DS-lite concept



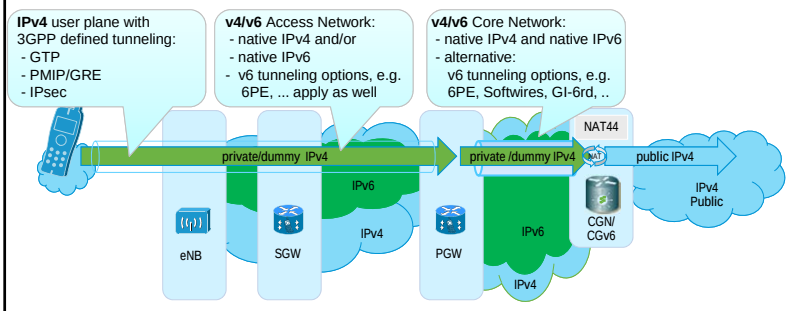
NAT Integrated in Gateway

- Limited IPv4 life extension for large domains
  - Run-out of private IPv4 addresses (more than ~16M addresses needed)
  - Provider does not want to utilize private IPv4 addresses on handset
- Approaches
  - Standalone CGN: Access tunnels extended to NAT44 (e.g. using MPLS VPN)
    - "Gateway-Initiated Dual Stack Lite" (draft-ietf-softwire-gateway-init-ds-lite-02)
  - Gateway-Integrated NAT w/ distributed local address pools
    - Per gateway RFC1918 address space

A. Enable IPv6 Transport: Dual Stack Network

Enable IPv6 within the Service Provider Network

IPv4/IPv6 Coexistence: Transport Network

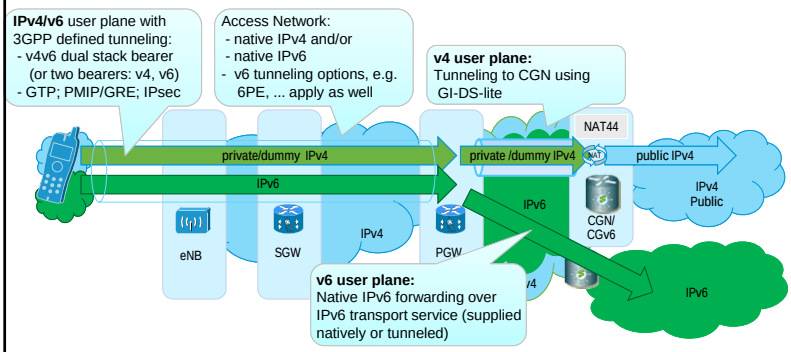


- Enable Dual-Stack IPv4/IPv6 Transport Network
  - Access Network: 3GPP standards already support dual-stack (GTP/PMIP/IPsec tunneling)
  - Routing Protocols handle IPv4 / IPv6
- Core needs to support IPv6 transport (in parallel with IPv4): Options
  - Native IPv6 (in parallel to IPv4 forwarding)
  - IPv6-over-IPv4: Manually Configured Tunnels (IPinIP/GRE); Gateway-Initiated 6rd
  - IPv6-over-MPLSv4: 6PE, (6vPE)

B. Enable IPv6 Services: Dual-Stack Handset

IPv4/IPv6 services available to user

IPv4/IPv6 Coexistence: Handset

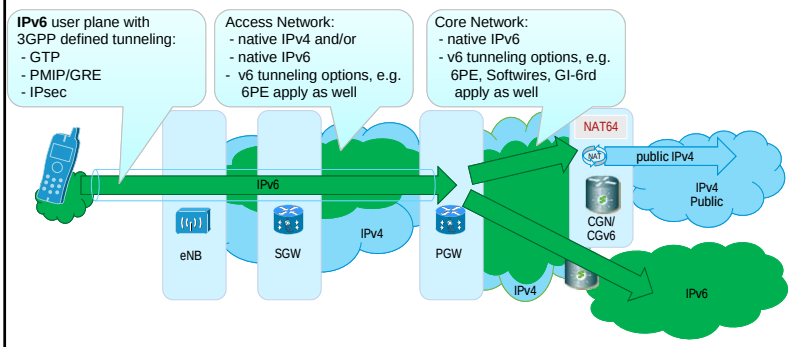


Historically, "Dual-Stack" (with NAPT44) used to be the typical strategy for transition into IPv6

Several 4G/LTE networks (will) start with DS UE offering
- 4G/LTE allows for single v4v6 bearer right from the start

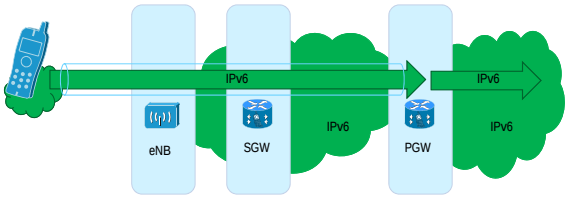
Dual-Stack challenges
- 3G: < Rel. 9: 2 PDP contexts needed dual stack (cost and scalability concern)
- Current OS-behavior (preferences, stack-selection)
- Often BSS/OSS/PCC infrastructure uses **the** IP-address/prefix to identify the subscriber: There can only be one address/prefix… not two…
- Operational overhead to operate two networks (routing, addressing, etc.)
- DS handset offerings still (very) limited

Simplify Handset: IPv6-only handset
NAT64 to allow access to legacy IPv4 services



- Multiple SPs are considering IPv6-only UE connectivity
- advanced service": v6/v4 phones with v6-only connectivity – will require BIH/NAT46 on handset (there are still a lot of IPv4 only applications out there…)
- IPv4 only kept as backup – in case IPv6 service not avalable (e.g. Roaming scenarios)
- Stateful NAT64 as natural evolution from NAT44

The Far Future: IPv6 only
A Dream Has Come True ☺



- All services delivered via v6
- IPv4 discontinued on Handset and Transport Network

Q and A

Thank you.