IPv6 Transition for Mobile Operators

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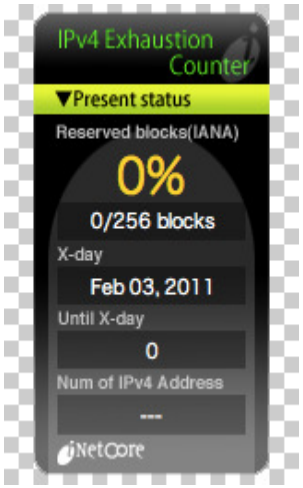
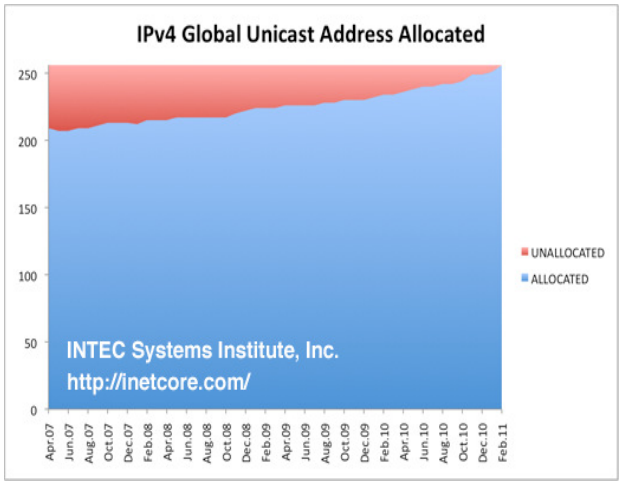
Agenda

- Motivation
- IPv6 in GSM/UMTS Architecture
- IPv6 in EPS (LTE/EPC) Architecture
- Transition Solutions
- Summary

Motivation

- Success of Mobile Internet and increase in Smartphone numbers is rapidly exhausting IPv4 address pools
- IANA global IPv4 -address pool exhausted on FEB 03 2011
- Even private IPv4 addresses has become scarce
  - Each 10.0.0.0 network can support about 16.7 million addresses
- 3GPP and IETF already have well defined standards
- IPv6 simplifies Network Architecture by providing universal connectivity
  - Global endpoint reachability
  - Peer-2-Peer networking as an example





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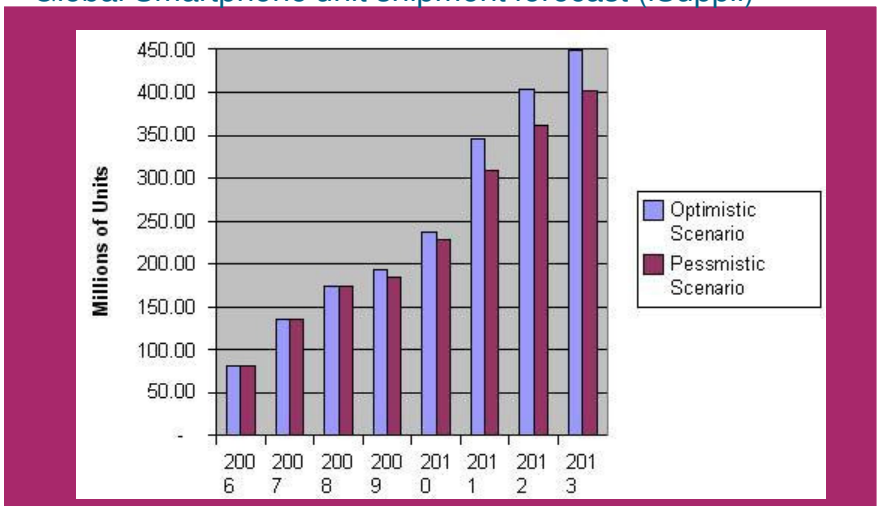
Global Smartphone unit shipment forecast (iSuppli) **

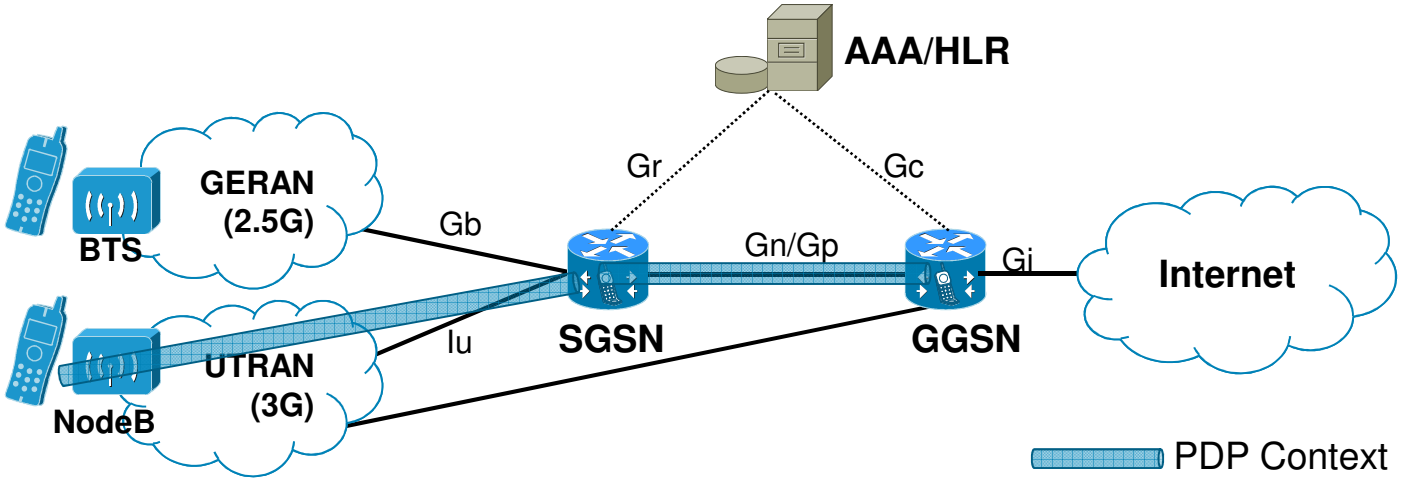


* Source: http://www.mobile-tech-today.com/story.xhtml?story_id=65091
** Source: http://www.ciol.com/Biz-Watch/News-Reports/Smartphones-ring-in-healthy-growth-in-2009/5309116823/0/
*** See see http://www.potaroo.net/tools/ipv4/index.html for more details

IPv6 in GSM/UMTS Architecture

Mobile 3G Internet Access

GPRS/UMTS



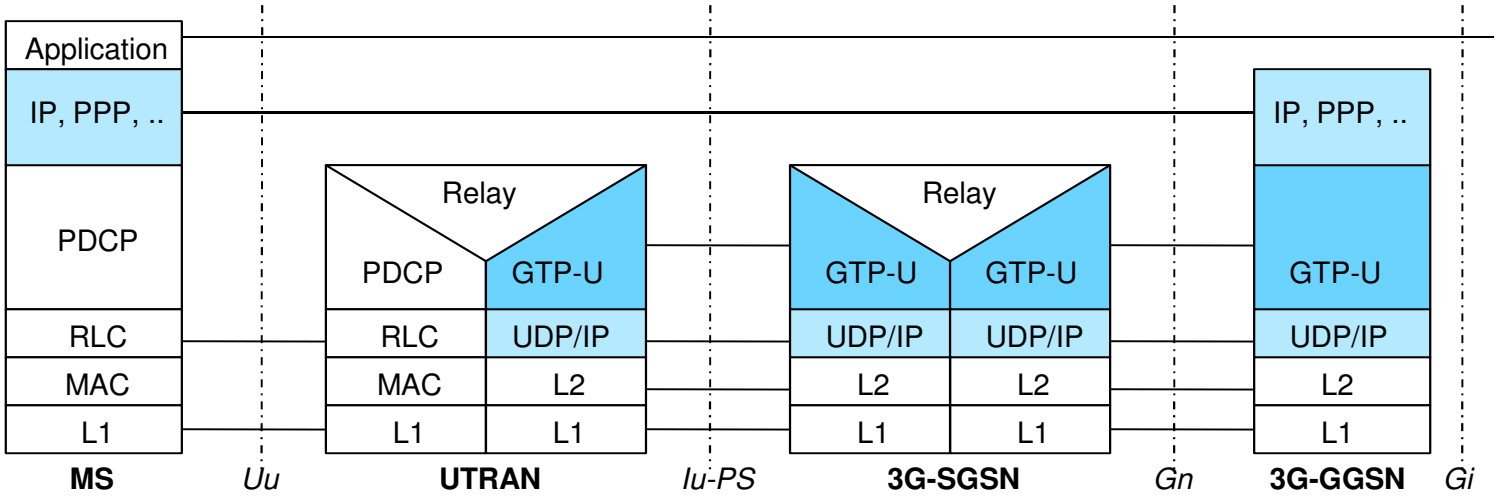
- PDP Contexts / Bearer

  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 Impact on RAN and SGSN



- Assumption: NodeB, RNC, SGSN, GGSN not co-located
- GPRS/UMTS attachment: Standard UMTS procedure

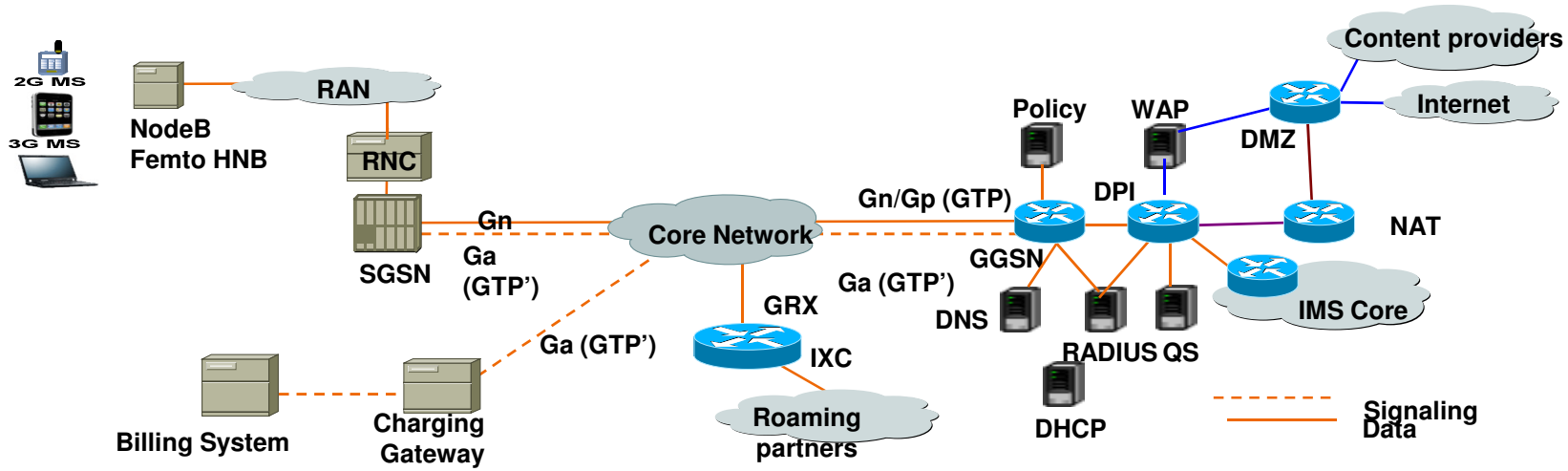
  UE will send PDP create request.
  RNC will forward attach request to SGSN using IuPS signaling:
  Can be over IPv4 or IPv6
- SGSN (and RNC in case of direct tunneling) need IPv6 awareness

  PCO relay

  APN selection

IPv6 Integration in 3G Networks

Design Considerations

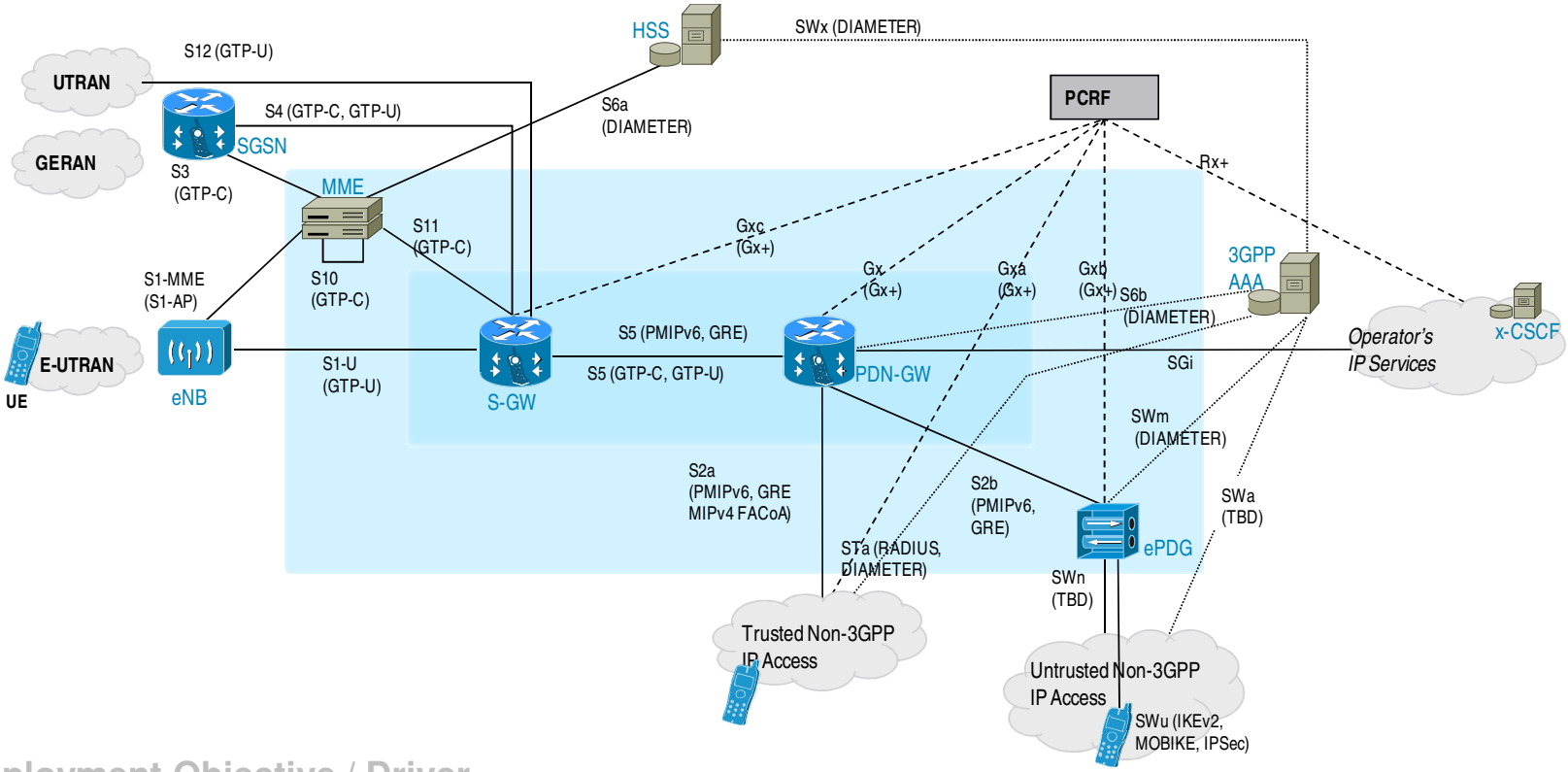


Element	Design consideration (If IPv6 is used for internet & internal Apps)	Impact
eNodeB	Radio layer. Can use IPv4 backhaul	No
RNC	Iu-CS/Iu-PS can use IPv4 backhaul	No
SGSN	Initiate mobile APN query & authentication	Yes
HLR/HSS	IPv6 capable	Yes
GGSN	IPv6 PDP, standards IPv6 features, prefix allocation	Yes
Billing	Mediation and processing of IPv6 CDR	Yes
DPI, Quote Server	Pre-paid implementation, IPv6 parsing & CDR capability	Yes
WAP, Data Accelerator	IPv6 packet compressions, cache capability	Yes
Firewalls	IPv6 rules capability, performance	Yes
DNS	IPv6 DNS capability	Yes

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)

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

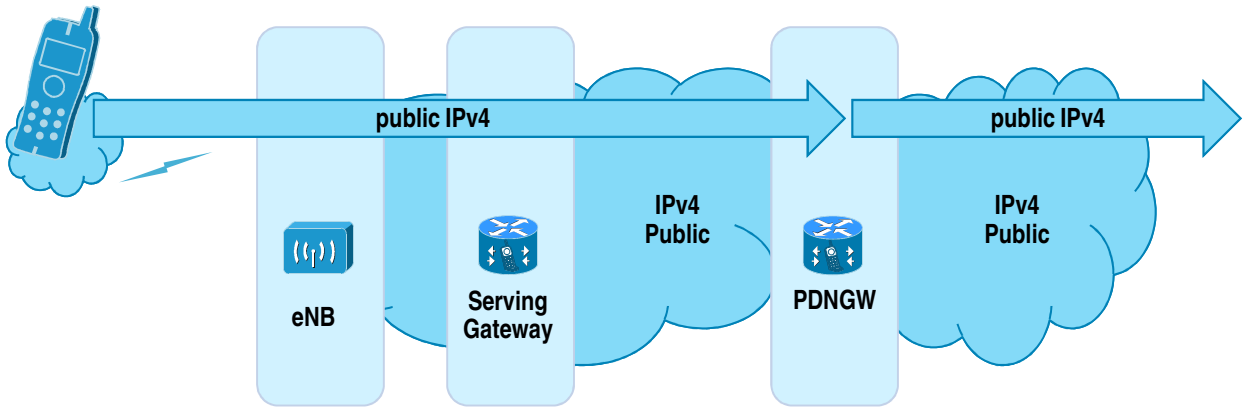
Enable IPv6 Transport for Access Network

- 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

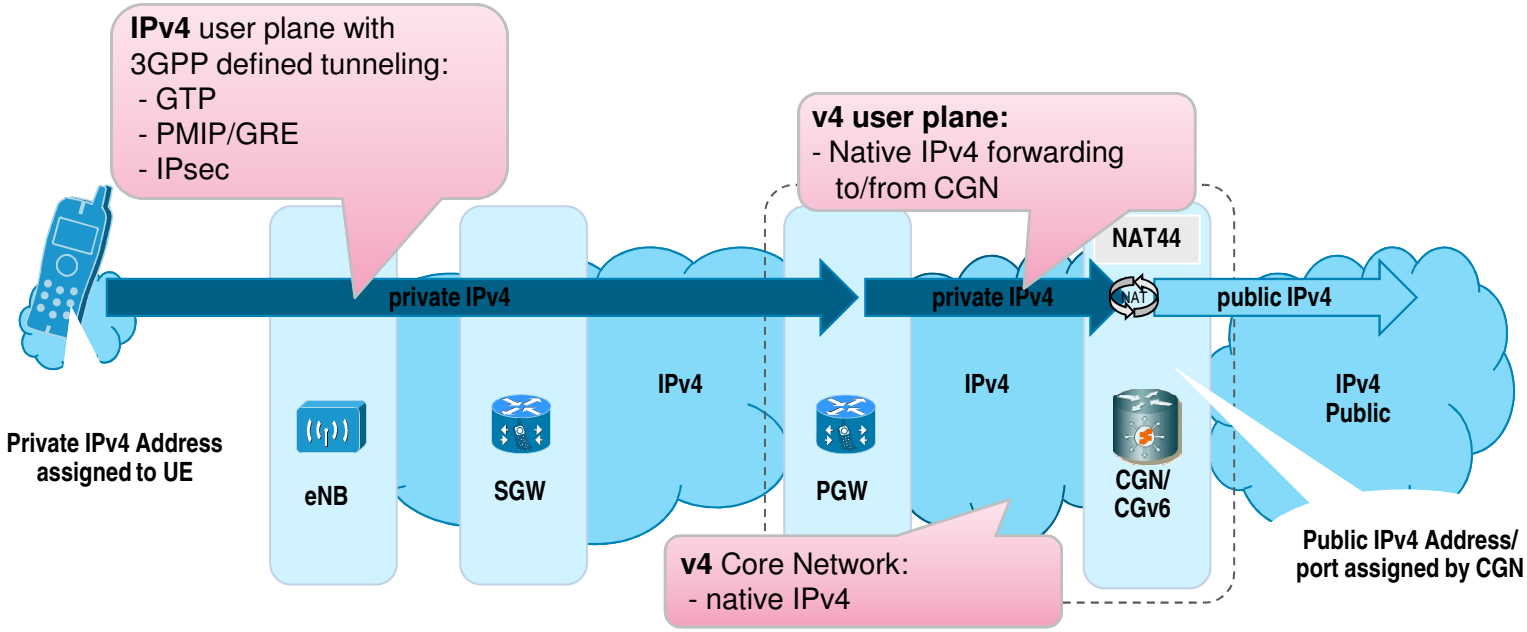


- Public IPv4 addresses used in Transport Network
- Public IPv4 addresses used on Handset for Service access
- Declining Adoption

  ~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

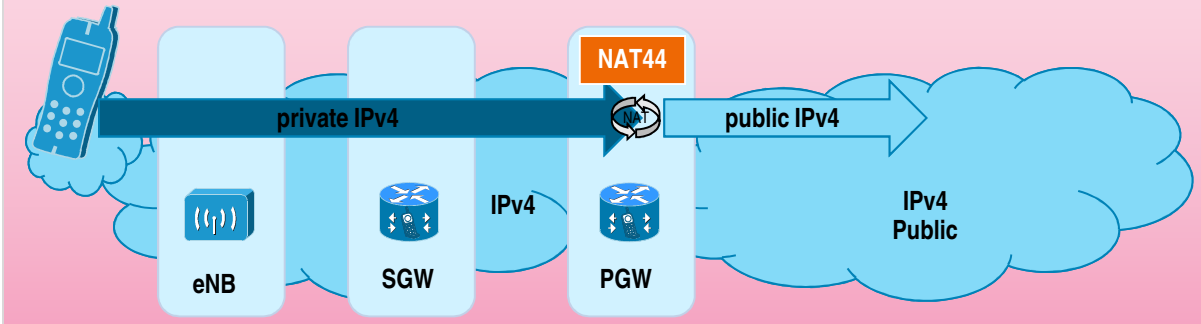
Evolution of current NAT solutions

- ~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?

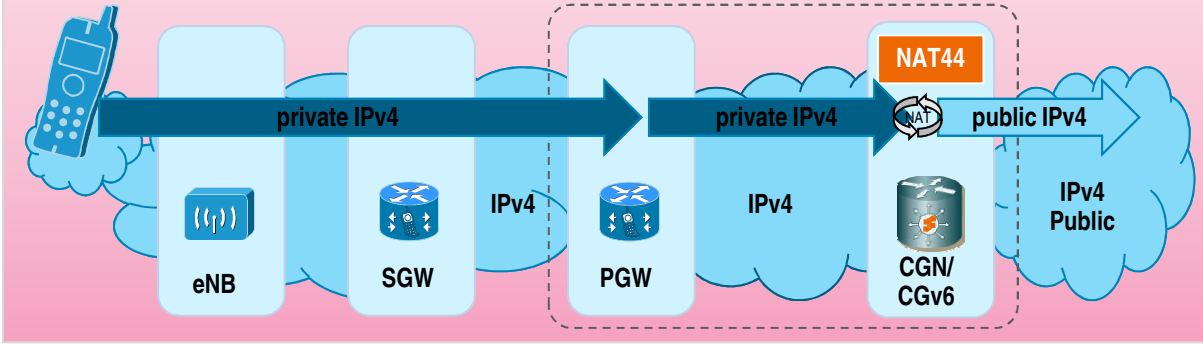
Option 1: NAT on Gateway (Distributed)



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)

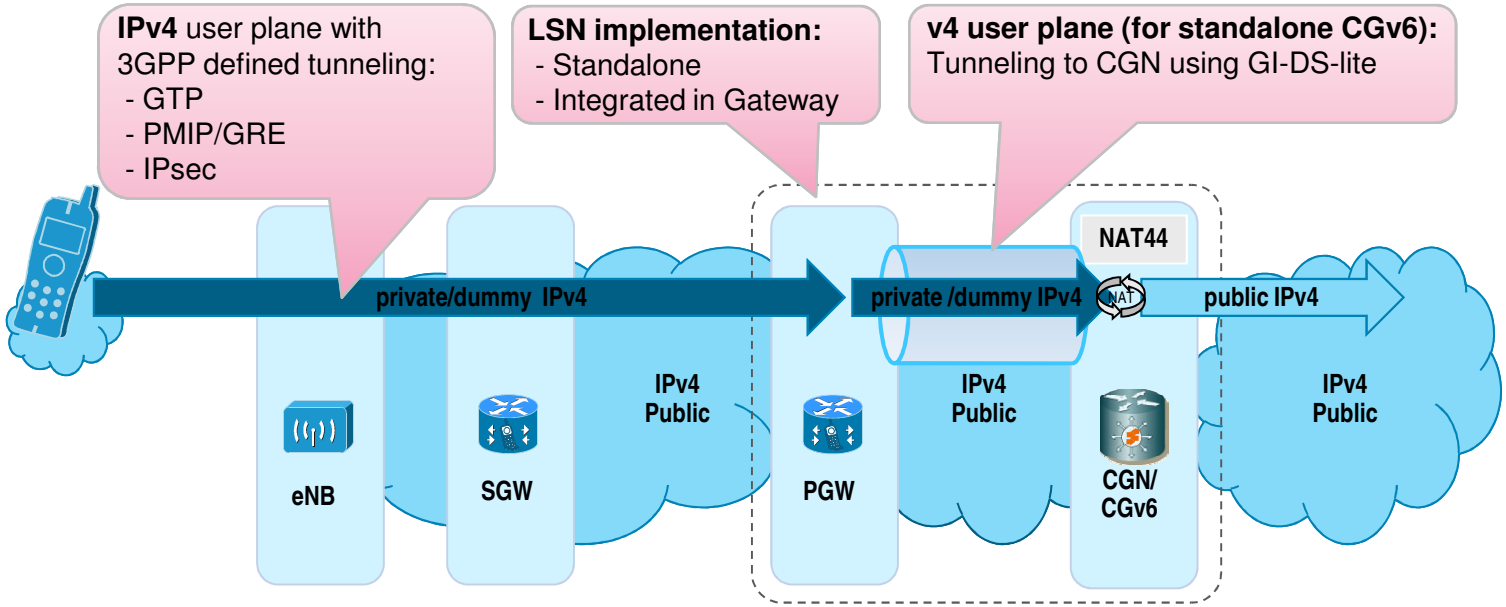


Key Benefits:

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

Preserve IPv4: Public & Private IPv4 Exhaust

Overlapping private IPv4 addresses / Large Deployments

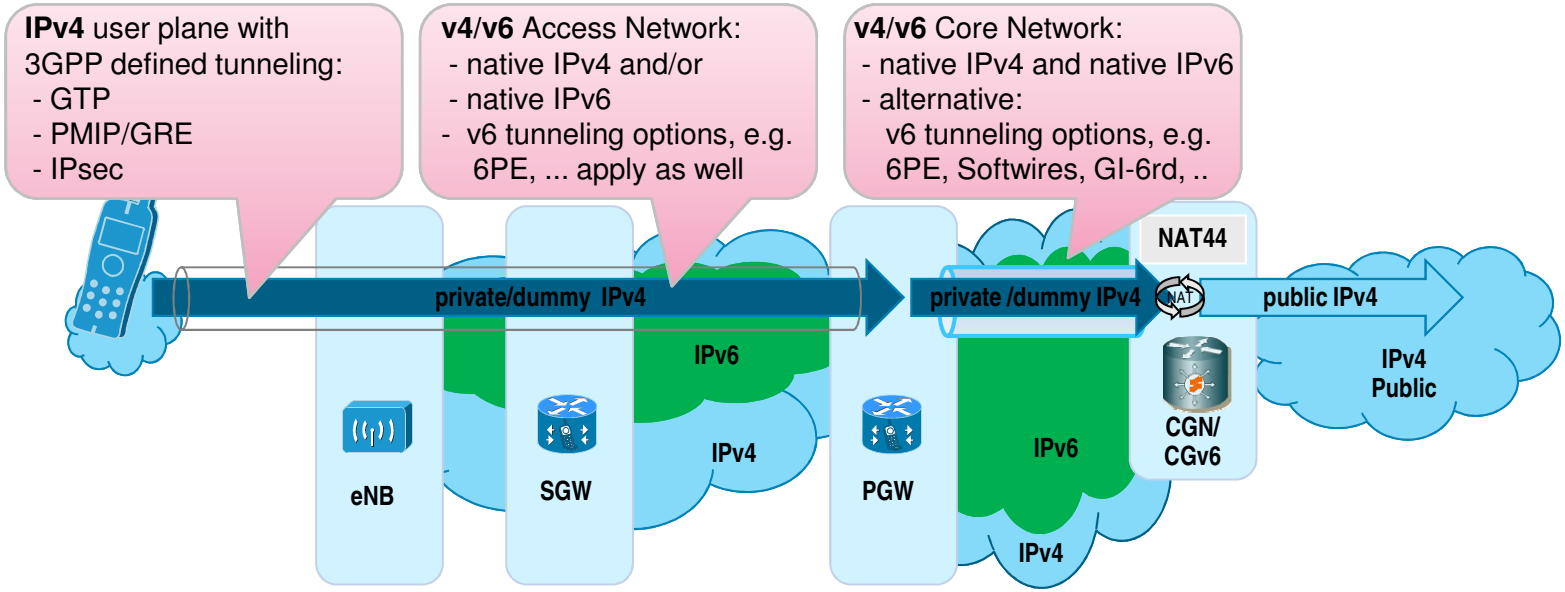


- Limited IPv4 life extension for large domains
  - Run-out of private IPv4 addresses (more than ~16M addresses needed)
  - Provider does not want to utilize private IPv4 addresses on handset
- Approaches
  - Standalone CGN: Mobile Access tunnels extended to NAT44
    - “Gateway-Initiated Dual Stack Lite”
  - 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

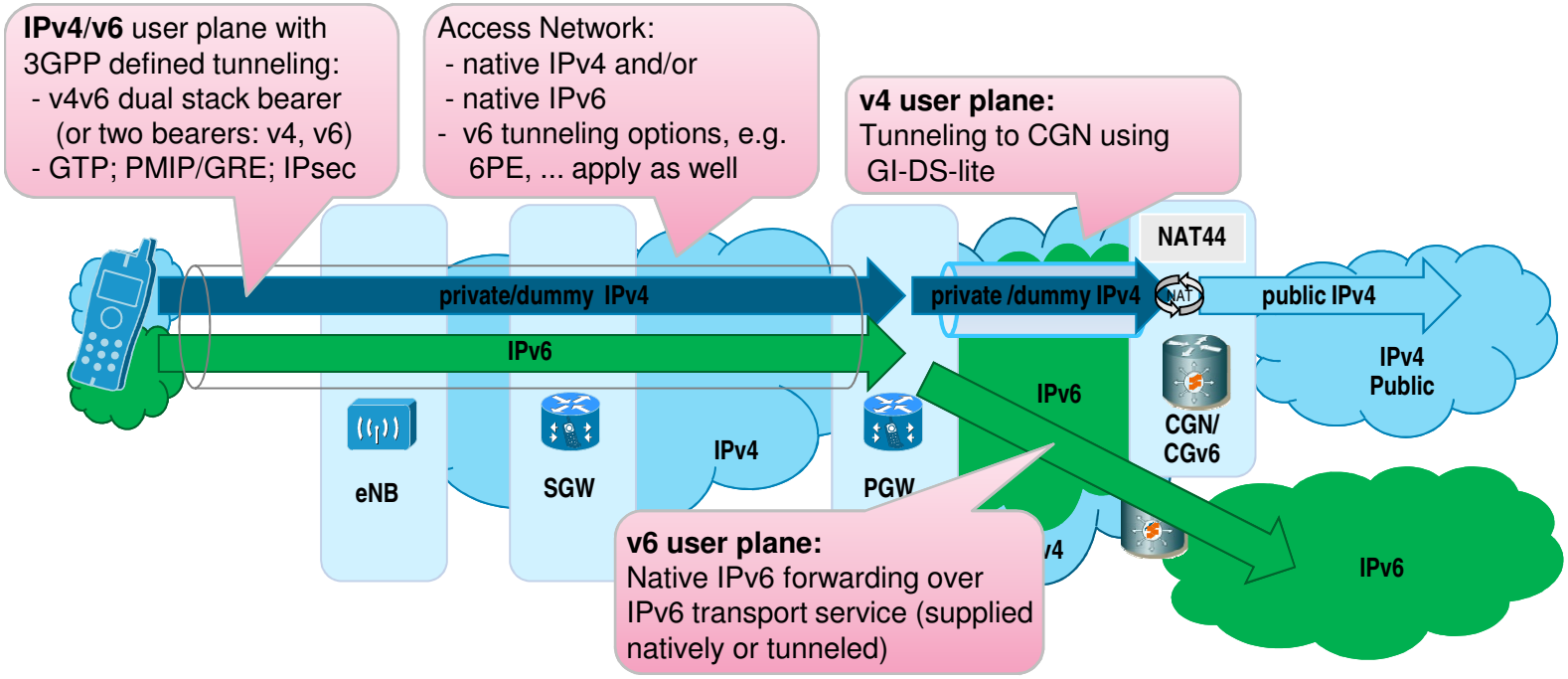


- Enable Dual-Stack IPv4/IPv6 Transport Network
  - Access Network: 3GPP standards already support dual-stack (GTP/PMIP/IPsec tunneling)
  - Routing Protocols handle IPv4 / IPv6
- Core needs to support IPv6 transport (in parallel with IPv4): Options
  - Native IPv6 (in parallel to IPv4 forwarding)
  - 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

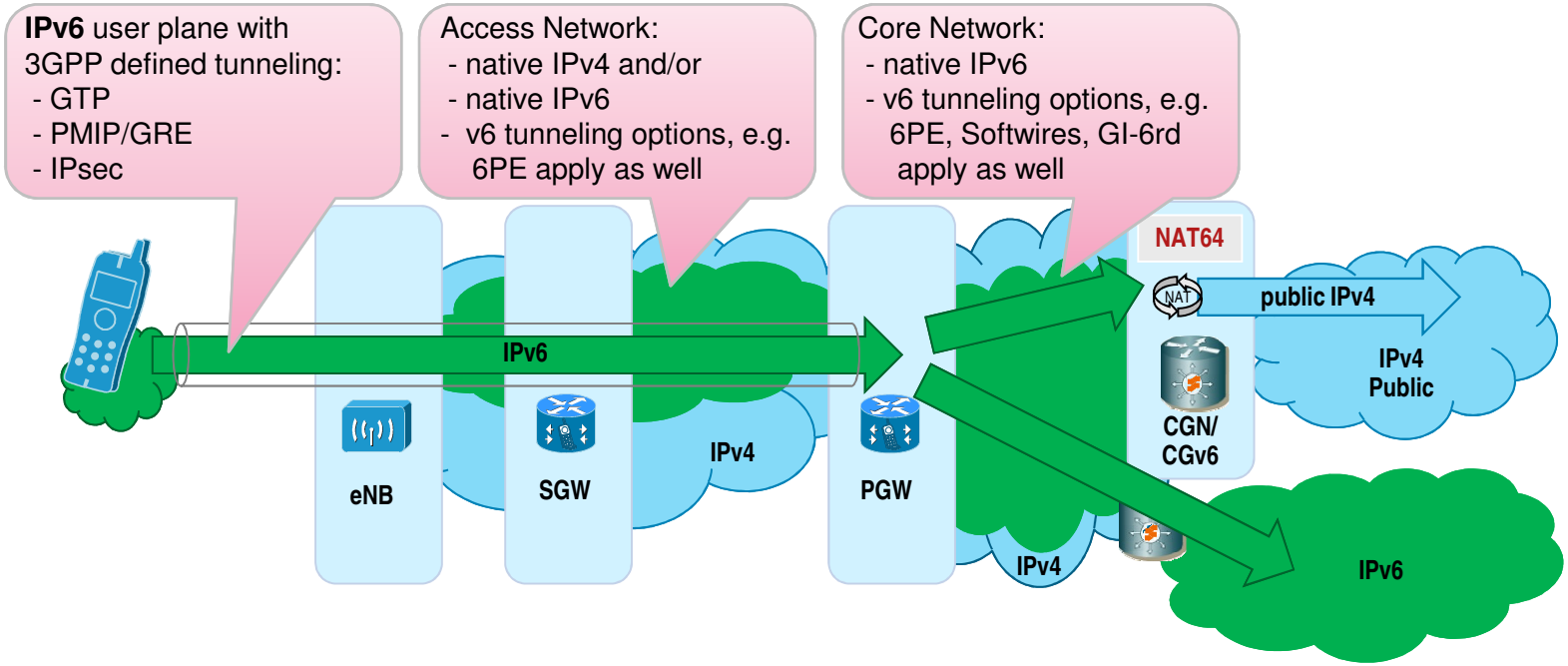
IPv4/IPv6 Coexistence: Handset



- IPv6 support on handset added (establishes v4/v6 bearer)
- Both IP Stacks available to the user, enable Dual-Stack IPv4/IPv6 Transport Network
  - 3GPP standards already support dual-stack access network (GTP/PMIP/IPsec tunneling)
- User Plane traffic transport over core network:
  - IPv4 User Plane: Gateway Initiated DS-Lite – tunneling between PGW and CGN
  - IPv6 User Plane: Native IPv6 forwarding (v6 transport supplied as native or tunneled service)

Simplify Handset: IPv6-only handset

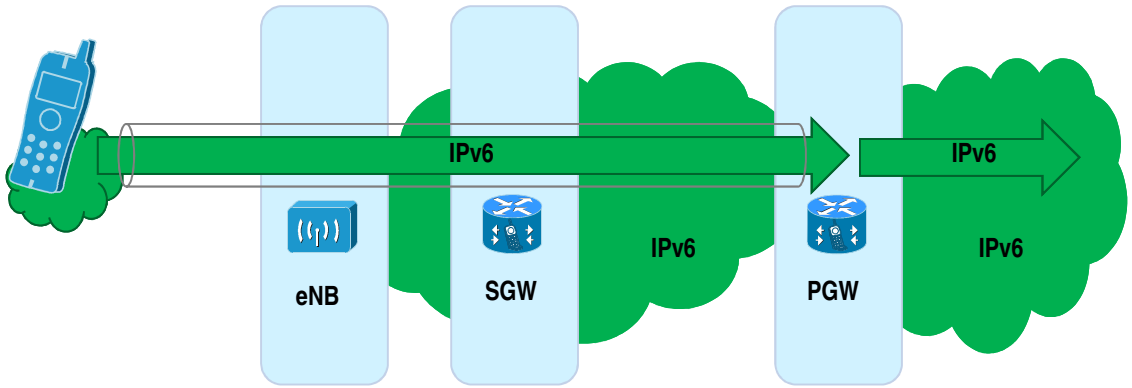
NAT64 to allow access to legacy IPv4 services



- Handset: IPv6 only as default service
  - Simplify Operations, Optimize Resource Usage
  - 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

Summary

- Mobile Network Architectures are well suited for a gradual deployment of IPv6
- Well planned phased approach is the key
- IPv6 architecture choices will define business opportunities for many years
- Expect innovation in applications as characteristics of IPv6 are understood
- Start the IPv6 journey as soon as possible…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