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

*** See [http://www.potaroo.net/tools/ipv4/index.html](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**

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

- **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
  - Dual Stack results in 1 EPC Bearers (i.e. **one** interface on PGW)
  - 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
  - Can be supported within the same APN
### Summary of Enabling Features for IPv6

**Gateway Focused**

<table>
<thead>
<tr>
<th>Enable IPv6 customer applications</th>
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</thead>
<tbody>
<tr>
<td>IPv6 PDP Context support</td>
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<tr>
<td>Protocols/Encapsulation</td>
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<tr>
<td>GTP-U (v6 over v4/v6)</td>
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<tr>
<td>IPsec (incl. IPsec for GTP-C/GTP-U)</td>
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<tr>
<td>Addressing</td>
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<tr>
<td>ICMPv6, ND, SLAAC, Stateless-DHCPv6</td>
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<tr>
<td>Prefix allocation w/ priority from</td>
</tr>
<tr>
<td>Local-pool, Radius, DHCP</td>
</tr>
<tr>
<td>Mobile-specific parameterization</td>
</tr>
<tr>
<td>(29.061, clause 11.2.1.3.4)</td>
</tr>
<tr>
<td>Enable IPv6 Transport for Access Network</td>
</tr>
<tr>
<td>Control Protocols</td>
</tr>
<tr>
<td>v6 AVPs in Gx, Gy, Rf</td>
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<tr>
<td>v6 AVPs/VSAs for S6b</td>
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<tr>
<td>v6 IE in GTP'</td>
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<tr>
<td>v6 IE in GTP-C</td>
</tr>
<tr>
<td>v6 LI – SNMP, UDP, FTP</td>
</tr>
<tr>
<td>Session Services</td>
</tr>
<tr>
<td>Per APN &amp; interface redirect, ...</td>
</tr>
<tr>
<td>Security</td>
</tr>
</tbody>
</table>

| IPv6 routing/forwarding infrastructure |
| IPv4/v6 concurrent support on interfaces |
| IPv6 IGPs |
| IPv6 VPN – 6PE/6vPE |
| Security |
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

- **IPv4 user plane with 3GPP defined tunneling:**
  - GTP
  - PMIP/GRE
  - IPsec

- **LSN implementation:**
  - Standalone
  - Integrated in Gateway

- **v4 user plane (for standalone CGv6):**
  Tunneling to CGN using GI-DS-lite

- **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 available (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…