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 endpoints
  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

- Internal Apps
  - Dual stack

- External Apps
  - Dual stack

- Dual stack

- Native IPv6
  - Load Balancing
  - IPv6 support

- PDP Type
  - IPv4, IPv6
  - IPv4v6

- PCC

- GGSN
  - Load Balancing

- NAT
  - Large Scale NAT
  - NAT

- Policy support for IPv6 users

- Changing 0V / 0S

- PCRF
  - Policy support for IPv6 users

- Dual Stack
  - Support for IPv6

- IPv6 Internet

- Dual Stack IPv6
  - Support for IPv6 users

- GGSN
  - Load Balancing

- IPv6
  - Support for IPv6

- Native IPv6
  - Load Balancing

- IPv6 support

- PDP Type
  - IPv4, IPv6
  - IPv4v6
IPv6 in EPS (LTE/EPC) Architecture

IPv6 Deployment Domains

- Enable IPv6 customer applications
  - IPv6 for user plane interfaces
  - IPv6 related attributes for control plane interfaces
  - IPv6 related attributes for policy/charging/control interfaces

- Enable IPv6 transport
  - IPv6 Home-PLMN
  - IPv6 Visited-PLMN
  - IPv6 Interconnect-PLMN

Note: Protocol choice analysis in TR 22.803
### 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
  - 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

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

<table>
<thead>
<tr>
<th>Access Network</th>
<th>Core</th>
<th>Release</th>
<th>IPv4-bearing</th>
<th>IPv6-bearing</th>
<th>IPv4v6-bearing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2G/3G</td>
<td>GPRS (SGSN/GGSN)</td>
<td>&lt; Rel-9</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>2G/3G</td>
<td>GPRS (SGSN/GGSN)</td>
<td>&gt;= Rel-9</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>2G/3G</td>
<td>EPC (PDN-GW via S4 Release-8 SGSN)</td>
<td>&gt;=Rel-8</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>LTE/E-UTRAN</td>
<td>EPC</td>
<td>&gt;=Rel-8</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>
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

- 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/ priority 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
- IPv6 routing/forwarding infrastructure
  IPv4/IPv6 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)

Option 2: NAT on Router (Centralized)
Considerations: Where to place NAT?

Summary

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

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: 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/IPMP/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 NAT44) 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 v6 handed right from the start
Dual-Stack challenges
  3G: < Rel. 9: 2 PDP contexts needed dual stack (cost and scalability concern)
  Current OSS behavior/preferences, stack-selection
  Often SS/SSP/CSC 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
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 available (e.g. Roaming scenarios)
- Stateful NAT64 as natural evolution from NAT44

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

Thank you.