IPv6 and 3G

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Outline

• Why using IPv6 in 3G?
• IPv6 and 3GPP
• IPv6 and 3GPP2
• Conclusions
Why using IPv6 in 3G?

• Why using IPv6 in 3G terminals?
  – Why 3G?
    • Capacities
      – Voice service is still the main stream
    • Services/applications
      – Mobile data
      – Lesson learned from GSM/SMS
      – How about EMS/MMS/MIM (mobile instant messaging)
  • (Internet) data services/applications over 3G
  • All-IP (VoIP) over 3G
Why using IPv6 in 3G?

- SMS statistics

![2002 SMS Traffic](chart1)

![2001-2002 SMS yearly growth](chart2)
Why using IPv6 in 3G?

- VoIP/Data services over 3G
  - We need more IP addresses
  - We need e2e security
  - We need mobility between 3G and other networks
  - We need e2e QoS

![Graph showing the number of subscriptions for different types of services from 2000 to 2007.](image-url)
Why using IPv6 in 3G?

• How about NAT (network address translation)?
  – Management effort
  – Performance issue
  – SIP
  – End-to-end security
  – End-to-end QoS
  – Seamless mobility
Why using IPv6 in 3G?

- Why using IPv6 in 3G network transport?
  - IP transport network
Why using IPv6 in 3G?

- Why using IPv6 in 3G network transport? (Cont.)
  - Benefits to use IPv6 in IP transport network
    - Offer QoS transport
    - Easy to manage networks
      - Intra-PLMN
      - Inter-PLMN
IPv6 and 3GPP

- 3GPP R99
  - Transport network
    - Core network IPv4 transport
  - User Equipment
    - IPv4

- 3GPP R4
  - Transport network
    - Core / Radio access network IPv4/IPv6 transport
  - User Equipment
    - IPv4

- 3GPP R5
  - Transport network
    - CN/RAN (IPv4 or IPv6) transport
      - **IPv6 for IP multimedia subsystem (IMS) elements**
  - User Equipment
    - IPv4 and IPv6 to Internet
    - **IPv6 for IMS**
IPv6 and 3GPP (Cont.)

- 3GPP R5 architecture requirements
  - IP transport between network elements
    - both IPv4 / IPv6 are options for IP Connectivity
  - IM CN subsystem elements
    - The architecture shall make optimum use of IPv6
    - The IM CN subsystem shall exclusively support IPv6
    - The UE shall exclusively support IPv6 for the connection to services provided by the IM CN subsystem.
  - Access to existing data services
    - The UE can access IPv4 and IPv6 based services.
IPv6 and 3GPP (Cont.)

• Packet Domain Access Interfaces and Reference Points

![Diagram showing Packet Domain Access Interfaces and Reference Points]
IPv6 and 3GPP (Cont.)

- Transparent mode
**IPv6 and 3GPP (Cont.)**

- Non-transparent mode

```plaintext
<table>
<thead>
<tr>
<th>TE</th>
<th>MT</th>
<th>SGSN</th>
<th>GGSN</th>
<th>ISP</th>
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<tbody>
<tr>
<td>PPP/L2</td>
<td>PPP/L2</td>
<td>SM</td>
<td>GTP-C</td>
<td>DHCP/</td>
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<td>Phy. layer</td>
<td>Phy. layer</td>
<td>Lower layers</td>
<td>Lower layers</td>
<td>RADIUS</td>
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<td></td>
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<td>UDP</td>
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<td>IP</td>
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<td>Lower layers</td>
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</tbody>
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IPv6 and 3GPP (Cont.)

- Methods to obtain IPv6 address
  - Network access mode
    - Transparent mode
    - Non-transparent mode
  - IPv6 address type
    - Static IPv6 address
    - Dynamic IPv6 address
  - Automatic configuration
    - Stateless
    - DHCPv6
IPv6 and 3GPP (Cont.)

• Static IPv6 address

1. Activate PDP Context Request
   (PDP type=IPv6, PDP address=IPv6 address, PCO)

2. C1

3. Non-transparent mode
   Send RADIUS to ISP

4. Create PDP Context Request

5. Create PDP Context Response

6. Invoke Trace

7. Radio Access Bearer Setup

8. Update PDP Context Request

9. Update PDP Context Response

10. Activate PDP Context Accept
    (PDP address=IPv6 address, PCO)
IPv6 and 3GPP (Cont.)

- Stateless IPv6 address

1. Activate PDP Context Request
   - (PDP type=IPv6, PDP address=null, PCO)

2. Create PDP Context Request

3. Activate PDP Context Accept
   - (PDP address=prefix+IID, PCO)

4. Router Solicitation

5. Router Advertisement
   - (prefix)

- Ignore prefix
- Store IID
- Generate link local address
- Duplicated address detection is not necessary

- Can change its IID (IPv6 address) or generate a new IID (IPv6 address)

- Prefix = Step 2 prefix
IPv6 and 3GPP (Cont.)

• In a PLMN
  – UE A
    • Prefix\textsubscript{a} + IID\textsubscript{c}
  – UE B
    • Prefix\textsubscript{b} + IID\textsubscript{d}

  – Prefix\textsubscript{a} \neq Prefix\textsubscript{b}
  – IID\textsubscript{c} = IID\textsubscript{d} or IID\textsubscript{c} \neq IID\textsubscript{d}
  – Prefix\textsubscript{a} + IID\textsubscript{c} \neq Prefix\textsubscript{b} + IID\textsubscript{d}
IPv6 and 3GPP (Cont.)

- Address assignment solutions
  - #1 assign one or more entire /64s to a PDP context
    - Is a /64 per PDP context too much?
    - Still has 61 bits (3-bit prefix 001 for aggregatable global unicast addresses) = 490x10^22 /64 prefixes can be used
  - #2 share the same prefix between multiple PDP context connected to the same PLMN
    - DAD is required
    - Increase GGSN workload
      - Prefix match or complete address match
      - Determine temporary addresses that are no longer in use
IPv6 and 3GPP (Cont.)

- Stateless IPv6 address (Cont.)

<table>
<thead>
<tr>
<th>MS</th>
<th>SGSN</th>
<th>GGSN</th>
<th>ISP/intranet</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>RADIUS/DHCPv6</td>
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</table>

(PDP type=IPv6, PDP address=null, PCO)

Activate PDP Context → Create PDP Context

(PDP address=prefix+IID, PCO)

Router Solicitation

Router Advertisement

[M-flag=0, O-flag, Prefix, Lifetime, A-flag=1, L-flag=0]

Router Advertisement

[M-flag=0, O-flag, Prefix, Lifetime, A-flag=1, L-flag=0]

Get network prefix through DHCP

• Generate global unique IPv6 address or site-local address
Stateless IPv6 address (Cont.)

- **TE**
  - AT-Commands
    - [APN]
  - LCP negotiation
    - [MRU, Auth. prot.]
  - Authentication
    - [CHAP/PAP/none]
  - IPV6CP Configure-request
    - [Interface Identifier, Compression]

- **MT**
  - The MT stores the authentication parameters

- **SGSN**
  - GGSN performs:
    - APN -> ISP address translation via DNS
    - allocates 1) RADIUS client or 2) RADIUS client and DHCP client
    - Translates the Protocol Configuration Options, DHCP Option and RADIUS attributes.

- **IP/intranet**
  - GGSN stores IP-address

- **GGSN RADIUS/DHCP client**
  - Create PDP ContextReq.
    - [APN, QoS, PDP-type, TID, Protocol Configuration Options]
  - GGSN stores IP-address

- **ISP/intranet**
  - GGSN stores IP-address

- **Non-transparent mode**
  - Option 1: RADIUS
    - RADIUS Access-Request
      - Authentication, Configuration
    - RADIUS Access-Accept
      - Authentication, Configuration

- **Non-transparent mode or transparent mode**
  - Option 2: RADIUS+DHCP
    - RADIUS Access-Request
      - Authentication
      - RADIUS Access-Accept
      - Authentication
      - DHCPv6 (Note)
    - Configuration

- **IPV6CP Configure-Ack/Nak**
  - [Interface Identifier, Compression]

- **IPV6CP Configure-Request**
  - [Interface Identifier, Compression]

- **IPV6CP Configure-Ack**
  - [Interface Identifier, Compression]

- **Create PDP Context Response**
  - [PDP Address, Protocol Configuration Options, Cause]

- **Activate PDP Context Request**
  - [PDP Address, Protocol Configuration Options, Cause]
IPv6 and 3GPP (Cont.)

- DHCPv6

Using link local address
### IPv6 and 3GPP (Cont.)

- **DHCPv6 (Cont.)**

<table>
<thead>
<tr>
<th>TE</th>
<th>MT</th>
<th>SGSN</th>
<th>GGSN DHCP Relay Agent</th>
<th>Intranet or ISP</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT commands</td>
<td>Activate PDP Context</td>
<td>Create PDP Context</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Router Advertisement (M-flag=1 )</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1. SOLICIT</td>
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<tr>
<td>2. RELAY-FORWARD( SOLICIT )</td>
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<tr>
<td>3. RELAY-REPLY( ADVERTISE ) (maybe several)</td>
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<tr>
<td>4. ADVERTISE (maybe several)</td>
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<tr>
<td>5. REQUEST</td>
<td></td>
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<tr>
<td>6. RELAY-FORWARD(REQUEST )</td>
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<tr>
<td>7. RELAY-REPLY(REPLY)</td>
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<tr>
<td>8. REPLY</td>
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<tr>
<td>10. Modify PDP Context req.</td>
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<tr>
<td>11. Modify PDP Context acc.</td>
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<tr>
<td>12. Update PDP Context resp.</td>
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<tr>
<td>13. Router Advertisement (M-flag=1 )</td>
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</tbody>
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IPv6 and 3GPP (Cont.)

- Other DHCPv6 configuration

<table>
<thead>
<tr>
<th>TE</th>
<th>MT</th>
<th>SGSN</th>
<th>GGSN DHCP Relay Agent</th>
<th>Intranet or ISP DHCP Server(s)</th>
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<tr>
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<tr>
<td>1.</td>
<td>Router Advertisement (O-flag=1)</td>
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<td>RELAY-FORWARD( INFORMATION-REQUEST )</td>
</tr>
<tr>
<td>2.</td>
<td>INFORMATION-REQUEST</td>
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</tr>
<tr>
<td>3.</td>
<td>REPLY (maybe several)</td>
<td></td>
<td></td>
<td>RELAY-REPLY( REPLY )</td>
</tr>
</tbody>
</table>
IPv6 and 3GPP (Cont.)

- IPv4 to IPv6 transition in 3GPP
  - GPRS Scenarios (data service)
    - Dual Stack UE connecting to IPv4 and IPv6 nodes
    - IPv6 UE connecting to an IPv6 node through an IPv4 network
    - IPv4 UE connecting to an IPv4 node through an IPv6 network
    - IPv6 UE connecting to an IPv4 node
    - IPv4 UE connecting to an IPv6 node
  - Transition scenarios with IMS (IMS service)
    - UE connecting to a node in an IPv4 network through IMS
    - Two IPv6 IMS islands connected via an IPv4 network
IPv6 and 3GPP (Cont.)

• Dual stack UE connecting to IPv4 and IPv6 nodes
IPv6 and 3GPP (Cont.)

• IPv6 UE connecting to IPv6 node through an IPv4 network
• IPv6 UE connecting to an IPv4 node
IPv6 and 3GPP (Cont.)

- IPv4 UE connecting to IPv4 node through an IPv6 network
- IPv4 UE connecting to an IPv6 node
IPv6 and 3GPP (Cont.)

- UE connecting to a node in an IPv4 network through IMS
IPv6 and 3GPP (Cont.)

• Two IPv6 IMS islands connected via an IPv4 network
IPv6 and 3GPP2

- 3GPP2 Architecture
  - Simple IPv4 and Simple IPv6
IPv6 and 3GPP2 (Cont.)

- Simple IP protocol stack
IPv6 and 3GPP2 (Cont.)

- 3GPP2 Architecture
  - Mobile IPv4
IPv6 and 3GPP2 (Cont.)

- Mobile IP protocol stack
IPv6 and 3GPP2 (Cont.)

- 3GPP2 Wireless All-IP Network Architecture Model

[Diagram of 3GPP2 Wireless All-IP Network Architecture Model]

- IP Multimedia Domain
- RAN Domain
- Packet CN Domain
- Legacy MS Domain
• Current 3GPP 2 architectural principal
  – “The All-IP architecture shall be designed in such a way that a migration from IPv4 to IPv6 is feasible and that IPv4 and IPv6 based All-IP networks may interoperate”
Conclusions

- IPv6, an infrastructure work
- 3G, still seeking for APs
- R99 and R4 still use IPv4
- In R5, IPv6 is a MUST
- In 3GPP2 All-IP, IPv6 is recommended

- Killer mobile data (Internet) service/applications will speed up the deployment of IPv6 over 3G
  - Messaging service
  - All-IP (VoIP) over 3G
    - Still need to wait
References

- 3GPP
  - 3GPP TS 29.061
  - 3GPP TS 23.060
  - 3GPP TS 24.228
  - 3GPP TS 24.229
  - 3GPP TS 22.941
  - 3GPP TS 23.221
  - 3GPP TS 27.060
- 3GPP2
  - 3GPP2 S.R0037-0
  - 3GPP2 P.S0001-B
- IETF
  - RFC 3316
  - RFC 3314