                 Transition Scenarios for 3GPP Networks

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Abstract

   This document describes different scenarios in Third Generation
   Partnership Project (3GPP) defined packet network, i.e., General
   Packet Radio Service (GPRS) that would need IP version 6 and IP
   version 4 transition. The focus of this document is on the scenarios
   where the User Equipment (UE) connects to nodes in other networks,
   e.g., in the Internet. GPRS network internal transition scenarios,
   i.e., between different GPRS elements in the network, are out of
   scope.   The purpose of the document is to list the scenarios for
   further discussion and study.

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1. Introduction

   This document describes the transition scenarios in 3GPP packet data
   networks that might come up in the deployment phase of IPv6. The
   main purpose of this document is to identify and to document those
   scenarios for further discussion and study them in the v6ops working
   group.

   Just a brief overview of the 3GPP packet data network, GPRS, is given
   to help the reader to better understand the transition scenarios. A
   better overview of the 3GPP specified GPRS can be found for example
   from [6]. The GPRS architecture is defined in [1].

2. Scope of the Document

   The scope is to describe the possible transition scenarios in the
   3GPP defined GPRS network where a UE connects to, or is contacted
   from, the Internet or another UE. The document describes scenarios
   with and without the usage of the SIP-based (Session Initiation
   Protocol [5]) IP Multimedia Core Network Subsystem (IMS). The 3GPP
   releases 1999, 4, and 5 are considered as the basis.

   Out of scope are scenarios inside the GPRS network, i.e., on the
   different interfaces of the GPRS network. This document neither
   changes 3GPP specifications, nor proposes changes to the current
   specifications.

   In addition, the possible transition scenarios are described. The
   solutions will be documented in a separate document.

   All the possible scenarios are listed here. Further analysis may
   show that some of the scenarios are not actually relevant in this
   context.

3. Brief Description of the 3GPP Network Environment

   This section describes the most important concepts of the 3GPP
   environment for understanding the transition scenarios. The first
   part of the description gives a brief overview to the GPRS network as
   such. The second part concentrates on the IP Multimedia Core Network
   Subsystem (IMS).

3.1. GPRS Architecture Basics

   This section gives an overview to the most important concepts of the
   3GPP packet architecture. For more detailed description, please see
   [1].

   From the point of view of this document, the most relevant 3GPP
   architectural elements are the User Equipment (UE), and the Gateway
   GPRS Support Node (GGSN). A simplified picture of the architecture
   is shown in Figure 1.

   The UE is the mobile phone. It can either be an integrated device
   comprising a combined GPRS part, and the IP stack, or it might be a
   separate GPRS device, and separate equipment with the IP stack, e.g.,
   a laptop.

   The GGSN serves as an anchor-point for the GPRS mobility management.
   It also serves as the default router for the UE.

   The Peer node mentioned in the picture refers to a node with which
   the UE is communicating.

```
    --           ----         ************        ---------
   |UE|- ... -|GGSN|--+--* IPv4/v6 NW *--+--|Peer node|
    --           ----         ************        ---------
```

            Figure 1: Simplified GPRS Architecture

   There is a dedicated link between the UE and the GGSN called the
   Packet Data Protocol (PDP) Context. This link is created through the
   PDP Context activation process. During the activation the UE is
   configured with its IP address and other information needed to
   maintain IP access, e.g., DNS server address. There are three
   different types of PDP Contexts: IPv4, IPv6, and Point-to-Point
   Protocol (PPP).

   A UE can have one or more simultaneous PDP Contexts open to the same
   or to different GGSNs. The PDP Context can be either of the same or
   different types.

3.2. IP Multimedia Core Network Subsystem (IMS)

   IP Multimedia Core Network Subsystem (IMS) is an architecture for
   supporting multimedia services via a SIP infrastructure. It is
   specified in 3GPP Release 5. This section provides an overview of
   the 3GPP IMS and is not intended to be comprehensive. A more
   detailed description can be found in [2], [3] and [4].

The IMS comprises a set of SIP proxies, servers, and registrars. In
addition, there are Media Gateways (MGWs) that offer connections to
non-IP networks such as the Public Switched Telephony Network (PSTN).
A simplified overview of the IMS is depicted in figure 2.

```
              +-------------+   +------------------------------------+
              |             |   |                         +------+   |
              |             |   |                         |S-CSCF|---
              |             |   |                         +------+   |
    +- +      |             |   |                          /         |
    |   |     |   SIP Sig.  |   |   +------+        +------+          |
    |   |-----|------+------|--|----|P-CSCF|--------|I-CSCF|          |
    |   |     |      |      |   |   +------+        +------+          |
    |   |     --------------+---------------------------------------- -
    +--+      |   User traf.|   |                                    |
    UE        |             |   |                                    |
              |   GPRS access|   |   IP Multimedia CN Subsystem       |
              +-------------+   +------------------------------------+
```
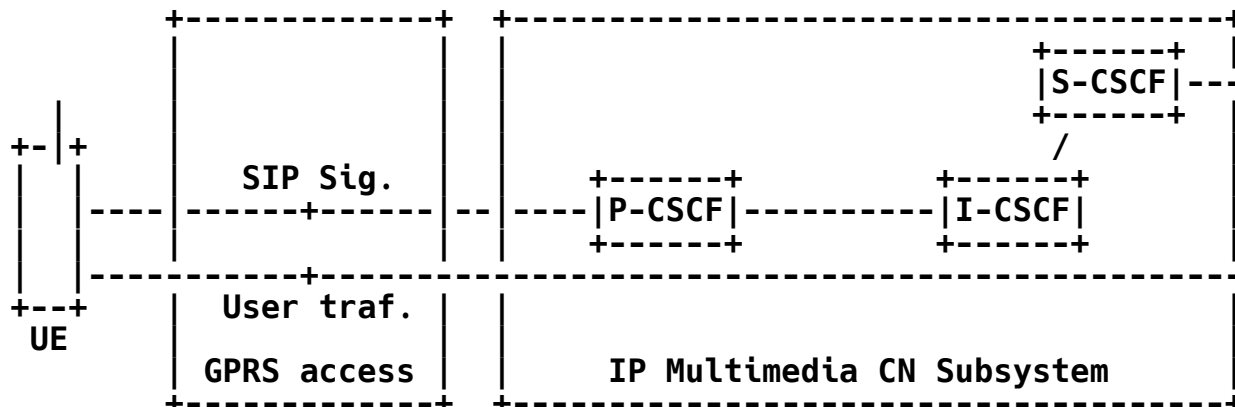
         Figure 2: Overview of the 3GPP IMS architecture

The SIP proxies, servers, and registrars shown in Figure 2 are as
follows.

   - P-CSCF (Proxy-Call Session Control Function) is the first
     contact point within the IMS for the subscriber.

   - I-CSCF (Interrogating-CSCF) is the contact point within an
     operator's network for all connections destined to a subscriber
     of that network operator, or a roaming subscriber currently
     located within that network operator's service area.

   - S-CSCF (Serving-CSCF) performs the session control services for
     the subscriber. It also acts as a SIP Registrar.

IMS capable UEs utilize the GPRS network as an access network for
accessing the IMS. Thus, a UE has to have an activated PDP Context
to the IMS before it can proceed to use the IMS services. The PDP
Context activation is explained briefly in section 3.1.

The IMS is exclusively IPv6. Thus, the activated PDP Context is of
PDP Type IPv6. This means that a 3GPP IP Multimedia terminal uses
exclusively IPv6 to access the IMS, and the IMS SIP server and proxy
support exclusively IPv6. Hence, all the traffic going to the IMS is
IPv6, even if the UE is dual stack capable - this comprises both
signaling and user traffic.

This, of course, does not prevent the usage of other unrelated
services (e.g., corporate access) on IPv4.

4. Transition Scenarios

This section is divided into two main parts - GPRS scenarios, and
scenarios with the IP Multimedia Subsystem (IMS). The first part -
GPRS scenarios - concentrates on scenarios with a User Equipment (UE)
connecting to services in the Internet, e.g., mail, web. The second
part - IMS scenarios - then describes how an IMS capable UE can
connect to other SIP-capable nodes in the Internet using the IMS
services.

4.1. GPRS Scenarios

This section describes the scenarios that might occur when a GPRS UE
contacts services, or nodes outside the GPRS network, e.g., web-
server in the Internet.

Transition scenarios of the GPRS internal interfaces are outside of
the scope of this document.

The following scenarios are described here. In all of the scenarios,
the UE is part of a network where there is at least one router of the
same IP version, i.e., GGSN, and it is connecting to a node in a
different network.

The scenarios here apply also for PDP Context type Point-to-Point
Protocol (PPP) where PPP is terminated at the GGSN. On the other
hand, where the PPP PDP Context is terminated e.g., at an external
ISP, the environment is the same as for general ISP cases.

    1) Dual Stack UE connecting to IPv4 and IPv6 nodes
    2) IPv6 UE connecting to an IPv6 node through an IPv4 network
    3) IPv4 UE connecting to an IPv4 node through an IPv6 network
    4) IPv6 UE connecting to an IPv4 node
    5) IPv4 UE connecting to an IPv6 node

1) Dual Stack UE connecting to IPv4 and IPv6 nodes

    The GPRS system has been designed in a manner that there is the
    possibility to have simultaneous IPv4, and IPv6 PDP Contexts open.
    Thus, in cases where the UE is dual stack capable, and in the
    network there is a GGSN (or separate GGSNs) that supports both
    connections to IPv4 and IPv6 networks, it is possible to connect
    to both at the same time. Figure 3 depicts this scenario.

```
   +-------------+
   |             |
   |     UE      |                                          +------+
   |             |                                        / | IPv4 |
   | ------+------+                                      /  |      |
   | IPv6 | IPv4 |                     +--------+       /   +------+
   +-------------+        IPv4         |        |      /
   |          |---------------------------|        |     /
   |               IPv6               |  GGSN  |    \
   |-------------------------------|        |     \
   |             +-----------+     |        |      \   +------+
   |             | GPRS Core |     |        |       \  | IPv6 |
   |             +-----------+     +--------+        \ |      |
   |                                                   \+------+
   |                                                    +------+
```
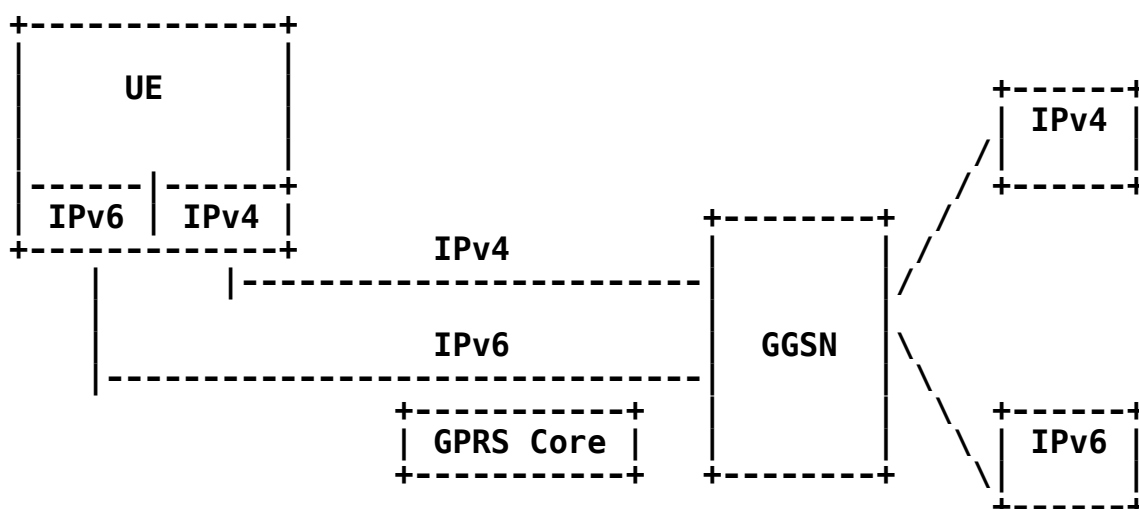
                    Figure 3: Dual-Stack Case

   However, the IPv4 addresses may be a scarce resource for the
   mobile operator or an ISP. In that case, it might not be possible
   for the UE to have a globally unique IPv4 address allocated all
   the time. Hence, the UE could either activate the IPv4 PDP
   Context only when needed, or be allocated an IPv4 address from a
   private address space.

2) IPv6 UE connecting to an IPv6 node through an IPv4 network

   Especially in the initial stages of IPv6 deployment, there are
   cases where an IPv6 node would need to connect to the IPv6
   Internet through a network that is IPv4. For instance, this can
   be seen in current fixed networks, where the access is provided
   via IPv4 only, but there is an IPv6 network deeper in the
   Internet. This scenario is shown in Figure 4.

```
   +------+                       +------+                        +------+
   |  UE  |-------------------|      |-----------------|      |
   |      |    +-----------+  | GGSN |   +---------+   | IPv6 |
   | IPv6 |    | GPRS Core |  |      |   | IPv4 Net|   |      |
   +------+    +-----------+  +------+   +---------+   +------+
```
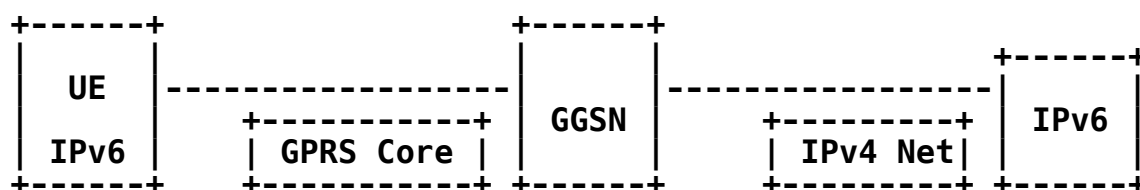
                Figure 4: IPv6 nodes communicating over IPv4

   In this case, in the GPRS system, the UE would be IPv6 capable,
   and the GPRS network would provide an IPv6 capable GGSN in the
   network. However, there is an IPv4 network between the GGSN, and
   the peer node.

3) IPv4 UE connecting to an IPv4 node through an IPv6 network

   Further in the future, there are cases where the legacy UEs are
   still IPv4 only, capable of connecting only to the legacy IPv4
   Internet. However, the GPRS operator network has already been
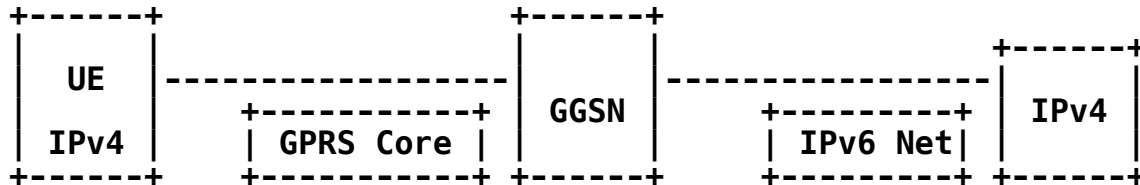   upgraded to IPv6. Figure 5 represents this scenario.

```
    +------+                        +------+
    |      |                        |      |                  +------+
    |  UE  |------------------------|      |------------------|      |
    |      |        +-----------+   | GGSN |    +---------+   | IPv4 |
    | IPv4 |        | GPRS Core |   |      |    | IPv6 Net|   |      |
    +------+        +-----------+ +------+    +---------+ +------+
```

             Figure 5: IPv4 nodes communicating over IPv6

   In this case, the operator would still provide an IPv4 capable
   GGSN, and a connection through the IPv6 network to the IPv4
   Internet.

4) IPv6 UE connecting to an IPv4 node

   In this scenario, an IPv6 UE connects to an IPv4 node in the IPv4
   Internet. As an example, an IPv6 UE connects to an IPv4 web
   server in the legacy Internet. In the figure 6, this kind of
   possible installation is described.

```
    +------+                        +------+
    |      |                        |      |      +---+   +------+
    |  UE  |------------------------|      |------|   |----|      |
    |      |        +-----------+   | GGSN |      | ? |    | IPv4 |
    | IPv6 |        | GPRS Core |   |      |      |   |    |      |
    +------+        +-----------+ +------+      +---+   +------+
```
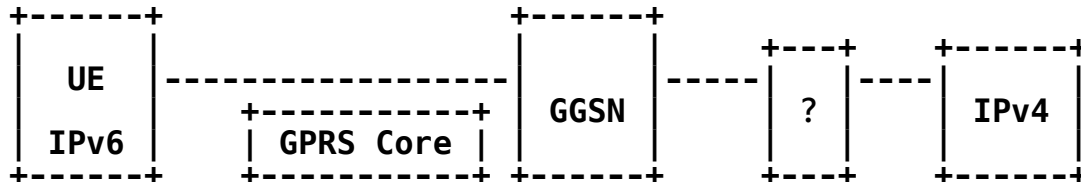
           Figure 6: IPv6 node communicating with IPv4 node

5) IPv4 UE connecting to an IPv6 node

   This is similar to the case above, but in the opposite direction.
   Here an IPv4 UE connects to an IPv6 node in the IPv6 Internet. As
   an example, a legacy IPv4 UE is connected to an IPv6 server in the
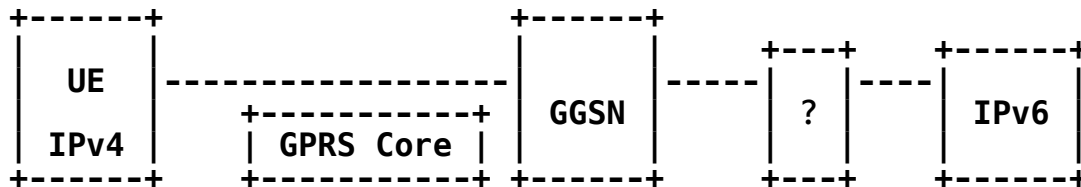   IPv6 Internet. Figure 7 depicts this configuration.

```
       +------+                      +------+         +---+  +------+
       |      |                      |      |         |   |  |      |
       |  UE  |----------------------|      |------   | ? |----| IPv6 |
       |      |     +-----------+    | GGSN |          |   |     |      |
       | IPv4 |     | GPRS Core |    |      |          |   |     |      |
       +------+     +-----------+    +------+         +---+  +------+
```

              Figure 7: IPv4 node communicating with IPv6 node

4.2. IMS Scenarios

   As described in section 3.2, IMS is exclusively IPv6. Thus, the
   number of possible transition scenarios is reduced dramatically. In
   the following, the possible transition scenarios are listed.

      1) UE connecting to a node in an IPv4 network through IMS
      2) Two IPv6 IMS connected via an IPv4 network

   1) UE connecting to a node in an IPv4 network through IMS

      This scenario occurs when an IMS UE (IPv6) connects to a node in
      the IPv4 Internet through the IMS, or vice versa. This happens
      when the other node is a part of a different system than 3GPP,
      e.g., a fixed PC, with only IPv4 capabilities. This scenario is
      shown in the Figure 8.

```
       +------+       +------+        +-----+   +---+  +------+
       |      |       |      |        |     |   |   |  |      |
       |  UE  |-...-  |      |-----   | IMS |-- | ? |--| IPv4 |
       |      |       | GGSN |        |     |   |   |  |      |
       | IPv6 |       |      |        |     |   |   |  |      |
       +------+       +------+        +-----+   +---+  +------+
```
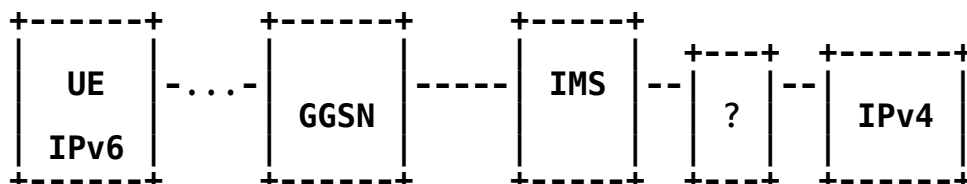
              Figure 8: IMS UE connecting to an IPv4 node

2) Two IPv6 IMS connected via an IPv4 network

   At the early stages of IMS deployment, there may be cases where
   two IMS islands are only connected via an IPv4 network such as the
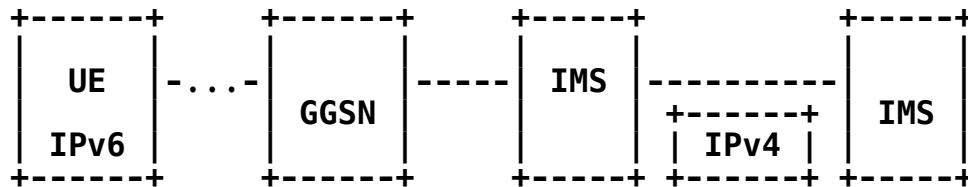   legacy Internet. See Figure 9 for illustration.

```
   +------+     +------+     +-----+            +-----+
   |      |     |      |     |     |            |     |
   |  UE  |-...-|      |-----| IMS |------------|     |
   |      |     | GGSN |     |     | +------+   | IMS |
   | IPv6 |     |      |     |     | | IPv4 |   |     |
   +------+     +------+     +-----+ +------+   +-----+
```

            Figure 9: Two IMS islands connected over IPv4

5. Security Considerations

   This document describes possible transition scenarios for 3GPP
   networks for future study. Solutions and mechanism are explored in
   other documents. The description of the 3GPP network scenarios does
   not have any security issues.

6. Contributing Authors

   This document is a result of a joint effort of a design team. The
   members of the design team are listed in the following.

      Alain Durand, Sun Microsystems
      <Alain.Durand@sun.com>

      Karim El-Malki, Ericsson Radio Systems
      <Karim.El-Malki@era.ericsson.se>

      Niall Richard Murphy, Enigma Consulting Limited
      <niallm@enigma.ie>

      Hugh Shieh, AT&T Wireless
      <hugh.shieh@attws.com>

      Jonne Soininen, Nokia
      <jonne.soininen@nokia.com>

      Hesham Soliman, Ericsson Radio Systems
      <hesham.soliman@era.ericsson.se>

      Margaret Wasserman, Wind River
      <mrw@windriver.com>

      Juha Wiljakka, Nokia
      <juha.wiljakka@nokia.com>

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       call control based on SIP and SDP; Stage 3 (Release 5)", March
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       Partnership Project (3GPP) Standards", RFC 3314, September 2002.

9. Editor's Address

   Jonne Soininen
   Nokia
   313 Fairchild Dr.
   Mountain View, CA, USA

   Phone: +1-650-864-6794
   EMail: jonne.soininen@nokia.com

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