

Network Working Group
Internet-Draft
Intended status: Informational
Expires: May 08, 2014

G. Chen
H. Deng
China Mobile
D. Michaud
Rogers
J. Korhonen
Renesas Mobile
M. Boucadair
France Telecom
A. Vizdal
Deutsche Telekom AG
C. Byrne
T-Mobile USA
November 04, 2013

IPv6 Roaming Behavior Analysis
draft-chen-v6ops-ipv6-roaming-analysis-02

Abstract

This document intends to enumerate failure cases when a IPv6 subscriber roams into visited network areas. The investigations on those failed cases reveal the causes in order to notice improper configurations, equipment's incomplete functions or inconsistent IPv6 strategy.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of [BCP 78](#) and [BCP 79](#).

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at <http://datatracker.ietf.org/drafts/current/>.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on May 08, 2014.

Copyright Notice

Copyright (c) 2013 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to [BCP 78](#) and the IETF Trust's Legal Provisions Relating to IETF Documents (<http://trustee.ietf.org/license-info>) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions with respect to this document. Code Components extracted from this document must include Simplified BSD License text as described in Section 4.e of the Trust Legal Provisions and are provided without warranty as described in the Simplified BSD License.

Table of Contents

- [1.](#) Introduction [2](#)
- [2.](#) Roaming Architecture Descriptions [3](#)
- [3.](#) Roaming Scenario Overview [4](#)
- [4.](#) Failure Cases Descriptions [5](#)
 - [4.1.](#) Failure Case 1: Incompatible with Extended PDP/PDN Type . 5
 - [4.2.](#) Failure Case 2: Splitting Dual-stack Bearer [6](#)
 - [4.3.](#) Failure Case 3: Shortage of IPv6 support [7](#)
 - [4.4.](#) Failure Case 4: Fallback Incapability [7](#)
 - [4.5.](#) Failure Case 5: 464xlat Support [7](#)
- [5.](#) Discussions [8](#)
- [6.](#) IANA Considerations [9](#)
- [7.](#) Security Considerations [9](#)
- [8.](#) Acknowledgements [9](#)
- [9.](#) References [9](#)
 - [9.1.](#) Normative References [9](#)
 - [9.2.](#) Informative References [10](#)
- Authors' Addresses [11](#)

1. Introduction

IPv6 has been deployed globally to overcome the IPv4 depletion. Operators likely start or plan to upgrade the networks that allow IPv6 subscribers to access. As the dramatical uses of Internet services with a mobile access, IPv6 is an essential part to be considered in the mobile network evolution. 3rd Generation Partnership Project (3GPP) published the IPv6 migration guidance [[TR23.975](#)], which describes different technical evolution paths. In general, operators may deploy dual-stack or IPv6 single-stack depending on network's conditions. It has been observed that those deployments are rolled out in multiple provisioning domains. In the early IPv6 stage, a mobile subscriber roaming around the different areas may experience service degradations or interruptions due to the inconsistent configurations and incomplete functions in the networks nodes. This memo intends to document the observed failed cases and analyze the causes. It's expected that operators could notice the issues and prevent potential risks.

2. Roaming Architecture Descriptions

The roaming process could be triggered in the following scenarios:

- o International roaming: a mobile subscriber may entry a visited network, where different PLMN identity is used. The subscribers could either in an automatic mode or a manual mode to attach a PLMN cell.
- o Intra-PLMN mobility: a subscriber moves to a visited network as that of the Home Public Land Mobile Network (HPLMN). However, the subscriber profiles may not be stored in the area. Once the subscriber attaches to the network, the subscriber profile should be extracted from the home network for the network registration.

When a mobile device is turned on or is transferred via a handover to a visited network, the mobile device will scan all radio channels and find available Public Land Mobile Networks (PLMNs) to attach. Serving GPRS Support Node (SGSN) or Mobility Management Entity (MME) in the visited networks must contact the home Home Location Register(HLR) or Home Subscriber Server(HSS) and obtain the subscriber profile. Once the authentication and registration process is completed, the PDP activation and traffic flows may be operated differently according to the subscriber data configuration. Two modes have been shown at the figure to illustrate, that are "Home routed traffic" and "Local breakout".

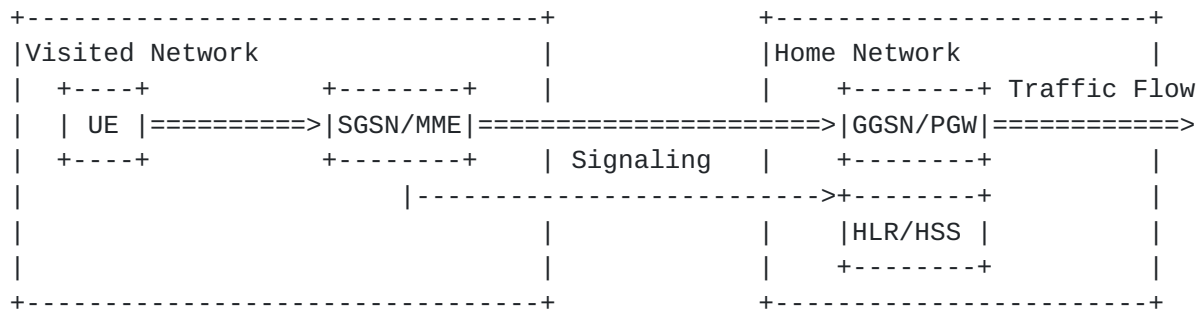
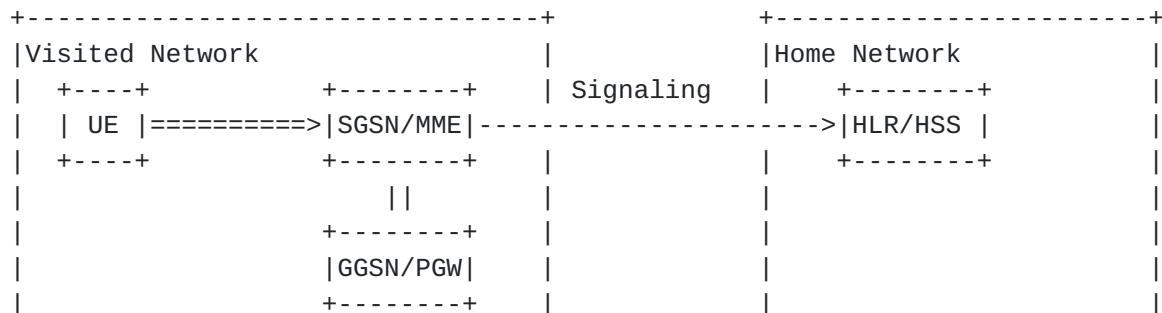


Figure 1: Home Routed Traffic



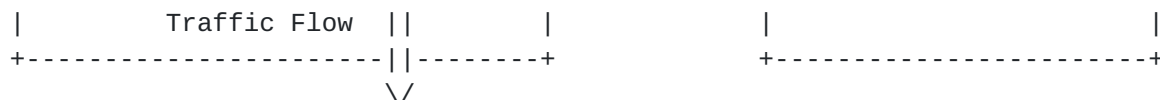


Figure2: Local Breakout

In the home routed mode, subscribers will activate the PDP/PDN context and get address from the home network. All traffic would be routed back to the home networks. That is the default case for an international roaming except for the IP Multimedia Subsystem (IMS) scenario.

In the local breakout mode, the subscriber address will be assigned from the visited network. The traffic flow would directly offloaded locally at a network node close to that device's point of attachment in the visited networks. Therefore, more efficient route would be achieved. The following will describe the cases where there is local breakout mode adopted.

- o Operators may add the APN-OI-Replacement flag defined in 3GPP [TS29.272] into user's subscription-data. The visited network indicates a local domain name to replace the user requested Access Point Name (APN). As the consequence, the traffic would be steered to the visited network. Those functions are normally deployed for the Intra-PLMN mobility cases.
- o Operators could also configure VPLMN-Dynamic-Address-Allowed flag[TS29.272] in the user profile to enable local breakout mode in Visited Public Land Mobile Networks (VPLMNs).
- o 3GPP specified Selected IP Traffic Offload (SIPTO) function[TS23.401] since Release 10 in order to get efficient route paths. It enables an operator to offload certain types of traffic at a network node close to that device's point of attachment to the access network.
- o GSMA has defined RAVEL[IR.65] as IMS international roaming architecture. Local breakout mode has been adopted for the roaming architecture.

3. Roaming Scenario Overview

3GPP specified three types of Packet Data Protocol (PDP)/Packet Data Networks (PDN) to describe each connection, i.e. PDP/PDN Type IPv4, PDP/PDN Type IPv6 and PDP/PDN Type IPv4v6. User devices can be set to request a particular PDP/PDN Type. Those PDP/PDN types should also be restored in Home Subscriber Server (HSS) as a part of subscriber profile, as defined in [TS29.272]. When a subscriber

roams to a visited network, the new visited network notices that it is not registered with its own system, and attempts to identify its home network. Afterwards, the visited network will contact the home network and request the subscriber profile from HSS. In this process, service may be provided in a home routed or local breakout mode. The IP address can be allocated from home network or visited network accordingly. There may be a mismatch between the subscriber request and network capability. The following table lists the potential failure cases.

UE Request	Visited Network Capability	Home routed	Local Breakout
Dual stack	IPv4-only	Failure case 1	Failure case 1
Dual stack	IPv4-only/IPv6-only	Failure case 1	Failure case 2
Dual stack	IPv6-only	Failure case 1	Failure case 3
IPv6-only	IPv4-only	OK	Failure case 4
IPv6-only with 464xlat	Dual stack	OK	Failure case 5
IPv6-only with 464xlat	IPv6-only	OK	OK
IPv4-only	Dual stack	OK	OK

Table 1: Roaming Scenario Descriptions

4. Failure Cases Descriptions

4.1. Failure Case 1: Incompatible with Extended PDP/PDN Type

A mobile device in a dual-stack network likely requests PDP/PDN type IPv4v6 to allocate address. Such PDP/PDN type should be understandable in the network nodes, including Serving GPRS Support Node(SGSN), Gateway GPRS Support Node(GGSN), Mobility Management Entity (MME), Serving Gateway(SGW), PDN Gateway(PGW), Home Location Registrar(HLR) and Home Subscriber Server(HSS). When a subscriber roams to the IPv4 network, the visited SGSN or MME has to communicate with HLR/HSS in the home land to retrieve the subscriber profile. The issue we observe is that multiple SGSN/MME will be unable to correctly process a subscriber profile received in the Insert Subscriber Data procedure if it contains an Ext-PDP-Type defined in

3GPP [[TS29.002](#)]. Therefore, it will likely refuse the subscriber registration.

Operators may have to remove the PDP/PDN type IPv4v6 from HLR/HSS in home networks, that will restrict UEs only initiates IPv4 PDP or IPv6 PDP activation. In order to avoid this situation, operators should make a comprehensive roaming agreement to support IPv6 and ensure that aligns with GSMA document, e.g [[IR.33](#)], [[IR.88](#)] and [[IR.21](#)]. Since the agreement requires visited operators to upgrade all SGSN nodes, some short- or medium-term solutions have been implemented to fix the issue. There are some specific configurations in HLR/HSS of home network. Multiple PDP/PDN subscription information will be added in the subscriber profiles, for example it may include both PDP/PDN type IPv4 and PDP/PDN type IPv4v6 for a user profile. Once the HLR/HSS receives an Update Location message from visited SGSN/MME, only the subscription data with PDP/PDN type IPv4 will be sent to SGSN/MME in the Insert Subscriber Data procedure. It guarantee the user profile could compatible with visited SGSN/MME capability.

[4.2.](#) Failure Case 2: Splitting Dual-stack Bearer

Dual-stack capability can also be provided in a early mobile network(i.e. Pre-Release 8 network) using separate PDP/PDN activations. That means only a single IPv4 and IPv6 PDP/PDN can be initiated to allocate IPv4 and IPv6 address separately. Once a UE with PDP/PDN type IPv4v6 request roams to those networks, same issue described in failure case 1 will be occurred if the UE initiate a network attachment process.

If networks could allow UE to make a success attachment, a roaming subscriber with IPv4v6 PDP/PDN type should change the request to two separated PDP/PDN request with single IP version in order to achieve equivalent results. This restriction may be occurred in the below two cases.

- o The GGSN/PGW preferences dictate the use of IPv4 addressing only or IPv6 prefix only for a specific APN.
- o The SGSN/MME does not set the Dual Address Bearer Flag due to the operator using single addressing per bearer to support interworking with nodes of earlier releases

Above process would likely double PDP/PDN allocation costs. Some operators may only allow one PDP/PDN is alive for each subscriber. For example, IPv6 PDP/PDN would be rejected if the subscriber has an active IPv4 PDP/PDN. Therefore, the subscriber will lost IPv6 connection in the visited network. Even the two parallel PDP/PDN activations are allowed, it will require additional correlation of

those two sessions of single IP version on the charging system. If there are Policy and Charging Rules Function(PCRF)/Policy and Charging Enforcement Function (PCEF) deployed, the system would treat IPv4 and IPv6 session as independent and perform different Quality of Service(QoS) policies. The subscriber may have unstable experiences due to different behaviors on each IP version connection.

4.3. Failure Case 3: Shortage of IPv6 support

Some operators may adopt IPv6-only configuration for the IMS service, e.g. Voice over LTE(VoLTE) or Rich Communication Suite (RCS). Since IMS roaming architecture will offload all traffic in the visited network, a dual-stack subscriber can only be assigned with IPv6 address. There is no IPv4 address returned. It requires all the IMS based applications should be IPv6 enable. A translation-based method, for example Bump-in-the-host (BIH)[[RFC6535](#)] and 464xlat[[RFC6877](#)] , may help to address the issue if there is IPv6 compatibility problems. Operators may could automatically enable the function in a IPv6-only network and disable in a dual-stack or IPv4 network.

4.4. Failure Case 4: Fallback Incapability

3GPP specified the PDP/PDN type IPv6 as early as PDP/PDN type IPv4. Therefore, the IPv6 single PDP/PDN type has been well supported and interpretable in the 3GPP network nodes. When a subscriber requests PDP/PDN type IPv6, the network should only return the expected IPv6 address. Otherwise, the request should be dropped and the error code should be sent to the user. Roaming to IPv4-only networks with IPv6 PDP/PDN request would fail to get addresses. A proper fallback is desirable however the behavior is implementation specific. There are some UE have the ability to provide a different configuration for home network and visited network respectively. It guarantees UE will always initiate PDP/PDN type IPv4 in the roaming area. Android system solves the issue by setting the roaming Access Point Name(APN). The mobile terminal is allowed to ignore the original requested protocol and always adhere to IPv4 when roaming. Those fallback mechanisms are deserved to be implemented timely.

4.5. Failure Case 5: 464xlat Support

464xlat[[RFC6877](#)] is proposed to address IPv4 compability issue in a IPv6 single-stack environment. The function on a mobile terminal likely gets along with PDP/PDN IPv6 type request to cooperate with a remote NAT64[[RFC6146](#)] gateway. 464xlat may use the mechanism defined in [[I-D.ietf-behave-nat64-discovery-heuristic](#)] to automatically discover NAT64 prefixes. Those behaviors depend on the network deployment. If the DNS64 or NAT64 is not deployed in the visited

networks, 4G4xlat may be failed to perform. Considering the various network's situations, operators may adopt 4G4xlat in the home networks and use IPv4-only in the roaming networks with different roaming profile configurations.

As an alternative solution, an AAA Server could be deployed to connect with GGSN/PGW. Once the GGSN/PGW receive the session creation requests, it will initiate an Access-Request to an AAA server via Radius protocol. The Access-Request contains subscriber and visited network information, e.g. PDP/PDN Type, International Mobile Equipment Id (IMEI), Software Version(SV) and visited SGSN/MME location code, etc. The AAA server could take IMEI and SV components to verify if device has 4G4XLAT support. Combining with the visited network information, the AAA server will ultimately decide to enable 4G4xlat in an IPv6-only roaming or fallback to IPv4.

5. Discussions

The dual-stack deployment is recommended in most cases. However, it may take some times in a mobile environment. 3GPP didn't specify PDP/PDN type IPv4v6 in the early release. Such PDP/PDN type is supported in new-built Long Term Evolution(LTE)/System Architecture Evolution(SAE) network, but didn't support well in the third generation network. The situations may cause the roaming issues dropping the attachment from dual-stack subscribers in the case of LTE to 3G and IPv6-enabled 3G to IPv4 3G. Operators may have to adopt temporary solution unless all the interworking nodes(i.e. SSGN and SGW) in the visited network have been upgraded to support Ext-PDP-Type feature.

As an alternative solution for dual-stack, operators may change a unified PDP/PDN request into two separated single IP version requests. However, this approach is problematic in the Charging records and QoS policy enforcement. In addition, it doubles the PDP resource uses. It may be unappealing for the deployment.

Conversely, some operators may choose PDP/PDN Type IPv6 to start the communications in home networks and use different profile in the roaming area. Since PDP/PDN Type IPv6 has been introduced in 3GPP early release, it didn't require upgrading on the interworking nodes to make compatibility. The proper IPv4 fallback mechanism should be supported either on the mobile terminal or network equipment.

A roaming to IPv6-only network occurs when operators deploy roaming function for IMS service. A dual-stack capable device could implement translation-based function to support the IPv4 applications. Those inserted translation function can be turned off properly when the terminals roam back to dual-stack or IPv4 networks. Operators can also deploy AAA servers to make final decision

6. IANA Considerations

This document makes no request of IANA.

7. Security Considerations

The draft didn't introduce additional security concerns to the networks.

8. Acknowledgements

The authors would like to thank V6ops chairs(Fred Baker and John Brzozowski) to encourage us to continue the work. This document is the result of the IETF V6ops IPv6-Roaming design team effort.

9. References

9.1. Normative References

- [I-D.ietf-behave-nat64-discovery-heuristic]
Savolainen, T., Korhonen, J., and D. Wing, "Discovery of the IPv6 Prefix Used for IPv6 Address Synthesis", [draft-ietf-behave-nat64-discovery-heuristic-17](#) (work in progress), April 2013.
- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), March 1997.
- [RFC6052] Bao, C., Huitema, C., Bagnulo, M., Boucadair, M., and X. Li, "IPv6 Addressing of IPv4/IPv6 Translators", [RFC 6052](#), October 2010.
- [RFC6146] Bagnulo, M., Matthews, P., and I. van Beijnum, "Stateful NAT64: Network Address and Protocol Translation from IPv6 Clients to IPv4 Servers", [RFC 6146](#), April 2011.
- [RFC6147] Bagnulo, M., Sullivan, A., Matthews, P., and I. van Beijnum, "DNS64: DNS Extensions for Network Address Translation from IPv6 Clients to IPv4 Servers", [RFC 6147](#), April 2011.

- [RFC6535] Huang, B., Deng, H., and T. Savolainen, "Dual-Stack Hosts Using "Bump-in-the-Host" (BIH)", [RFC 6535](#), February 2012.
- [RFC6877] Mawatari, M., Kawashima, M., and C. Byrne, "464XLAT: Combination of Stateful and Stateless Translation", [RFC 6877](#), April 2013.

[9.2.](#) Informative References

- [IR.21] Global System for Mobile Communications Association, GSMA., "Roaming Database, Structure and Updating Procedures", July 2012.
- [IR.33] Global System for Mobile Communications Association, GSMA., "GPRS Roaming Guidelines", July 2012.
- [IR.65] Global System for Mobile Communications Association, GSMA., "IMS Roaming & Interworking Guidelines", May 2012.
- [IR.88] Global System for Mobile Communications Association, GSMA., "LTE Roaming Guidelines", January 2012.
- [RFC6052] Bao, C., Huitema, C., Bagnulo, M., Boucadair, M., and X. Li, "IPv6 Addressing of IPv4/IPv6 Translators", [RFC 6052](#), October 2010.
- [RFC6586] Arkko, J. and A. Keranen, "Experiences from an IPv6-Only Network", [RFC 6586](#), April 2012.
- [TR23.975] 3rd Generation Partnership Project, 3GPP., "IPv6 migration guidelines", June 2011.
- [TS23.401] 3rd Generation Partnership Project, 3GPP., "General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access v9.00", March 2009.
- [TS29.002] 3rd Generation Partnership Project, 3GPP., "Mobile Application Part (MAP) specification v9.00", December 2009.
- [TS29.272]

3rd Generation Partnership Project, 3GPP., "Mobility Management Entity (MME) and Serving GPRS Support Node (SGSN) related interfaces based on Diameter protocol v9.00", September 2009.

Authors' Addresses

Gang Chen
China Mobile
53A,Xibianmennei Ave.,
Xuanwu District,
Beijing 100053
China

Email: phdgang@gmail.com

Hui Deng
China Mobile
53A,Xibianmennei Ave.,
Xuanwu District,
Beijing 100053
China

Email: denghui@chinamobile.com

Dave Michaud
Rogers

Email: Michaud@rci.rogers.com

Jouni Korhonen
Renesas Mobile
Porkkalankatu 24
FIN-00180 Helsinki, Finland

Email: jouni.nospam@gmail.com

Mohamed Boucadair
France Telecom
No.32 Xuanwumen West Street
Rennes,
35000
France

Email: mohamed.boucadair@orange.com

Vizdal Ales
Deutsche Telekom AG
Tomickova 2144/1
Prague 4, 149 00
Czech Republic

Email: ales.vizdal@t-mobile.cz

Cameron Byrne
T-Mobile USA
Bellevue
Washington 98105
USA

Email: cameron.byrne@t-mobile.com

