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An Internet Protocol Version 6 (IPv6) Profile for 3GPP Mobile Devices
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Abstract

This document defines an IPv6 profile for 3GPP mobile devices. It lists the set of features a 3GPP mobile device is to be compliant with to connect to an IPv6-only or dual-stack wireless network (including 3GPP cellular network and IEEE 802.11 network).

This document defines a different profile than the one for general connection to IPv6 cellular networks defined in [I-D.ietf-v6ops-rfc3316bis]. In particular, this document identifies also features to deliver IPv4 connectivity service over an IPv6-only transport.

Both hosts and devices with capability to share their WAN (Wide Area Network) connectivity are in scope.

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1. Introduction

IPv6 deployment in 3GPP mobile networks is the only perennial solution to the exhaustion of IPv4 addresses in those networks. Several mobile operators have already deployed IPv6 [RFC2460] or are in the pre-deployment phase. One of the major hurdles encountered by mobile operators is the availability of non-broken IPv6 implementation in mobile devices.

[I-D.ietf-v6ops-rfc3316bis] lists a set of features to be supported by cellular hosts to connect to 3GPP mobile networks. In the light of recent IPv6 production deployments, additional features to facilitate IPv6-only deployments while accessing IPv4-only service are to be considered.

This document defines a different profile than the one for general connection to IPv6 mobile networks defined in [I-D.ietf-v6ops-rfc3316bis]; in particular:

- o It lists an extended list of features while [I-D.ietf-v6ops-rfc3316bis] identifies issues and explains how to implement basic IPv6 features in a cellular context.

- o It identifies also features to ensure IPv4 service delivery over an IPv6-only transport.

This document specifies an IPv6 profile for mobile devices listing specifications produced by various Standards Developing Organizations (in particular 3GPP and IETF). The objectives of this effort are:

1. List in one single document a comprehensive list of IPv6 features for a mobile device, including both IPv6-only and dual-stack mobile deployment contexts. These features cover various network types such as GPRS (General Packet Radio Service), EPC (Evolved Packet Core) or IEEE 802.11 network.

2. Help Operators with the detailed device requirement list preparation (to be exchanged with device suppliers). This is also a contribution to harmonize Operators' requirements towards device vendors.

3. Vendors to be aware of a set of features to allow for IPv6 connectivity and IPv4 service continuity (over an IPv6-only transport).

Pointers to some requirements listed in [RFC6434] are included in this profile. The justification for using a stronger language compared to what is specified in [RFC6434] is provided for some requirements.

The requirements do not include 3GPP release details. For more information on the 3GPP releases detail, the reader may refer to Section 6.2 of [RFC6459].

Some of the features listed in this profile document require to activate dedicated functions at the network side. It is out of scope of this document to list these network-side functions.

A detailed overview of IPv6 support in 3GPP architectures is provided in [RFC6459].

This document makes use of the terms defined in [RFC6459]. In addition, the following terms are used:

- "3GPP cellular host" (or cellular host for short) denotes a 3GPP device which can be connected to 3GPP mobile networks or IEEE 802.11 networks.

- "3GPP cellular device" (or cellular device for short) refers to a cellular host which supports the capability to share its WAN (Wide Area Network) connectivity.

- "Cellular host" and "mobile host" are used interchangeably.

- "Cellular device" and "mobile device" are used interchangeably.

PREFIX64 denotes an IPv6 prefix used to build IPv4-converted IPv6 addresses [RFC6052].

1.1. Scope

A 3GPP mobile network can be used to connect various user equipments such as a mobile telephone, a CPE (Customer Premises Equipment) or a M2M (machine-to-machine) device. Because of this diversity of terminals, it is necessary to define a set of IPv6 functionalities valid for any node directly connecting to a 3GPP mobile network. This document describes these functionalities.

This document is structured to provide the generic IPv6 requirements which are valid for all nodes, whatever their function or service (e.g., SIP [RFC3261]) capability. The document also contains sections covering specific functionalities for devices providing some LAN functions (e.g., mobile CPE or broadband dongles).

The requirements listed below are valid for both 3GPP GPRS and 3GPP EPS (Evolved Packet System) access. For EPS, PDN-Connection term is used instead of PDP-Context.

This document identifies also some WLAN-related IPv6 requirements. Other non-3GPP accesses [TS.23402] are out of scope of this document.

1.2. Special Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

This document is not a standard. It uses the normative keywords only for precision.

2. Connectivity Requirements

REQ#1: The cellular host MUST be compliant with Section 5.9.1 (IPv6 Addressing Architecture) and Section 5.8 (ICMPv6 support) of [RFC6434].

REQ#2: The cellular host MUST support both IPv6 and IPv4v6 PDP-Contexts.

This allows each operator to select their own strategy regarding IPv6 introduction. Both IPv6 and IPv4v6 PDP-Contexts MUST be supported. IPv4, IPv6 or IPv4v6 PDP-Context request acceptance depends on the cellular network configuration.

REQ#3: The cellular host MUST comply with the behavior defined in [TS.23060] [TS.23401] [TS.24008] for requesting a PDP-Context type. In particular, the cellular host MUST request by default an IPv6 PDP-Context if the cellular host is IPv6-only and requesting an IPv4v6 PDP-Context if the cellular host is dual-stack or when the cellular host is not aware of connectivity types requested by devices connected to it (e.g., cellular host with LAN capabilities as discussed in Section 4):

* If the requested IPv4v6 PDP-Context is not supported by the network, but IPv4 and IPv6 PDP types are allowed, then the cellular host will be configured with an IPv4 address or an IPv6 prefix by the network. It MUST initiate another PDP-Context activation in addition to the one already activated for a given APN (Access Point Name).

* If the requested PDP type and subscription data allows only one IP address family (IPv4 or IPv6), the cellular host MUST NOT request a second PDP-Context to the same APN for the other IP address family.

The text above focuses on the specification part which explains the behavior for requesting IPv6-related PDP-Context(s). Understanding this behavior is important to avoid having broken IPv6 implementations in cellular devices.

REQ#4: The cellular host MUST support the PCO (Protocol Configuration Options) [TS.24008] to retrieve the IPv6 address(es) of the Recursive DNS server(s).

In-band signaling is a convenient method to inform the cellular host about various services, including DNS server information. It does not require any specific protocol to be supported and it is already deployed in IPv4 cellular networks to convey such DNS information.

REQ#5: The cellular host MUST support IPv6 aware Traffic Flow Templates (TFT) [TS.24008].

Traffic Flow Templates are employing a packet filter to couple an IP traffic with a PDP-Context. Thus a dedicated PDP-Context and radio resources can be provided by the cellular network for certain IP traffic.

REQ#6: The device MUST support the Neighbor Discovery Protocol ([RFC4861] and [RFC5942]).

This is a stronger form compared to what is specified in Section 5.2 and Section 12.2 of [RFC6434].

The support of Neighbor Discovery Protocol is mandatory in 3GPP cellular environment as it is the only way to convey IPv6 prefix towards the 3GPP cellular device.

In particular, MTU (Maximum Transmission Unit) communication via Router Advertisement MUST be supported since many 3GPP networks do not have a standard MTU setting.

REQ#7: The cellular host MUST comply with Section 5.6.1 of [RFC6434]. If the MTU used by cellular hosts is larger than 1280 bytes, they can rely on Path MTU discovery function to discover the real path MTU.

REQ#8: The cellular host MUST support IPv6 Stateless Address Autoconfiguration ([RFC4862]) apart from the exceptions noted in [TS.23060] (3G) and [TS.23401] (LTE):

Stateless mode is the only way to configure a cellular host. The GGSN/PGW must allocate a prefix that is unique within its scope to each primary PDP-Context.

To configure its link local address, the cellular host MUST use the Interface Identifier conveyed in 3GPP PDP-Context setup signaling received from a GGSN/PGW. The cellular host may use a different Interface Identifiers to configure its global addresses (see also REQ#24 about privacy addressing requirement).

For more details, refer to [RFC6459] and [I-D.ietf-v6ops-rfc3316bis].

REQ#9: The cellular host MUST comply with Section 7.3 of [RFC6434].

REQ#10: The cellular host MUST comply with Section 7.2.1 of [RFC6434].

Stateless DHCPv6 is useful to retrieve other information than DNS.

If [RFC6106] is not supported at the network side, the cellular host SHOULD retrieve DNS information using stateless DHCPv6 [RFC3736].

REQ#11: If the cellular host receives the DNS information in several channels for the same interface, the following preference order MUST be followed:

1. PCO

2. RA

3. DHCPv6

REQ#12: The cellular host SHOULD support a method to locally construct IPv4-embedded IPv6 addresses [RFC6052]. A method to learn PREFIX64 SHOULD be supported by the cellular host.

This solves the issue when applications use IPv4 referrals on IPv6-only access networks.

In PCP-based environments, cellular hosts SHOULD follow [I-D.ietf-pcp-nat64-prefix64] to learn the IPv6 Prefix used by an upstream PCP-controlled NAT64 device. If PCP is not enabled, the cellular host SHOULD implement the method specified in [I-D.ietf-behave-nat64-discovery-heuristic] to retrieve the PREFIX64.

REQ#13: The cellular host SHOULD implement the Customer Side Translator (CLAT, [RFC6877]) function which is compliant with [RFC6052][RFC6145][RFC6146].

CLAT function in the cellular host allows for IPv4-only application and IPv4-referals to work on an IPv6-only connectivity. CLAT function requires a NAT64 capability [RFC6146] in the core network.

REQ#14: The cellular device SHOULD embed a DNS64 function [RFC6147].

Local DNS64 functionality allows for compatibility with DNS Security Extensions (DNSSEC, [RFC4033], [RFC4034], [RFC4035]). Means to configure or discover a PREFIX64 is also required on the cellular device as discussed in REQ#12.

REQ#15: The cellular host SHOULD support PCP [RFC6887].

The support of PCP is seen as a driver to save battery consumption exacerbated by keepalive messages. PCP also gives the possibility of enabling incoming connections to the cellular device. Indeed, because several stateful devices may be deployed in wireless networks (e.g., NAT and/or Firewalls), PCP can be used by the cellular host to control network-based NAT and Firewall functions which will reduce per-application signaling and save battery consumption.

REQ#16: When the cellular host is dual-stack connected (i.e., configured with an IPv4 address and IPv6 prefix), it SHOULD support means to prefer native IPv6 connection over connection established through translation devices (e.g., NAT44 and NAT64).

When both IPv4 and IPv6 DNS servers are configured, a dual-stack host MUST contact first its IPv6 DNS server.

Cellular hosts SHOULD follow the procedure specified in [RFC6724] for source address selection.

REQ#17: The cellular host SHOULD support Happy Eyeballs procedure defined in [RFC6555].

REQ#18: The cellular device MAY embed a BIH function [RFC6535] facilitating the communication between an IPv4 application and an IPv6 server.

REQ#19: Because of potential operational deficiencies to be experienced in some roaming situations, the cellular host MUST be able to be configured with a home IP profile and a roaming IP profile. The aim of the roaming profile is to limit the PDP type(s) requested by the cellular host when out of the home network. Note, distinct PDP type(s) can be configured for home and roaming cases.

2.1. WLAN Connectivity Requirements

It is increasingly common for cellular hosts have a WLAN interface in addition to their cellular interface. These hosts are likely to be connected to private or public hotspots. Below are listed some generic requirements:

REQ#20: IPv6 MUST be supported on the WLAN interface. In particular, IPv6-only connectivity MUST be supported over the WLAN interface.

Some tests revealed that IPv4 configuration is required to enable IPv6-only connectivity. Indeed, some cellular handsets can access a WLAN IPv6-only network by configuring first a static IPv4 address. Once the device is connected to the network and the wlan0 interface got an IPv6 global address, the IPv4 address can be deleted from the configuration. This avoids the device to ask automatically for a DHCPv4 server, and allows to connect to IPv6-only networks. Failing to configure an IPv4 address on the interface MUST NOT prohibit using IPv6 on the same interface.

IPv6 Stateless Address Autoconfiguration ([RFC4862]) MUST be supported.

REQ#21: DHCPv6 client SHOULD be supported on WLAN interface.

Refer to Section 7.2.1 of [RFC6434].

REQ#22: WLAN interface SHOULD support Router Advertisement Options for DNS configuration (See Section 7.3 of [RFC6434]).

REQ#23: If the device receives the DNS information in several channels for the same interface, the following preference order MUST be followed:

1. RA

2. DHCPv6

3. Advanced Requirements

REQ#24: The cellular host MUST be able to generate IPv6 addresses which preserve privacy.

The activation of privacy extension (e.g., using [RFC4941]) makes it more difficult to track a host over time when compared to using a permanent Interface Identifier. Note, [RFC4941] does not require any DAD mechanism to be activated as the GGSN/PGW MUST NOT configure any global address based on the prefix allocated to the cellular host.

Tracking a host is still possible based on the first 64 bits of the IPv6 address. Means to prevent against such tracking issues may be enabled in the network side.

REQ#25: The cellular host MUST support ROHC RTP Profile (0x0001) and ROHC UDP Profile (0x0002) for IPv6 ([RFC5795]). Other ROHC profiles MAY be supported.

Bandwidth in cellular networks must be optimized as much as possible. ROHC provides a solution to reduce bandwidth consumption and to reduce the impact of having bigger packet headers in IPv6 compared to IPv4.

"RTP/UDP/IP" ROHC profile (0x0001) to compress RTP packets and "UDP/IP" ROHC profile (0x0002) to compress RTCP packets are required for Voice over LTE (VoLTE) by IR.92.4.0 section 4.1 [IR92]. Note, [IR92] indicates also the host must be able to apply the compression to packets that are carried over the radio bearer dedicated for the voice media.

REQ#26: The cellular host MUST comply with Section 5.3 of [RFC6434] and SHOULD support Router Advertisement extension for communicating default router preferences and more-specific routes as described in [RFC4191].

This function can be used for instance for traffic offload.

4. Cellular Devices with LAN Capabilities

This section focuses on cellular devices (e.g., CPE, smartphones or dongles with tethering features) which provide IP connectivity to other devices connected to them. In such case, all connected devices are sharing the same 2G, 3G or LTE connection. In addition to the generic requirements listed in Section 2, these cellular devices have to meet the requirements listed below.

REQ#27: The cellular device MUST support Prefix Delegation capabilities [RFC3633] and MUST support Prefix Exclude Option for DHCPv6-based Prefix Delegation as defined in [RFC6603]. Particularly, it MUST behave as a Requesting Router.

Cellular networks are more and more perceived as an alternative to fixed networks for home IP-based services delivery; especially with the advent of smartphones and 3GPP data dongles. There is a need for an efficient mechanism to assign shorter prefix than /64 to cellular hosts so that each LAN segment can get its own /64 prefix and multi-link subnet issues to be avoided.

In case a prefix is delegated to a cellular host using DHCPv6, the cellular device will be configured with two prefixes:

(1) one for 3GPP link allocated using SLAAC mechanism and

(2) another one delegated for LANs acquired during Prefix Delegation operation.

Note that the 3GPP network architecture requires both the WAN (Wide Area Network) and the delegated prefix to be aggregatable, so the subscriber can be identified using a single prefix.

Without the Prefix Exclude Option, the delegating router (GGSN/PGW) will have to ensure [RFC3633] compliancy (e.g., halving the delegated prefix and assigning the WAN prefix out of the 1st half and the prefix to be delegated to the terminal from the 2nd half).

REQ#28: The cellular device MUST be compliant with the CPE requirements specified in [RFC6204].

REQ#29: For deployments requiring to share the same /64 prefix, the cellular device SHOULD support [I-D.ietf-v6ops-64share] to enable sharing a /64 prefix between the 3GPP interface towards the GGSN/PGW (WAN interface) and the LAN interfaces.

REQ#30: The cellular device SHOULD support the Customer Side Translator (CLAT) [RFC6877].

Various IP devices are likely to be connected to cellular device, acting as a CPE. Some of these devices can be dual-stack, others are IPv6-only or IPv4-only. IPv6-only connectivity for cellular device does not allow IPv4-only sessions to be established for hosts connected on the LAN segment of cellular devices.

In order to allow IPv4 sessions establishment initiated from devices located on LAN segment side and target IPv4 nodes, a solution consists in integrating the CLAT function in the cellular device. As elaborated in Section 2, the CLAT function allows also IPv4 applications to continue running over an IPv6-only host.

REQ#31: If a RA MTU is advertised from the 3GPP network, the cellular device SHOULD relay that upstream MTU information to the downstream attached LAN devices in RA.

Receiving and relaying RA MTU values facilitates a more harmonious functioning of the mobile core network where end nodes transmit packets that do not exceed the MTU size of the mobile network's GTP tunnels.

[TS.23060] indicates providing a link MTU value of 1358 octets to the 3GPP cellular device will prevent the IP layer fragmentation within the transport network between the cellular device and the GGSN/PGW.

5. APIs & Applications

REQ#32: Name resolution libraries MUST support both IPv4 and IPv6.

In particular, the cellular host MUST support [RFC3596].

REQ#33: Applications MUST be independent of the underlying IP address family.

This means applications must be IP version agnostic.

REQ#34: Applications using URIs MUST follow [RFC3986]. For example, SIP applications MUST follow the correction defined in [RFC5954].

6. Security Considerations

The security considerations identified in [I-D.ietf-v6ops-rfc3316bis] and [RFC6459] are to be taken into account.

Security-related considerations that apply when the cellular device provides LAN features are specified in [RFC6092].

7. IANA Considerations

This document does not require any action from IANA.

8. Acknowledgements

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