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Advanced Requirements for IPv6 Customer Edge Routers
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Abstract

This document continues the work undertaken by the IPv6 CE Router Phase I work in the IETF v6ops Working Group. Advanced requirements or Phase II work is covered in this document.

Status of this Memo

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1. Introduction

This document defines Advanced IPv6 features for a residential or small office router referred to as an IPv6 CE router. Typically these routers also support IPv4. The IPv6 End-user Network Architecture for such a router is described in [I-D.ietf-v6ops-ipv6-cpe-router]. This version of the document includes the requirements for Advanced features.

1.1. Requirements 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].

2. Terminology

End-user Network — one or more links attached to the IPv6 CE router that connect IPv6 hosts.

IPv6 Customer Edge router — a node intended for home or small office use which forwards IPv6 packets not explicitly addressed to itself. The IPv6 CE router connects the end-user network to a service provider network.

IPv6 host — any device implementing an IPv6 stack receiving IPv6 connectivity through the IPv6 CE router

LAN interface — an IPv6 CE router’s attachment to a link in the end-user network. Examples are Ethernets (simple or bridged), 802.11 wireless or other LAN technologies. An IPv6 CE router may have one or more network layer LAN Interfaces.

Service Provider — an entity that provides access to the Internet. In this document, a Service Provider specifically offers Internet access using IPv6, and may also offer IPv4 Internet access. The Service Provider can provide such access over a variety of different transport methods such as DSL, cable, wireless, and others.

WAN interface an IPv6 CE router’s attachment to a link used to provide connectivity to the Service Provider network; example link technologies include Ethernets (simple or bridged), PPP links, Frame Relay, or ATM networks as well as Internet-layer (or higher-layer) "tunnels", such as tunnels over IPv4 or IPv6 itself.

3. Conceptual Configuration Variables

The CE Router maintains such a list of conceptual optional configuration variables.

1. Enable an IGP on the LAN.

4. Architecture

This document extends the architecture described in [I-D.ietf-v6ops-ipv6-cpe-router] to cover a strictly larger set of operational scenarios. In particular, QoS, multicast, DNS, routed network in the home, transition technologies, and conceptual configuration variables. This document also extends the model described in [I-D.ietf-v6ops-ipv6-cpe-router] to a two router topology where the two routers are connected back-to-back (the LAN of one router is connected to the WAN of the other router). This topology is depicted below:

```
                     +-------+-------+                   \
                     |   Service     |                    \
                     |   Provider    |                     | Service
                     |    Router     |                     | Provider
                     +-------+-------+                     | network
                             |                             /
                             | Customer                   /
                             | Internet connection       /
                             |
                      +------+--------+                  \
                      |     IPv6      |                   \
                      | Customer Edge |                    \
                      |    Router     |                    |
                      +----+-+-----+--+                    |
          Network A        | |     |   Network B           |
    ----+-------------+----+ |   --+--+-------------+---   |
        |             |    | |      |             |      |
   +----+-----+ +-----+----+ |   +----+-----+ +-----+----+ |
   |IPv6 Host | |IPv6 Host | |   | IPv6 Host| |IPv6 Host | |
   |          | |          | |   |          | |          | |
   +----------+ +----------+ |   +----------+ +----------+ |
                             |                             |
                      +------+--------+                    | End-User
                      |     IPv6      |                    | networks
                      |   Interior    |                    |
                      |    Router     |                    |
                      +---+-------+-+-+                    |
          Network C       |       |   Network D            |
    ----+-------------+---+-    --+---+-------------+---   |
        |             |               |             |      |
   +----+-----+ +-----+----+     +----+-----+ +-----+----+ |
   |IPv6 Host | |IPv6 Host |     | IPv6 Host| |IPv6 Host | |
   |          | |          |     |          | |          | /
   +----------+ +----------+     +----------+ +----------+/
```

Figure 1.

For DNS, the operational expectation is that the end-user would be able to access home hosts from the home using DNS names instead of more cumbersome IPv6 addresses. Note that this is distinct from the requirement to access home hosts from outside the home.

End-users are expected to be able to receive multicast video in the home without requiring the CE router to include the cost of supporting full multicast routing protocols.

5. Advanced Features and Feature Requirements

The IPv6 CE router will need to support connectivity to one or more access network architectures. This document describes an IPv6 CE router that is not specific to any particular architecture or Service Provider, and supports all commonly used architectures.

5.1. DNS

D-1: For local DNS queries for configuration, the CE Router may include a DNS server to handle local queries. Non-local queries can be forwarded unchanged to a DNS server specified in the DNS server DHCPv6 option. The CE Router may also include DNS64 functionality which is specified in [I-D.bagnulo-behave-dns64].

D-2: The local DNS server MAY also handle renumbering from the Service Provider provided prefix for local names used exclusively inside the home (the local AAAA and PTR records are updated). This capability provides connectivity using local DNS names in the home after a Service Provider renumbering. A CE Router MAY add local DNS entries based on dynamic requests from the LAN segment(s). The protocol to carry such requests from hosts to the CE Router is yet to be described.

5.2. Multicast Behavior

This section is only applicable to a CE Router with at least one LAN interface. A host in the home is expected to receive multicast video. Note the CE Router resides at edge of the home and the Service Provider, and the CE Router has at least one WAN connection for multiple LAN connections. In such a multiple LAN to a WAN toplogy at the CE Router edge, it is not necessary to run a multicast routing protocol and thus MLD Proxy as specified in [RFC4605] can be used. The CE Router discovers the hosts via a MLDv2 Router implementation on a LAN interface. A WAN interface of the CE Router interacts with the Service Provider router by sending MLD Reports and replying to MLD queries for multicast Group memberships for hosts in the home.

The CE router SHOULD implement MLD Proxy as specified in [RFC4605]. For the routed topology shown in Figure 1, each router implements a MLD Proxy. If the CE router implements MLD Proxy, the requirements on the CE Router for MLD Proxy are listed below.

WAN requirements, MLD Proxy:

WMLD-1: Consistent with [RFC4605], the CE router MUST NOT implement the router portion of MLDv2 for the WAN interface.

LAN requirements, MLD Proxy:

LMMLD-1: The CPE Router MUST follow the model described for MLD Proxy in [RFC4605] to implement multicast.

LMMLD-2: Consistent with [RFC4605], the LAN interfaces on the CPE router MUST NOT implement an MLDv2 Multicast Listener.

LAN requirements:

LM-1: If the CE Router has bridging configured between the LAN interfaces, then the LAN interfaces MUST support snooping of MLD [RFC3810] messages.

5.3. ND Proxy

LAN requirements:

LNDP-1: If the CE Router has only one /64 prefix to be used across multiple LAN interfaces and the CE Router supports any two LAN interfaces that cannot bridge data between them because the two interfaces have disparate MAC layers, then the CE Router MUST support Proxying Neighbor Advertisements as specified in Section 7.2.8 of [RFC4861]. If any two LAN interfaces support bridging between the interfaces, then Proxying Neighbor Advertisements is not necessary between the two interfaces. Legacy 3GPP networks have the following requirements:

1. No DHCPv6 prefix is delegated to the CE Router.

2. Only one /64 is available on the WAN link.

3. The link types between the WAN interface and LAN interface(s) are disparate and, therefore, can’t be bridged.

4. No NAT66 is to be used.

5. Each LAN interface needs global connectivity.

6. Uses SLAAC to configure LAN interface addresses.

For these legacy 3GPP networks, the CPE Router MUST support ND Proxy between the WAN and LAN interface(s). If a CE

Router will never be deployed in an environment with these characteristics, then ND Proxy is not necessary.

5.4. Prefix Delegation on LAN interface(s) (More details are TBD)

This section is only applicable to a CE Router with at least one LAN interface. The LAN interface(s) are delegated prefixes subnetted from the delegated prefix acquired by the WAN interface and the ULA prefix. After the CE router has assigned prefixes for all of its internally defined needs (its interfaces and any other purposes defined in its internal logic), any leftover prefixes are available for delegation. Any automated prefix delegation mechanism is TBD.

5.5. Routed network behavior(General Cases TBD)

CPE Router Behavior in a routed network:

R-1: One example of the CPE Router use in the home is shown below. The home has a broadband modem combined with a CPE Router, all in one device. The LAN interface of the device is connected to another standalone CPE Router that supports a wireless access point. To support such a network, this document recommends using prefix delegation of the prefix obtained either via IA_PD from WAN interface or a ULA from the LAN interface . The network interface of the downstream router may obtain an IA_PD via stateful DHCPv6. If the CPE router supports the routed network through automatic prefix delegation, the CPE router MUST support a DHCPv6 server or DHCPv6 relay agent. Further, if an IA_PD is used, the Service Provider or user MUST allocate an IA_PD or ULA prefix short enough to be delegated and subsequently used for SLAAC. Therefore, a prefix length shorter than /64 is needed. The CPE Router MAY support and IGP in the home network.

```
        /-------+-----------\    /-----------+-----\
SP <--+ Modem | CPE Router    +--+ CPE Router | WAP + --> PC
        \-------+-----------/    \-----------+-----/

WAP = Wireless Access Point
```

Figure 2.

5.6. Transition Technologies Support

5.6.1. Dual-Stack(DS)-Lite

Even as users migrate from IPv4 to IPv6 addressing, a significant percentage of Internet resources and content will remain accessible only through IPv4. Also, many end-user devices will only support IPv4. As a consequence, Service Providers require mechanisms to allow customers to continue to access content and resources using IPv4 even after the last IPv4 allocations have been fully depleted. One technology that can be used for IPv4 address extension is DS-Lite.

DS-Lite enables a Service Provider to share IPv4 addresses among multiple customers by combining two well-known technologies: IP in IP (IPv4-in-IPv6) tunneling and Carrier Grade NAT. More specifically, Dual-Stack-Lite encapsulates IPv4 traffic inside an IPv6 tunnel at the IPv6 CE Router and sends it to a Service Provider Address Family Translation Router (AFTR). Configuration of the IPv6 CE Router to support IPv4 LAN traffic is outside the scope of this document.

The IPv6 CE Router SHOULD implement DS-Lite functionality as specified in [I-D.ietf-softwire-dual-stack-lite].

WAN requirements:

DLW-1: To facilitate IPv4 extension over an IPv6 network, if the CE Router supports DS-Lite functionality, the CE Router WAN interface MUST implement a B4 Interface as specified in [I-D.ietf-softwire-dual-stack-lite].

DLW-2: If the IPv6 CE Router implements DS-Lite functionality, the CE Router MUST support using a DS-Lite DHCPv6 option [I-D.ietf-softwire-ds-lite-tunnel-option] to configure the DS-Lite tunnel. The IPv6 CE Router MAY use other mechanisms to configure DS-Lite parameters. Such mechanisms are outside the scope of this document.

DLW-3: IPv6 CE Router MUST NOT perform IPv4 Network Address Translation (NAT) on IPv4 traffic encapsulated using DS-Lite.

DLW-4: If the IPv6 CE Router is configured with an non-RFC1918 IPv4 address on its WAN interface, the IPv6 CE Router MUST disable the DS-Lite B4 element.

DLW-5: If DS-Lite is operational on the IPv6 CE Router, multicast data MUST NOT be sent on any DS-Lite tunnel.

5.6.2. 6rd

The IPv6 CE Router can be used to offer IPv6 service to a LAN, even when the WAN access network only supports IPv4. One technology that supports IPv6 service over an IPv4 network is IPv6 Rapid Deployment (6rd). 6rd encapsulates IPv6 traffic from the end user LAN inside IPv4 at the IPv6 CE Router and sends it to a Service Provider Border Relay (BR). The IPv6 CE Router calculates a 6rd delegated IPv6 prefix during 6rd configuration, and sub-delegates the 6rd delegated prefix to devices in the LAN.

The IPv6 CE Router SHOULD implement 6rd functionality as specified in [RFC5969].

6rd requirements:

6RD-1: If the IPv6 CE Router implements 6rd functionality, the CE Router WAN interface MUST support at least one 6rd Virtual Interface and 6rd CE functionality as specified in [RFC5969].

6RD-2: If the IPv6 CE Router implements 6rd CE functionality, it MUST support using the 6rd DHCPv4 Option (212) for 6rd configuration. The IPv6 CE Router MAY use other mechanisms to configure 6rd parameters. Such mechanisms are outside the scope of this document.

6RD-3: If 6rd is operational on the IPv6 CE Router, multicast data MUST NOT be sent on any 6rd tunnel.

5.6.3. Transition Technologies Coexistence

Run the following four in parallel to provision CPE router connectivity to the Service Provider:

1. Initiate IPv4 address acquisition.

2. Initiate IPv6 address acquisition as specified by [I-D.ietf-v6ops-ipv6-cpe-router].

3. If 6rd is provisioned, initiate 6rd.

4. If DS-Lite is provisioned, initiate DS-Lite.

The default route for IPv6 through the native physical interface should have preference over the 6rd tunnel interface. The default route for IPv4 through the native physical interface should have preference over the DS-Lite tunnel interface.

5.7. Quality Of Service

Q-1: The CPE router MAY support differentiated services [RFC2474].

5.8. Unicast Data Forwarding

The null route introduced by the WPD-6 requirement in [I-D.ietf-v6ops-ipv6-cpe-router] has lower precedence than other routes except for the default route.

5.9. ZeroConf

The CE Router MAY support manual configuration via the web using a URL string like http://router.local as per multicast DNS (mDNS). Zero-configuration is vendor-dependent.

6. Security Considerations

None.

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9. IANA Considerations

This memo includes no request to IANA.

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