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Deployment Considerations for Lightweight 4over6
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Abstract

Lightweight 4over6 is a mechanism which moves the translation function from tunnel Concentrator (AFTR) to Initiators (B4s), and hence reduces the mapping scale on the Concentrator to per-customer level. This document discusses various deployment models of Lightweight 4over6. It also describes the deployment considerations and applicability of the Lightweight 4over6 architecture.

Status of this Memo

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Table of Contents

1. Introduction

Lightweight 4over6 [I-D.cui-softwire-b4-translated-ds-lite] is an extension to DS-Lite which simplifies the AFTR module [RFC6333] with distributed NAT function among B4 elements. The Initiator in Lightweight 4over6 is provisioned with an IPv6 address, an IPv4 address and a port-set. It performs NAPT on end user's packets with the provisioned IPv4 address and port-set. IPv4 packets are forwarded between the Initiator and the Concentrator over a Softwire using IPv4-in-IPv6 encapsulation. The Concentrator maintains one mapping entry per subscriber with the IPv6 address, IPv4 address and port-set. Therefore, this extension removes the NAT44 module from the AFTR and replaces the session-based NAT table to a per-subscriber based mapping table. This should relax the requirement to create dynamic session-based log entries. This mechanism preserves the dynamic feature of IPv4/IPv6 address binding as in DS-Lite, so it won't require to couple IPv4 and IPv6 address schemas as MAP [I-D.mdt-softwire-mapping-address-and-port] requires. This document discusses various deployment models of Lightweight 4over6. It also describes the deployment considerations and applicability of the Lightweight 4over6 architecture.

Terminology of this document follows the definitions and abbreviations of [I-D.cui-softwire-b4-translated-ds-lite].

2. 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 [RFC2119].

3. Case Studies

Lightweight 4over6 can be either deployed by itself, or combined with DS-Lite [RFC6333]. Lightweight 6over4 is suitable for operators who have many small and discontinued IPv4 blocks and would like to separate IPv4 and IPv6 address schemas. Compared to other technologies such as [I-D.mdt-softwire-mapping-address-and-port] and [I-D.despres-softwire-4rd-u], this mechanism won't require operators to administrate and manage IPv4 and IPv6 mapping rules planning in CPE and in the network.

3.1. case 1: Standalone Deployment Scenario

Lightweight 4over6 can be deployed in a new residential network (depicted in Figure1). In this scenario, an Initiator would acquire an IPv4 address and a port-set after successful user authentication process and IPv6 provisioning process. Then, it establishes an IPv4-in-IPv6 softwire using the IPv6 address to deliver IPv4 services to its connected host via the Concentrator in the network. The Concentrator supports only Lightweight 4over6 which keeps the mapping between Initiator's IPv6 address and its allocated IPv4 address + port set.

```
                    +---------------+-------------|
                    +               |             |
+---------+  +------+---+        +--+--+          |
|  Host   |  | LW 4over6|        |     |          |
|         |--| Initiator| ======-| BNG | === +---------+   +-----------+
+---------+  +----------+        +--|--+     |LW 4over6|   |   IPv4    |
                                             |Concen-  |---| Internet  |
+---------+  +------+---+        +--+--+     |trator   |   |           |
|  Host   |--| LW 4over6| =======|     | ====+---------+   +-----------+
|         |  | Initiator|        | BNG |          |
+---------+  +----------+        +--|--+          |
                    +               |             |
                    +---------------+-------------+
```

Figure 1 Standalone Deployment Scenario

3.2. Case 2: Integrated Network Element with Lightweight 4over6 and DS-Lite AFTR Scenario

Lightweight 4over6 can be deployed incrementally in existing DS-Lite network (depicted in Figure2). In this case, DS-Lite has been deployed in the network. Later in the deployment schedule, the operator decided to implement Lightweight 4over6 Concentrator function in the same network element. Therefore, the same network element needs to support both transition mechanisms. Two transition

mechanisms can be distinguished using the client!_s source IPv4 address. The IPv4 address from Lightweight 4over6 is public address as NAT has been done in the Initiator, and IPv4 address for DS-lite is private address as NAT will be done on AFTR. When the network element receives an encapsulated packet, it would de-capsulate packet and apply the transition mechanism based on the IPv4 source address in the packet. This requires the network element to examine every packet and may introduce significant load to the network element.

Lightweight 4over6 and DS-Lite use the same addressing scheme, routing policy, user management policy, etc. Since Lightweight 4over6 and DS-Lite is located in the same element network, both the B4 element and Lightweight 4over6 Initiator can use the same DHCPv6 option [RFC6334] to discover the FQDN of the AFTR and Concentrator.

```
                    +---------------+--------------|
                    +               |              |
+---------+  +------+---+        +--+--+           |
|  Host   |  | LW 4over6|        |     |           |
|         |--| Initiator| ======-| BNG | === +-------------+   +-----------+
+---------+  +----------+        +--|--+     |LW 4over6    |   |   IPv4    |
                                             |Concentrator/|---| Internet  |
+---------+  +------+---+        +--+--+     |DS-Lite AFTR |   |           |
|  Host   |--| DS-Lite  | =======|     | ====+-------------+   +-----------+
|         |  |    B4    |        | BNG |           |
+---------+  +----------+        +--|--+           |
                    +               |              |
                    +---------------+--------------+
```

Figure 2 DS-Lite Coexistence scenario with Integrated AFTR

3.3. case 3: DS-Lite Coexistent scenario with Seperated AFTR

This is similar to Case 2. The difference is the Concentrator and AFTR functions won!_t be co-located in the same network element (depicted in Figure3). This use case decouples the functions to allow more flexible deployment. For example, an operator may deploy AFTR closer to the edge and Concentrator closer to the core. Moreover, it does not require the network element to pre-configure with the CPE's IPv6 addresses. An operator can deploy more AFTR and Concentrator at needed. However, this requires the B4 and Initiator to discover the corresponding network element. B4 can continue to use [RFC6334] and [RFC6519] to discover AFTR. It may require to define a new discover mechanism for Initiator to discover the Concentrator. This discovery mechanism is out of scope.

```
                    +---+---------------+-----------------|
                    +                   |                 |
```

```
+---------+  +------+---+        +------+-----+           |
|  Host   |  | LW 4over6|        |    BNG     |           |
|         |--| Initiator| ======-|DS-Lite AFTR| === +------------+
+-----------+
+---------+  +----------+        +------+-----+     |LW 4over6   |   |
IPv4    |

                                                    |Concentrator|---|
Internet  |
+---------+  +------+---+        +------+-----+     |            |
|           |
|  Host   |--| DS-Lite  | =======|    BNG     | ====+------------+
+-----------+
|         |  |    B4    |        |DS-Lite AFTR|           |
+---------+  +----------+        +------+-----+           |
                    +                   |                 |
                    +-------------------+-----------------+
```

   Figure 3 DS-Lite Coexistence scenario with Integrated AFTR

4. Overall Deployment Considerations

4.1. Addressing and Routing

In Lightweight 4over6, there is no inter-dependency between IPv4 and IPv6 addressing schemes. IPv4 address pools are configured centralized in Concentrator for IPv6 subscribers. These IPv4 prefix must advertise to IPv4 Internet accordingly.

For IPv6 addressing and routing, there are no additional addressing and routing requirements. The existing IPv6 address assignment and routing announcement should not be affected, e.g. using PPPoE or IPoE, etc.

4.2. Port-set Management

In Lightweight 4over6, each Initiator will get its restricted IPv4 address and a valid port-set. This port-set assignment should be synchronized between port management server and the Concentrator. The port management server is responsible for allocating port restricted IPv4 address to the Initiator. It can be new option to the DHCPv4 server [I-D.bajko-pripaddrassign]. The DHCPv4 server can either collocated in the Concentrator or a dedicated server. If a dedicated server is used, the Concentrator must be the DHCP relay agent to the DHCPv4 server [I-D.ietf-dhc-dhcpv4-over-ipv6].

Different mechanisms including PCP- extended protocol [I-D.tsou-pcp-natcoord], DHCP-extended protocol or IPCP-extended protocol, etc., can also be used.

PCP-based mechanism is more flexible. An Initiator can send multiple PCP requests simultaneously to acquire a number of ports or use [I-D.tsou-pcp-natcoord] for one-time port-set allocation.

4.3. Concentrator Discovery

A Lightweight 4over6 Initiator must discover the Concentrator's IPv6 address before offering any IPv4 services. This IPv6 address can be learned through an out-of-band channel, static configuration, and dynamic configuration. For case 1 and case 2, Lightweight 4over6 Initiator can use the same DHCPv6 option [RFC6334]to discover the FQDN of the Concentrator. However, for case 3, a new discovery mechanism for Initiator to discover the Concentrator is required.

5. Concentrator Deployment Consideration

As Lightweight 4over6 is an extension to DS-Lite, both technologies share similar deployment considerations. For example: Interface consideration, MTU, Fragment, Lawful Intercept Considerations, Blacklisting a shared IPv4 Address, AFTR's Policies, AFTR Impacts on Accounting Process, etc., in [I-D.ietf-softwire-dslite-deployment] can also be applied here. This document only discusses new considerations specific to Lightweight 4over6.

5.1. Logging at the Concentrator

In Lightweight 4over6, operators only log one entry per subscriber. The log should include subscriber!_s IPv6 address used for the softwire, the public IPv4 address and the port-set. The port set algorithm implemented in Lightweight 4over6 Concentrator should be synchronized with the one implemented in logging system. For example, if contiguous port set algorithm is adopted in the Concentrator, the same algorithm should also been applied to the logging system.

5.2. Reliability Considerations of Concentrator

In Lightweight 4over6, subscriber to IPv4 and port-set mapping must be pre-provisioned in the Concentrator before providing IPv4 serives. For redundancy, the backup Concentrator must either have the subscriber mapping already provisioned or notify the Initiator to create a new mapping in the backup Concentrator. The first option can be consider as hot standby mode. The second option may require a new notification mechanism which is outside the scope of this document.

5.3. Placement of AFTR

The Concentrator can be deployed in a "centralized model" or a "distributed model".

In the "centralized model", the Concentrator could be located at the higher place, e.g. at the exit of MAN, etc. Since the Concentrator has good scalability and can handle numerous concurrent sessions, we recommend to adopt the "centralized model" for Lightweight 4over6 as it is cost-effective and easy to manage.

In the "distributed model", Concentrator is usually integrated with the BRAS/SR. Since newly emerging customers might be distributed in the whole Metro area, we have to deploy Concentrator on all BRAS/SRs. This will cost a lot in the initial phase of the IPv6 transition period.

5.4. Port set algorithm consideration

If each Initiator is given a set of ports, port randomization algorithm can only select port in the given port-set. This may introduce security risk because hackers can make a more predictable guess of what port a subscriber may use. Therefore, non-continuous port set algorithms (e.g. as defined in [I-D.mdt-softwire-mapping-address-and-port]) can be used to improve security.

6. Acknowledgement

TBD

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1. Appendix:Experimental Result

We have deployed Lightweight 4over6 in our operational network of HuNan province, China. It is designed for broadband access network, and different versions of Initiator have been implemented including a linksys box, a software client for windows XP, vista and Windows 7. It can be integrated with existing dial-up mechanisms such as PPPoE, etc. The major objectives listed below aimed to verify the functionality and performance of Lightweight 4over6:

- o Verify how to deploy Lightweight 4over6 in a practical network.

- o Verify the impact of applications with Lightweight 4over6.

- o Verify the performance of Lightweight 4over6.

1.1. Experimental environment

The network topology for this experiment is depicted in Figure 2.

```
                                             +--------+
+-----+  +---------+                         | Syslog |
|Host1+--+Initiator|--+                      | Server |     --------
+-----+  +---------+  |                      +---+----+   ///       \\\
                      |         /------\         |       //           \\
                      |        //      \\    +---+----+ |               |
+-----+  +---------+  +-+--+  |   IPv6   |   |        | | IPv4 Internet |
|Host2+--|Initiator|--+BRAS+--|  Network |---| Concen-+-+               |
+-----+  +---------+  +-+--+   \\      //    | trator |  \\            //
                       |        \---+--/     +--------+   \\\        ///
                       |           |                        ---------
+-----+  +---------+   |           |
|Host3+--+Initiator+---+           |
+-----+  +---------+               |                         --------
                                   |                       //        \\
                                   |                      /            \
                                   +---------------------+IPv6 Internet +
                                                         |              |
                                                          \            /
                                                           \\        //
                                                             -------
```

Figure 2 Lightweight 4over6 experiment topology

In this deployment model, Concentrator is co-located with a extended PCP server to assign restricted IPv4 address and port set for Initiator. It also triggers subscriber-based logging event to a centrilized syslog server. IPv6 address pools for subscribers have

been distributed to BRASs for configuration, while the public available IPv4 address pools are configured by the centralized Concentrator with a default address sharing ratio. It is rather flexible for IPv6 addressing and routing, and there is little impact on existing IPv6 architecture.

In our experiment, Initiator will firstly get its IPv6 address and delegated prefix through PPPoE, and then initiate a PCP-extended request to get public IPv4 address and its valid port set. The Concentrator will thus create a subscriber-based state accordingly, and notify syslog server with {IPv6 address, IPv4 address, port set, timestamp}.

1.2. Experimental results

In our trial, we mainly focused on application test and performance test. The applications have widely include web, email, Instant Message, ftp, telnet, SSH, video, Video Camera, P2P, online game, voip and so on. For performance test, we have measured the parameters of concurrent session numbers and throughput performance.

The experimental results are listed as follows:

Application Type	Test Result	Port Number Occupation
Web	ok IE, Firefox, Chrome	normal websites: 10~20 Ajex Flash webs: 30~40
Video	ok, web based or client based	30~40
Instant Message	ok QQ, MSN, gtalk, skype	8~20
P2P	ok utorrent,emule,xunlei	lower speed: 20~600 (per seed) higher speed: 150~300
FTP	need ALG for active mode, flashxp	2
SSH, TELNET	ok	1 for SSH, 3 for telnet
online game	ok for QQ, flash game	20~40

Figure 3 Lightweight 4over6 experimental result

The performance test for Concentrator is taken on a normal PC. Due to limitations of the PC hardware, the overall throughput is limited to around 800 Mbps. However, it can still support more than one hundred million concurrent sessions.

1.3. Conclusions

From the experiment, we can have the following conclusions:

- o Lightweight 4over6 has good scalability. As it is a lightweight solution which only maintains per-subscriber state information, it can easily support a large amount of concurrent subscribers.

- o Lightweight 4over6 can be deployed rapidly. There is no modification to existing addressing and routing system in our operational network. And it is simple to achieve traffic logging.

- o Lightweight 4over6 can support a majority of current IPv4 applications.

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