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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.

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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 has no coupling between IPv6 address and IPv4 address/port-set as any full stateless solution ([RFC6052] or [I-D.ietf-softwire-map]) requires. This document discusses 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. Deployment Model

Lightweight 4over6 is suitable for operators who would like to free any correlation of the IPv6 address with IPv4 address and port-set (or port-range). In comparison to full stateless solutions like MAP [I-D.ietf-softwire-map] and 4rd [I-D.ietf-softwire-4rd], Lightweight 4over6 frees address planning of IPv6 delegation for CPE from mapping rule administration and management in the network. Thus, IPv6 addressing is completely flexible to fit other deployment requirements, e.g., auto-configuration, service classification, user management, QoS support, etc. The philosophy here is that bits of IPv6 address should be left for IPv6 usage first.

Lightweight 4over6 can be deployed in a residential network (depicted in Figure1). In this scenario, an Initiator would acquire an IPv4 address and a port-set after a 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 Initiator can act as a CPE, or software located in the host. The Concentrator supports Lightweight 4over6 which keeps the mapping between Initiator's IPv6 address and its allocated IPv4 address + port set. The supporting server may keep the binding information as well for logging and user management.

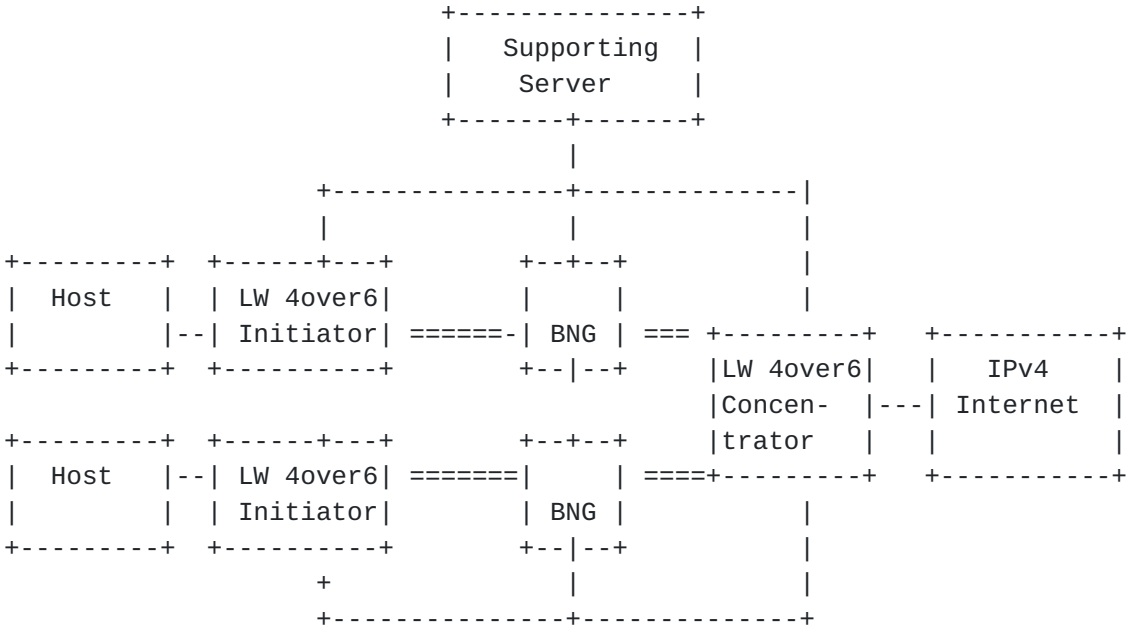


Figure 1 Deployment Model

There are two deployment models in practice: one is called bottom-up and the other is top-down. In bottom-up model, after port-restricted

IPv4 address is allocated to a given subscriber, the Concentrator will report mapping records to the support server on creating a binding for traffic logging if necessary. In this way, the Concentrator can determine the binding by its own and there is little impact on existing network architecture. In top-down model, the Supporting system should firstly determine the binding information for each subscriber and then synchronize it with the Concentrator. With this method, one binding record can be easily synchronized with multiple Concentrators and stateless failover can be achieved. However, new mechanism (e.g. Netconf) needs to be introduced to notify each individual binding record between the Supporting system and the Concentrator.

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. For example, in PPPoE scenario, a CPE could obtain a prefix via prefix delegation procedure, and the hosts behind CPE would get its own IPv6 addresses within the prefix through SLAAC or DHCPv6 statefully. This IPv6 address assignment procedure has nothing to do with restricted IPv4 address allocation.

4.2. Port-set Management

In Lightweight 4over6, each Initiator will get its restricted IPv4 address and a valid port-set after successful user authentication process and IPv6 provisioning process. 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 be collocated in the Concentrator or a dedicated server.

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

Compared with DHCP-based mechanism, 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, or dynamic configuration. In practice, Lightweight 4over6 Initiator can use the same DHCPv6 option [RFC6334]to discover the FQDN of the Concentrator. When Lightweight 4over6 is deployment in the same place with DS-Lite, different FQDNs can be configured for Lightweight

4over6 and DS-Lite separately (More detailed consideration on DS-Lite compatibility will be discussed in Section...).

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.ietf-softwire-map]) can be used to improve security.

6. DS-Lite Compatibility

Lightweight 4over6 can be either deployed all alone, or combined with DS-Lite [RFC6333]. Since Lightweight 4over6 does not any have extra requirement on IPv6 addressing, it can use use the same addressing scheme with DS-Lite, together with routing policy, user management policy, etc. Besides, the bottom-up model has quite similar requirement and workflow on the support server with DS-Lite. Therefore, it is suitable for operators to deploy incrementally in existing DS-Lite network

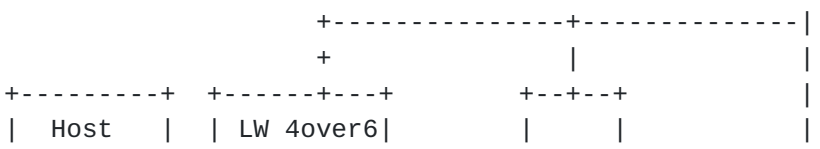
6.1. Case 1: Integrated Network Element with Lightweight 4over6 and DS-Lite AFTR Scenario

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(depicted in Figure2). Therefore, the same network element needs to support both transition mechanisms.

There are two options to distinguish the traffic from two transition mechanisms.

The first one is to distinguish 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 extra load to the network element. However, both the B4 element and Lightweight 4over6 Initiator can use the same DHCPv6 option [RFC6334] with the same FQDN of the AFTR and Concentrator.

The second one is to distinguish using the destination's tunnel IPv6 address. One network element can run separated instances for Lightweight 4over6 and DS-Lite with different tunnel addresses. Then B4 element and Lightweight 4over6 Initiator can use the same DHCPv6 option [RFC6334] with different FQDNs pointing to corresponding tunnel addresses. This requires the support server should distinguish different types of users when assigning the FQDNs in DHCPv6 process.



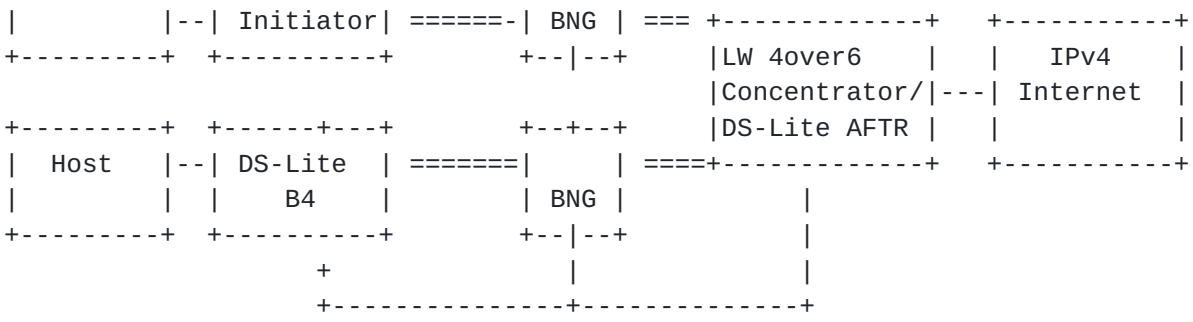


Figure 2 DS-Lite Coexistence scenario with Integrated AFTR

6.2. Case 2: DS-Lite Coexistent scenario with Separated AFTR

This is similar to Case 1. 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. In this case, B4 element and Lightweight 4over6 Initiator can still use [RFC6334] with different FQDNs pointing to corresponding tunnel end-point addresses, and the support server should distinguish different types of users.

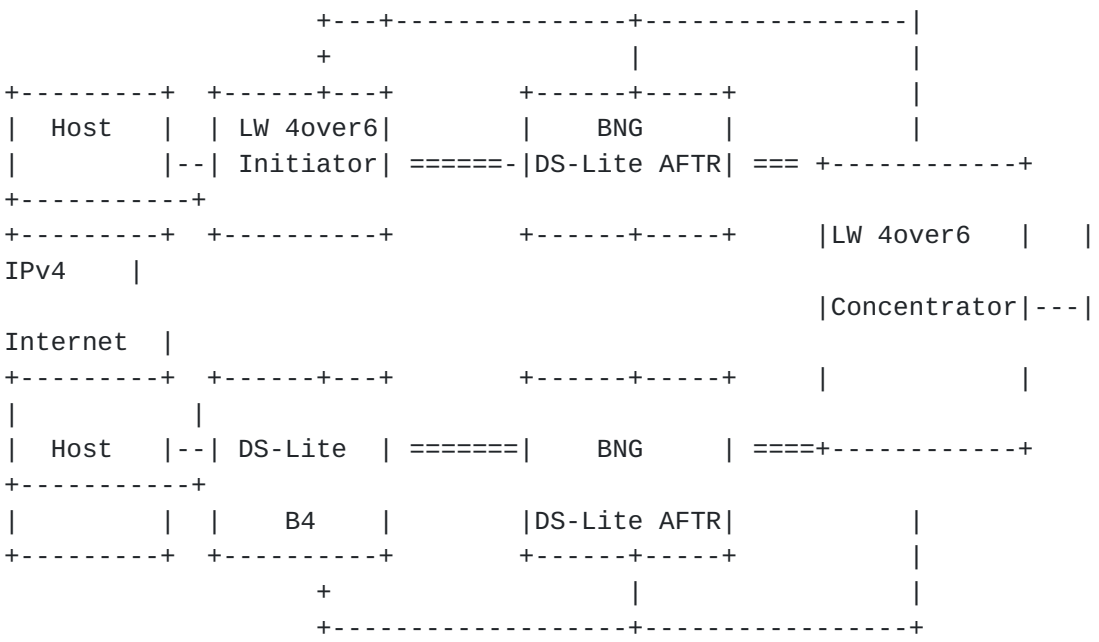


Figure 3 DS-Lite Coexistence scenario with Seperated AFTR

7. 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:

- Verify how to deploy Lightweight 4over6 in a practical network.
- Verify the impact of applications with Lightweight 4over6.
- Verify the performance of Lightweight 4over6.

1.1. Experimental environment

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

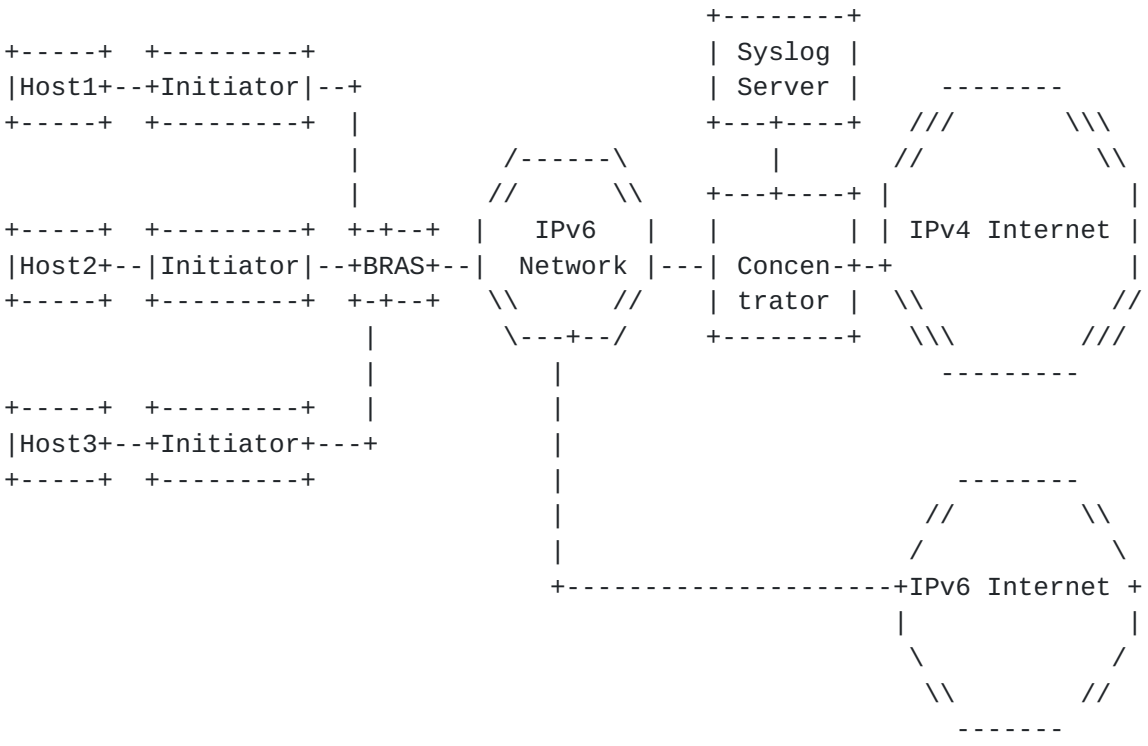

Figure 2 Lightweight 4over6 experiment topology

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:

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

- 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.

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

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