HOMENET
Internet-Draft
Intended status: Standards Track
Expires: January 06, 2014

D. Migault (Ed)
Francetelecom - Orange
W. Cloetens
SoftAtHome
C. Griffiths
Dyn
R. Weber
Nominum

July 05, 2013

IPv6 Home Network Naming Delegation
draft-mglt-homenet-front-end-naming-delegation-02.txt

Abstract

CPEs are designed to provide IP connectivity to home networks. Most CPEs assigns IP addresses to the nodes of the home network which makes it a good candidate for hosting the naming service. With IPv6, the naming service makes nodes reachable from the home network as well as from the Internet.

However, CPEs have not been designed to host such a naming service. More specifically, CPE have been designed neither to host a service exposed on the Internet, nor to support heavy operations like zone signing. Both MAY expose the CPEs to resource exhaustion which would make the home network unreachable, and most probably would also affect the home network inner communications.

In addition, DNSSEC management and configuration may not be well understood or mastered by regular end users. Misconfiguration MAY also results in naming service disruption, thus these end users MAY prefer to rely on third party naming providers.

This document describes a homenet naming architecture where the CPEs manage the DNS zone associates to its home network, and outsource both DNSSEC management and naming service on the Internet to a third party designated as the Public Authoritative Servers.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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1. Requirements notation

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].

2. Introduction

IPv6 provides global end to end IP reachability from the Internet and into the Home Network. End Users to access services hosted in the Home Network with IPv6 addresses would prefer to use names instead of long and complex IPv6 addresses.

CPEs are already providing IPv6 connectivity to the Home Network and generally provide IPv6 addresses or prefixes to the nodes of the Home Network. This makes the CPEs a good candidate to manage binding between names and IP addresses of the nodes. In other words, the CPE is the natural candidate for setting the DNS(SEC) zone file.

CPEs are usually low powered devices designed for the Home Network, but not for heavy traffic. CPEs can host the Naming Service for the Home Network but should not be exposed on the Internet. This would expose the CPE to resource exhaustion. As a consequence, it may isolate the Home Network from the Internet and affects the services hosted by the CPEs, thus affecting Home Network communications. As a result, CPE SHOULD NOT host the Naming Service of the Home Network for resolutions coming from the Internet.

Similarly, CPEs have not been designed to handle heavy computation such as DNSSEC zone signing. Such operations could also result in CPE resource exhaustion. As a consequence, resource expensive operations such as zone signing SHOULD NOT be handled by the CPE, but SHOULD be handled by other third party.

In addition to heavy operations such as zone signing, DNSSEC comes with complex configurations as well as complex operation management like (DNSSEC secure delegation, DNSSEC key roll over, DNSSEC zone updates). These operations can hardly be understood by the average end user, and a misconfiguration MAY result in invalid naming resolutions that MAY make an host, or the whole home network unreachable. As a consequence, DNSSEC management operations SHOULD NOT be handled by the average end user, but SHOULD be handled by a third party.

The goal of this document is to describe an architecture where the CPE outsources the authoritative naming service and DNSSEC zone management to a third party designated as Public Authoritative Servers. This document describes the involved protocols as well as their respective configurations to properly set the homenet naming architecture.

The document is organized as follows. Section 4 provides an overview of the homenet naming architecture and presents the CPE and the Public Authoritative Server that handles the authoritative naming service of the home network as well as DNSSEC management operations on behalf of the CPE. Section 5 describes in details protocols and configurations to set the homenet naming architecture. Section 6 sums up the various configuration parameters that MAY be filled by the end user on the CPE for example via a GUI. Finally Section 7 provides security considerations.

3. Terminology

- Customer Premises Equipment: (CPE) is the router providing connectivity to the home network. It is configured and managed by the end user. In this document, the CPE MAY also hosts services such as DHCPv6. This device MAY be provided by the ISP.

- Registered Homenet Domain: is the Domain Name associated to the home network.

- DNS Homenet Zone: is the DNS zone associated to the home network. This zone is set by the CPE and essentially contains the bindings between names and IP addresses of the nodes of the home network. In this document, the CPE does neither perform any DNSSEC management operations such as zone signing nor provide an authoritative service for the zone. Both are delegated to the Public Authoritative Server. The CPE synchronizes the DNS Homenet Zone with the Public Authoritative Server via a hidden master / slave architecture. The Public Authoritative Server MAY use specific servers for the synchronization of the DNS Homenet Zone: the Public Authoritative Name Server Set.

- Public Authoritative Server: performs DNSSEC management operations as well as provides the authoritative service for the zone. In this document, the Public Authoritative Server synchronizes the DNS Homenet Zone with the CPE via a hidden master / slave architecture. The Public Authoritative Server acts as a slave and MAY use specific servers called Public Authoritative Name Server Set. Once the Public Authoritative Server synchronizes the DNS Homenet Zone, it signs the zone and generates the DNSSEC Public Zone. Then the Public Authoritative Server hosts the zone as an authoritative server on the Public Authoritative Master(s).

- DNSSEC Public Zone: corresponds to the signed version of the DNS Homenet Zone. It is hosted by the Public Authoritative Server,

which is authoritative for this zone, and is reachable on the Public Authoritative Master(s).

- Public Authoritative Master(s): are the visible name server hosting the DNSSEC Public Zone. End users' resolutions for the Homenet Domain are sent to this server, and this server is a master for the zone.

- Public Authoritative Name Server Set: is the server the CPE synchronizes the DNS Homenet Zone. It is configured as a slave and the CPE acts as master. The CPE sends information so the DNSSEC zone can be set and served.

4. Architecture Overview

Figure 1 provides an overview of the homenet naming architecture.

The CPE is in charge of building the DNS Homenet Zone that contains all FQDN bindings of the home network. The home network is associated to a FQDN, the Registered Homenet Domain (example.com). Any node in the home network is associated to a FQDN (node1.example.com) that MAY be provided via DHCP or statically configured on the CPE via a GUI for example.

The goal of the homenet naming architecture is that the CPE does not handle any DNSSEC operations and does not host the authoritative naming service while FQDNs in the Homenet Zone can be resolved with DNSSEC by any node on the Internet.

In order to achieve this goal, when a node on the Internet sends a DNS(SEC) query like for node1.example.com, this DNS(SEC) query MUST be treated by a third party designated in figure 1 as the Public Authoritative Servers.

The Public Authoritative Servers are in charge of DNS(SEC) traffic for the Registered Homenet Domain (example.com) as well as all DNSSEC management operations like zone signing, key rollover. The DNSSEC zone hosted by the Public Authoritative Servers is called the DNSSEC Public Zone.

The purpose of our architecture is to describe how the CPE can outsource the DNS Homenet Zone hosted on the CPE to the DNSSEC Public Zone hosted on the Public Authoritative Servers. This includes description of the synchronization protocols between the CPE and the Public Authoritative Servers in Section 5.1 as well as configurations of the DNS Homenet Zone Section 5.2.

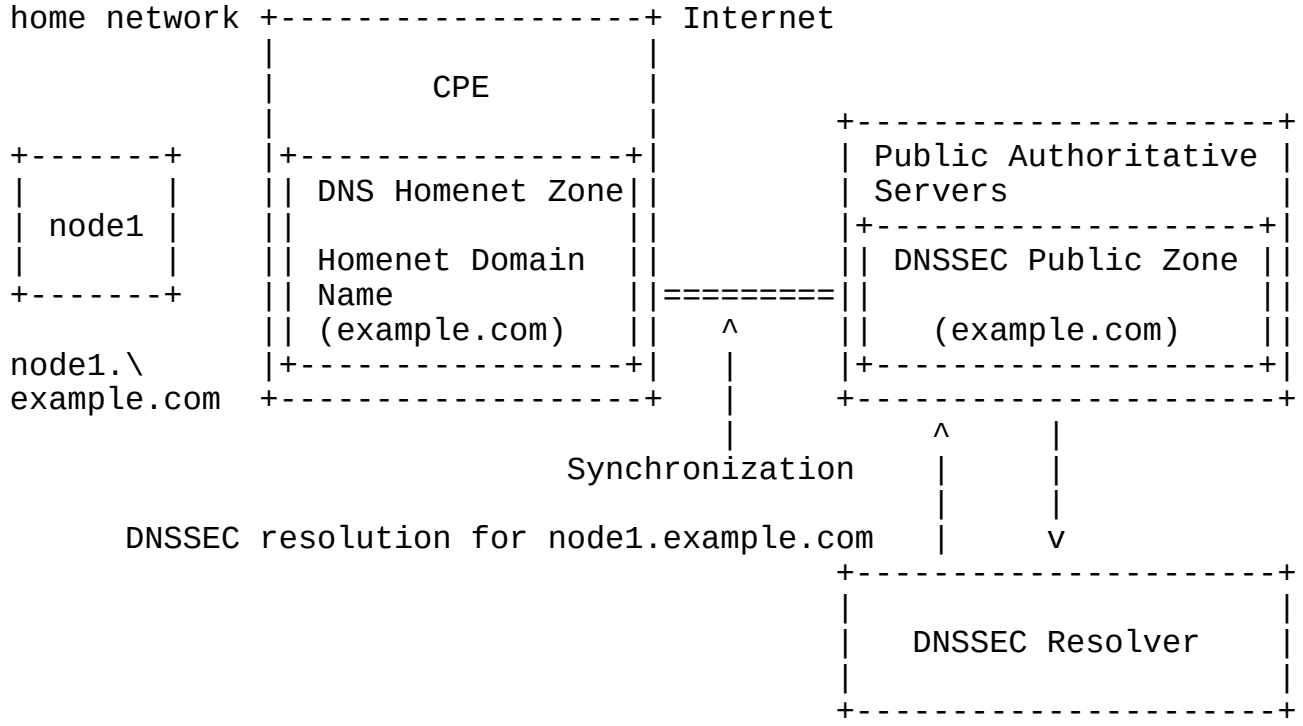

Figure 1: Homenet Naming Architecture Description

The content of the DNS Homenet Zone is out of the scope of this document. The CPE MAY host multiple services like a web GUI, DHCP [RFC6644] or mDNS [RFC6762]. These services MAY coexist and MAY be used to populate the DNS Homenet Zone. This document does not address this issue.

CPE MAY chose to host an authoritative naming server for the home network. Whether this service is implemented or not on the CPE is out of the scope of this document. Some implementations MAY chose to set a DNS authoritative server for the DNS Homenet Zone for resolutions coming from the home network. Other implementations MAY chose to synchronize the DNSSEC zone on the Public Authoritative Servers to provide DNSSEC responses. This latest option MAY require specific configurations on the Public Authoritative Servers.

Similarly, CPE MAY host a DNS(SEC) resolution service for nodes in the home network. There are multiple ways to configure the resolver service on the CPE. Detailing these various configurations is out of the scope of this document, and is considered as an implementation issue. Some implementers MAY chose to forward DNS(SEC) queries from the home network to the resolving server of its ISP or any other public resolver. In that case, the DNS(SEC) response from the Public

Authoritative Servers is forwarded to the home network, which provide DNS and DNSSEC resolution for the home network. Alternative implementations MAY chose to lookup in the DNS Homenet Zone, and thus provide only DNS responses in the home network. Other implementation MAY chose to synchronize the DNSSEC Public Zone on the CPE either using DNS master slave mechanisms, or by caching the whole zone. This latest option MAY require some additional configuration the Public Authoritative Servers.

5. Architecture Description

This section describes how the CPE and the Public Authoritative Servers SHOULD be configured to outsource authoritative naming service as well as DNSSEC management operations. Section 5.1 describes how a secure synchronization between the CPE and the Public Authoritative server is set. Section 5.2 provides guide lines for the DNS Homenet Zone set in the CPE and uploaded on the Public Authoritative Servers. Section 5.3 describes DNSSEC settings on the Public Authoritative Servers. Finally, Section 5.4 provides the security policies that SHOULD be set on the CPE.

5.1. CPE and Public Authoritative Servers Synchronization

5.1.1. Synchronization with a Hidden Master

Uploading and dynamically updating the zone file on the Public Servers can be seen as zone provisioning between the CPE (Hidden Master) and the Public Server (Slave Server). This can be handled either in band or out of band. DNS dynamic update [RFC2136] may be used. However, in this section we detail how to take advantage of the DNS slave / master architecture to deploy updates to public zones.

The Public Authoritative Server is configured as a slave for the Homenet Domain Name. This slave configuration has been previously agreed between the end user and the provider of the Public Authoritative Servers. In order to set the master/ slave architecture, the CPE acts as a Hidden Master Server, which is a regular Authoritative DNS(SEC) Server listening on the WAN interface.

The Hidden Master Server is only expected to initiate AXFR [RFC1034], IXFR [RFC1995] transfers to configured slave DNS servers. The Hidden Master Server SHOULD send NOTIFY messages [RFC1996] in order to update Public DNS server zones as updates occur.

Hidden Master Server differs from a regular authoritative server for the home network by:

- Interface Binding: the Hidden Master Server listens on the WAN Interface, whereas a regular authoritative server for the home network would listen on the home network interface.

- Limited exchanges: the purpose of the Hidden Master Server is to synchronizes with the Public Authoritative Servers, not to serve zone. As a result, exchanges are performed with specific nodes (the Public Authoritative Servers). Then exchange types are limited. The only legitimate exchanges are: NOTIFY initiated by the Hidden Master and IXFR or AXFR exchanges initiated by the Public Authoritative Servers. On the other hand regular authoritative servers would respond any hosts on the home network, and any DNS(SEC) query would be considered. The CPE SHOULD filter IXFR/AXFR traffic and drop traffic not initiated by the Public Authoritative Server. The CPE MUST listen for DNS on TCP and UDP and at least allow SOA lookups to the DNS Homenet Zone.

5.1.2. Securing Synchronization

Exchange between the Public Servers and the CPE MUST be secured, at least for integrity protection and for authentication. This is the case whatever mechanism is used between the CPE and the Public Authoritative DNS(SEC) Servers.

TSIG [RFC2845] can be used to secure the DNS communications between the CPE and the Public DNS(SEC) Servers. TKEY [RFC2931] can be used for re-keying the key used for TSIG. The advantage of this mechanism is that this mechanisms are only associated with the DNS application. Not relying on shared libraries ease testing and integration. On the other hand, using TSIG and TKEY requires that this mechanism is implemented on the DNS(SEC) Server’s implementation running on the CPE, which adds codes. Another disadvantage is that TKEY does not provides authentication mechanism.

Protocols like TLS [RFC5246] / DTLS [RFC6347] can be used to secure the transactions between the Public Authoritative Servers and the CPE. The advantage of TLS/DTLS is that this technology is widely deployed, and most of the boxes already embeds a TLS/DTLS libraries, eventually taking advantage of hardware acceleration. Then TLS/DTLS provides authentication facilities and can use certificates to authenticate the Public Authoritative Server and the CPE. On the other hand, using TLS/DTLS requires to integrate DNS exchange over TLS/DTLS, as well as a new service port. This is why we do not recommend this option.

IPsec [RFC4301] IKEv2 [RFC5996] can also be used to secure the transactions between the CPE and the Public Authoritative Servers.

Similarly to TLS/DTLS, most CPE already embeds a IPsec stack, and IKEv2 provides multiple authentications possibilities with its EAP framework. In addition, IPsec can be used to protect the DNS exchanges between the CPE and the Public Authoritative Servers without any modifications of the DNS Servers or client. DNS integration over IPsec only requires an additional security policy in the Security Policy Database. One disadvantage of IPsec is that it hardly goes through NATs and firewalls. However, in our case, the CPE is connected to the Internet, and IPsec communication between the CPE and Public Authoritative Server SHOULD NOT be impacted by middle boxes.

As mentioned above, TSIG, IPsec and TLS/DTLS may be used to secure transactions between the CPE and the Public Authentication Servers. The CPE and Public Authoritative Server SHOULD implement TSIG and IPsec.

How the PSK can be used by any of the TSIG, TLS/DTLS or IPsec protocols. Authentication based on certificates implies a mutual authentication and thus requires the CPE to manage a private key, a public key or certificates as well as Certificate Authorities. This adds complexity to the configuration especially on the CPE side. For this reason, we recommend that CPE MAY use PSK or certificate base authentication and that Public Authentication Servers MUST support PSK and certificate based authentication.

5.2. DNS Homenet Zone configuration

As depicted in figure 1, he DNSSEC Public Zone is hosted on the Public Authoritative Server, whereas the DNS Homenet Zone is hosted on the CPE. As a result, the CPE MUST configure the DNS Homenet Zone as if the DNS Homenet Zone were hosted by the Public Authoritative Servers instead of the CPE.

If one considers the case where the CPE has a single Homenet Domain Name and has an agreement with a single Public Authoritative Server. In that case, the DNS Homenet Zone SHOULD configure its Name Server RRset and Start of Authority with the ones associated to the Public Authoritative Servers. This is illustrated in figure 2. public.autho.servers.example.net is the domain name associated to the Public Authoritative Server, and IP1, IP2, IP3, IP4 are the IP addresses associated.

```
$ORIGIN example.com
$TTL 1h

@  IN  SOA  public.autho.servers.example.net
            user.example.com. (
```

```
                2013120710 ; serial number of this zone file
                1d         ; slave refresh
                2h         ; slave retry time in case of a problem
                4w         ; slave expiration time
                1h         ; maximum caching time in case of failed
                           ; lookups
                )

        @   NS  public.authoritative.servers.example.net

        public.autho.servers.example.net   A @IP1
        public.autho.servers.example.net   A @IP2
        public.autho.servers.example.net   AAAA @IP3
        public.autho.servers.example.net   AAAA @IP4
```

Figure 2: DNS Homenet Zone

When the end user considers multiple Public Authoritative Servers for a given Registered Homenet Domain, the DNS Homenet Zone MAY contain all associated Name Servers and IP addresses.

Some additional verification can check whether the CPE IP address is mentioned in the Public Zone file, and raise a warning to the End User.

5.3. DNSSEC outsourcing configuration

In this document we assumed that the Public Authoritative Server signs the DNS Homenet Zone. Multiple variants MAY be proposed by the Public Authoritative Servers. Public Authoritative Servers MAY propose to sign the DNS Homenet Zone with keys generated by the Public Authoritative Servers and unknown to the CPE. Alternatively some MAY propose the end user to provide the private keys. Although not considered in this document some end user MAY still prefer to sign their zone with their own keys they do not communicate to the Public Authoritative Servers. All these alternatives result from a negotiation between the end user and the Public Authoritative Servers. This negotiation is performed out-of-band and is out of scope of this document.

In this document, we consider that the Public Authoritative Server has all the necessary cryptographic elements to perform zone signing and key management operations.

Note that Public Authoritative Servers described in this document accomplish different functions, and thus different entities MAY be involved.

- DNS Slave function synchronizes the DNS Homenet Zone between the CPE and the Public Authoritative Servers. The DNS Homenet Zone on the Public Authoritative Servers is not available, and the Public Authoritative Server MUST NOT address any DNS queries for that zone. As a result, the Public Authoritative Servers MAY chose a dedicated set of servers to serve the DNS Homenet Zone: the Public Authoritative Name Server Set.

- DNS Zone Signing function signs the DNS Zone Homenet Zone to generate an DNSSEC Public Zone.

- DNSSEC Authoritative Server hosts the naming service for the DNSSEC Public Zone. Any DNS(SEC) query associated to the Homenet Zone SHOULD be done using the specific servers designated as the Public Authoritative Master(s).

5.4. CPE Security Policies

This section details security policies related to the Hidden Master / Slave synchronization.

The Hidden Master, as described in this document SHOULD drop any queries from the home network. This can be performed with port binding and/or firewall rules.

The Hidden Master SHOULD drop on the WAN interface any DNS queries that is not issued from the Public Authoritative Server Name Server Set.

The Hidden Master SHOULD drop any outgoing packets other than DNS NOTIFY query, SOA response, IXFR response or AXFR responses.

The Hidden Master SHOULD drop any incoming packets other than DNS NOTIFY response, SOA query, IXFR query or AXFR query.

The Hidden Master SHOULD drop any non protected IXFR or AXFR exchange. This depends how the synchronization is secured.

6. Homenet Naming Configuration

This section specifies the various parameters required by the CPE to configure the naming architecture of this document. This section is informational, and is intended to clarify the information handled by the CPE and the various settings to be done.

Public Authoritative Servers MAY be defined with the following parameters. These parameters are necessary to establish a secure channel between the CPE and the Public Authoritative Server, and to set the appropriated DNS Homenet Zone file:

- Public Authoritative Name Server Set: The associated FQDNs or IP addresses of the Public Authoritative Server. IP addresses are optional and the FQDN is sufficient. To secure the binding name and IP addresses, a DNSSEC exchange is required. Otherwise, the IP addresses SHOULD be entered manually.

- Authentication Method: How the CPE authenticates itself to the Public Server. This MAY depend on the implementation but we should consider at least IPsec, DTLS and TSIG

- Authentication data: Associated Data. PSK only requires a single argument. If other authentication mechanisms based on certificates are used, then, files for the CPE private keys, certificates and certification authority SHOULD be specified.

- Public Authoritative Master(s): The FQDN or IP addresses of the Public Authoritative Master. It corresponds to the data that will be set in the NS RRsets and SOA of the DNS Homenet Zone. IP addresses are optional and the FQDN is sufficient. To secure the binding name and IP addresses, a DNSSEC exchange is required. Otherwise, the IP addresses SHOULD be entered manually.

- Registered Homenet Domain: The domain name the Public Authoritative is configured for DNS slave, DNSSEC zone signing and DNSSEC zone hosting.

Setting the DNS Homenet Zone requires the following information.

- Registered Homenet Domain: The Domain Name of the zone. Multiple Registered Homenet Domain MAY be provided. This will generate the creation of multiple DNS Homenet Zones.

- Public Authoritative Server: The Public Authoritative Servers associated to the Registered Homenet Domain. Multiple Public Authoritative Server MAY be provided.

7. Security Considerations

The Homenet Naming Architecture described in this document solves exposing the CPE’s DNS service as a DoS attack vector.

7.1. Names are less secure than IP addresses

This document describes how an End User can make his services and devices from his Home Network reachable on the Internet with Names rather than IP addresses. This exposes the Home Network to attackers since names are expected to provide less randomness than IP addresses. The naming delegation protects the End User's privacy by not providing the complete zone of the Home Network to the ISP. However, using the DNS with names for the Home Network exposes the Home Network and its components to dictionary attacks. In fact, with IP addresses, the Interface Identifier is 64 bit length leading to 2^64 possibilities for a given subnetwork. This is not to mention that the subnet prefix is also of 64 bit length, thus providing another 2^64 possibilities. On the other hand, names used either for the Home Network domain or for the devices present less randomness (livebox, router, printer, nicolas, jennifer, ...) and thus exposes the devices to dictionary attacks.

7.2. Names are less volatile than IP addresses

IP addresses may be used to locate a device, a host or a Service. However, Home Networks are not expected to be assigned the same Prefix over time. As a result observing IP addresses provides some ephemeral information about who is accessing the service. On the other hand, Names are not expected to be as volatile as IP addresses. As a result, logging Names, over time, may be more valuable that logging IP addresses, especially to profile End User's characteristics.

PTR provides a way to bind an IP address to a Name. In that sense responding to PTR DNS queries may affect the End User's Privacy. For that reason we recommend that End Users may choose to respond or not to PTR DNS queries and may return a NXDOMAIN response.

8. IANA Considerations

This document has no actions for IANA.

9. Acknowledgment

The authors wish to thank Philippe Lemordant for its contributions on the early versions of the draft, Ole Troan for pointing out issues with the IPv6 routed home concept and placing the scope of this document in a wider picture, Mark Townsley for encouragement and injecting a healthy debate on the merits of the idea, Ulrik de Bie for providing alternative solutions, Paul Mockapetris, Christian Jacquenet, Francis Dupont and Ludovic Eschard for their remarks on CPE and low power devices.

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Appendix A. Document Change Log

[RFC Editor: This section is to be removed before publication]

-02:

*remove interfaces: "Public Authoritative Server Naming Interface" is replaced by "Public Authoritative Master(s)". "Public Authoritative Server Management Interface" is replaced by "Public Authoritative Name Server Set".

-01.3:

*remove the authoritative / resolver services of the CPE. Implementation dependent

*remove interactions with mdns and dhcp. Implementation dependent.

*remove considerations on low powered devices

*remove position toward homenet arch

*remove problem statement section

-01.2:

* add a CPE description to show that the architecture can fit CPEs

* specification of the architecture for very low powered devices.

* integrate mDNS and DHCP interactions with the Homenet Naming Architecture.

* Restructuring the draft. 1) We start from the homenet-arch draft to derive a Naming Architecture, then 2) we show why CPE need mechanisms that do not expose them to the Internet, 3) we describe the mechanisms.

* I remove the terminology and expose it in the figures A and B.

* remove the Front End Homenet Naming Architecture to Homenet Naming

-01:

* Added C. Griffiths as co-author.

* Updated section 5.4 and other sections of draft to update section on Hidden Master / Slave functions with CPE as Hidden Master/Homenet Server.

* For next version, address functions of MDNS within Homenet Lan and publishing details northbound via Hidden Master.

-00: First version published.

Authors' Addresses

Daniel Migault
Francetelecom - Orange
38 rue du General Leclerc
92794 Issy-les-Moulineaux Cedex 9
France

Phone: +33 1 45 29 60 52
Email: mglt.ietf@gmail.com

Wouter Cloetens
SoftAtHome
vaartdijk 3 701
3018 Wijgmaal
Belgium

Email: wouter.cloetens@softathome.com

Chris Griffiths
Dyn
150 Dow Street
Manchester, NH 03101
US

Email: cgriffiths@dyn.com
URI: http://dyn.com

Ralf Weber
Nominum
2000 Seaport Blvd #400
Redwood City, CA 94063
US

Email: ralf.weber@nominum.com
URI: http://www.nominum.com