DOTS
Internet-Draft
Intended status: Standards Track
Expires: December 28, 2019

M. Boucadair
Orange
T. Reddy
McAfee

June 26, 2019

Distributed-Denial-of-Service Open Threat Signaling (DOTS) Server Discovery
draft-ietf-dots-server-discovery-04

Abstract

It may not be possible for a network to determine the cause for an attack, but instead just realize that some resources seem to be under attack. To fill that gap, Distributed-Denial-of-Service Open Threat Signaling (DOTS) allows a network to inform a DOTS server that it is under a potential attack so that appropriate mitigation actions are undertaken.

This document specifies mechanisms to configure DOTS clients with DOTS servers. The discovery procedure also covers the DOTS Signal Channel Call Home.

Table of Contents

1. Introduction

DDoS Open Threat Signaling (DOTS) [I-D.ietf-dots-architecture] specifies an architecture, in which a DOTS client can inform a DOTS server that the network is under a potential attack and that appropriate mitigation actions are required. Indeed, because the lack of a common method to coordinate a real-time response among involved actors and network domains inhibits the effectiveness of DDoS attack mitigation, DOTS signal channel protocol [I-D.ietf-dots-signal-channel] is meant to carry requests for DDoS attack mitigation, thereby reducing the impact of an attack and leading to more efficient defensive actions in various deployment scenarios such as those discussed in [I-D.ietf-dots-use-cases]. Moreover, DOTS clients can instruct a DOTS server to install filtering rules by means of DOTS data channel [I-D.ietf-dots-data-channel].

The basic high-level DOTS architecture is illustrated in Figure 1 ([I-D.ietf-dots-architecture]):

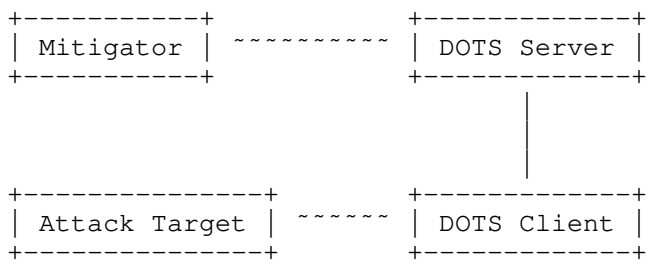


Figure 1: Basic DOTS Architecture

[I-D.ietf-dots-architecture] specifies that the DOTS client may be provided with a list of DOTS servers; each associated with one or more IP addresses. These addresses may or may not be of the same address family. The DOTS client establishes one or more DOTS sessions by connecting to the provided DOTS server addresses.

This document specifies methods for DOTS clients to discover their DOTS server(s). The rationale for specifying multiple discovery mechanisms is discussed in Section 3.

The discovery methods can also be used by a DOTS server to locate a DOTS client in the context of DOTS Signal Channel Call Home [I-D.ietf-dots-signal-call-home].

Considerations for the selection of DOTS server(s) by multi-homed DOTS clients is out of scope; the reader should refer to [I-D.ietf-dots-multihoming] for more details.

This document assumes that security credentials to authenticate DOTS server(s) are provisioned to a DOTS client using a variety of means such as (but not limited to) those discussed in [I-D.ietf-netconf-zerotouch] or [I-D.ietf-anima-bootstrapping-keyinfra]. DOTS clients use those credentials for authentication purposes following the rules documented in [I-D.ietf-dots-signal-channel].

2. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119][RFC8174] when, and only when, they appear in all capitals, as shown here.

The reader should be familiar with the terms defined in [I-D.ietf-dots-architecture] and [RFC3958].

DHCP refers to both DHCPv4 [RFC2131] and DHCPv6 [RFC8415].

"Peer DOTS agent" refers to the peer DOTS server (normal DOTS operation) or to a peer DOTS client (for DOTS Signal Channel Call Home).

3. Why Multiple Discovery Mechanisms?

It is tempting to specify one single discovery mechanism for DOTS. Nevertheless, the analysis of the various use cases sketched in [I-D.ietf-dots-use-cases] reveals that it is unlikely that one single discovery method can be suitable for all the sample deployments. Concretely:

- Many use cases discussed in [I-D.ietf-dots-use-cases] do involve a CPE device. Multiple CPEs, connected to distinct network providers may even be considered. It is intuitive to leverage on existing mechanisms such as discovery using service resolution or DHCP to provision the CPE acting as a DOTS client with the DOTS server(s).

- Resolving a DOTS server domain name offered by an upstream transit provider provisioned to a DOTS client into IP address(es) require the use of the appropriate DNS resolvers; otherwise, resolving those names will fail. The use of protocols such as DHCP does

allow to associate provisioned DOTS server domain names with a list of DNS servers to be used for name resolution. Furthermore, DHCP allows to directly provision IP addresses avoiding therefore the need for extra lookup delays.

- Some of the use cases may allow DOTS clients to have direct communications with upstream DOTS servers; that is no DOTS gateway is involved. Leveraging on existing features that do not require specific feature on the node embedding the DOTS client may ease DOTS deployment. Typically, the use of Straightforward-Naming Authority Pointer (S-NAPTR) lookups [RFC3958] allows the DOTS server administrators to provision the preferred DOTS transport protocol between the DOTS client and the DOTS server and allows the DOTS client to discover this preference.

- The upstream network provider is not the DDoS mitigation provider for some of these use cases. It is safe to assume that for such deployments, the DOTS server(s) domain name is provided during the service subscription (i.e., manual/local configuration).

- Multiple DOTS clients may be enabled within a network (e.g., enterprise network). Dynamic means to discover DOTS servers in a deterministic manner are interesting from an operational standpoint.

- Some of the use cases may involve a DOTS gateway that is responsible for selecting the appropriate DOTS server(s) to relay requests received from DOTS clients.

Consequently, this document describes a unified discovery logic (Section 4) which involves the following mechanisms:

- Dynamic discovery using DHCP (Section 5).

- A resolution mechanism based on straightforward Naming Authority Pointer (S-NAPTR) resource records in the Domain Name System (DNS) (Section 6).

- DNS Service Discovery (Section 7).

4. Unified DOTS Discovery Procedure

A key point in the deployment of DOTS is the ability of network operators to be able to configure DOTS clients with the correct DOTS server(s) information consistently. To accomplish this, operators will need a consistent set of ways in which DOTS clients can discover this information, and a consistent priority among these options. If some devices prefer manual configuration over dynamic discovery,

while others prefer dynamic discovery over manual configuration, the result will be a process of "whack-a-mole", where the operator must find devices that are using the wrong DOTS server(s), determine how to ensure the devices are configured properly, and then reconfigure the device through the preferred method.

All DOTS clients MUST support at least one of the three mechanisms below to determine a DOTS server list. All DOTS clients SHOULD implement all three, or as many as are practical for any specific device, of these ways to discover DOTS servers, in order to facilitate the deployment of DOTS in large scale environments:

1. Explicit configuration:

    * Local/Manual configuration: A DOTS client, will learn the DOTS server(s) by means of local or manual DOTS configuration (i.e., DOTS servers configured at the system level). Configuration discovered from a DOTS client application is considered as local configuration.

      An implementation may give the user an opportunity (e.g., by means of configuration file options or menu items) to specify DOTS server(s) for each address family. These MAY be specified either as IP addresses or the DNS name of a DOTS server. When only DOTS server's IP addresses are configured, a reference identifier must also be configured for authentication purposes.

    * Automatic configuration (e.g., DHCP, an automation system): The DOTS client attempts to discover DOTS server(s) names and/or addresses from DHCP, as described in Section 5.

2. Service Resolution : The DOTS client attempts to discover DOTS server name(s) using service resolution, as specified in Section 6.

3. DNS SD: DNS Service Discovery. The DOTS client attempts to discover DOTS server name(s) using DNS service discovery, as specified in Section 7.

Some of these mechanisms imply the use of DNS to resolve the IP address(es) of the DOTS server, while others imply an IP address of the relevant DOTS server is obtained directly. Implementation options may vary on a per device basis, as some devices may not have DNS capabilities and/or proper configuration.

DOTS clients will prefer information received from the discovery methods in the order listed.

On hosts with more than one interface or address family (IPv4/v6), the DOTS server discovery procedure has to be performed for each combination of interface and address family. A client MAY choose to perform the discovery procedure only for a desired interface/address combination if the client does not wish to discover a DOTS server for all combinations of interface and address family.

The above procedure MUST also be followed by a DOTS gateway. Likewise, this procedure MUST be followed by a DOTS server in the context of DOTS Signal Channel Call Home [I-D.ietf-dots-signal-call-home].

The discovery method MUST be reiterated upon the following events:

- Expiry of a lease associated with a discovered DOTS server.
- Expiry of a DOTS server's certificate currently in use.
- Attachment to a new network.

5. DHCP Options for DOTS Agent Discovery

As reported in Section 1.7.2 of [RFC6125]:

> "few certification authorities issue server certificates based on IP addresses, but preliminary evidence indicates that such certificates are a very small percentage (less than 1%) of issued certificates".

In order to allow for PKIX-based authentication between a DOTS client and server while accommodating for the current best practices for issuing certificates, this document allows for configuring names to DOTS clients. These names can be used for two purposes: to retrieve the list of IP addresses of a DOTS server or to be presented as a reference identifier for authentication purposes.

Defining the option to include a list of IP addresses would avoid a dependency on an underlying name resolution, but that design requires to also supply a name for PKIX-based authentication purposes.

The design assumes that the same peer DOTS agent is used for establishing both signal and data channels. For more customized configurations (e.g., transport-specific configuration, distinct DOTS servers for the signal and the data channels), an operator can supply only a DOTS reference identifier that will be then passed to the procedure described in Section 6.

5.1. DHCPv6 DOTS Options

5.1.1. Format of DOTS Reference Identifier Option

The DHCPv6 DOTS Reference Identifier option is used to configure a name of the DOTS server (or the name of the DOTS client for DOTS Signal Channel Call Home). The format of this option is shown in Figure 2.

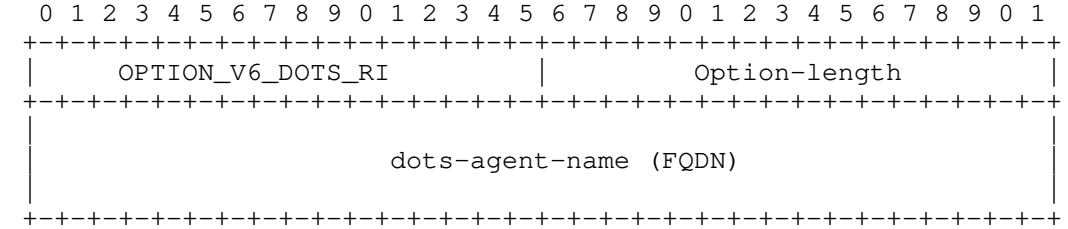


Figure 2: DHCPv6 DOTS Reference Identifier Option

The fields of the option shown in Figure 2 are as follows:

- Option-code: OPTION_V6_DOTS_RI (TBA1, see Section 9.1)
- Option-length: Length of the dots-server-name field in octets.
- dots-agent-name: A fully qualified domain name of the peer DOTS agent. This field is formatted as specified in Section 10 of [RFC8415].

An example of the dots-agent-name encoding is shown in Figure 3. This example conveys the FQDN "dots.example.com.".

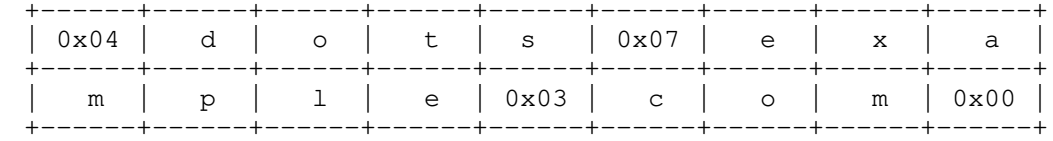


Figure 3: An example of the dots-agent-name Encoding

5.1.2. Format of DOTS Address Option

The DHCPv6 DOTS Address option can be used to configure a list of IPv6 addresses of a DOTS server (or a DOTS client for DOTS Signal Channel Call Home). The format of this option is shown in Figure 4. As a reminder, this format follows the guidelines for creating new DHCPv6 options (Section 5.1 of [RFC7227]).

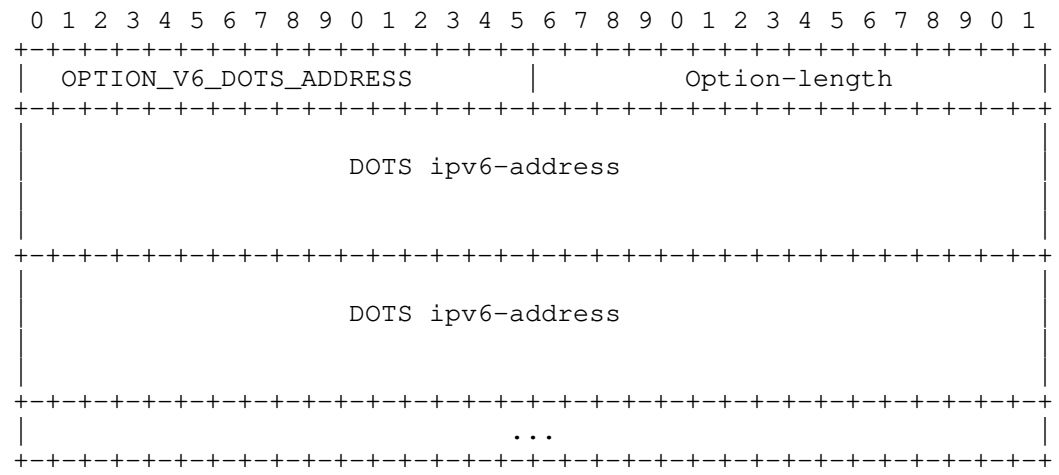


Figure 4: DHCPv6 DOTS Address Option

The fields of the option shown in Figure 4 are as follows:

- Option-code: OPTION_V6_DOTS_ADDRESS (TBA2, see Section 9.1)
- Option-length: Length of the 'DOTS ipv6-address(es)' field in octets. MUST be a multiple of 16.
- DOTS ipv6-address: Includes one or more IPv6 addresses [RFC4291] of the peer DOTS agent to be used by a DOTS agent for establishing a DOTS session.

  Note, IPv4-mapped IPv6 addresses (Section 2.5.5.2 of [RFC4291]) are allowed to be included in this option.

To return more than one DOTS agents to the requesting DHCPv6 client, the DHCPv6 server returns multiple instances of OPTION_V6_DOTS_ADDRESS.

5.1.3. DHCPv6 Client Behavior

DHCP clients MAY request options OPTION_V6_DOTS_RI and OPTION_V6_DOTS_ADDRESS, as defined in [RFC8415], Sections 18.2.1, 18.2.2, 18.2.4, 18.2.5, 18.2.6, and 21.7. As a convenience to the reader, it is mentioned here that the DHCP client includes the requested option codes in the Option Request Option.

If the DHCP client receives more than one instance of OPTION_V6_DOTS_RI (or OPTION_V6_DOTS_ADDRESS) option, it MUST use only the first instance of that option.

If the DHCP client receives both OPTION_V6_DOTS_RI and OPTION_V6_DOTS_ADDRESS, the content of OPTION_V6_DOTS_RI is used as reference identifier for authentication purposes (e.g., PKIX [RFC6125]), while the addresses included in OPTION_V6_DOTS_ADDRESS are used to reach the peer DOTS agent. In other words, the name conveyed in OPTION_V6_DOTS_RI MUST NOT be passed to underlying resolution library in the presence of OPTION_V6_DOTS_ADDRESS in a response.

If the DHCP client receives OPTION_V6_DOTS_RI only, but OPTION_V6_DOTS_RI option contains more than one name, as distinguished by the presence of multiple root labels, the DHCP client MUST use only the first name. Once the name is validated (Section 8 of [RFC8415]), the name is passed to a name resolution library. Moreover, that name is also used as a reference identifier for authentication purposes.

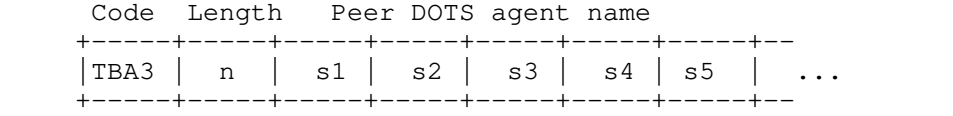
If the DHCP client receives OPTION_V6_DOTS_ADDRESS only, the address(es) included in OPTION_V6_DOTS_ADDRESS is used to reach the peer DOTS agent. In addition, these addresses can be used as identifiers for authentication.

The DHCP client MUST silently discard multicast and host loopback addresses [RFC6890] conveyed in OPTION_V6_DOTS_ADDRESS.

5.2. DHCPv4 DOTS Options

5.2.1. Format of DOTS Reference Identifier Option

The DHCPv4 DOTS Reference Identifier option is used to configure a name of the peer DOTS agent. The format of this option is illustrated in Figure 5.



The values s1, s2, s3, etc. represent the domain name labels in the domain name encoding.

Figure 5: DHCPv4 DOTS Reference Identifier Option

The fields of the option shown in Figure 5 are as follows:

- Code: OPTION_V4_DOTS_RI (TBA3, see Section 9.2);

- Length: Includes the length of the "DOTS server name" field in octets; the maximum length is 255 octets.
- Peer DOTS agent name: The domain name of the peer DOTS agent. This field is formatted as specified in Section 10 of [RFC8415].

5.2.2. Format of DOTS Address Option

The DHCPv4 DOTS Address option can be used to configure a list of IPv4 addresses of a peer DOTS agent. The format of this option is illustrated in Figure 6.

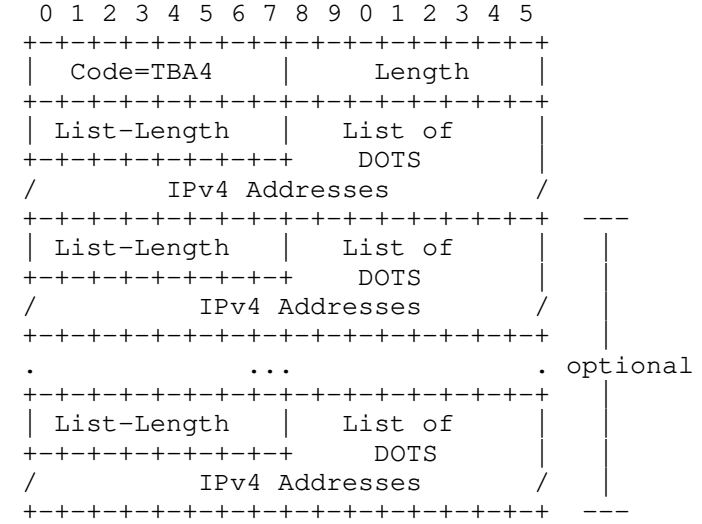
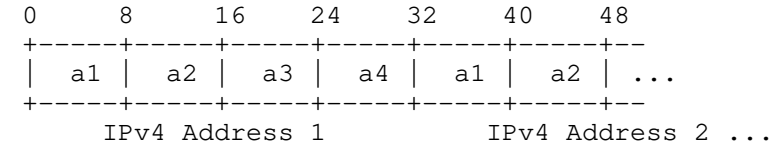


Figure 6: DHCPv4 DOTS Address Option

The fields of the option shown in Figure 6 are as follows:

- Code: OPTION_V4_DOTS_ADDRESS (TBA4, see Section 9.2);
- Length: Length of all included data in octets. The minimum length is 5.
- List-Length: Length of the "List of DOTS IPv4 Addresses" field in octets; MUST be a multiple of 4.
- List of DOTS IPv4 Addresses: Contains one or more IPv4 addresses of the peer DOTS agent to be used by a DOTS agent. The format of this field is shown in Figure 7.
- OPTION_V4_DOTS_ADDRESS can include multiple lists of DOTS IPv4 addresses; each list is treated separately as it corresponds to a given peer DOTS agent.

When several lists of DOTS IPv4 addresses are to be included, "List-Length" and "DOTS IPv4 Addresses" fields are repeated.



This format assumes that an IPv4 address is encoded as a1.a2.a3.a4.

Figure 7: Format of the List of DOTS IPv4 Addresses

OPTION_V4_DOTS_ADDRESS is a concatenation-requiring option. As such, the mechanism specified in [RFC3396] MUST be used if OPTION_V4_DOTS_ADDRESS exceeds the maximum DHCPv4 option size of 255 octets.

5.2.3. DHCPv4 Client Behavior

To discover a peer DOTS agent, the DHCPv4 client MUST include both OPTION_V4_DOTS_RI and OPTION_V4_DOTS_ADDRESS in a Parameter Request List Option [RFC2132].

If the DHCP client receives more than one instance of OPTION_V4_DOTS_RI (or OPTION_V4_DOTS_ADDRESS) option, it MUST use only the first instance of that option.

If the DHCP client receives both OPTION_V4_DOTS_RI and OPTION_V4_DOTS_ADDRESS, the content of OPTION_V6_DOTS_RI is used as reference identifier for authentication purposes, while the addresses included in OPTION_V4_DOTS_ADDRESS are used to reach the peer DOTS agent. In other words, the name conveyed in OPTION_V4_DOTS_RI MUST NOT be passed to underlying resolution library in the presence of OPTION_V4_DOTS_ADDRESS in a response.

If the DHCP client receives OPTION_V4_DOTS_RI only, but OPTION_V4_DOTS_RI option contains more than one name, as distinguished by the presence of multiple root labels, the DHCP client MUST use only the first name. Once the name is validated (Section 10 of [RFC8415]), the name is passed to a name resolution library. Moreover, that name is also used as a reference identifier for authentication purposes.

If the DHCP client receives OPTION_V4_DOTS_ADDRESS only, the address(es) included in OPTION_V4_DOTS_ADDRESS is used to reach the peer DOTS server. In addition, these addresses can be used as identifiers for authentication.

The DHCP client MUST silently discard multicast and host loopback addresses conveyed in OPTION_V4_DOTS_ADDRESS.

6. Discovery using Service Resolution

This mechanism is performed in two steps:

1. A DNS domain name is retrieved for each combination of interface and address family. A DOTS client has to determine the domain in which it is located relying on dynamic means such as DHCP (Section 5) . Implementations MAY allow the user to specify a default name that is used, if no specific name has been configured.

2. Retrieved DNS domain names are then used for S-NAPTR lookups [RFC3958]. Further DNS lookups may be necessary to determine DOTS server IP address(es).

Once the DOTS client has retrieved client's DNS domain or discovered the peer DOTS agent name that needs to be resolved (e.g., Section 5), an S-NAPTR lookup with 'DOTS' application service and the desired protocol tag is made to obtain information necessary to connect to the authoritative DOTS server within the given domain.

This specification defines "DOTS" and "DOTS-CALL-HOME" as application service tags (Sections 9.3.1 and 9.3.2). It also defines "signal.udp" (Section 9.3.3), "signal.tcp" (Section 9.3.4), and "data.tcp" (Section 9.3.5) as application protocol tags. An example is provided in Figure 8.

In the example below, for domain 'example.net', the resolution algorithm will result in IP address(es), port, tag and protocol tuples as follows:

```
example.net.
IN NAPTR 100 10 "" DOTS:signal.udp "" signal.example.net.
IN NAPTR 200 10 "" DOTS:signal.tcp "" signal.example.net.
IN NAPTR 300 10 "" DOTS:data.tcp "" data.example.net.

signal.example.net.
IN NAPTR 100 10 "s" DOTS:signal.udp "" _dots._signal._udp.example.net.
IN NAPTR 200 10 "s" DOTS:signal.tcp "" _dots._signal._tcp.example.net.

data.example.net.
IN NAPTR 100 10 "s" DOTS:data.tcp "" _dots._data._tcp.example.net.

_dots._signal._udp.example.net.
IN SRV   0 0 5000 a.example.net.

_dots._signal._tcp.example.net.
IN SRV   0 0 5001 a.example.net.

_dots._data._tcp.example.net.
IN SRV   0 0 5002 a.example.net.

a.example.net.
IN AAAA  2001:db8::1
```

Order	Protocol	IP address	Port	Tag
1	UDP	2001:db8::1	5000	Signal
2	TCP	2001:db8::1	5001	Signal
3	TCP	2001:db8::1	5002	Data

Figure 8: Sample Example

An example is provided in Figure 9 for the Call Home case.

In the example below, for domain 'example.net', the resolution algorithm will result in IP address(es), port, tag and protocol tuples as follows:

```
example.net.
IN NAPTR 100 10 "" DOTS-CALL-HOME:signal.udp "" signal.example.net.
IN NAPTR 200 10 "" DOTS-CALL-HOME:signal.tcp "" signal.example.net.

signal.example.net.
IN NAPTR 100 10 "s" DOTS-CALL-HOME:signal.udp ""
            _dots-call-home._signal._udp.example.net.
IN NAPTR 200 10 "s" DOTS-CALL-HOME:signal.tcp ""
          _dots-call-home._signal._tcp.example.net.

_dots-call-home._signal._udp.example.net.
IN SRV   0 0 6000 b.example.net.

_dots-call-home._signal._tcp.example.net.
IN SRV   0 0 6001 b.example.net.

b.example.net.
IN AAAA  2001:db8::2
```

Order	Protocol	IP address	Port	Tag
1	UDP	2001:db8::2	6000	Signal
2	TCP	2001:db8::2	6001	Signal

Figure 9: Sample Example for DOTS Signal Channel Call Home

If no DOTS-specific S-NAPTR records can be retrieved, the discovery procedure fails for this domain name (and the corresponding interface and IP protocol version). If more domain names are known, the discovery procedure MAY perform the corresponding S-NAPTR lookups immediately. However, before retrying a lookup that has failed, a DOTS client MUST wait a time period that is appropriate for the encountered error (e.g., NXDOMAIN, timeout, etc.).

7. DNS Service Discovery

DNS-based Service Discovery (DNS-SD) [RFC6763] provides generic solutions for discovering services. DNS-SD defines a set of naming rules for certain DNS record types that they use for advertising and discovering services.

Section 4.1 of [RFC6763] specifies that a service instance name in DNS-SD has the following structure:

<Instance> . <Service> . <Domain>

The <Domain> portion specifies the DNS sub-domain where the service instance is registered. It may be "local.", indicating the mDNS local domain, or it may be a conventional domain name such as "example.com.".

The <Service> portion of the DOTS service instance name MUST be "_dots._signal._udp" or "_dots._signal._tcp" or "_dots._data._tcp" or "_dots-call-home._signal._udp" or "_dots-call-home._signal._tcp".

8. Security Considerations

DOTS-related security considerations are discussed in Section 4 of [I-D.ietf-dots-architecture] is to be considered. DOTS agents must authenticate each other using (D)TLS before a DOTS session is considered valid according to the [I-D.ietf-dots-signal-channel].

8.1. DHCP

The security considerations in [RFC2131] and [RFC8415] are to be considered.

8.2. Service Resolution

The primary attack against the methods described in Section 6 is one that would lead to impersonation of a DOTS server. An attacker could attempt to compromise the S-NAPTR resolution. The use of mutual authentication makes it difficult to redirect a DOTS client to an illegitimate DOTS server.

8.3. DNS Service Discovery

Since DNS-SD is just a specification for how to name and use records in the existing DNS system, it has no specific additional security requirements over and above those that already apply to DNS queries and DNS updates. For DNS queries, DNS Security Extensions (DNSSEC) [RFC4033] SHOULD be used where the authenticity of information is important. For DNS updates, secure updates [RFC2136][RFC3007] SHOULD generally be used to control which clients have permission to update DNS records.

9. IANA Considerations

IANA is requested to allocate the SRV service name of "_dots._signal" for DOTS signal channel over UDP or TCP, and the service name of "_dots._data" for DOTS data channel over TCP.

9.1. DHCPv6 Option

IANA is requested to assign the following new DHCPv6 Option Code in the registry maintained in: http://www.iana.org/assignments/dhcpv6-parameters.

Value	Description	Client ORO	Singleton Option
TBD1	OPTION_V6_DOTS_RI	Yes	Yes
TBD2	OPTION_V6_DOTS_ADDRESS	Yes	No

9.2. DHCPv4 Option

IANA is requested to assign the following new DHCPv4 Option Code in the registry maintained in: http://www.iana.org/assignments/bootp-dhcp-parameters/.

Option Name	Value	Data length	Meaning
OPTION_V4_DOTS_RI	TBA3	Variable; the maximum length is 255 octets.	Includes the name of the DOTS server.
OPTION_V4_DOTS_ADDRESS	TBA4	Variable; the minimum length is 5.	Includes one or multiple lists of DOTS IP addresses; each list is treated as a separate DOTS server.

9.3. Application Service & Application Protocol Tags

This document requests IANA to make the following allocations from the registry available at: https://www.iana.org/assignments/s-naptr-parameters/s-naptr-parameters.xhtml.

9.3.1. DOTS Application Service Tag Registration

- Application Protocol Tag: DOTS
- Intended Usage: See Section 6
- Security Considerations: See Section 8
- Contact Information: <one of the authors>

9.3.2. DOTS Call Home Application Service Tag Registration

- Application Protocol Tag: DOTS-CALL-HOME
- Intended Usage: See Section 6
- Security Considerations: See Section 8
- Contact Information: <one of the authors>

9.3.3. signal.udp Application Protocol Tag Registration

- Application Protocol Tag: signal.udp
- Intended Usage: See Section 6
- Security Considerations: See Section 8
- Contact Information: <one of the authors>

9.3.4. signal.tcp Application Protocol Tag Registration

- Application Protocol Tag: signal.tcp
- Intended Usage: See Section 6
- Security Considerations: See Section 8
- Contact Information: <one of the authors>

9.3.5. data.tcp Application Protocol Tag Registration

- Application Protocol Tag: data.tcp
- Intended Usage: See Section 6
- Security Considerations: See Section 8
- Contact Information: <one of the authors>

10. Contributors

Prashanth Patil
Cisco Systems, Inc.

Email: praspati@cisco.com

11. Acknowledgements

Thanks to Brian Carpenter for the review of the BRSKI text.

Many thanks to Russ White for the review, comments, and text contribution.

Thanks for Dan Wing and Pei Wei for the review and comments.

Thanks to Bernie Volz for the review of the DHCP section.

12. References

12.1. Normative References

[I-D.ietf-dots-signal-channel]
K, R., Boucadair, M., Patil, P., Mortensen, A., and N. Teague, "Distributed Denial-of-Service Open Threat Signaling (DOTS) Signal Channel Specification", draft-ietf-dots-signal-channel-34 (work in progress), May 2019.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[RFC2131] Droms, R., "Dynamic Host Configuration Protocol", RFC 2131, DOI 10.17487/RFC2131, March 1997, <https://www.rfc-editor.org/info/rfc2131>.

[RFC2132] Alexander, S. and R. Droms, "DHCP Options and BOOTP Vendor Extensions", RFC 2132, DOI 10.17487/RFC2132, March 1997, <https://www.rfc-editor.org/info/rfc2132>.

[RFC3396] Lemon, T. and S. Cheshire, "Encoding Long Options in the Dynamic Host Configuration Protocol (DHCPv4)", RFC 3396, DOI 10.17487/RFC3396, November 2002, <https://www.rfc-editor.org/info/rfc3396>.

[RFC3958] Daigle, L. and A. Newton, "Domain-Based Application Service Location Using SRV RRs and the Dynamic Delegation Discovery Service (DDDS)", RFC 3958, DOI 10.17487/RFC3958, January 2005, <https://www.rfc-editor.org/info/rfc3958>.

[RFC4291] Hinden, R. and S. Deering, "IP Version 6 Addressing Architecture", RFC 4291, DOI 10.17487/RFC4291, February 2006, <https://www.rfc-editor.org/info/rfc4291>.

[RFC6763] Cheshire, S. and M. Krochmal, "DNS-Based Service Discovery", RFC 6763, DOI 10.17487/RFC6763, February 2013, <https://www.rfc-editor.org/info/rfc6763>.

[RFC6890] Cotton, M., Vegoda, L., Bonica, R., Ed., and B. Haberman, "Special-Purpose IP Address Registries", BCP 153, RFC 6890, DOI 10.17487/RFC6890, April 2013, <https://www.rfc-editor.org/info/rfc6890>.

[RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174, May 2017, <https://www.rfc-editor.org/info/rfc8174>.

[RFC8415] Mrugalski, T., Siodelski, M., Volz, B., Yourtchenko, A., Richardson, M., Jiang, S., Lemon, T., and T. Winters, "Dynamic Host Configuration Protocol for IPv6 (DHCPv6)", RFC 8415, DOI 10.17487/RFC8415, November 2018, <https://www.rfc-editor.org/info/rfc8415>.

12.2. Informative References

[I-D.ietf-anima-bootstrapping-keyinfra]
Pritikin, M., Richardson, M., Behringer, M., Bjarnason, S., and K. Watsen, "Bootstrapping Remote Secure Key Infrastructures (BRSKI)", draft-ietf-anima-bootstrapping-keyinfra-21 (work in progress), June 2019.

[I-D.ietf-dots-architecture]
Mortensen, A., K, R., Andreasen, F., Teague, N., and R. Compton, "Distributed-Denial-of-Service Open Threat Signaling (DOTS) Architecture", draft-ietf-dots-architecture-14 (work in progress), May 2019.

[I-D.ietf-dots-data-channel]
Boucadair, M. and R. K, "Distributed Denial-of-Service Open Threat Signaling (DOTS) Data Channel Specification", draft-ietf-dots-data-channel-29 (work in progress), May 2019.

[I-D.ietf-dots-multihoming]
Boucadair, M. and R. K, "Multi-homing Deployment Considerations for Distributed-Denial-of-Service Open Threat Signaling (DOTS)", draft-ietf-dots-multihoming-01 (work in progress), January 2019.

[I-D.ietf-dots-signal-call-home]
K, R., Boucadair, M., and J. Shallow, "Distributed Denial-of-Service Open Threat Signaling (DOTS) Signal Channel Call Home", draft-ietf-dots-signal-call-home-02 (work in progress), May 2019.

[I-D.ietf-dots-use-cases]
Dobbins, R., Migault, D., Fouant, S., Moskowitz, R., Teague, N., Xia, L., and K. Nishizuka, "Use cases for DDoS Open Threat Signaling", draft-ietf-dots-use-cases-17 (work in progress), January 2019.

[I-D.ietf-netconf-zerotouch]
Watsen, K., Abrahamsson, M., and I. Farrer, "Secure Zero Touch Provisioning (SZTP)", draft-ietf-netconf-zerotouch-29 (work in progress), January 2019.

[RFC2136] Vixie, P., Ed., Thomson, S., Rekhter, Y., and J. Bound, "Dynamic Updates in the Domain Name System (DNS UPDATE)", RFC 2136, DOI 10.17487/RFC2136, April 1997, <https://www.rfc-editor.org/info/rfc2136>.

[RFC3007] Wellington, B., "Secure Domain Name System (DNS) Dynamic Update", RFC 3007, DOI 10.17487/RFC3007, November 2000, <https://www.rfc-editor.org/info/rfc3007>.

[RFC4033] Arends, R., Austein, R., Larson, M., Massey, D., and S. Rose, "DNS Security Introduction and Requirements", RFC 4033, DOI 10.17487/RFC4033, March 2005, <https://www.rfc-editor.org/info/rfc4033>.

[RFC6125] Saint-Andre, P. and J. Hodges, "Representation and Verification of Domain-Based Application Service Identity within Internet Public Key Infrastructure Using X.509 (PKIX) Certificates in the Context of Transport Layer Security (TLS)", RFC 6125, DOI 10.17487/RFC6125, March 2011, <https://www.rfc-editor.org/info/rfc6125>.

[RFC7227] Hankins, D., Mrugalski, T., Siodelski, M., Jiang, S., and S. Krishnan, "Guidelines for Creating New DHCPv6 Options", BCP 187, RFC 7227, DOI 10.17487/RFC7227, May 2014, <https://www.rfc-editor.org/info/rfc7227>.

Authors' Addresses

Mohamed Boucadair
Orange
Rennes 35000
France

Email: mohamed.boucadair@orange.com

Tirumaleswar Reddy
McAfee, Inc.
Embassy Golf Link Business Park
Bangalore, Karnataka 560071
India

Email: TirumaleswarReddy_Konda@McAfee.com