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DDoS Open Threat Signaling (DOTS) Agent Discovery

Abstract

This document specifies mechanisms to configure DDoS Open Threat Signaling (DOTS) clients with their DOTS servers. The discovery procedure also covers the DOTS signal channel Call Home. It can be useful to know the appropriate DOTS server for a given location in order to engage mitigation actions. This is true even in cases where the DOTS client cannot localize the attack: cases where it only knows that some resources are under attack and that help is needed.

Status of This Memo

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Contributors

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1. Introduction

DDoS Open Threat Signaling (DOTS) [RFC8811] 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, the DOTS signal channel protocol [RFC8782] is meant to carry requests for DDoS attack mitigation. With this approach, DOTS can reduce the impact of an attack and lead to more efficient defensive actions in various deployment scenarios, such as those discussed in [DOTS-USE-CASES]. Moreover, DOTS clients can instruct a DOTS server to install named filtering rules by means of the DOTS data channel protocol [RFC8783].

The basic high-level DOTS architecture is illustrated in [Figure 1](#).

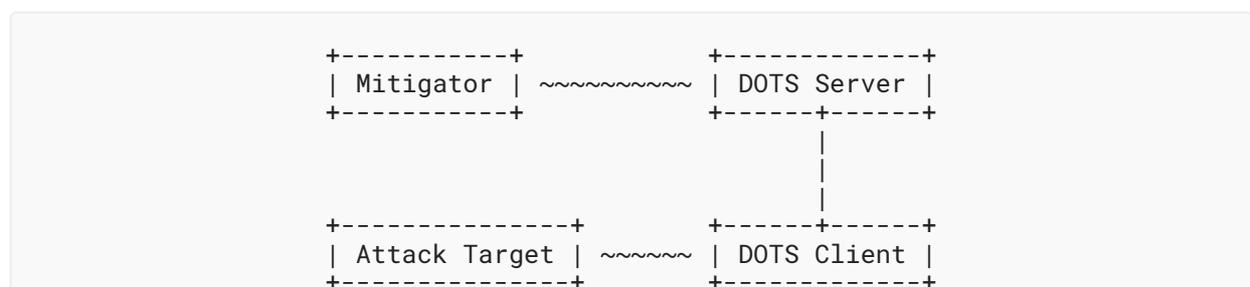


Figure 1: Basic DOTS Architecture

[RFC8811] 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 [DOTS-SIG-CALL-HOME]. The basic high-level DOTS Call Home architecture is illustrated in Figure 2.

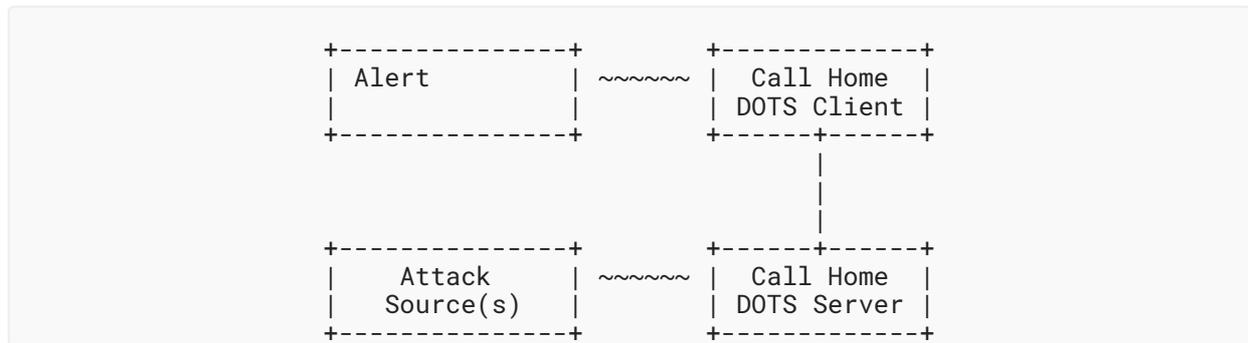


Figure 2: Basic DOTS Signal Channel Call Home Functional Architecture

A DOTS agent may be used to establish base DOTS channels, DOTS Call Home, or both. This specification accommodates all these deployment cases.

Considerations for the selection of DOTS server(s) by multihomed DOTS clients are out of this document's scope; readers should refer to [DOTS-MULTIHOMING] for more details.

This document assumes that security credentials to authenticate DOTS server(s) are pre-provisioned to a DOTS client using a mechanism such as (but not limited to) those discussed in [RFC8572] or [BTSRP-KEYINF]. DOTS clients use those credentials for authentication purposes following the rules documented in [RFC8782].

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 [RFC3958].

This document makes use of the following terms:

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

DOTS client: refers to a DOTS-aware software module responsible for requesting attack response coordination with other DOTS-aware elements.

DOTS server: is a DOTS-aware software module handling and responding to messages from DOTS clients. The DOTS server enables mitigation on behalf of the DOTS client, if requested, by communicating the DOTS client's request to the mitigator and returning selected mitigator feedback to the requesting DOTS client.

Call Home DOTS client or server: refers to a DOTS client or server deployed in a Call Home scenario ([Figure 2](#)).

DOTS agent: is any DOTS-aware software module capable of participating in a DOTS channel.

Peer DOTS agent: refers to the peer DOTS server (base DOTS operation) or to a peer Call Home DOTS client (for DOTS signal channel Call Home).

3. Why Multiple Discovery Mechanisms?

Analysis of the various use cases sketched in [[DOTS-USE-CASES](#)] reveals that it is unlikely that one single discovery method can be suitable for all the sample deployments. Concretely:

- Many of the use cases discussed in [[DOTS-USE-CASES](#)] do involve Customer Premises Equipment (CPE). Multiple CPEs connected to distinct network providers may even be considered. It is intuitive to leverage 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) requires the use of the appropriate DNS resolvers; otherwise, resolving those names will fail. The use of protocols, such as DHCP, does allow associating provisioned DOTS server domain names with a list of DNS servers to be used for name resolution. Furthermore, DHCP allows for directly providing IP addresses, therefore, avoiding 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 existing protocol behaviors that do not require specific features 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., an enterprise network). Dynamic discovery needs to be deterministic 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](#)) that involves the following mechanisms:

- dynamic discovery using DHCP ([Section 5](#))
- a resolution mechanism based on S-NAPTR resource records in the DNS ([Section 6](#))
- DNS Service Discovery ([Section 7](#))

4. DOTS Discovery Procedure

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 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 the following ways to discover DOTS servers in order to facilitate the deployment of DOTS in large-scale environments. For example, a CPE will support the first two mechanisms, a host within a LAN will support the last two mechanisms, or an application server will support a local configuration. More examples are discussed in [Section 3](#). DOTS clients will prefer information received from the discovery methods in the order listed below.

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 a 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 a list of IP addresses or the DNS name of a DOTS server. When only DOTS server IP addresses are configured, a reference identifier must also be configured for authentication purposes.

Automatic Configuration (e.g., DHCP): 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-based 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 suitable DNS configuration.

On hosts with more than one interface or address family (IPv4/IPv6), the DOTS server discovery procedure has to be performed for each interface-/address-family combination. A DOTS 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 interface-/address-family combinations.

This procedure is also followed by a Call Home DOTS server to discover its Call Home DOTS client in the context of [[DOTS-SIG-CALL-HOME](#)].

The discovery method is performed upon the bootstrapping of a DOTS agent and is reiterated by the DOTS agent upon the following events:

- expiry of a validity timer (e.g., DHCP lease, DHCP information refresh time, or DNS TTL) associated with a discovered DOTS agent
- expiry of the certificate of a peer DOTS agent currently in use
- attachment to a new network

5. DHCP Options for DOTS Agent Discovery

As reported in [Section 1.7.2](#) of [[RFC6125](#)]:

Some 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 the current best practices for issuing certificates, this document allows DOTS agents to retrieve the names of their peer DOTS agents. These names can be used for two purposes: (1) to retrieve the list of IP addresses of a peer DOTS agent or (2) to be presented as a reference identifier for authentication purposes.

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

Given that DOTS gateways can be involved in a DOTS session, a peer DOTS agent can be reachable using a link-local address. Such addresses can also be discovered using the options defined in [Section 5.1](#).

The list of the IP addresses returned by DHCP servers is typically used to feed the DOTS server selection procedure, including when DOTS agents are provided with primary and backup IP addresses of their peer DOTS agents. An example of the DOTS server selection procedure is specified in [Section 4.3](#) of [[RFC8782](#)].

5.1.3. DHCPv6 Client Behavior

DHCP clients **MAY** request options `OPTION_V6_DOTS_RI` and `OPTION_V6_DOTS_ADDRESS`, as defined in Sections 18.2.1, 18.2.2, 18.2.4, 18.2.5, 18.2.6, and 21.7 of [RFC8415]. 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 `OPTION_V6_DOTS_RI` (or `OPTION_V6_DOTS_ADDRESS`), it **MUST** use only the first instance of that option.

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

If the DHCP client receives and validates both `OPTION_V6_DOTS_RI` and `OPTION_V6_DOTS_ADDRESS`, the content of `OPTION_V6_DOTS_RI` is used as the reference identifier for authentication purposes (e.g., PKIX [RFC6125]), while the valid 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 an underlying resolution library in the presence of a valid `OPTION_V6_DOTS_ADDRESS` in a response.

If the DHCP client receives `OPTION_V6_DOTS_RI` only, but `OPTION_V6_DOTS_RI` contains more than one name, 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_V6_DOTS_ADDRESS` only, the address(es) included in `OPTION_V6_DOTS_ADDRESS` are used to reach the peer DOTS agent. In addition, these addresses can be used as identifiers for authentication.

5.2. DHCPv4 DOTS Options

5.2.1. Format of DOTS Reference Identifier Option

The DHCPv4 [RFC2132] DOTS Reference Identifier option is used to configure a name of the peer DOTS agent. The format of this option is illustrated in Figure 6.

| Code | Length | Peer DOTS agent name | | | | | |
|------|--------|----------------------|----|----|----|----|-----|
| 147 | n | s1 | s2 | s3 | s4 | s5 | ... |

Figure 6: DHCPv4 DOTS Reference Identifier Option

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

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

Code: OPTION_V4_DOTS_RI (147, see [Section 9.3](#)).

Length: Includes the length of the "Peer DOTS agent name" field in 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 7](#).

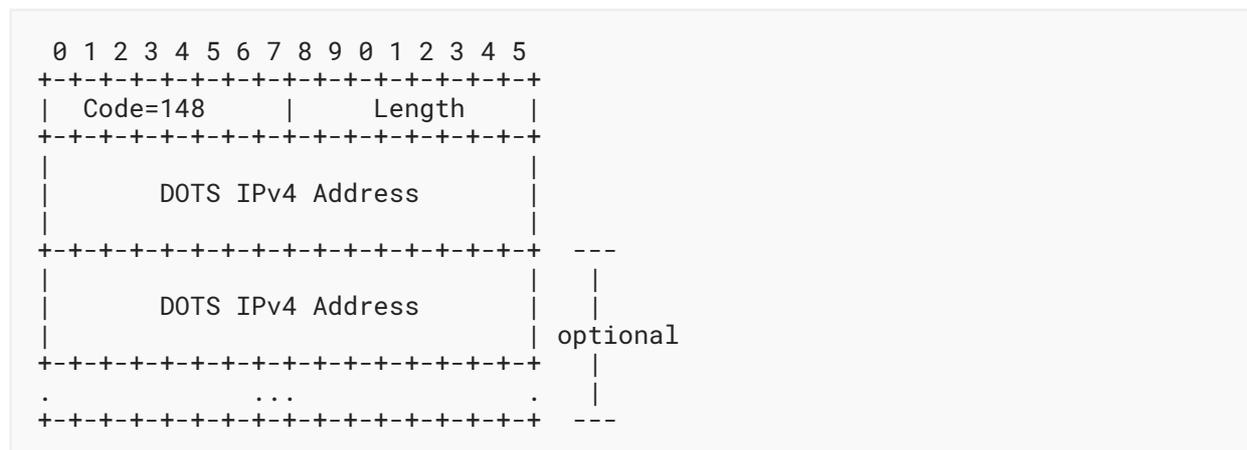


Figure 7: DHCPv4 DOTS Address Option

The fields of the option shown in [Figure 7](#) are as follows:

Code: OPTION_V4_DOTS_ADDRESS (148, see [Section 9.3](#)).

Length: Set to $4*N$, where N is the number of IPv4 addresses included in the option.

DOTS IPv4 Address(es): Contains one or more IPv4 addresses of the peer DOTS agent to be used by a DOTS agent. The addresses are listed in the order of preference for use by the DOTS agent.

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 option, it **MUST** use only the first instance of that option.

The DHCP client **MUST** silently discard multicast and host loopback addresses [\[RFC6890\]](#) conveyed in OPTION_V4_DOTS_ADDRESS.

If the DHCP client receives and validates both `OPTION_V4_DOTS_RI` and `OPTION_V4_DOTS_ADDRESS`, the content of `OPTION_V4_DOTS_RI` is used as the reference identifier for authentication purposes (e.g., PKIX [RFC6125]), while the valid 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 an underlying resolution library in the presence of valid `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` are used to reach the peer DOTS server. In addition, these addresses can be used as identifiers for authentication.

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 agent 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 the peer DOTS agent IP address(es).

Once the DOTS agent has retrieved its DNS domain or discovered the peer DOTS agent name that needs to be resolved, an S-NAPTR lookup with the appropriate application service and the desired protocol tag is made to obtain information necessary to connect to the authoritative peer DOTS agent within the given domain.

This specification defines "DOTS" and "DOTS-CALL-HOME" as application service tags (Sections 9.4.1 and 9.4.2). It also defines "signal.udp" (Section 9.4.3), "signal.tcp" (Section 9.4.4), and "data.tcp" (Section 9.4.5) 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, port, tag, and protocol tuples listed in Table 1.

```

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.
IN NAPTR 200 10 "a" DOTS:data.tcp "" b.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

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

```

Figure 8: Example of Discovery of DOTS Servers Using Service Resolution

| 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 |
| 4 | TCP | 2001:db8::2 | 443 | Data |

Table 1: Resolution Results

An example is provided in [Figure 9](#) for the Call Home case. In this example, the resolution algorithm will result in IP address, port, and protocol tuples listed in [Table 2](#) for domain "example.net".

```

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

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

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

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

```

Figure 9: Example of Discovery of DOTS Call Home Client Using Service Resolution

| Order | Protocol | IP address | Port |
|-------|----------|-------------|------|
| 1 | UDP | 2001:db8::2 | 6000 |
| 2 | TCP | 2001:db8::2 | 6001 |

Table 2: Resolution Results (Call Home)

Note that customized port numbers are used for the DOTS signal channel, DOTS data channel, and DOTS signal channel Call Home in the examples shown in Figures 8 and 9 for illustration purposes. If default port numbers are used in a deployment, the discovery procedure will return 4646 (DOTS signal channel) and 443 (DOTS data channel) as DOTS service port numbers.

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 subdomain where the service instance is registered. It is a conventional domain name, such as "example.com".

The <Service> portion of the DOTS service instance name **MUST** be "_dots-signal._udp", "_dots-signal._tcp", "_dots-data._tcp", "_dots-call-home._udp", or "_dots-call-home._tcp".

This document does not define any keys; the TXT record of a DNS-SD service is thus empty (Section 6 of [RFC6763]).

Figure 10 depicts an excerpt of the DNS zone configuration file listing record examples to discover two DOTS signal channel servers. In this example, only UDP is supported as transport for the establishment of the DOTS signal channel.

```
_dots-signal._udp.example.net. PTR a._dots-signal._udp.example.net.  
_dots-signal._udp.example.net. PTR b._dots-signal._udp.example.net.  
a._dots-signal._udp.example.net. SRV 0 0 4646 a.example.net.  
b._dots-signal._udp.example.net. SRV 0 0 4646 b.example.net.  
a._dots-signal._udp.example.net. TXT ""  
b._dots-signal._udp.example.net. TXT ""
```

Figure 10: An Example of DNS-SD Records for the UDP DOTS Signal Channel Involving Two Servers with the Same Priority

8. Security Considerations

DOTS-related security considerations are discussed in Section 5 of [RFC8811]. As a reminder, DOTS agents must authenticate each other using (D)TLS before a DOTS session is considered valid according to the [RFC8782].

An attacker may block some protocol messages (e.g., DHCP) to force the client to use a discovery mechanism with a lower priority. The security implications of such attack are those inherent to the fallback discovery mechanism discussed in the following subsections.

The results of the discovery procedure are a function of the interface/address family. Contacting a discovered DOTS server via an interface to which it is not bound may exacerbate the delay required to establish a DOTS channel. Moreover, such behavior may reveal that a DOTS service is enabled by a DOTS client domain and exposes the identity of the DOTS service provider (which can be inferred from the name and the destination IP address) to external networks.

Security considerations related to how security credentials to authenticate DOTS server(s) are provisioned to a DOTS client are those inherent to the mechanism used for that purpose (for example, see [RFC8572]).

8.1. DHCP

The security considerations in [\[RFC2131\]](#) and [\[RFC8415\]](#) are to be considered. In particular, issues related to rogue DHCP servers and means to mitigate many of these attacks are discussed in [Section 22](#) of [\[RFC8415\]](#).

An attacker can get a domain name, get a domain-validated public certificate from a certification authority (CA), and host a DOTS agent. An active attacker can then spoof DHCP responses to include the attacker's DOTS agent. Such an attacker can also launch other attacks, as discussed in [Section 22](#) of [\[RFC8415\]](#). In addition to the mitigations listed in [Section 22](#) of [\[RFC8415\]](#), a DOTS agent may be preconfigured with a list of trusted DOTS domain names. If such a list is preconfigured, a DOTS agent will accept a DHCP-discovered name if it matches a name in that list. Also, the DOTS agent has to check that the "DNS-ID" identifier type within subjectAltName in the server certificate matches a preconfigured name. If the DOTS agent is instructed to trust subdomains of the names in that list as well (e.g., "*.example.com"), a DOTS agent will accept a DHCP-discovered name that matches a name in the preconfigured list (e.g., "dots-1.example.com" or "dots-2.example.com").

Relying on an underlying resolution library to resolve a supplied reference identifier has similar security issues as those discussed in [Section 8.2](#) (e.g., an active attacker may modify DNS messages used to resolve the supplied reference identifier and point the client to an attacker server).

Supplying both an IP address and the reference identifier makes it easier to use a mis-issued certificate.

8.2. Service Resolution

The primary attack against the methods described in [Section 6](#) is one that would lead to impersonation of a peer DOTS agent. An attacker could attempt to compromise the S-NAPTR resolution.

The DOTS client (or a Call Home DOTS server) constructs one reference identifier for the DOTS server (or a Call Home DOTS client) based on the domain name that is used for S-NAPTR lookup: DNS-ID. If the reference identifier is found (as described in [Section 6](#) of [\[RFC6125\]](#)) in the PKIX certificate's subjectAltName extension, the DOTS client should accept the certificate for the server.

DNS Security Extensions (DNSSEC) [\[RFC4033\]](#) uses cryptographic keys and digital signatures to provide authentication of DNS data. The information that is retrieved from the S-NAPTR lookup and that is validated using DNSSEC is thereby proved to be the authoritative data.

8.3. DNS Service Discovery

Since DNS-SD is 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, DNSSEC **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.

Note that means such as DNS over TLS (DoT) [RFC7858] or DNS over HTTPS (DoH) [RFC8484] can be used to prevent eavesdroppers from accessing DNS messages.

9. IANA Considerations

9.1. Service Name and Transport Protocol Port Number Registry

IANA has allocated the following service names from the registry available at: <<https://www.iana.org/assignments/service-names-port-numbers/>>.

| | |
|------------------------|--|
| Service Name: | dots-data |
| Port Number: | N/A |
| Transport Protocol(s): | TCP |
| Description: | DOTS Data Channel Protocol. The service name is used to construct the SRV service name "_dots-data._tcp" for discovering DOTS servers used to establish DOTS data channel. |
| Assignee: | IESG: iesg@ietf.org |
| Contact: | IETF Chair: chair@ietf.org |
| Reference: | [RFC8973] |

| | |
|------------------------|---|
| Service Name: | dots-call-home |
| Transport Protocol(s): | TCP/UDP |
| Description: | DOTS Signal Channel Call Home Protocol. The service name is used to construct the SRV service names "_dots-call-home._udp" and "_dots-call-home._tcp" for discovering Call Home DOTS clients used to establish DOTS signal channel Call Home. |
| Assignee: | IESG: iesg@ietf.org |
| Contact: | IETF Chair: chair@ietf.org |
| Reference: | [RFC8973] |

IANA has updated the following entry from the registry available at: <<https://www.iana.org/assignments/service-names-port-numbers/>>.

| | |
|------------------------|---------|
| Port Number: | 4646 |
| Transport Protocol(s): | TCP/UDP |

Description: DOTS Signal Channel Protocol. The service name is used to construct the SRV service names "_dots-signal._udp" and "_dots-signal._tcp" for discovering DOTS servers used to establish DOTS signal channel.

Assignee: IESG: iesg@ietf.org

Contact: IETF Chair: chair@ietf.org

Reference: [RFC8782][RFC8973]

9.2. DHCPv6 Options

IANA has assigned the following new DHCPv6 Option Codes in the registry maintained in <https://www.iana.org/assignments/dhcpv6-parameters/>.

| Value | Description | Client ORO | Singleton Option |
|-------|------------------------|------------|------------------|
| 141 | OPTION_V6_DOTS_RI | Yes | Yes |
| 142 | OPTION_V6_DOTS_ADDRESS | Yes | Yes |

Table 3: DHCPv6 Options

9.3. DHCPv4 Options

IANA has assigned the following new DHCPv4 Option Codes in the registry maintained in <https://www.iana.org/assignments/bootp-dhcp-parameters/>.

| Name | Tag | Data Length | Meaning | Reference |
|------------------------|-----|-----------------------------|---|-----------|
| OPTION_V4_DOTS_RI | 147 | N | The name of the peer DOTS agent. | [RFC8973] |
| OPTION_V4_DOTS_ADDRESS | 148 | N (the minimal length is 4) | N/4 IPv4 addresses of peer DOTS agent(s). | [RFC8973] |

Table 4: DHCPv4 Options

9.4. Application Service & Application Protocol Tags

IANA has made the following allocations from the registries available at <https://www.iana.org/assignments/s-naptr-parameters/> for application service tags and application protocol tags.

9.4.1. DOTS Application Service Tag Registration

Application Service Tag: DOTS

Intended Usage: See [Section 6](#)

Security Considerations: See [Section 8](#)

Interoperability Considerations: None

Relevant Publications: RFC 8973

9.4.2. DOTS Call Home Application Service Tag Registration

Application Service Tag: DOTS-CALL-HOME
Intended Usage: See [Section 6](#)
Security Considerations: See [Section 8](#)
Interoperability Considerations: None
Relevant Publications: RFC 8973

9.4.3. signal.udp Application Protocol Tag Registration

Application Protocol Tag: signal.udp
Intended Usage: See [Section 6](#)
Security Considerations: See [Section 8](#)
Interoperability Considerations: None
Relevant Publications: RFC 8973

9.4.4. signal.tcp Application Protocol Tag Registration

Application Protocol Tag: signal.tcp
Intended Usage: See [Section 6](#)
Security Considerations: See [Section 8](#)
Interoperability Considerations: None
Relevant Publications: RFC 8973

9.4.5. data.tcp Application Protocol Tag Registration

Application Protocol Tag: data.tcp
Intended Usage: See [Section 6](#)
Security Considerations: See [Section 8](#)
Interoperability Considerations: None
Relevant Publications: RFC 8973

10. References

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