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**Distributed-Denial-of-Service Open Threat Signaling (DOTS) Server  
Discovery  
draft-ietf-dots-server-discovery-01**

**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.

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## 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](#)]):

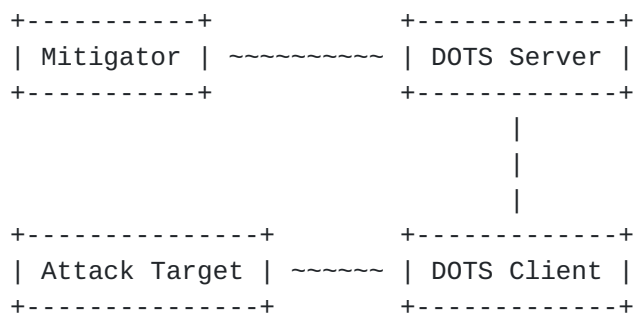


Figure 1: Basic DOTS Architecture

[[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](#).

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.



Likewise, happy eyeballs considerations for DOTS signal channel protocol are out of scope. The reader should refer to Section 4 of [\[I-D.ietf-dots-signal-channel\]](#).

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 [\[I-D.ietf-netconf-zero-touch\]](#) 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 [\[RFC8415\]](#).

## 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:

- o 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).
- o 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.



- o 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.
- o 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).
- o 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.
- o 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:

- o Dynamic discovery using DHCP ([Section 5](#)).
- o A resolution mechanism based on straightforward Naming Authority Pointer (S-NAPTR) resource records in the Domain Name System (DNS) ([Section 6](#)).
- o 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.

The discovery method **MUST** be reiterated upon the following events:

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

## **5. DHCP Options for DOTS**

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 DOTS server 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 option is used to configure a name of the DOTS server. The format of this option is shown in Figure 2.







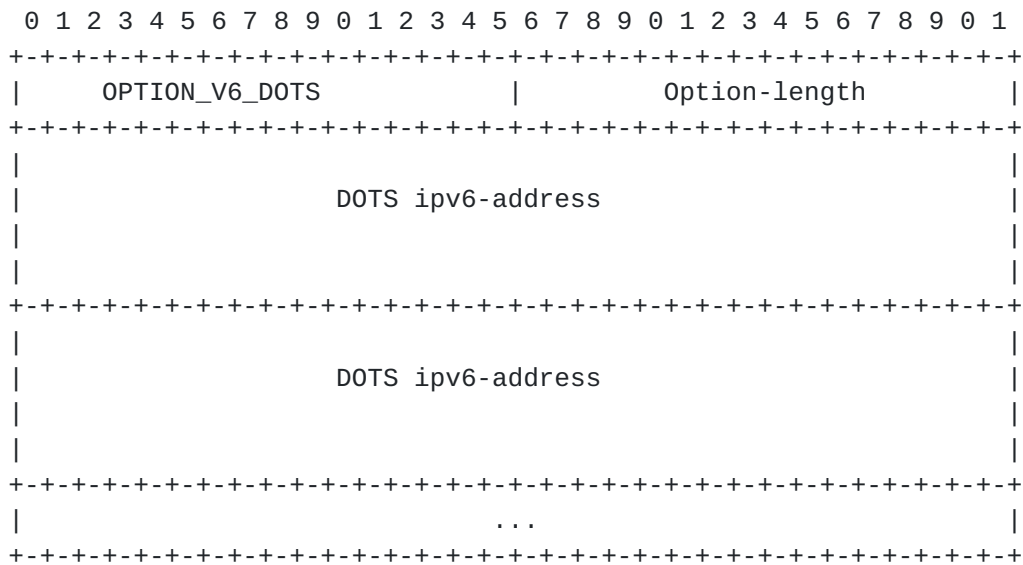


Figure 4: DHCPv6 DOTS Address option

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

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

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 servers to the requesting DHCPv6 client, the DHCPv6 server returns multiple instances of `OPTION_V6_DOTS`.

### 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` (resp. `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 DOTS server. 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 DOTS server. 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 option is used to configure a name of the DOTS server. The format of this option is illustrated in Figure 5.

```

Code  Length  DOTS server name
+-----+-----+-----+-----+-----+-----+-----+
|TBA3| | n | | s1 | | s2 | | s3 | | s4 | | s5 | | ...
+-----+-----+-----+-----+-----+-----+-----+

```

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:

- o Code: `OPTION_V4_DOTS_RI` (TBA3, see [Section 9.2](#));
- o Length: Includes the length of the "DOTS server name" field in octets; the maximum length is 255 octets.
- o DOTS server name: The domain name of the DOTS server. This field is formatted as specified in [Section 10 of \[RFC8415\]](#).



### 5.2.2. Format Format of DOTS Address Option

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

```

  0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5
+---+---+---+---+---+---+---+---+---+
| Code=TBA4      |      Length      |
+---+---+---+---+---+---+---+---+---+
| List-Length    |      List of      |
+---+---+---+---+---+---+---+---+
/      IPv4 Addresses      /
+---+---+---+---+---+---+---+---+ ---
| List-Length    |      List of      |  |
+---+---+---+---+---+---+---+---+  |
/      IPv4 Addresses      /  |
+---+---+---+---+---+---+---+---+  |
.      ...      . optional
+---+---+---+---+---+---+---+---+  |
| List-Length    |      List of      |  |
+---+---+---+---+---+---+---+---+  |
/      IPv4 Addresses      /  |
+---+---+---+---+---+---+---+---+ ---

```

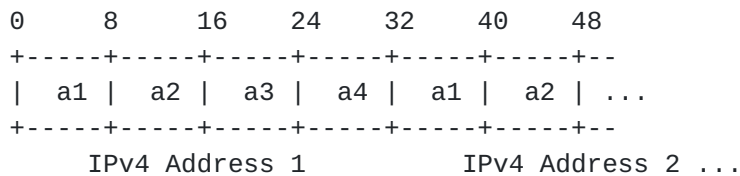
Figure 6: DHCPv4 DOTS Address option

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

- o Code: OPTION\_V4\_DOTS\_ADDRESS (TBA4, see [Section 9.2](#));
- o Length: Length of all included data in octets. The minimum length is 5.
- o List-Length: Length of the "List of DOTS IPv4 Addresses" field in octets; MUST be a multiple of 4.
- o List of DOTS IPv4 Addresses: Contains one or more IPv4 addresses of the DOTS server to be used by the DOTS client. The format of this field is shown in Figure 7.
- o OPTION\_V4\_DOTS can include multiple lists of DOTS IPv4 addresses; each list is treated separately as it corresponds to a given DOTS server.

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 is a concatenation-requiring option. As such, the mechanism specified in [\[RFC3396\]](#) MUST be used if OPTION\_V4\_DOTS exceeds the maximum DHCPv4 option size of 255 octets.

### 5.2.3. DHCPv4 Client Behavior

To discover a DOTS server, 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 (resp. 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\_V4\_DOTS\_RI is used as reference identifier for authentication purposes, while the addresses included in OPTION\_V4\_DOTS\_ADDRESS are used to reach the DOTS server. 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 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. 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 DOTS server 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" as an application service tag ([Section 9.3.1](#)) and "signal.udp" ([Section 9.3.2](#)), "signal.tcp" ([Section 9.3.3](#)), and "data.tcp" ([Section 9.3.4](#)) as application protocol tags.





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

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".

## **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/>:

Option Name	Value
-----	
OPTION_V6_DOTS_RI	TBA1
OPTION_V6_DOTS_ADDRESS	TBA2

### 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; length is 255 octets.	Includes the name of the maximum DOTS server.
OPTION_V4_DOTS_ADDRESS	TBA4	Variable; 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

- o Application Protocol Tag: DOTS
- o Intended Usage: See [Section 6](#)



- o Security Considerations: See [Section 8](#)
- o Contact Information: <one of the authors>

#### **[9.3.2.](#) signal.udp Application Protocol Tag Registration**

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

#### **[9.3.3.](#) signal.tcp Application Protocol Tag Registration**

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

#### **[9.3.4.](#) data.tcp Application Protocol Tag Registration**

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

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