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Discovery of Designated Resolvers

Abstract

This document defines Discovery of Designated Resolvers (DDR), a mechanism for DNS clients to use DNS records to discover a resolver's encrypted DNS configuration. This mechanism can be used to move from unencrypted DNS to encrypted DNS when only the IP address of a resolver is known. This mechanism is designed to be limited to cases where unencrypted resolvers and their designated resolvers are operated by the same entity or cooperating entities. It can also be used to discover support for encrypted DNS protocols when the name of an encrypted resolver is known.

Discussion Venues

This note is to be removed before publishing as an RFC.

Discussion of this document takes place on the Adaptive DNS Discovery Working Group mailing list (add@ietf.org), which is archived at https://mailarchive.ietf.org/arch/browse/add/.

Source for this draft and an issue tracker can be found at https://github.com/ietf-wg-add/draft-ietf-add-ddr.

Status of This Memo

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1. Introduction

When DNS clients wish to use encrypted DNS protocols such as DNS-over-TLS (DoT) [RFC7858] or DNS-over-HTTPS (DoH) [RFC8484], they require additional information beyond the IP address of the DNS server, such as the resolver's hostname, non-standard ports, or URL paths. However, common configuration mechanisms only provide the resolver's IP address during configuration. Such mechanisms include

network provisioning protocols like DHCP [RFC2132] and IPv6 Router Advertisement (RA) options [RFC8106], as well as manual configuration.

This document defines two mechanisms for clients to discover designated resolvers using DNS server Service Binding (SVCB, [I-D.ietf-dnsop-svcb-https]) records:

1. When only an IP address of an Unencrypted Resolver is known, the client queries a special use domain name (SUDN) [RFC6761] to discover DNS SVCB records associated with one or more Encrypted Resolvers the Unencrypted Resolver has designated for use when support for DNS encryption is requested (Section 4).

2. When the hostname of an Encrypted Resolver is known, the client requests details by sending a query for a DNS SVCB record. This can be used to discover alternate encrypted DNS protocols supported by a known server, or to provide details if a resolver name is provisioned by a network (Section 5).

Both of these approaches allow clients to confirm that a discovered Encrypted Resolver is designated by the originally provisioned resolver. "Designated" in this context means that the resolvers are operated by the same entity or cooperating entities; for example, the resolvers are accessible on the same IP address, or there is a certificate that claims ownership over the IP address for the original designating resolver.

1.1. Specification of Requirements

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.

2. Terminology

This document defines the following terms:

DDR: Discovery of Designated Resolvers. Refers to the mechanisms defined in this document.

Designated Resolver: A resolver, presumably an Encrypted Resolver, designated by another resolver for use in its own place. This designation can be verified with TLS certificates.

Encrypted Resolver: A DNS resolver using any encrypted DNS transport. This includes current mechanisms such as DoH and DoT as well as future mechanisms.

Unencrypted Resolver:
A DNS resolver using TCP or UDP port 53.

3. DNS Service Binding Records

DNS resolvers can advertise one or more Designated Resolvers that may offer support over encrypted channels and are controlled by the same entity.

When a client discovers Designated Resolvers, it learns information such as the supported protocols and ports. This information is provided in ServiceMode Service Binding (SVCB) records for DNS Servers, although AliasMode SVCB records can be used to direct clients to the needed ServiceMode SVCB record per [I-D.ietf-dnsop-svcb-https]. The formatting of these records, including the DNS-unique parameters such as "dohpath", are defined by [I-D.ietf-add-svcb-dns].

The following is an example of an SVCB record describing a DoH server discovered by querying for _dns.example.net:

```
_dns.example.net.  7200  IN SVCB 1 example.net. (
     alpn=h2 dohpath=/dns-query{?dns} )
```

The following is an example of an SVCB record describing a DoT server discovered by querying for _dns.example.net:

```
_dns.example.net  7200  IN SVCB 1 dot.example.net (
     alpn=dot port=8530 )
```

If multiple Designated Resolvers are available, using one or more encrypted DNS protocols, the resolver deployment can indicate a preference using the priority fields in each SVCB record [I-D.ietf-dnsop-svcb-https].

If the client encounters a mandatory parameter in an SVCB record it does not understand, it MUST NOT use that record to discover a Designated Resolver. The client can still use others records in the same response if the client can understand all of their mandatory parameters. This allows future encrypted deployments to simultaneously support protocols even if a given client is not aware of all those protocols. For example, if the Unencrypted Resolver returns three SVCB records, one for DoH, one for DoT, and one for a yet-to-exist protocol, a client which only supports DoH and DoT should be able to use those records while safely ignoring the third record.

To avoid name lookup deadlock, Designated Resolvers SHOULD follow the guidance in Section 10 of [RFC8484] regarding the avoidance of DNS-based references that block the completion of the TLS handshake.

This document focuses on discovering DoH and DoT Designated Resolvers. Other protocols can also use the format defined by [I-D.ietf-add-svcb-dns]. However, if any protocol does not involve some form of certificate validation, new validation mechanisms will need to be defined to support validating designation as defined in Section 4.2.

4. Discovery Using Resolver IP Addresses

When a DNS client is configured with an Unencrypted Resolver IP address, it SHOULD query the resolver for SVCB records for "dns://resolver.arpa" before making other queries. Specifically, the client issues a query for _dns.resolver.arpa with the SVCB resource record type (64) [I-D.ietf-dnsop-svcb-https].

Because this query is for an SUDN, which no entity can claim ownership over, the ServiceMode SVCB response MUST NOT use the "." value for the TargetName. Instead, the domain name used for DoT or used to construct the DoH template MUST be provided.

The following is an example of an SVCB record describing a DoH server discovered by querying for _dns.resolver.arpa:

```
_dns.resolver.arpa  7200  IN SVCB 1 doh.example.net (
     alpn=h2 dohpath=/dns-query{?dns} )
```

The following is an example of an SVCB record describing a DoT server discovered by querying for _dns.resolver.arpa:

```
_dns.resolver.arpa  7200  IN SVCB 1 dot.example.net (
     alpn=dot port=8530 )
```

If the recursive resolver that receives this query has one or more Designated Resolvers, it will return the corresponding SVCB records. When responding to these special queries for "dns://resolver.arpa", the recursive resolver SHOULD include the A and AAAA records for the name of the Designated Resolver in the Additional Answers section. This will allow the DNS client to make queries over an encrypted connection without waiting to resolve the Encrypted Resolver name per [I-D.ietf-dnsop-svcb-https]. If no A/AAAA records or SVCB IP address hints are included, clients will be forced to delay use of the Encrypted Resolver until an additional DNS lookup for the A and AAAA records can be made to the Unencrypted Resolver (or some other resolver the DNS client has been configured to use).

If the recursive resolver that receives this query has no Designated Resolvers, it SHOULD return NODATA for queries to the "resolver.arpa" SUDN.

4.1. Use of Designated Resolvers

When a client discovers Designated Resolvers from an Unencrypted Resolver IP address, it can choose to use these Designated Resolvers either automatically, or based on some other policy, heuristic, or user choice.

This document defines two preferred methods to automatically use Designated Resolvers:

- Verified Discovery Section 4.2, for when a TLS certificate can be used to validate the resolver's identity.

- Opportunistic Discovery Section 4.3, for when a resolver is accessed using a non-public IP address.

A client MAY additionally use a discovered Designated Resolver without either of these methods, based on implementation-specific policy or user input. Details of such policy are out of scope of this document. Clients SHOULD NOT automatically use a Designated Resolver without some sort of validation, such as the two methods defined in this document or a future mechanism.

A client MUST NOT use a Designated Resolver designated by one Unencrypted Resolver in place of another Unencrypted Resolver. As these are known only by IP address, this means each unique IP address used for unencrypted DNS requires its own designation discovery. This ensures queries are being sent to a party designated by the resolver originally being used.

Generally, clients also SHOULD NOT reuse the Designated Resolver discovered from an Unencrypted Resolver over one network connection in place of the same Unencrypted Resolver on another network connection. Instead, clients SHOULD repeat the discovery process on the other network connection.

However, if a given Unencrypted Resolver designates a Designated Resolver that uses a public IP address and can be verified using the mechanism described in Section 4.2, it MAY be used on different network connections so long as the subsequent connections over other networks can also be successfully verified using the mechanism described in Section 4.2. This is a tradeoff between performance (by having no delay in establishing an encrypted DNS connection on the new network) and functionality (if the Unencrypted Resolver intends to designate different Designated Resolvers based on the network from which clients connect).

4.2. Verified Discovery

Verified Discovery is a mechanism that allows automatic use of a Designated Resolver that supports DNS encryption that performs a TLS handshake.

In order to be considered a verified Designated Resolver, the TLS certificate presented by the Designated Resolver MUST contain the IP address of the designating Unencrypted Resolver in a subjectAltName extension. If the certificate can be validated, the client SHOULD use the discovered Designated Resolver for any cases in which it would have otherwise used the Unencrypted Resolver. If the Designated Resolver has a different IP address than the Unencrypted Resolver and the TLS certificate does not cover the Unencrypted Resolver address, the client MUST NOT automatically use the discovered Designated Resolver. Additionally, the client SHOULD suppress any further queries for Designated Resolvers using this Unencrypted Resolver for the length of time indicated by the SVCB record's Time to Live (TTL).

If the Designated Resolver and the Unencrypted Resolver share an IP address, clients MAY choose to opportunistically use the Designated Resolver even without this certificate check (Section 4.3).

If resolving the name of a Designated Resolver from an SVCB record yields an IP address that was not presented in the Additional Answers section or ipv4hint or ipv6hint fields of the original SVCB query, the connection made to that IP address MUST pass the same TLS certificate checks before being allowed to replace a previously known and validated IP address for the same Designated Resolver name.

4.3. Opportunistic Discovery

There are situations where Verified Discovery of encrypted DNS configuration over unencrypted DNS is not possible. This includes Unencrypted Resolvers on non-public IP addresses such as those defined in [RFC1918] whose identity cannot be confirmed using TLS certificates.

Opportunistic Privacy is defined for DoT in Section 4.1 of [RFC7858] as a mode in which clients do not validate the name of the resolver presented in the certificate. A client MAY use information from the SVCB record for "dns://resolver.arpa" with this "opportunistic" approach (not validating the names presented in the SubjectAlternativeName field of the certificate) as long as the IP address of the Encrypted Resolver does not differ from the IP address of the Unencrypted Resolver. Clients SHOULD use this mode

only for resolvers using non-public IP addresses. This approach can be used for any encrypted DNS protocol that uses TLS.

5. Discovery Using Resolver Names

A DNS client that already knows the name of an Encrypted Resolver can use DDR to discover details about all supported encrypted DNS protocols. This situation can arise if a client has been configured to use a given Encrypted Resolver, or if a network provisioning protocol (such as DHCP or IPv6 Router Advertisements) provides a name for an Encrypted Resolver alongside the resolver IP address.

For these cases, the client simply sends a DNS SVCB query using the known name of the resolver. This query can be issued to the named Encrypted Resolver itself or to any other resolver. Unlike the case of bootstrapping from an Unencrypted Resolver (Section 4), these records SHOULD be available in the public DNS.

For example, if the client already knows about a DoT server resolver.example.com, it can issue an SVCB query for _dns.resolver.example.com to discover if there are other encrypted DNS protocols available. In the following example, the SVCB answers indicate that resolver.example.com supports both DoH and DoT, and that the DoH server indicates a higher priority than the DoT server.

```
_dns.resolver.example.com.  7200  IN SVCB 1 resolver.example.com. (
     alpn=h2 dohpath=/dns-query{?dns} )
_dns.resolver.example.com.  7200  IN SVCB 1 resolver.example.com. (
     alpn=dot )
```

Clients MUST validate that for any Encrypted Resolver discovered using a known resolver name, the TLS certificate of the resolver contains the known name in a subjectAltName extension. In the example above, this means that both servers need to have certificates that cover the name resolver.example.com. Often, the various supported encrypted DNS protocols will be specified such that the SVCB TargetName matches the known name, as is true in the example above. However, even when the TargetName is different (for example, if the DoH server had a TargetName of doh.example.com), the clients still check for the original known resolver name in the certificate.

Note that this resolver validation is not related to the DNS resolver that provided the SVCB answer.

As another example, being able to discover a Designated Resolver for a known Encrypted Resolver is useful when a client has a DoT configuration for foo.resolver.example.com but is on a network that blocks DoT traffic. The client can still send a query to any other accessible resolver (either the local network resolver or an

accessible DoH server) to discover if there is a designated DoH server for foo.resolver.example.com.

6. Deployment Considerations

Resolver deployments that support DDR are advised to consider the following points.

6.1. Caching Forwarders

A DNS forwarder SHOULD NOT forward queries for "resolver.arpa" upstream. This prevents a client from receiving an SVCB record that will fail to authenticate because the forwarder's IP address is not in the upstream resolver's Designated Resolver's TLS certificate SAN field. A DNS forwarder which already acts as a completely blind forwarder MAY choose to forward these queries when the operator expects that this does not apply, either because the operator knows the upstream resolver does have the forwarder's IP address in its TLS certificate's SAN field or that the operator expects clients of the unencrypted resolver to use the SVCB information opportunistically.

Operators who choose to forward queries for "resolver.arpa" upstream should note that client behavior is never guaranteed and use of DDR by a resolver does not communicate a requirement for clients to use the SVCB record when it cannot be verified.

6.2. Certificate Management

Resolver owners that support Verified Discovery will need to list valid referring IP addresses in their TLS certificates. This may pose challenges for resolvers with a large number of referring IP addresses.

6.3. Server Name Handling

Clients MUST NOT use "resolver.arpa" as the server name either in the TLS Server Name Indication (SNI) ([RFC8446]) for DoT or DoH connections, or in the URI host for DoH requests.

When performing discovery using resolver IP addresses, clients MUST use the IP address as the URI host for DoH requests.

Note that since IP addresses are not supported by default in the TLS SNI, resolvers that support discovery using IP addresses will need to be configured to present the appropriate TLS certificate when no SNI is present for both DoT and DoH.

7. Security Considerations

Since clients can receive DNS SVCB answers over unencrypted DNS, on-path attackers can prevent successful discovery by dropping SVCB packets. Clients should be aware that it might not be possible to distinguish between resolvers that do not have any Designated Resolver and such an active attack. To limit the impact of discovery queries being dropped either maliciously or unintentionally, clients can re-send their SVCB queries periodically.

DoH resolvers that allow discovery using DNS SVCB answers over unencrypted DNS MUST NOT provide differentiated behavior based on the HTTP path alone, since an attacker could modify the "dohpath" parameter.

While the IP address of the Unencrypted Resolver is often provisioned over insecure mechanisms, it can also be provisioned securely, such as via manual configuration, a VPN, or on a network with protections like RA guard [RFC6105]. An attacker might try to direct Encrypted DNS traffic to itself by causing the client to think that a discovered Designated Resolver uses a different IP address from the Unencrypted Resolver. Such a Designated Resolver might have a valid certificate, but be operated by an attacker that is trying to observe or modify user queries without the knowledge of the client or network.

If the IP address of a Designated Resolver differs from that of an Unencrypted Resolver, clients applying Verified Discovery (Section 4.2) MUST validate that the IP address of the Unencrypted Resolver is covered by the SubjectAlternativeName of the Designated Resolver's TLS certificate.

Clients using Opportunistic Discovery (Section 4.3) MUST be limited to cases where the Unencrypted Resolver and Designated Resolver have the same IP address.

The constraints on the use of Designated Resolvers specified here apply specifically to the automatic discovery mechanisms defined in this document, which are referred to as Verified Discovery and Opportunistic Discovery. Clients MAY use some other mechanism to verify and use Designated Resolvers discovered using the DNS SVCB record. However, use of such an alternate mechanism needs to take into account the attack scenarios detailed here.

8. IANA Considerations

8.1. Special Use Domain Name "resolver.arpa"

This document calls for the addition of "resolver.arpa" to the Special-Use Domain Names (SUDN) registry established by [RFC6761].

This will allow resolvers to respond to queries directed at themselves rather than a specific domain name. While this document uses "resolver.arpa" to return SVCB records indicating designated encrypted capability, the name is generic enough to allow future reuse for other purposes where the resolver wishes to provide information about itself to the client.

The "resolver.arpa" SUDN is similar to "ipv4only.arpa" in that the querying client is not interested in an answer from the authoritative "arpa" name servers. The intent of the SUDN is to allow clients to communicate with the Unencrypted Resolver much like "ipv4only.arpa" allows for client-to-middlebox communication. For more context, see the rationale behind "ipv4only.arpa" in [RFC8880].

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Appendix A. Rationale for using SVCB records

This mechanism uses SVCB/HTTPS resource records [I-D.ietf-dnsop-svcb-https] to communicate that a given domain designates a particular Designated Resolver for clients to use in place of an Unencrypted Resolver (using a SUDN) or another Encrypted Resolver (using its domain name).

There are various other proposals for how to provide similar functionality. There are several reasons that this mechanism has chosen SVCB records:

* Discovering encrypted resolver using DNS records keeps client logic for DNS self-contained and allows a DNS resolver operator to define which resolver names and IP addresses are related to one another.

* Using DNS records also does not rely on bootstrapping with higher-level application operations (such as [I-D.schinazi-httpbis-doh-preference-hints]).

* SVCB records are extensible and allow definition of parameter keys. This makes them a superior mechanism for extensibility as compared to approaches such as overloading TXT records. The same keys can be used for discovering Designated Resolvers of different transport types as well as those advertised by Unencrypted Resolvers or another Encrypted Resolver.

* Clients and servers that are interested in privacy of names will already need to support SVCB records in order to use Encrypted TLS Client Hello [I-D.ietf-tls-esni]. Without encrypting names in TLS, the value of encrypting DNS is reduced, so pairing the solutions provides the largest benefit.

* Clients that support SVCB will generally send out three queries when accessing web content on a dual-stack network: A, AAAA, and HTTPS queries. Discovering a Designated Resolver as part of one of these queries, without having to add yet another query, minimizes the total number of queries clients send. While [RFC5507] recommends adding new RRTypes for new functionality, SVCB provides an extension mechanism that simplifies client behavior.

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