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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. It can also be used to discover support for encrypted DNS protocols when the name of an encrypted 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.

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

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

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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 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 both resolvers.

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 authenticated 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, ports, and server name to use in certificate validation. This information is provided in Service Binding (SVCB) records for DNS Servers, defined by [[I-D.schwartz-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 . (  
    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](#)].

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.schwartz-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 4.1](#).

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 SVCB response MUST NOT use the "." value for the

SvcDomainName. 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. Authenticated Discovery

In order to be considered an authenticated Designated Resolver, the TLS certificate presented by the Encrypted Resolver MUST contain both the domain name (from the SVCB answer) and the IP address of the designating Unencrypted Resolver within the SubjectAlternativeName certificate field. The client MUST check the SubjectAlternativeName field for both the Unencrypted Resolver's IP address and the advertised name of the Designated Resolver. 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 use the discovered Encrypted 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 Encrypted Resolver even without this certificate check ([Section 4.2](#)).

If resolving the name of an Encrypted 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 Encrypted Resolver name.

4.2. Opportunistic Discovery

There are situations where authenticated 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. 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 . (
    alpn=h2 dohpath=/dns-query{?dns} )
_dns.resolver.example.com 7200 IN SVCB 2 . (
    alpn=dot )
```

Often, the various supported encrypted DNS protocols will be accessible using the same hostname. In the example above, both DoH and DoT use the name `resolver.example.com` for their TLS certificates. If a deployment uses a different hostname for one protocol, but still wants clients to treat both DNS servers as designated, the TLS certificates **MUST** include both names in the `SubjectAlternativeName` fields. Note that this name verification is not related to the DNS resolver that provided the SVCB answer.

For 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 authenticated.

6.2. Certificate Management

Resolver owners that support authenticated 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.

7. Security Considerations

Since client 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.

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 an Encrypted 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 MUST validate that the IP address of the Unencrypted Resolver is covered by the SubjectAlternativeName of the Encrypted Resolver's TLS certificate ([Section 4.1](#)).

Opportunistic use of Encrypted Resolvers MUST be limited to cases where the Unencrypted Resolver and Designated Resolver have the same IP address ([Section 4.2](#)).

8. IANA Considerations

8.1. Special Use Domain Name "resolver.arpa"

This document calls for the creation of the "resolver.arpa" SUDN. 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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