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M. Boucadair
Orange
T. Reddy
McAfee
D. Wing
Citrix
V. Smyslov
ELVIS-PLUS

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Internet Key Exchange Protocol Version 2 (IKEv2) Configuration for Encrypted DNS
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Abstract

This document specifies a new Internet Key Exchange Protocol Version 2 (IKEv2) Configuration Payload Attribute Types for encrypted DNS with a focus on DNS-over-HTTPS (DoH), DNS-over-TLS (DoT), and DNS-over-QUIC (DoQ).

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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This Internet-Draft will expire on August 23, 2021.

Table of Contents

1. Introduction

This document specifies encrypted DNS configuration for an Internet Key Exchange Protocol Version 2 (IKEv2) [RFC7296] initiator, particularly the Authentication Domain Name (ADN) of DNS-over-HTTPS (DoH) [RFC8484], DNS-over-TLS (DoT) [RFC7858], or DNS-over-QUIC (DoQ) [I-D.ietf-dprive-dnsoquic].

This document introduces new IKEv2 Configuration Payload Attribute Types (Section 4) for the support of DoT, DoH, and DoQ DNS servers. These attributes can be used to provision authentication domain names, a list of IP addresses, alternate port numbers, and a list of DoH URI Template. The use of IKEv2 to provide these template is meant to allow deployments where customized DoH configuration (e.g., per-subscriber or per-site) is required.

Sample use cases are discussed in Section 3. The Configuration Payload Attribute Types defined in this document are not specific to these deployments, but can also be used in other deployment contexts. It is out of the scope of this document to provide a comprehensive list of deployment contexts.

The encrypted DNS server hosted by the VPN provider can get a domain-validate certificate from a public CA. The VPN client does not need to be provisioned with the root certificate of a private CA to authenticate the certificate of the encrypted DNS server. The encrypted DNS server can run on private IP addresses and its access can be restricted to clients connected to the VPN.

Note that, for many years, typical designs have often considered that the DNS server was usually located inside the protected domain, but could be located outside of it. With encrypted DNS, the latter option becomes plausible.

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.

This document makes use of the terms defined in [RFC8499].

Also, this document makes use of the terms defined in [RFC7296]. In particular, readers should be familiar with "initiator" and "responder" terms used in that document.

This document makes use of the following terms:

'Do53': refers to unencrypted DNS.

'Encrypted DNS': refers to as scheme where DNS messages are sent over an encrypted channel. Examples of encrypted DNS are DoT, DoH, and DoQ.

'ENCDNS_IP*_*': refers to any IKEv2 Configuration Payload Attribute Types defined in Section 4.

'ENCDNS_IP4_*': refers to an IKEv2 Configuration Payload Attribute Type that carries one or multiple IPv4 addresses of an encrypted DNS server.

'ENCDNS_IP6_*': refers to an IKEv2 Configuration Payload Attribute Type that carries one or multiple IPv6 addresses of an encrypted DNS server.

3. Sample Deployment Scenarios

3.1. Roaming Enterprise Users

In this Enterprise scenario (Section 1.1.3 of [RFC7296]), a roaming user connects to the Enterprise network through an IPsec tunnel. The split-tunnel Virtual Private Network (VPN) configuration allows the endpoint to access hosts that resides in the Enterprise network [RFC8598] using that tunnel; other traffic not destined to the Enterprise does not traverse the tunnel. In contrast, a non-split-tunnel VPN configuration causes all traffic to traverse the tunnel into the enterprise.

For both split- and non-split-tunnel configurations, the use of encrypted DNS instead of Do53 provides privacy and integrity protection along the entire path (rather than just to the VPN termination device) and can communicate the encrypted DNS server policies.

For split-tunnel VPN configurations, the endpoint uses the Enterprise-provided encrypted DNS server to resolve internal-only domain names.

For non-split-tunnel VPN configurations, the endpoint uses the Enterprise-provided encrypted DNS server to resolve both internal and external domain names.

Enterprise networks are susceptible to internal and external attacks. To minimize that risk all enterprise traffic is encrypted (Section 2.1 of [I-D.arkko-farrell-arch-model-t]).

3.2. VPN Service Provider

Legacy VPN service providers usually preserve end-users' data confidentiality by sending all communication traffic through an encrypted tunnel. A VPN service provider can also provide guarantees about the security of the VPN network by filtering malware and phishing domains.

Browsers and OSes support DoH/DoT; VPN providers may no longer expect DNS clients to fallback to Do53 just because it is a closed network.

The encrypted DNS server hosted by the VPN service provider can be securely discovered by the endpoint using the IKEv2 Configuration Payload Attribute Type.

3.3. DNS Offload

VPN service providers typically allow split-tunnel VPN configuration in which users can choose applications that can be excluded from the tunnel. For example, users may exclude applications that restrict VPN access.

The encrypted DNS server hosted by the VPN service provider can be securely discovered by the endpoint using the IKEv2 Configuration Payload Attribute Type.

4. IKEv2 Configuration Payload Attribute Types for Encrypted DNS

4.1. ENCDNS_IP*_* Configuration Payload Attributes

The ENCDNS_IP*_* IKEv2 Configuration Payload Attribute Types are used to configure a DoT, DoH, or DoQ DNS server. All these attributes share the format shown in Figure 1.

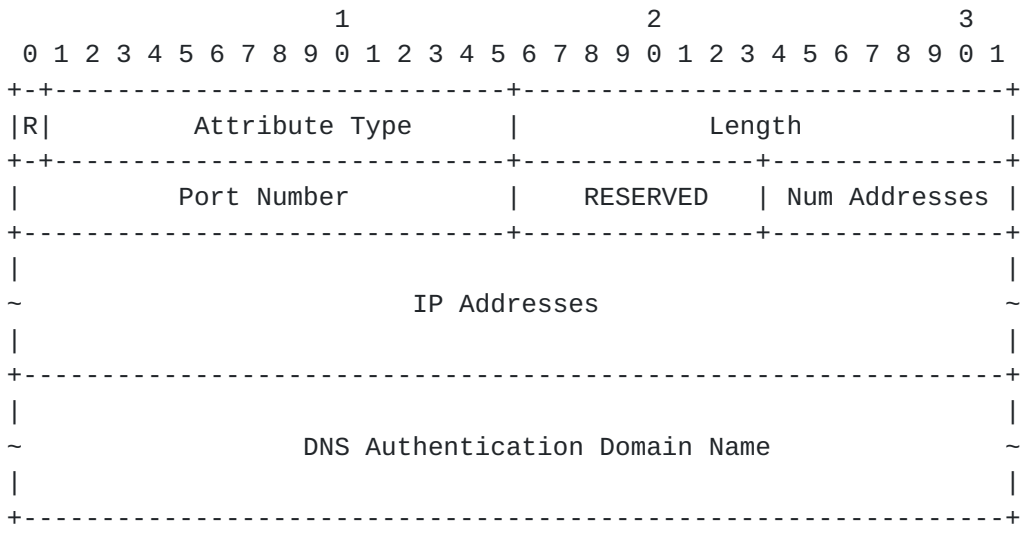


Figure 1: Attributes Format

The fields of the attribute shown in Figure 1 are as follows:

- R (Reserved, 1 bit) - This bit MUST be set to zero and MUST be ignored on receipt (see Section 3.15.1 of [RFC7296] for details).
- Attribute Type (15 bits) - Identifier for Configuration Attribute Type; is set to one of the TBA1-TBA6 values listed in Section 7.1.
- Length (2 octets, unsigned integer) - Length of the data in octets. In particular, this field is set to:

  * 0 if the Configuration payload has types CFG_REQUEST or CFG_ACK.

  * (2 + Length of the ADN + N * 4) for ENCDNS_IP4_* attributes if the Configuration payload of a has types CFG_REPLY or CFG_SET; N being the number of included IPv4 addresses ('Num addresses').

  * (2 + Length of the ADN + N * 16) for ENCDNS_IP6_* attributes if the Configuration payload has types CFG_REPLY or CFG_SET; N being the number of included IPv6 addresses ('Num addresses').

- Port Number (2 octets, unsigned integer) - Indicates the port number to be used for the encrypted DNS. As a reminder, the default port number is 853 for DoT and 443 for DoH.

- RESERVED (1 octet) - These bits are reserved for future use. These bits MUST be set to zero by the sender and MUST be ignored by the receiver.

- Num Addresses (1 octet) - Indicates the number of enclosed IPv4 (for ENCDNS_IP4_* attribute types) or IPv6 (for ENCDNS_IP6_* attribute types) addresses.

- IP Address(es) (variable) - One or more IPv4 or IPv6 addresses to be used to reach the encrypted DNS identified by the name in the DNS Authentication Domain Name.

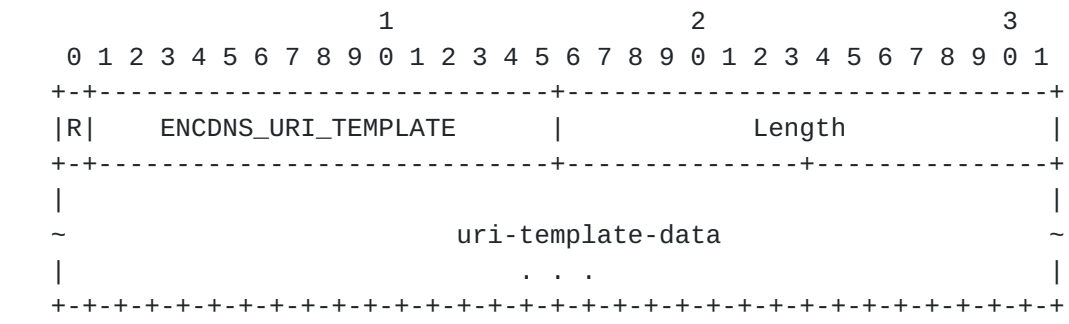
- Authentication Domain Name (variable) - A fully qualified domain name of the DoT, DoH, or DoQ DNS server following the syntax defined in [RFC5890]. The name MUST NOT contain any terminators (e.g., NULL, CR).

  An example of valid ADN for DoH server is "doh1.example.com".

4.2. ENCDNS_URI_TEMPLATE Configuration Payload Attribute

DoH servers may support more than one URI Template [RFC8484]. Also, if the resolver hosts several DoH services (e.g., no-filtering, blocking adult content, blocking malware), these services can be discovered as templates.

Figure 2 depictes the format of the ENCDNS_URI_TEMPLATE IKEv2 Configuration Payload Attribute Type whihc is used to configure DoH URI Template(s).



Each instance of the uri-template-data is formatted as follows:

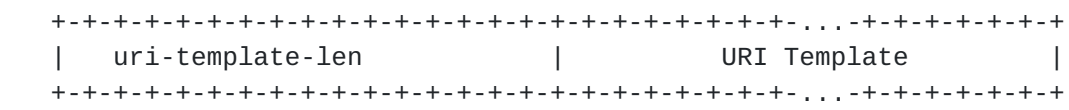


Figure 2: DoH URI Template Attribute Format

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

- R (Reserved, 1 bit) - This bit MUST be set to zero and MUST be ignored on receipt (see Section 3.15.1 of [RFC7296] for details).

- Attribute Type (15 bits) - Identifier for Configuration Attribute Type; is set to ENCDNS_URI_TEMPLATE (TBA7) (see Section 7.1).

- Length (2 octets, unsigned integer) - Length of the data in octets. In particular, this field is set to '0' if the Configuration payload has types CFG_REQUEST or CFG_ACK.

- uri-template-data (variable) - XXXX.

  An example of valid URI Template is "XXXX".

How a DoH client makes use of the configured DoH services is out of the scope of this document.

5. IKEv2 Protocol Exchange

This section describes how an initiator can be configured with an encrypted DNS server (e.g., DoH, DoT) using IKEv2.

Initiators indicate the support of an encrypted DNS in the CFG_REQUEST payloads by including one or multiple ENCDNS_IP*_* attributes, while responders supply the encrypted DNS configuration in the CFG_REPLY payloads. Concretely:

If the initiator supports encrypted DNS, it includes one or more ENCDNS_IP*_* attributes in the CFG_REQUEST with the "Attribute Type" set to the requested encrypted DNS type (Section 4). For each supported encrypted DNS type the initiator MUST include exactly one attribute with the Length field set to 0, so that no data is included for these attributes. If DoH is requested, the initiator includes also ENCDNS_URI_TEMPLATE in the CFG_REQUEST with "Length" set to 0.

For each ENCDNS_IP*_* attribute from the CFG_REQUEST, if the responder supports the corresponding encrypted DNS type, and absent any policy, the responder sends back an ENCDNS_IP*_* attribute in the CFG_REPLY with this encrypted DNS type and an appropriate list of IP addresses, a port number, and an ADN. The list of IP addresses MUST NOT be empty. Multiple instances of the same ENCDNS_IP*_* attribute MAY be returned if distinct ADNs (or port numbers) are to be returned by the responder. If the responder includes ENCDNS_IP4_DOH or ENCDNS_IP6_DOH in the response, it MUST also include ENCDNS_URI_TEMPLATE carrying one or more URI Templates.

If the CFG_REQUEST includes an ENCDNS_IP*_* attribute but the CFG_REPLY does not include an ENCDNS_IP*_* matching the requested encrypted DNS type, this is an indication that requested encrypted DNS type(s) is not supported by the responder or the responder is not configured to provide corresponding server addresses.

The behavior of the responder if it receives both ENCDNS_IP*_* and INTERNAL_IP6_DNS (or INTERNAL_IP4_DNS) attributes is policy-based and deployment-specific. However, it is RECOMMENDED that if the responder includes at least one ENCDNS_IP*_* attribute in the reply, it should not include any of INTERNAL_IP4_DNS/ INTERNAL_IP6_DNS attributes.

The DNS client establishes an encrypted DNS session (e.g., DoT, DoH, DoQ) with the address(es) conveyed in ENCDNS_IP*_* and uses the mechanism discussed in Section 8 of [RFC8310] to authenticate the DNS server certificate using the authentication domain name conveyed in ENCDNS_IP*_*.

If the IPsec connection is a split-tunnel configuration and the initiator negotiated INTERNAL_DNS_DOMAIN as per [RFC8598], the DNS client MUST resolve the internal names using ENCDNS_IP*_* DNS servers.

Note: [RFC8598] requires INTERNAL_IP6_DNS (or INTERNAL_IP4_DNS) attribute to be mandatory present when INTERNAL_DNS_DOMAIN is

included. This specification relaxes that constraint in the presence of ENCDNS_IP*_* attributes.

6. Security Considerations

This document adheres to the security considerations defined in [RFC7296]. In particular, this document does not alter the trust on the DNS configuration provided by a responder.

Networks are susceptible to internal attacks as discussed in Section 3.2 of [I-D.arkko-farrell-arch-model-t]. Hosting encrypted DNS server even in case of split-VPN configuration minimizes the attack vector (e.g., a compromised network device cannot monitor/ modify DNS traffic). This specification describes a mechanism to restrict access to the DNS messages to only the parties that need to know.

The initiator may trust the encrypted DNS servers supplied by means of IKEv2 from a trusted responder more than the locally provided DNS servers, especially in the case of connecting to unknown or untrusted networks (e.g., coffee shops or hotel networks).

If IKEv2 responder has used NULL Authentication method [RFC7619] to authenticate itself, the initiator MUST NOT use returned ENCDNS_IP*_* servers configuration unless it is pre-configured in the OS or the browser.

This specification does not extend the scope of accepting DNSSEC trust anchors beyond the usage guidelines defined in Section 6 of [RFC8598].

7. IANA Considerations

7.1. Configuration Payload Attribute Types

This document requests IANA to assign the following new IKEv2 Configuration Payload Attribute Types from the "IKEv2 Configuration Payload Attribute Types" namespace available at https://www.iana.org/assignments/ikev2-parameters/ikev2-parameters.xhtml#ikev2-parameters-21.

Value	Attribute Type	Multi-Valued	Length	Reference
TBA1	ENCDNS_IP4_DOT	YES	0 or more	RFC XXXX
TBA2	ENCDNS_IP6_DOT	YES	0 or more	RFC XXXX
TBA3	ENCDNS_IP4_DOH	YES	0 or more	RFC XXXX
TBA4	ENCDNS_IP6_DOH	YES	0 or more	RFC XXXX
TBA5	ENCDNS_IP4_DOQ	YES	0 or more	RFC XXXX
TBA6	ENCDNS_IP6_DOQ	YES	0 or more	RFC XXXX
TBA7	ENCDNS_URI_TEMPLATE	YES	0 or more	RFC XXXX

8. Acknowledgements

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Yoav and Paul suggested the use of one single attribute carrying both the name and an IP address instead of depending on the existing INTERNAL_IP6_DNS and INTERNAL_IP4_DNS attributes.

Christian Huitema suiggested to return a port number in the attributes.

9. References

9.1. Normative References

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9.2. Informative References

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Authors' Addresses

Mohamed Boucadair
Orange
Rennes 35000
France

Email: mohamed.boucadair@orange.com

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

Email: TirumaleswarReddy_Konda@McAfee.com

Dan Wing
Citrix Systems, Inc.
USA

Email: dwing-ietf@fuggles.com

Valery Smyslov
ELVIS-PLUS
RU

Email: svan@elvis.ru