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Redirect Mechanism for the Internet Key Exchange Protocol Version 2 (IKEv2)

Abstract

The Internet Key Exchange Protocol version 2 (IKEv2) is a protocol for setting up Virtual Private Network (VPN) tunnels from a remote location to a gateway so that the VPN client can access services in the network behind the gateway. This document defines an IKEv2 extension that allows an overloaded VPN gateway or a VPN gateway that is being shut down for maintenance to redirect the VPN client to attach to another gateway. The proposed mechanism can also be used in Mobile IPv6 to enable the home agent to redirect the mobile node to another home agent.

Status of This Memo

This document specifies an Internet standards track protocol for the Internet community, and requests discussion and suggestions for improvements. Please refer to the current edition of the "Internet Official Protocol Standards" (STD 1) for the standardization state and status of this protocol. Distribution of this memo is unlimited.

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1. Introduction

IKEv2 [2] is used for setting up IPsec-based [7] VPNs. The IP address of the VPN gateway can be configured on the VPN client. But this does not scale well when the number of VPN gateways is large. Dynamic discovery of VPN gateways using DNS is quite widely used too. However, using DNS is not flexible when it comes to assigning a VPN gateway to the VPN client based on the load on the VPN gateways. The VPN client typically tries to connect to the IP address of the VPN gateway that appears first in the DNS response. If the VPN tunnel setup fails, then the VPN client tries to attach to the other VPN gateways returned in the DNS response.

This document proposes a redirect mechanism for IKEv2 that enables a VPN gateway to redirect the VPN client to another VPN gateway, for example, based on the load condition. The redirect can be done during the IKE_SA_INIT or the IKE_AUTH exchange. Gateway-initiated

redirect in the middle of a session is also supported. The redirect mechanism can also be used in conjunction with anycast addresses. In this case, an anycast address for the cluster of VPN gateways is stored in the DNS instead of a list of unicast IP addresses of the VPN gateways.

The redirect can also happen because of administrative or optimal-routing reasons. This document does not attempt to provide an exhaustive list of reasons for redirecting a VPN client to another VPN gateway.

2. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [1].

3. IKEv2 Initial Exchange with Redirect

This section describes the use of the redirect mechanism during the IKE_SA_INIT exchange. Gateway-initiated redirect during an active session and the use of redirect during IKE_AUTH exchange are explained in subsequent sections.

The VPN client indicates support for the IKEv2 redirect mechanism and its willingness to be redirected by including a REDIRECT_SUPPORTED notification message in the initial IKE_SA_INIT request (see Section 9.1). The gateway MUST keep track of those clients that indicated support for the redirect mechanism and those that didn't.

To redirect an IKEv2 session to another VPN gateway, the VPN gateway that initially received the IKE_SA_INIT request selects another VPN gateway (how the selection is made is beyond the scope of this document) and replies with an IKE_SA_INIT response containing a REDIRECT notification message (see Section 9.2). The notification includes information about the selected VPN gateway and the nonce data from the Ni payload in the IKE_SA_INIT request. If the IKE_SA_INIT request did not indicate support for the redirect mechanism, the responder MUST NOT send the REDIRECT payload to the VPN client. This is applicable to all REDIRECT scenarios described in this document.

Note that when the IKE_SA_INIT response includes the REDIRECT notification, the exchange does not result in the creation of an IKE_SA and the responder Security Parameter Index (SPI) will be zero.

```
   Initiator                    Responder (initial VPN GW)
   ---------                    --------------------------

(IP_I:500 -> Initial_IP_R:500)
HDR(A,0), SAi1, KEi, Ni,   -->
N(REDIRECT_SUPPORTED)

                            (Initial_IP_R:500 -> IP_I:500)
                       <-- HDR(A,0), N(REDIRECT, New_GW_ID, Ni_data)
```

When the client receives the IKE_SA_INIT response, it MUST verify that the nonce data matches the value sent in the IKE_SA_INIT request. If the values do not match, the client MUST silently discard the response (and keep waiting for another response). This prevents certain denial-of-service (DoS) attacks on the initiator that could be caused by an attacker injecting IKE_SA_INIT responses with REDIRECT payloads.

After verifying the nonce data, the client initiates a new IKE_SA_INIT exchange with the VPN gateway listed in the REDIRECT payload, provided this is allowed by its Peer Authorization Database (PAD) entries. In the IKE_SA_INIT exchange with the new VPN gateway, the client MUST include the REDIRECTED_FROM payload (see Section 9.3). The VPN client includes the IP address of the original VPN gateway that redirected the client in the REDIRECTED_FROM notification. The IKEv2 exchange then proceeds as it would have proceeded with the original VPN gateway.

```
   Initiator                    Responder (Selected VPN GW)
   ---------                    ---------------------------

(IP_I:500 -> IP_R:500)
HDR(A,0), SAi1, KEi, Ni,   -->
N(REDIRECTED_FROM, Initial_IP_R)

                            (IP_R:500 -> IP_I:500)
                       <-- HDR(A,B), SAr1, KEr, Nr,[CERTREQ]

(IP_I:500 -> IP_R:500)
HDR(A,B), SK {IDi, [CERT,] [CERTREQ,]
[IDr,]AUTH, SAi2, TSi, TSr} -->

                            (IP_R:500 -> IP_I:500)
                       <-- HDR(A,B), SK {IDr, [CERT,] AUTH,
                                         SAr2, TSi, TSr}
```

The client MAY get redirected again by the new VPN gateway if the new VPN gateway also cannot serve the client. The client does not have to include the REDIRECT_SUPPORTED payload again in the IKE_SA_INIT exchange with the new gateway after a redirect. The presence of the REDIRECT_FROM payload in the IKE_SA_INIT exchange with the new gateway indicates to the new gateway that the client supports the redirect mechanism.

When the client gets redirected, it MUST use the same Peer Authorization Database (PAD) and Security Policy Database (SPD) entries as it would have used with the original gateway. Receiving a redirect notification MUST NOT result in the modification of any PAD or SPD entries. In practice, this means the new gateway either has to use the same responder identity (IDr) as the original gateway, or both should be part of a group of responders that are authorized by the same PAD entry. See Section 4.4.3.1 of [7] on using DNS names to represent a group of peers in a PAD entry.

This document allows the client to be redirected in several protocol states. In some of them, the gateway is already authenticated at the point of redirect; in others, it is not. We emphasize that the above rules regarding the identity of the new gateway and the PAD and SPD entries apply equally to all these scenarios.

4. Use of Anycast Addresses with the Redirect Mechanism

Using anycast addresses will avoid the necessity of configuring a particular VPN gateway's IP address in the DNS. Instead, the anycast address that represents the group of VPN gateways is stored in the DNS. When the VPN client performs a DNS lookup for the VPN gateway, it receives the anycast address of the VPN gateway in the DNS response.

If an anycast address is returned in response to the DNS resolution of a Fully Qualified Domain Name (FQDN), the VPN client sends the IKE_SA_INIT request to the anycast address. The REDIRECT_SUPPORTED payload is included in the IKE_SA_INIT request sent to the anycast address. The IKE_SA_INIT request is routed to one of the VPN gateways that is part of the anycast group. The VPN gateway that receives the IKE_SA_INIT request responds with an IKE_SA_INIT reply from the anycast address.

```
   Initiator                    Responder (any VPN GW)
   ---------                    ----------------------

(IP_I:500 -> ANYCAST:500)
HDR(A,0), SAi1, KEi, Ni)   -->
N(REDIRECT_SUPPORTED)

                             (ANYCAST:500 -> IP_I:500)
                        <-- HDR(A,0), N(REDIRECT, New_GW_ID, Ni_data)
```

If the destination address on the IKE_SA_INIT request is an anycast address, the VPN gateway that received the IKE_SA_INIT request MUST include the REDIRECT payload to redirect the VPN client to a unicast address of one of the VPN gateways. The VPN gateway that received the IKE_SA_INIT request MAY redirect the client to its own unicast address if it is not overloaded.

The rest of the IKEv2 exchange is the same as described in Section 3.

5. Redirect during an Active Session

The redirect mechanism may also be used by a VPN gateway to redirect the client to another VPN gateway in the middle of a session. To redirect a client, the gateway should send an INFORMATIONAL message with the REDIRECT Notify payload. The REDIRECT payload MUST carry information about the new VPN gateway. The gateway MUST NOT include any nonce data in the REDIRECT payload, since it is a gateway-initiated redirect and is protected by the IKEv2 security association. When the client receives this message, it sends a response (usually empty) to the gateway. The gateway retransmits the redirect INFORMATIONAL message as described in [2], until it gets a response. The following illustrates the INFORMATIONAL message exchange for gateway-initiated redirect.

```
    Initiator (VPN client)        Responder (VPN GW)
    ----------------------        ------------------

                            <--  HDR, SK {N(REDIRECT, New_GW_ID)}

  HDR, SK {} -->
```

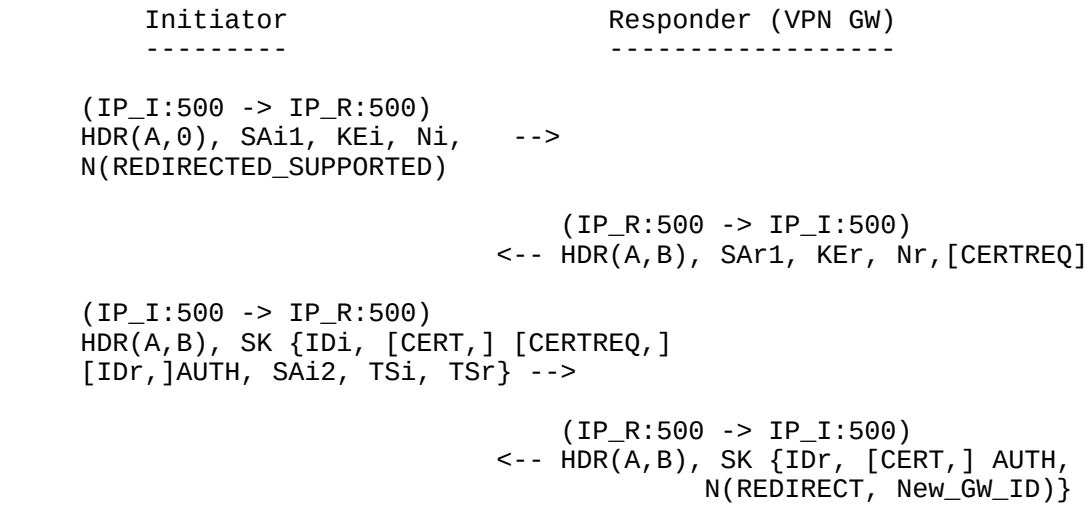
The INFORMATIONAL message exchange described above is protected by the existing IKEv2 SA between the client and the gateway.

Once the client sends an acknowledgement to the gateway, it SHOULD delete the existing security associations with the old gateway by sending an INFORMATIONAL message with a DELETE payload. The gateway MAY also decide to delete the security associations without any

signaling from the client, again by sending an INFORMATIONAL message with a DELETE payload; however, it should allow sufficient time for the client to set up the required security associations with the new security gateway. This time period should be configurable on the gateway.

6. Redirect during IKE_AUTH Exchange

If the gateway decides to redirect the client during the IKE_AUTH exchange, based on the identity presented by the client in the IKE_AUTH request message, it prevents the creation of a CHILD SA and sends the REDIRECT payload in the IKE_AUTH response. The gateway MUST verify the client's AUTH payload before sending the REDIRECT payload, and the client MUST verify the gateway's AUTH payload before acting on the REDIRECT payload. Since the AUTH payloads were exchanged and successfully verified, the IKEv2 security association is valid. When the client receives the IKE_AUTH response with the REDIRECT payload, it SHOULD delete the IKEv2 security association with the gateway by sending an INFORMATIONAL message with a DELETE payload.



In case the IKE_AUTH exchange involves Extensible Authentication Protocol (EAP) authentication (as described in Section 2.16 of RFC 4306 [2]) or multiple authentication methods (as described in RFC 4739 [6]), the gateway may decide to redirect the client based on the interaction with the Authentication, Authorization, and Accounting (AAA) server or the external authentication server. In this case, the gateway MUST send the REDIRECT Notify payload in either the first or the last IKE_AUTH response. The client and the gateway MUST verify the AUTH payloads as described above.

When EAP is used, the gateway MAY also redirect the client based on the unauthenticated identity presented by the client in the first IKE_AUTH exchange, itself. Since EAP is used as the authentication mechanism, the client does not include AUTH payload to authenticate its identity, but the server MUST still include its own AUTH payload, and the client MUST verify it. Note that the IKEv2 SA is not created in this case and the client does not have to explicitly delete the IKEv2 SA.

In all of the cases above, the client MUST accept the REDIRECT notification only in the first IKE_AUTH response or the last IKE_AUTH response. It MUST NOT accept the REDIRECT notification in an intermediate IKE_AUTH response.

7. Handling Redirect Loops

The client could end up getting redirected multiple times in a sequence, either because of a wrong configuration or a DoS attack. The client could even end up in a loop with two or more gateways redirecting the client to each other. This could deny service to the client. To prevent this, the client SHOULD be configured to not accept more than a certain number of redirects (MAX_REDIRECTS) within a short time period (REDIRECT_LOOP_DETECT_PERIOD) for a particular IKEv2 SA setup. The default value for the MAX_REDIRECTS configuration variable is 5. The default value for the REDIRECT_LOOP_DETECT_PERIOD configuration variable is 300 seconds. Client implementations may allow these variables to be configured, depending on a specific deployment or system configuration.

8. Using the Redirect Mechanism with Mobile IPv6

Mobile IPv6 [3] may use IKEv2 for mutual authentication between the mobile node and the home agent, for home address configuration, and for setting up security associations for protecting Mobile IPv6 signaling messages [4]. The IKEv2 exchange, if IKEv2 is used, precedes the exchange of Mobile IPv6 signaling messages. Therefore, the mechanism described in this document can also be used by a Mobile IPv6 home agent to redirect a mobile node to another home agent.

There is a Home Agent Switch mechanism available for redirecting a mobile node to another home agent, described in [5]. The Home Agent Switch mechanism can only be used after the binding cache has been created at the home agent for the mobile node. The disadvantage with this is that quite a bit of state is created on the home agent before the mobile node can be redirected to another home agent. The mechanism described in this document can be used for redirecting a mobile node before any state related to the Mobile IPv6 binding is created on the home agent.

When running IKEv2 between a Mobile IPv6 mobile node (MN) and home agent (HA), redirecting the IKEv2 exchange to another HA is not enough; the Mobile IPv6 signaling also needs to be sent to the new HA address. The MN MAY treat the information received in the IKE_SA_INIT response in a similar way as it would treat HA discovery information received from other unauthenticated (and potentially untrustworthy) sources (such as DNS lookups not protected with DNS Security (DNSSEC)). However, if the MN has authenticated information about its home agent, it MUST NOT be updated based on the IKE_SA_INIT response.

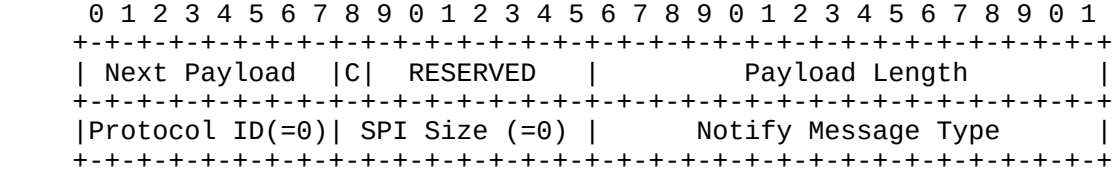
If the REDIRECT notification is received during the IKE_AUTH exchange (after the HA has been authenticated; see Section 6), the MN MAY pass the new address to Mobile IPv6 and treat it in a similar fashion as information from the Home Agent Switch message [5].

Gateway-initiated REDIRECT notifications exchanged in INFORMATIONAL exchanges (see Section 5) MUST NOT result in updating any Mobile IPv6 state. In such cases, the Home Agent Switch message specified in [5] is used instead.

9. Redirect Messages

9.1. REDIRECT_SUPPORTED

The REDIRECT_SUPPORTED payload is included in the initial IKE_SA_INIT request by the initiator to indicate support for the IKEv2 redirect mechanism described in this document.

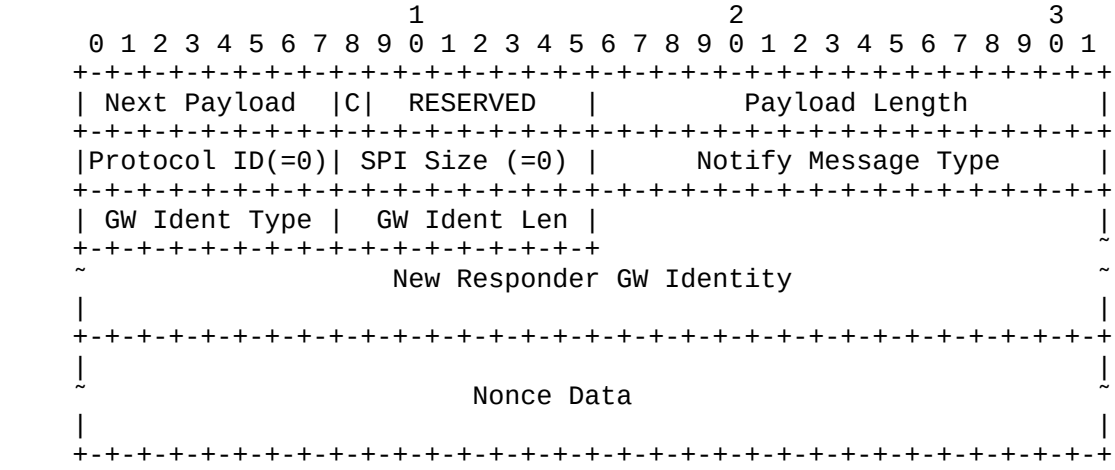


The 'Next Payload', 'Payload Length', 'Protocol ID', 'SPI Size', and 'Notify Message Type' fields are the same as described in Section 3.10 of [2]. The 'SPI Size' field MUST be set to 0 to indicate that the SPI is not present in this message. The 'Protocol ID' MUST be set to 0, since the notification is not specific to a particular security association.

The 'Payload Length' field is set to the length in octets of the entire payload, including the generic payload header. The 'Notify Message Type' field is set to indicate the REDIRECT_SUPPORTED payload (16406).

9.2. REDIRECT

When the responder wants to redirect the initiator to another VPN gateway, the REDIRECT payload is included in either an IKE_SA_INIT response from the responder or an INFORMATIONAL message from the responder. The message includes the new responder's IP address or DNS name.



The 'Next Payload', 'Payload Length', 'Protocol ID', 'SPI Size', and 'Notify Message Type' fields are the same as described in Section 3.10 of [2]. The 'SPI Size' field MUST be set to 0 to indicate that the SPI is not present in this message. The 'Protocol ID' MUST be set to 0, since the notification is not specific to a particular security association.

The 'Payload Length' field is set to the length in octets of the entire payload, including the generic payload header. The 'Notify Message Type' field is set to indicate the REDIRECT payload (16407). The 'GW Identity Type' field indicates the type of information that is sent to identify the new VPN gateway. The following values are valid in the REDIRECT payload.

1 - IPv4 address of the new VPN gateway

2 - IPv6 address of the new VPN gateway

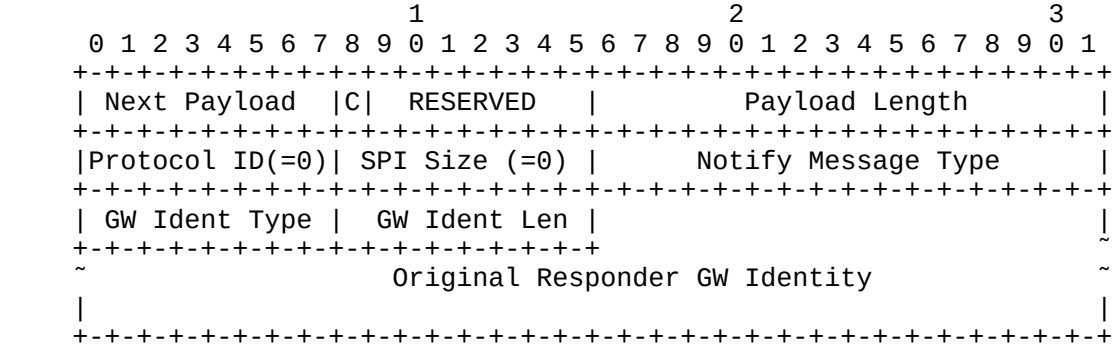
3 - FQDN of the new VPN gateway

The 'GW Ident Len' field is set to the length of the gateway identity information. The identity of the new VPN gateway is carried in the 'New Responder GW Identity' field. The IPv4 address, the IPv6 address, or the FQDN of the new VPN gateway MUST be encoded as described in Section 3.5 of [2].

The 'Nonce Data' field carries the nonce data from the Ni payload sent by the initiator. The size of the nonce MUST be between 16 and 256 bytes, as described in Section 3.9 of [2]. The 'Nonce Data' field is present in the REDIRECT payload only when the REDIRECT payload is sent in the IKE_SA_INIT response message. It MUST NOT be included in the REDIRECT payload if sent in an IKE_AUTH response or in a gateway-initiated redirect message.

9.3. REDIRECTED_FROM

The REDIRECTED_FROM Notify payload is included in the IKE_SA_INIT request from the initiator to the new VPN gateway to indicate the IP address of the original VPN gateway that redirected the initiator. The original VPN gateway's IP address is included in the message. If the IKE_SA_INIT request was sent to any anycast address (see Section 4), then the anycast address is included in the message. This payload also serves the purpose of indicating support for the redirect mechanism to the new VPN gateway after a redirect.



The 'Next Payload', 'Payload Length', 'Protocol ID', 'SPI Size', and 'Notify Message Type' fields are the same as described in Section 3.10 of [2]. The 'SPI Size' field MUST be set to 0 to indicate that the SPI is not present in this message. The 'Protocol ID' MUST be set to 0, since the notification is not specific to a particular security association.

The 'Payload Length' field is set to the length in octets of the entire payload, including the generic payload header. The 'Notify Message Type' field is set to indicate the REDIRECTED_FROM payload

(16408). The 'GW Identity Type' field indicates the type of information that is sent to identify the new VPN gateway. The following values are valid in the REDIRECTED_FROM payload.

1 - IPv4 address of the original VPN gateway

2 - IPv6 address of the original VPN gateway

The 'GW Ident Len' field is set to the length of the gateway identity information. The identity of the original VPN gateway is carried in the 'Original Responder GW Identity' field.

10. Use of the Redirect Mechanism between IKEv2 Peers

The redirect mechanism described in this document is mainly intended for use in client-gateway scenarios. However, the mechanism can also be used between any two IKEv2 peers. But this protocol is asymmetric, meaning that only the original responder can redirect the original initiator to another server.

11. Security Considerations

An eavesdropper on the path between a VPN client and server may send a redirect to the client upon receiving an IKE_SA_INIT message from this client. This is no problem regarding DoS attacks for the VPN connection, since an on-path-attacker can as well drop the IKE_SA_INIT requests to prevent VPN access for the client. But an eavesdropper on the path between VPN client and server can redirect a large number of clients to a victim, which is then flooded with IKE_SA_INIT requests. Flooding only happens if many clients initiate IKEv2 exchange at almost the same time, which is considered a rare event. However, this may happen if a home agent / VPN server is shutdown for maintenance and all clients need to re-establish VPN connections with another home agent / VPN server, or if the on-path attacker forces all IPsec security associations to expire by dropping all received IKEv2 messages.

The use of the REDIRECTED_FROM payload is intended to discourage a rogue VPN gateway from redirecting a large number of VPN clients to a particular VPN gateway. It does not prevent such a DoS attack.

The redirect mechanism MUST NOT update any state on the client apart from the VPN gateway information. When used with Mobile IPv6, care must be taken to ensure that the home agent information that the mobile node has configured is not modified wrongly by the redirect message.

Redirecting based on the unauthenticated identities from the client might leak out information about the user when an active attacker, pretending to be a VPN client, can get information on the gateway to which the real user was redirected. If redirection is based on some internal information of the user, it might leak information (that might not be available otherwise) about the user to the attacker. To prevent these kinds of attacks, redirection based on unauthenticated IDs should be avoided and should be done only after the client has also authenticated itself.

12. IANA Considerations

This document defines three new IKEv2 Notify Message Types, as described in Section 9. The three Notify Message Types have been assigned the following values:

16406 - REDIRECT_SUPPORTED

16407 - REDIRECT

16408 - REDIRECTED_FROM

This document creates a new namespace called the "Gateway Identity Type". This is used to indicate the type of information regarding the VPN gateway that is carried in the REDIRECT (Section 9.2) and REDIRECTED_FROM (Section 9.3) Notify payloads. The following values have been assigned.

1 - IPv4 address of the VPN gateway

2 - IPv6 address of the VPN gateway

3 - FQDN of the VPN gateway

Value '0' is reserved. Values 4-240 are unassigned. New values can be allocated by Expert Review [8]. Values 241-255 are set aside for private use. A specification that extends this registry MUST also mention which of the new values are valid in which Notify payload.

13. Acknowledgements

The use of anycast addresses with IKEv2 was first proposed by K. Weniger and F. Dupont in the context of home agent assignment in Mobile IPv6 / Network Mobility (NEMO) bootstrapping. It was then added to an early version of [4] and later removed before the RFC was published. The authors of RFC 5026 are acknowledged.

Thanks to Pasi Eronen, with whom the solution described in this document was extensively discussed. Thanks to Tero Kivinen for suggesting the use of the REDIRECTED_FROM payload and other comments that helped improve the document. The authors would also like to thank Yaron Sheffer, Sunil Kumar, Fan Zhao, Yoav Nir, Richard Graveman, Kanagavel Rajan, Srini Addepalli, Raj Singh, and Arnaud Ebalard for their reviews and comments.

14. References

14.1. Normative References

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[2] Kaufman, C., "Internet Key Exchange (IKEv2) Protocol", RFC 4306, December 2005.

14.2. Informative References

[3] Johnson, D., Perkins, C., and J. Arkko, "Mobility Support in IPv6", RFC 3775, June 2004.

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[8] Narten, T. and H. Alvestrand, "Guidelines for Writing an IANA Considerations Section in RFCs", BCP 26, RFC 5226, May 2008.

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