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Auxiliary Exchange in the IKEv2 Protocol
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Abstract

This documents defines a new exchange, called Auxiliary Exchange, for the Internet Key Exchange protocol Version 2 (IKEv2). This exchange can be used for transferring large amount of data in the process of IKEv2 Security Association (SA) establishment. Introducing Auxiliary Exchange allows to re-use existing IKE Fragmentation mechanism, that helps to avoid IP fragmentation of large IKE messages, but cannot be used in the initial IKEv2 exchange.

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 January 28, 2019.

Table of Contents

1. Introduction

The Internet Key Exchange protocol version 2 (IKEv2) defined in [RFC7296] uses UDP as a transport for its messages. If size of the messages is large enough, IP fragmentation takes place that may interfere badly with some network devices. The problem is described in more detail in [RFC7383], which also defines an extension to the IKEv2 called IKE Fragmentation. This extension allows IKE messages to be fragmented at IKE level, eliminating possible issues caused by IP fragmentation. However, the IKE Fragmentation cannot be used in the initial IKEv2 exchange, IKE_SA_INIT. This limitation in most cases is not a problem, since the IKE_SA_INIT messages used to be small enough to not cause IP fragmentation.

Recent progress in Quantum Computing has brought a concern that classical Diffie-Hellman key exchange methods will become insecure in a relatively near future and should be replaced with Quantum Computer (QC) resistant ones. Currently most of QC-resistant key exchange methods have large public keys. If these keys are exchanged in the IKE_SA_INIT, then most probably IP fragmentation would take place, therefore all the problems caused by it would become inevitable.

A possible solution to the problem would be to use TCP as a transport for IKEv2, as described in [RFC8229]. However this approach has

significant drawbacks and is intended to be a "last resort" when UDP transport is blocked by intermediate network devices.

This document defines a new exchange for the IKEv2 protocol, called Auxiliary Exchange or IKE_AUX. One or more these exchanges may take place right after the IKE_SA_INIT exchange and prior to the IKE_AUTH exchange. These exchanges may be used to exchange large amounts of data, which don't fit into the IKE_SA_INIT exchange without causing IP fragmentation. The IKE_AUX messages can be fragmented using IKE Fragmentation mechanism.

While ability to transfer large public keys of QC-resistant key exchange methods was a primary motivation for the Auxiliary Exchange, its application is not limited to this use case. This exchange may be used whenever some data need to be transferred before the IKE_AUTH exchange and for some reason the IKE_SA_INIT exchange is not suited for this purpose. It is expected that separate specifications will define how and when the IKE_AUX exchange is used in the IKEv2.

2. Terminology and Notation

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.

3. Auxiliary Exchange Details

3.1. Support for Auxiliary Exchange Negotiation

The initiator indicates its support for Auxiliary Exchange by including a notification of type AUX_EXCHANGE_SUPPORTED in the IKE_SA_INIT request message. If the responder also supports this exchange, it includes this notification in the response message.

```
Initiator                              Responder
-----------                            -----------
HDR, SAi1, KEi, Ni,
     [N(AUX_EXCHANGE_SUPPORTED)]  -->
                                  <--  HDR, SAr1, KEr, Nr, [CERTREQ],
                                          [N(AUX_EXCHANGE_SUPPORTED)]
```

The AUX_EXCHANGE_SUPPORTED is a Status Type IKEv2 notification. Its Notify Message Type is <TBA by IANA>. Protocol ID and SPI Size are both set to 0. This specification doesn't define any data this notification may contain, so the Notification Data is left empty. However, future enhancements of this specification may override this.

Implementations MUST ignore the non-empty Notification Data if they don't understand its purpose.

3.2. Using Auxiliary Exchange

If both peers indicated their support for the Auxiliary Exchange, the initiator may use one or more these exchanges to transfer additional data. Using the IKE_AUX exchange is optional, the initiator may find it unnecessary after completing the IKE_SA_INIT exchange.

The Auxiliary Exchange is denoted as IKE_AUX, its Exchange Type is <TBA by IANA>.

```
Initiator                              Responder
-----------                            -----------
HDR, ..., SK {...}  -->
                                  <--  HDR, ..., SK {...}
```

The initiator may use several IKE_AUX exchanges if necessary. Since initiator's Window Size is initially set to one (Section 2.3 of [RFC7296]), these exchanges MUST follow each other and MUST all be completed before the IKE_AUTH exchange is initiated. The IKE SA MUST NOT be considered as established until the IKE_AUTH exchange is successfully completed.

The Message IDs for the IKE_AUX exchanges MUST be chosen according to the standard IKEv2 rule, described in the Section 2.2. of [RFC7296], i.e. it is set to 1 for the first IKE_AUX exchange, 2 for the next (if any) and so on. The message ID for the first pair of the IKE_AUTH messages is one more than the last IKE_AUX Message ID.

The content of the IKE_AUX messages depends on the data being transferred and will be defined by specifications utilizing this exchange. However, since the main motivation for IKE_AUX is to avoid IP fragmentation when large amount of data need to be transferred prior to IKE_AUTH, the Encrypted payload SHOULD be present in the IKE_AUX messages and payloads containing large data SHOULD be placed inside. This will allow IKE Fragmentation [RFC7383] to take place, provided it is supported by the peers and negotiated in the initial exchange.

3.3. IKE_AUX Protection and Authentication

3.3.1. Protection of IKE_AUX Messages

The keys SK_e[i/r] and SK_a[i/r] for the Encrypted payload in the IKE_AUX exchanges are computed in a standard fashion, as defined in the Section 2.14 of [RFC7296]. Every subsequent IKE_AUX exchange

uses the most recently calculated keys before this exchange is started. The first IKE_AUX exchange always uses SK_e[i/r] and SK_a[i/r] keys that were computed as result the IKE_SA_INIT exchange. If this IKE_AUX exchange performs additional key exchange resulting in the update of SK_e[i/r] and SK_a[i/r], then these updated keys are used for encryption and authentication of next IKE_AUX exchange, otherwise the current keys are used, and so on.

3.3.2. Authentication of IKE_AUX Exchanges

The data transferred in the IKE_AUX exchanges must be authenticated in the IKE_AUTH exchange. For this purpose the definition of the blob to be signed (or MAC'ed) from the Section 2.15 of [RFC7296] is modified as follows:

```
InitiatorSignedOctets = RealMessage1 | AUX_I | NonceRData | MACedIDForI
AUX_I =  [AUX_PRF_I_1 [| AUX_PRF_I_2 [| AUX_PRF_I_3]]] ...
AUX_PRF_I_1 = prf(SK_pi_1, IKE_AUX_I_1_H [| IKE_AUX_I_1_E])
AUX_PRF_I_2 = prf(SK_pi_2, IKE_AUX_I_2_H [| IKE_AUX_I_2_E])
AUX_PRF_I_3 = prf(SK_pi_3, IKE_AUX_I_3_H [| IKE_AUX_I_3_E])
...

ResponderSignedOctets = RealMessage2 | AUX_R | NonceIData | MACedIDForR
AUX_R =  [AUX_PRF_R_1 [| AUX_PRF_R_2 [| AUX_PRF_R_3]]] ...
AUX_PRF_R_1 = prf(SK_pr_1, IKE_AUX_R_1_H [| IKE_AUX_R_1_E])
AUX_PRF_R_2 = prf(SK_pr_2, IKE_AUX_R_2_H [| IKE_AUX_R_2_E])
AUX_PRF_R_3 = prf(SK_pr_3, IKE_AUX_R_3_H [| IKE_AUX_R_3_E])
...
```

AUX_PRF_I_1/AUX_PRF_R_1, AUX_PRF_I_2/AUX_PRF_R_2, AUX_PRF_I_3/ AUX_PRF_R_1, etc. represent the results of applying the negotiated prf to the content of the IKE_AUX messages sent by the initiator (AUX_PRF_I_*) by the responder (AUX_PRF_R_*) in an order of increasing MessageIDs (i.e. in an order the IKE_AUX exchanges took place). The prf is applied to the two chunks of data: IKE_AUX_[I/ R]_*_H and optionally IKE_AUX_[I/R]_*_E. The IKE_AUX_[I/R]_*_H chunk lasts from the first octet of the IKE Header (not including prepended four octets of zeros, if any) to the last octet of the Encrypted Payload header (or to the end of the message in case the Encrypted payload is not present). The IKE_AUX_[I/R]_*_E chunk is computed if the Encrypted payload is present and consists of the not yet encrypted content of the Encrypted payload, excluding Initialization Vector, Padding, Pad Length and Integrity Checksum Data fields (see 3.14 of [RFC7296] for description of the Encrypted payload). In other words, the IKE_AUX_[I/R]_*_E chunk is the inner payloads of the Encrypted payload in plaintext form.

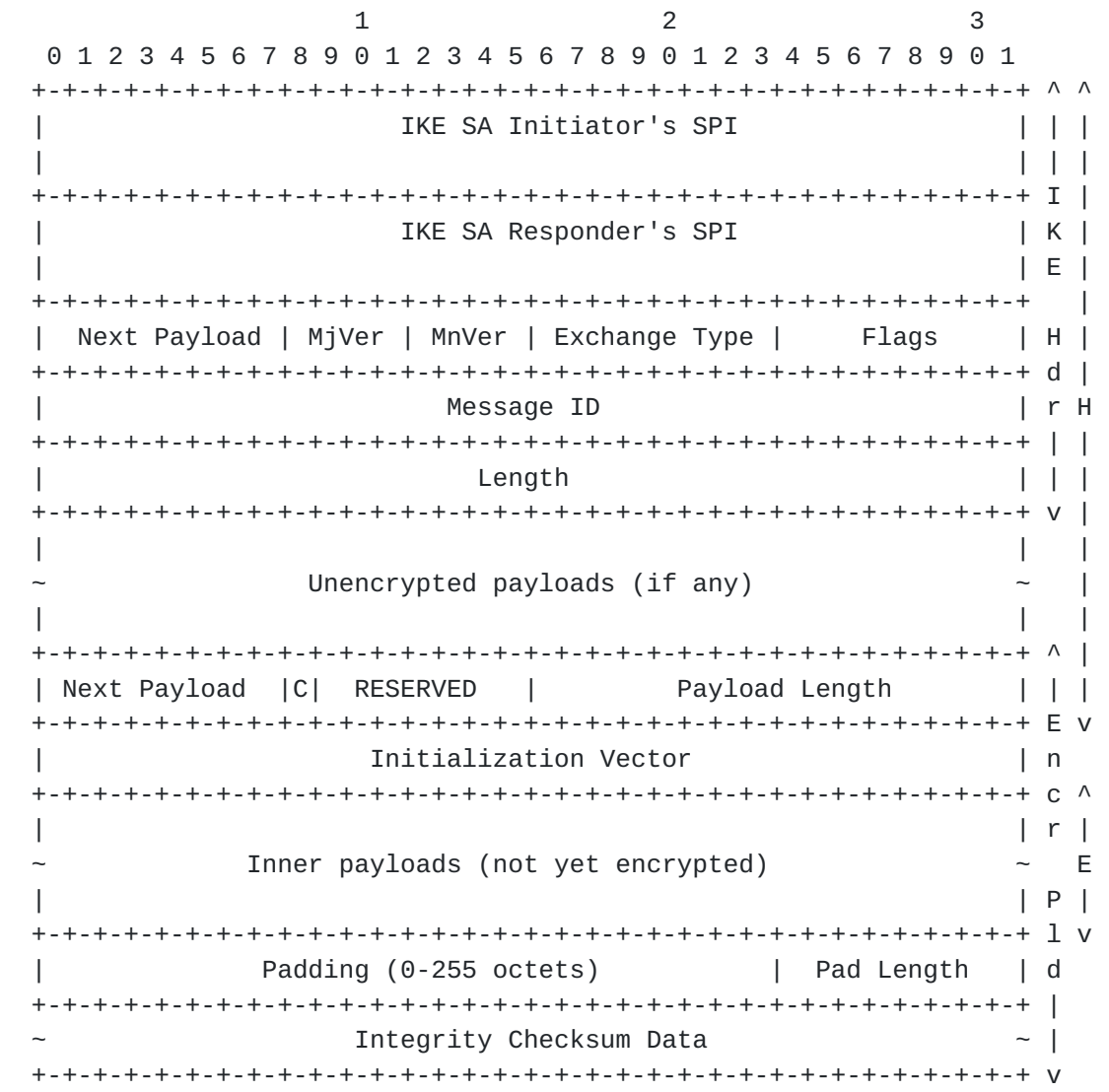

Figure 1: Data to Authenticate in IKE_AUX Exchange

Figure 1 illustrates the layout of the IKE_AUX_*_*_H (denoted as H) and the IKE_AUX_*_*_E (denoted as E) chunks in case the Encrypted payload is present in the message. Note, that while the Encrypted payload is not required to be present in the IKE_AUX messages, the intended purpose of this exchange is to allow transferring large amount of data utilizing IKE fragmentation, so in most cases the Encrypted payload will be present.

The calculations are applied to whole messages only, before possible fragmentation. This ensures that the AUX_I/AUX_R will be the same regardless of whether fragmentation takes place or not ([RFC7383] allows sending first unfragmented message and then trying fragmentation in case of no reply).

Each calculation of AUX_PRF_[I/R]_* uses its own key SK_p[i/r]_*, which is the most recently updated SK_p[i/r] key available before the corresponded IKE_AUX exchange is started. The first IKE_AUX exchange always uses SK_p[i/r] key that was computed in the IKE_SA_INIT as SK_p[i/r]_1. If the first IKE_AUX exchange performs additional key exchange resulting in SK_p[i/r] update, then this updated SK_p[i/r] is used as SK_p[i/r]_2, otherwise the original SK_p[i/r] is used, and so on. Note, that if keys are updated then for any given IKE_AUX exchange the keys SK_e[i/r] and SK_a[i/r] used for IKE_AUX messages protection (see Section 3.3.1) and the keys SK_p[i/r] for their authentication are always from the same generation.

3.4. Error Handling in IKE_AUX

Since IKE_AUX messages are not authenticated until the IKE_AUTH exchange successfully completes, possible errors need to be handled carefully. There is a trade-off between providing a better diagnostics of the problem and a risk to become a part of DoS attack. See Section 2.21.1 and 2.21.2 of [RFC7296] describe how errors are handled in initial IKEv2 exchanges, these considerations are applied to an IKE_AUX exchange too.

4. Interaction with other IKEv2 Extensions

The IKE_AUTH exchanges may be used in the IKEv2 Session Resumption [RFC5723] between the IKE_SESSION_RESUME and the IKE_AUTH exchanges.

5. Security Considerations

The data that is transferred by means of the IKE_AUX exchanges is not authenticated until the subsequent IKE_AUTH exchange is completed. However, if the data is placed inside the Encrypted payload, then it is protected from passive eavesdroppers. In addition the peers can be certain that they receives messages from the party he/she performed the IKE_SA_INIT with if they can successfully verify the Integrity Checksum Data of the Encrypted payload.

The main application for Auxiliary Exchange is to transfer large amount of data before IKE SA is set up without causing IP fragmentation. For that reason it is expected that in most cases IKE Fragmentation will be employed in the IKE_AUX exchanges. Section 5 of [RFC7383] contains security considerations for IKE Fragmentation.

Note, that if an attacker was able to break key exchange in real time (e.g. by means of Quantum Computer), then the security of IKE_AUX would degrade. In particular, such an attacker would be able both to read data contained in the Encrypted payload and to forge it. The forgery would become evident in the IKE_AUTH exchange (provided the

attacker cannot break employed authentication mechanism), but the ability to inject forged IKE_AUX messages with valid ICV would allow the attacker to mount Denial-of-Service attack. Moreover, if in this situation the negotiated prf was not secure against preimage attack with known key, then the attacker could forge IKE_AUX messages without later being detected in the IKE_AUTH exchange. To do this the attacker should find the same AUX_PRF_*_* value for the forged message as for original.

6. IANA Considerations

This document defines a new Exchange Type in the "IKEv2 Exchange Types" registry:

<TBA>	IKE_AUX

This document also defines a new Notify Message Types in the "Notify Message Types - Status Types" registry:

<TBA>	AUX_EXCHANGE_SUPPORTED

7. Acknowledgements

The idea to use an intermediate exchange between IKE_SA_INIT and IKE_AUTH was first suggested by Tero Kivinen. Scott Fluhrer and Daniel Van Geest identified a possible problem with authentication of IKE_AUX exchange and helped to resolve it.

8. References

8.1. Normative References

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8.2. Informative References

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