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## Running IKE Phase 2 over Artificial Kerberos IKE SA

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### Abstract

This document defines how to create artificial IKE SA using kerberos. It defines how to calculate SKEYID, cookies and IV needed by the IKE SA from the Kerberos session key. After the artificial IKE SA is created, it can be used to run normal IKE [[RFC-2409](#)] phase 2 negotiations. Those negotiations include quick Mode (creating IPsec SA), new group mode, delete notifications, and error notifications.

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[1.](#) Introduction

After the IKE [[RFC-2409](#)] phase 1 finishes it produces following information that is used to create the IKE SA:

CKY-I and CKY-R

cookies used to identify the IKE SA.

SKEYID

a string derived from secret material known only to the active players in the exchange.

SKEYID\_e

keying material used by the IKE SA to protect its own messages.

SKEYID\_a

keying material used by the IKE SA to authenticate its own messages.

SKEYID\_d

keying material used to derive keys for IPsec SAs.

IV

initialization vector used by the IKE SA for the phase 2 messages.

IKE SA algorithms  
encryption, hash, and authentication algorithms.

The SKEYID material can easily be created from the kerberos session key by just hashing it in the similar way they are created in the IKE [[RFC-2409](#)]. Cookies are just random numbers, but as they should remain constant over the negotiation between two parties, it would be desirable to derive them from the session key so they remain constant as long as the kerberos ticket is valid. Encryption, hash and authentication algorithms can be fixed to be 3DES, SHA-1 and HMAC-SHA1.

The IKE SA is authenticated using the normal kerberos AP request added to first packet in each phase 2 negotiations. The mutual authentication is done only if the phase 2 negotiation includes multiple packets, in which case the second packet encrypted using session key authenticates

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the responder.

Before this exchange can happen the initiator must first do normal kerberos authentication to KDC and receive valid kerberos ticket for the responder.

## [2.](#) Specification of Requirements

This document shall use the keywords "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" to describe requirements. They are to be interpreted as described in [[RFC-2119](#)] document.

## [3.](#) SKEYID material Calculation

>From the kerberos ticket we have the session key, which is just a shared secret with the other host. We use that session key instead of the Diffie-Hellman shared secret in the SKEYID calculation. Also there is no point of including the cookies in the SKEYID calculation, as they are generated from the session key. The SKEYID is calculated as follows:

```
SKEYID = kerberos_session_key
SKEYID_d = prf(SKEYID, kerberos_session_key | 0)
SKEYID_a = prf(SKEYID, SKEYID_d | kerberos_session_key | 1)
SKEYID_e = prf(SKEYID, SKEYID_a | kerberos_session_key | 2)
```

## [4.](#) IV and Cookie Calculation

To encrypt the Phase 2 messages the IKE SA needs a "last phase 1 CBC output block" to be used to calculate the IV for the Phase 2 messages. Because we do not have it we take the material used for the IV from the kerberos AP message included in the phase 2. The IV then used for the first encrypted block in the phase 2 message is derived from a hash of a concatenation of the kerberos AP message and the phase 2 message id using the fixed SHA-1 hash algorithm.

Cookies for the IKE SA are generated similarly from the AP message, i.e. it is taken as the 16 first bytes of the SHA-1 hash of the AP message. Note, that this means that there will be two possible IKE SAs, one for each direction.

## 5. Transmitting the AP Messages Inside the IKE Payload

The kerberos AP request and reply must be delivered from client to server and back inside the IKE payloads, and they cannot be encrypted, as the receiver of the packet does not yet know how to create the encryption key because it has not yet seen the AP message. Because of this we need to add a new payload to the beginning of each phase 2 payload and that must be transmitted without encryption. This means that we need to define new payload type for that kerberos AP message and if the next payload field in the generic header is that then the first payload is in clear, and encryption starts only after that payload. The whole packet is still authenticated as defined in [[REVISED-HASH](#)].

The final payload will look like this:

1																2																3															
0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1																
Initiator																																															
Cookie																																															
Responder																																															
Cookie																																															
NP = XXX																MjVer ! MnVer ! Exchange Type ! Flags																															
Message ID																																															
Length																																															
Next Payload																RESERVED																Payload Length															

```

+-----+
!                               Kerberos AP message                               !
+-----+
| Encrypted phase 2 payload starts here                                     |
+-----+

```

The Kerberos AP payload is only added to first phase 2 payload sent out in one negotiation, i.e it is always in the first quick mode packet going out, and it is always in all notifications and delete notifications.

The initiator can authenticate the responder by verifying the hash payload in the second quick mode packet. Only the responder can create it because it knows the session key used to create authentication MAC.

Note, that when the other end responds to quick mode it will use the same cookies that was inside the quick mode packet it received, but if it rekeys, i.e initiates itself, then it uses cookies and IV created from its own AP payload and adds the AP payload in the beginning of the packet.

Also because this quick mode is normally used without PFS the responder can immediately after receiving first packet instantiate inbound SA and then send reply back to initiator. This means that when the initiator receives the reply from responder it can also immediately start using the SA without need to wait for the third message to reach the responder. The third message only gives protection against replay attacks and because ipsec keys are derived also from the nonces inside the first and second packet any valid IPsec packet will also give proof of liveness. Thus responder can instantiate outbound SA immediately when it receives the third quick mode message, or when it receives valid authenticated IPsec packet for the inbound SA. This removes need for commit bit and reduces number of round trips from 1.5 to 1 (the last half round trip is already interleaved with the normal IPsec traffic). This optimization should NOT be used if PFS is used, because in that

case instantiating the IPsec SA requires costly Diffie-Hellman operation, which should be postponed to the point where replay attacks are not possible.

## 6. Security Considerations

This document assumes that the session key generated by the kerberos is safe and the whole security of the IKE SA is derived from that. The

IPsec SAs created using the Quick Mode negotiation over that IKE SA derive entropy also from the nonces passed in the negotiation, and also from the Diffie-Hellman if PFS is used in the quick mode.

## 7. References

[REVISED-HASH] Kivinen T., "Fixing IKE Phase 1 Authentication HASH", [draft-ietf-ipsec-ike-hash-revised-01.txt](#) (WORK IN PROGRESS)

[RFC-2409] Harkins D., Carrel D., "The Internet Key Exchange (IKE)", November 1998

[RFC-2119] Bradner, S., "Key words for use in RFCs to indicate Requirement Levels", March 1997

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