NC STATE UNIVERSITY Computer Science

CSC 774 -- Network Security

Topic 5.1: IKE

IKE Overview

- IKE = ISAKMP + part of OAKLEY + part of SKEME
  - ISAKMP determines
    - How two peers communicate
    - How these messages are constructed
    - How to secure the communication between the two peers
    - No actual key exchange
  - Oakley
    - Key exchange protocol
  - Combining these two requires a Domain of Interpretation (DOI)
    - RFC 2407

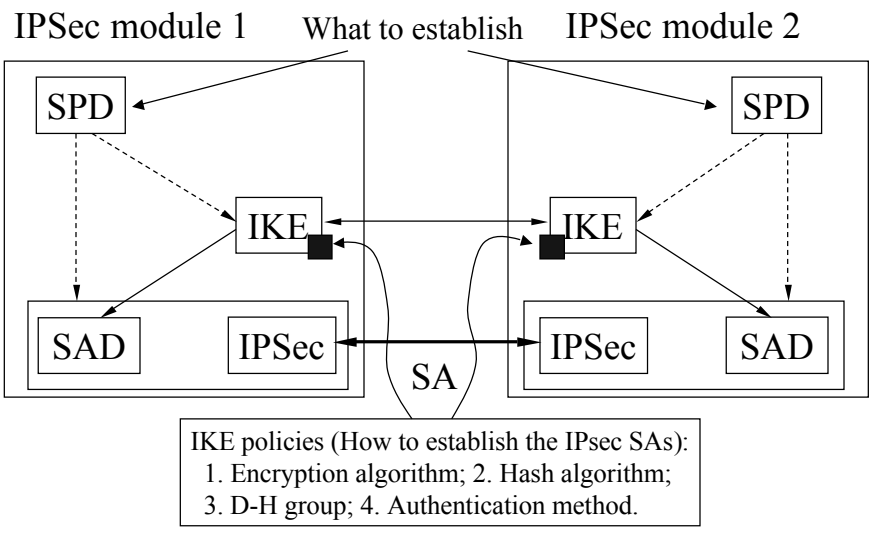
IKE Overview (Cont'd)

- A separate RFC has been published for IKE
  - RFC 2409
- Request-response protocol
  - Initiator
  - Responder
- Two phases
  - Phase 1: Establish an IKE (ISAKMP) SA
    - Essentially the ISAKMP phase 1
    - Bi-directional
  - Phase 2: Use the IKE SA to establish IPsec SAs
    - Key exchange phase
    - Directional

IKE Overview (Cont'd)

- Several Modes
  - Phase 1:
    - Main mode: identity protection
    - Aggressive mode
  - Phase 2:
    - Quick mode
  - Other modes
    - New group mode
      - Not in phase 1 or 2; Follows phase 1
      - Establish a new group to use in future negotiations
    - Informational exchanges
      - ISAKMP notify payload
      - ISAKMP delete payload

IPSEC Architecture Revisited



IKE Phase 1

- Four authentication methods
  - Digital signature
  - Authentication with public key encryption
  - The above method revised
  - Authentication with a pre-shared key

IKE Phase 1 (Cont'd)

- IKE Phase 1 goal:
  - Establish a shared secret SKEYID
  - With signature authentication
    - SKEYID = prf(Ni_b | Nr_b, g^{xy})
  - With public key encryption
    - SKEYID = prf(hash(Ni_b | Nr_b), CKY-I | CKY-R)
  - With pre-shared key
    - SKEYID = prf(pre-shared-key, Ni_b | Nr_b)
  - Notations:
    - prf: pseudo random function
    - CKY-I/CKY-R: I's (or R's) cookie
    - Ni_b/Nr_b: the body of I's (or R's) nonce

IKE Phase 1 (Cont'd)

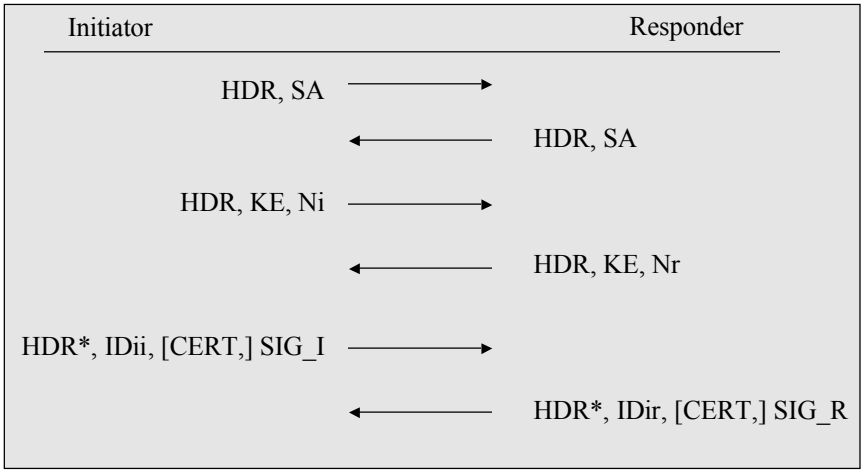
- Three groups of keys
  - Derived key for non-ISAKMP negotiations
    - SKEYID_d = prf(SKEYID, gxy | CKY-I | CKY-R | 0)
  - Authentication key
    - SKEYID_a = prf(SKEYID, SKEYID_d | gxy | CKY-I | CKY-R | 1)
  - Encryption key
    - SKEYID_e = prf(SKEYID, SKEYID_a | gxy | CKY-I | CKY-R | 2)

IKE Phase 1 (Cont'd)

- To authenticate the established key
  - Initiator generates
    - HASH_I = prf(SKEYID, g^xi | g^xr | CKY-I | CKY-R | SAi_b | IDii_b)
  - Responder generates
    - HASH_R = prf(SKEYID, g^xr | g^xi | CKY-R | CKY-I | SAi_b | IDir_b)
  - Authentication with digital signatures
    - HASH_I and HASH_R are signed and verified
  - Public key encryption or pre-shared key
    - HASH_I and HASH_R directly directly authenticate the exchange.

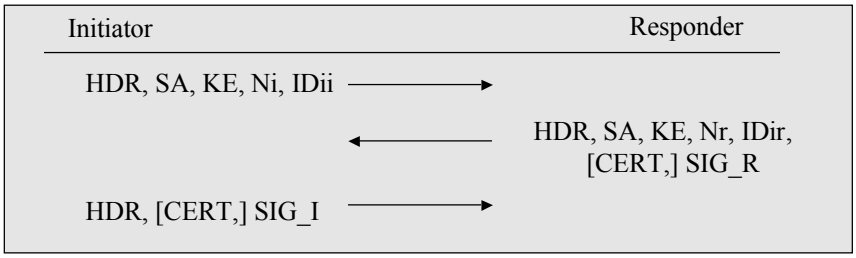
IKE Phase 1 Authenticated with Signatures

Main Mode



IKE Phase 1 Authenticated with Signatures

Agressive Mode



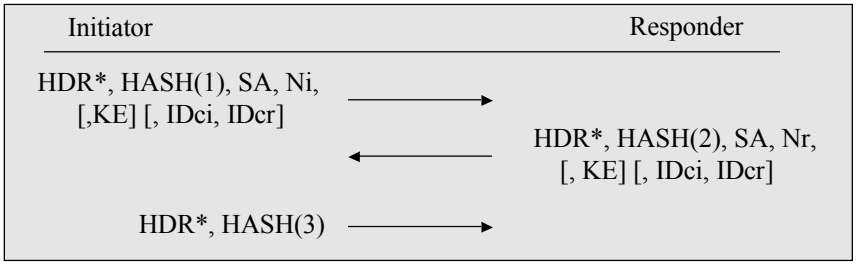
IKE Phase 2 -- Quick Mode

- Not a complete exchange itself
  - Must be bound to a phase 1 exchange
- Used to derive keying materials for IPsec SAs
- Information exchanged with quick mode must be protected by the ISAKMP SA
- Essentially a SA negotiation and an exchange of nonces
  - Generate fresh key material
  - Prevent replay attack

IKE Phase 2 -- Quick Mode (Cont'd)

- Basic Quick Mode
  - Refresh the keying material derived from phase 1
- Quick Mode with optional KE payload
  - Transport additional exponentiation
  - Provide PFS

IKE Phase 2 -- Quick Mode (Cont'd)



HASH(1) = prf(SKEYID_a, M-ID | SA | Ni [| KE] [| IDci | IDcr)
HASH(2) = prf(SKEYID_a, M-ID | Ni_b | SA | Nr [| KE] [| IDci | IDcr)
HASH(3) = prf(SKEYID_a, 0 | M-ID | Ni_b | Nr_b)

IKE Phase 2 -- Quick Mode (Cont'd)

If PFS is not needed, and KE payloads are not exchanged, the new keying material is defined as

KEYMAT = prf(SKEYID_d, protocol | SPI | Ni_b | Nr_b)

If PFS is desired and KE payloads were exchanged, the new keying material is defined as

KEYMAT = prf(SKEYID_d, $g(qm)^{xy}$ | protocol | SPI | Ni_b | Nr_b)

where $g(qm)^{xy}$ is the shared secret from the ephemeral Diffie-Hellman exchange of this Quick Mode.

In either case, "protocol" and "SPI" are from the ISAKMP Proposal Payload that contained the negotiated Transform.