CSCI 454/554 Computer and Network Security

Topic 8.1 IPsec

Outline

- IPsec Objectives
- IPsec architecture & concepts
- IPsec authentication header
- IPsec encapsulating security payload

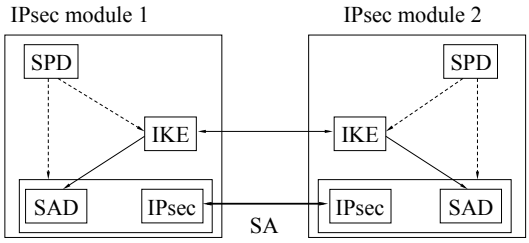
IPsec Objectives

- Why do we need IPsec?
  - IP V4 has no authentication
    - IP spoofing
    - Payload could be changed without detection.
  - IP V4 has no confidentiality mechanism
    - Eavesdropping
  - Denial of service (DOS) attacks
    - Cannot hold the attacker accountable due to the lack of authentication.

IPsec Objectives (Cont'd)

- IP layer security mechanism for IPv4 and IPv6
  - Not all applications need to be security aware
  - Can be transparent to users
  - Provide authentication and confidentiality mechanisms.

IPsec Architecture



SPD: *Security Policy Database*; IKE: *Internet Key Exchange*; SA: *Security Association*; SAD: *Security Association Database*.

IPsec Architecture (Cont'd)

- Two Protocols (Mechanisms)
  - Authentication Header (AH)
  - Encapsulating Security Payload (ESP)
- IKE Protocol
  - Internet Key Management

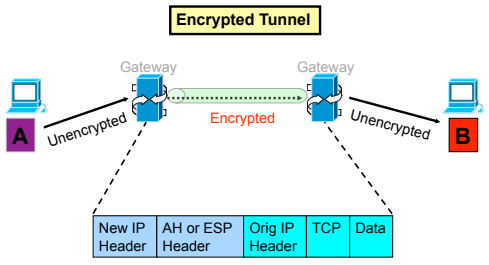
IPsec Architecture (Cont'd)

- Can be implemented in
  - Host or gateway
- Can work in two Modes
  - Tunnel mode
  - Transport mode

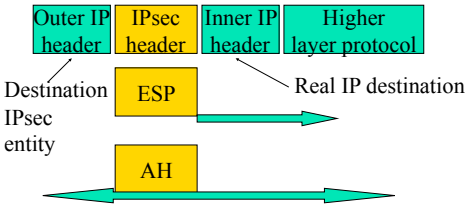
Hosts & Gateways

- Hosts can implement IPsec to connect to:
  - Other hosts in transport or tunnel mode
  - Or Gateways in tunnel mode
- Gateways to gateways
  - Tunnel mode

Tunnel Mode

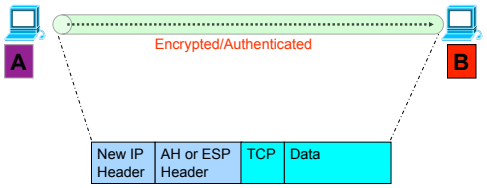


Tunnel Mode (Cont'd)

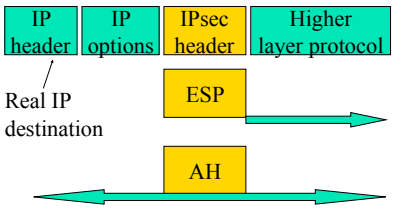


- ESP applies only to the tunneled packet
- AH can be applied to portions of the outer header

Transport Mode



Transport Mode (Cont'd)



- ESP protects higher layer payload only
- AH can protect IP headers as well as higher layer payload

Security Association (SA)

- An association between a sender and a receiver
  - Consists of a set of security related parameters
  - E.g., sequence number, encryption key
- One way relationship
- Determine IPsec processing for senders
- Determine IPsec decoding for destination
- SAs are not fixed! Generated and customized per traffic flows

Security Parameters Index (SPI)

- A bit string assigned to an SA.
- Carried in AH and ESP headers to enable the receiving system to select the SA under which the packet will be processed.
- 32 bits
- SPI + Dest IP address + IPsec Protocol
  - Uniquely identifies each SA in SA Database (SAD)

SA Database (SAD)

- Holds parameters for each SA
  - Sequence number counter
  - Lifetime of this SA
  - AH and ESP information
  - Tunnel or transport mode
- Every host or gateway participating in IPsec has their own SA database

SA Bundle

- More than 1 SA can apply to a packet
- Example: ESP does not authenticate new IP header. How to authenticate?
  - Use SA to apply ESP w/out authentication to original packet
  - Use 2nd SA to apply AH

Security Policy Database (SPD)

- Decide
  - What traffic to protect?
  - Has incoming traffic been properly secured?
- Policy entries define which SA or SA Bundles to use on IP traffic
- Each host or gateway has their own SPD
- Index into SPD by Selector fields
  - Selectors: IP and upper-layer protocol field values.
  - Examples: Dest IP, Source IP, Transport Protocol, IPSec Protocol, Source & Dest Ports, …

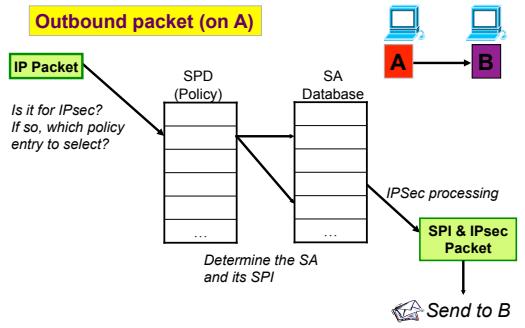
SPD Entry Actions

- Discard
  - Do not let in or out
- Bypass
  - Outbound: do not apply IPSec
  - Inbound: do not expect IPSec
- Protect – will point to an SA or SA bundle
  - Outbound: apply security
  - Inbound: security must have been applied

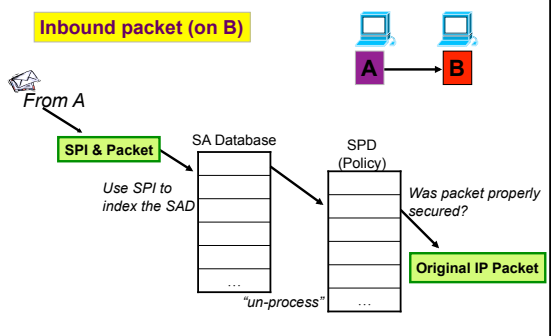
SPD Protect Action

- If the SA does not exist…
  - Outbound processing
    - Trigger key management protocols to generate SA dynamically, or
    - Request manual specification, or
    - Other methods
  - Inbound processing
    - Drop packet

Outbound Processing



Inbound Processing



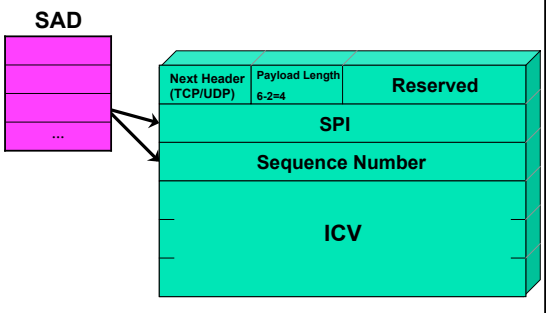
Authentication Header (AH)

- Data integrity
  - Entire packet has not been tampered with
- Authentication
  - Can "trust" IP address source
  - Use MAC to authenticate
- Anti-replay feature
- Integrity check value

Integrity Check Value - ICV

- Message authentication code (MAC) calculated over
  - IP header fields that do not change or are predictable
  - IP header fields that are unpredictable are set to zero.
  - IPsec AH header with the ICV field set to zero.
  - Upper-level data
- Code may be truncated to first 96 bits

IPsec Authentication Header



Encapsulated Security Protocol (ESP)

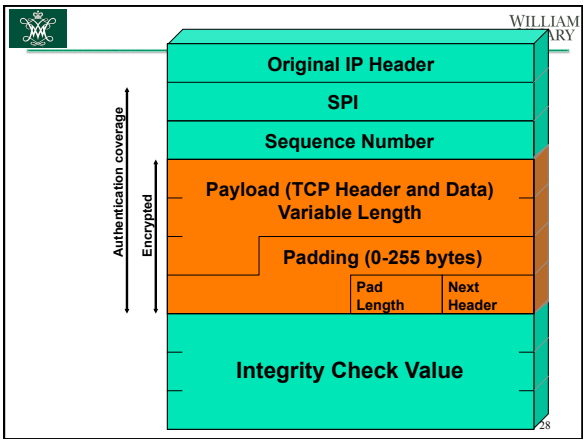
- Confidentiality for upper layer protocol
- Partial traffic flow confidentiality (Tunnel mode only)
- Data origin authentication and connectionless integrity (optional)

Outbound Packet Processing

- Form ESP payload
- Pad as necessary
- Encrypt result [payload, padding, pad length, next header]
- Apply authentication

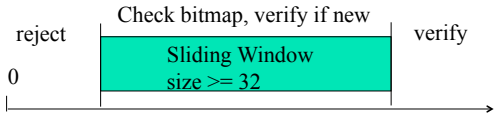
Outbound Packet Processing...

- Sequence number generation
  - Increment then use
  - With anti-replay enabled, check for rollover and send only if no rollover
  - With anti-replay disabled, still needs to increment and use but no rollover checking
- ICV calculation
  - ICV includes whole ESP packet except for authentication data field.
  - Implicit padding of '0's between next header and authentication data is used to satisfy block size requirement for ICV algorithm
  - *Not include the IP header.*



Inbound Packet Processing

- Sequence number checking
  - Anti-replay is used only if authentication is selected
  - Sequence number should be the first ESP check on a packet upon looking up an SA
  - Duplicates are rejected!



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Anti-replay Feature

- Optional
- Information to enforce held in SA entry
- Sequence number counter - 32 bit for outgoing IPsec packets
- Anti-replay window
  - 32-bit
  - Bit-map for detecting replayed packets

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Anti-replay Sliding Window

- Window should not be advanced until the packet has been authenticated
- Without authentication, malicious packets with large sequence numbers can advance window unnecessarily
  - Valid packets would be dropped!

Inbound Packet Processing...

- Packet decryption
  - Decrypt quantity [ESP payload,padding,pad length,next header] per SA specification
  - Processing (stripping) padding per encryption algorithm; In case of default padding scheme, the padding field SHOULD be inspected
  - Reconstruct the original IP datagram
- Authentication verification (option)

ESP Processing - Header Location...

- Transport mode IPv4 and IPv6

IPv4

IPv6

ESP Processing - Header Location...

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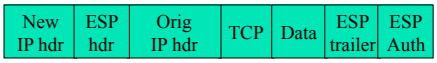
- Tunnel mode IPv4 and IPv6

IPv4



IPv6