# IP vulnerabilities

**Password sniffing**

**IP Spoofing**

- **host rename (LAN)**
- **DNS**
- **source routing**
- **TCP sequence number guessing / splicing**

**Session hijacking**

**Denial of service**

- **ICMP bombing, redirects, unreachable**
- **application(ftp,mail,echo) bombing**
- **TCP SYN flooding**

# Port probes

## AT&T attacks Feb/Mar '92

| | |
|---|---|
| guest/demo/visitor logins | 296 |
| rlogins | 62 |
| FTP passwd fetches | 27 |
| NNTP | 16 |
| portmapper | 11 |
| whois | 10 |
| SNMP | 9 |
| X11 | 8 |
| TFTP | 5 |
| systat | 2 |
| NFS | 2 |

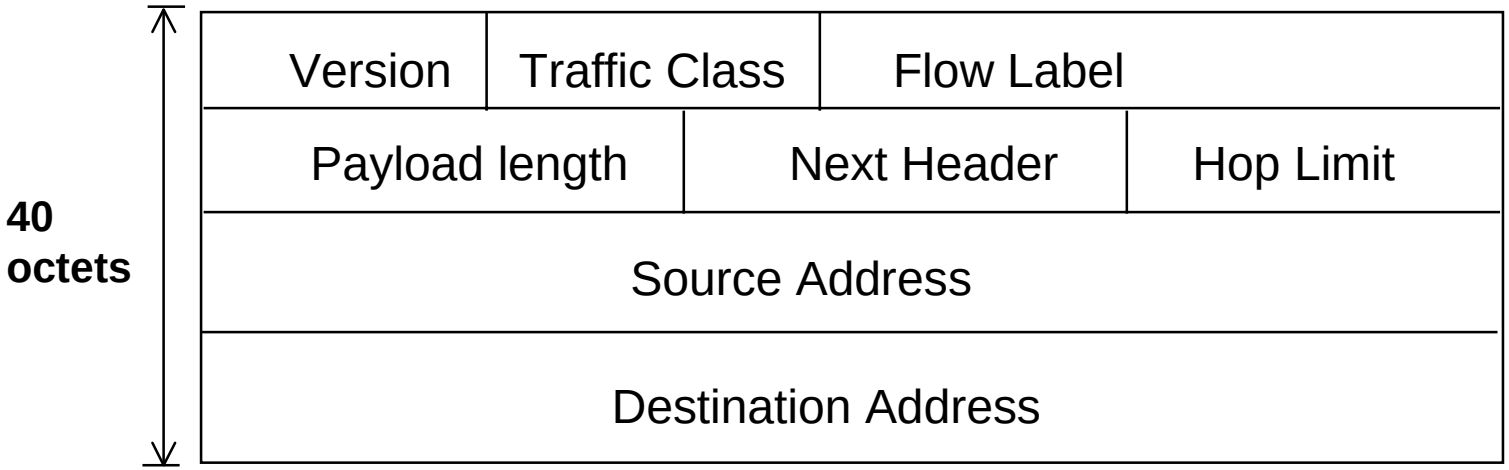
**Number of evil sites 95**

# IPv6

## next generation TCP/IP

- Larger addresses (128 bits)
- Improved performance
  - expanded routing
  - header format simplification
  - flow labeling
  - priority (QoS)
- Security
- Interoperability with IPv4

# IPv6 Header

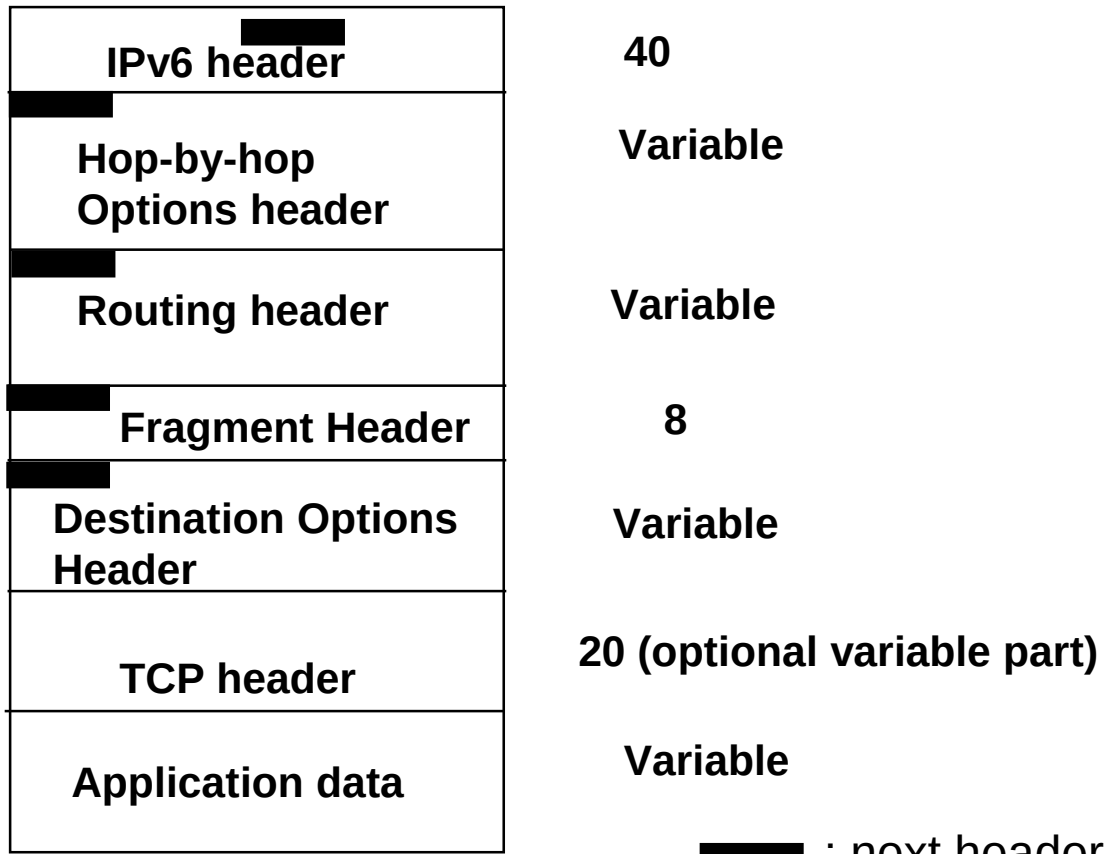



**V. (4bit) : 6**
**T. C.(8bit) : distinguish between different classes or priorities of IPv6 packet(under study)**
**F. L.(20bit) : used by a host to label packet for special handling**
**P. L.(16bit) : length of remainder of IPv6 packet following the header**
**N. H.(8bit) : Identify the type of header immediately following IPv6 packet**
**H. L.(8bit) : remaining number of allowable hops for this packet**
**S.A. (128bit) , D.A(128bit)**

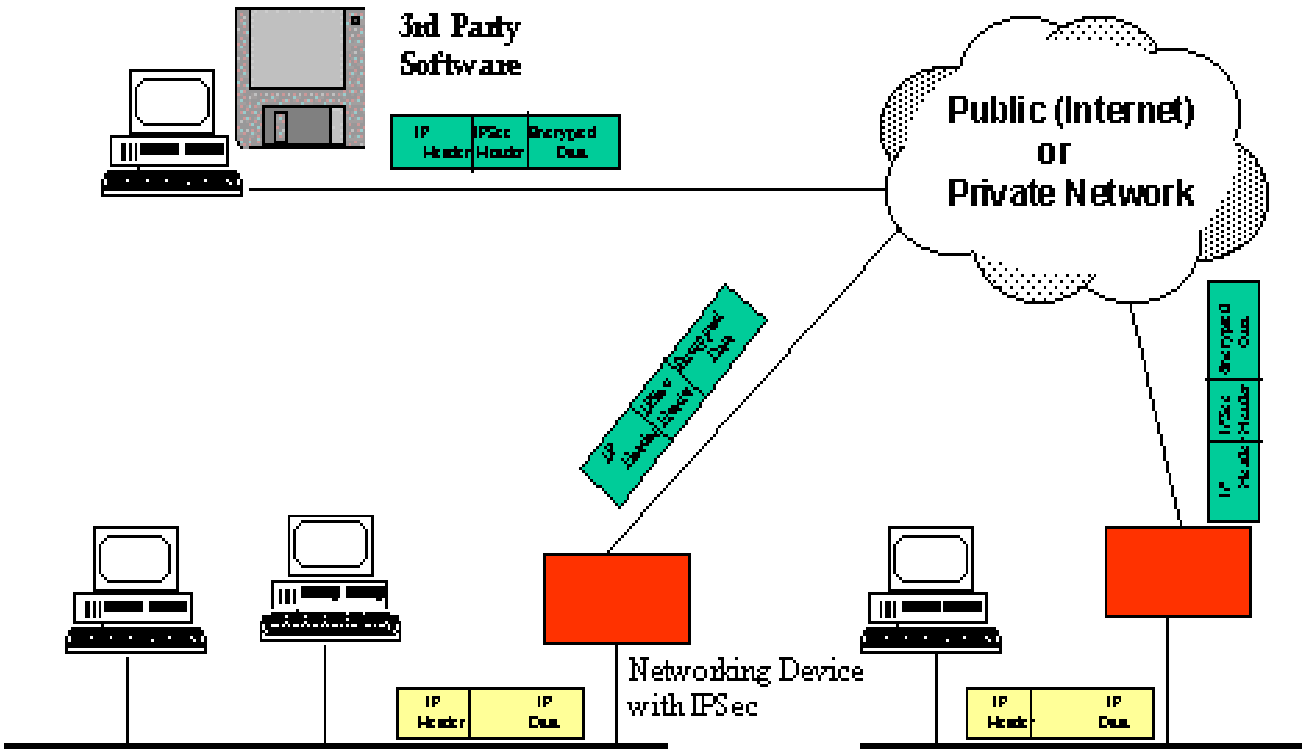
# IPv6 Extension Headers

- **Hop-by-hop Options header : define special options that require hop-by-hop processing consisting of Next Header (8bit), Header Extension Length (8bit),and Options**
- **Routing Header : Provides extended routing**
- **Fragment Header : Contains fragmentation and reassembly information**
- **Authentication Header : Provides packet integrity and authentication**
- **Encapsulating Security Payload : provides integrity and privacy**
- **Destination Option Header : contain optional information to be examined by the destination node**

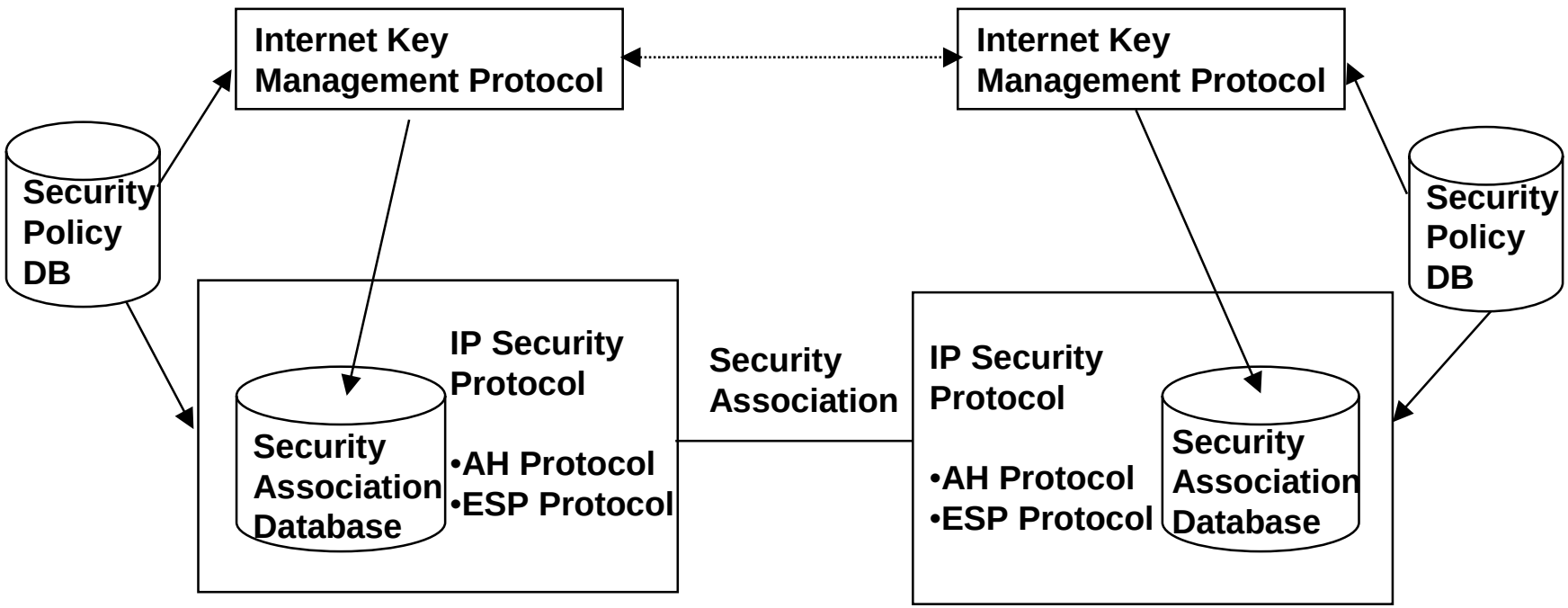
# IPv6 Packet with Extension Headers (containing TCP Segment)



# IP Security Scenario

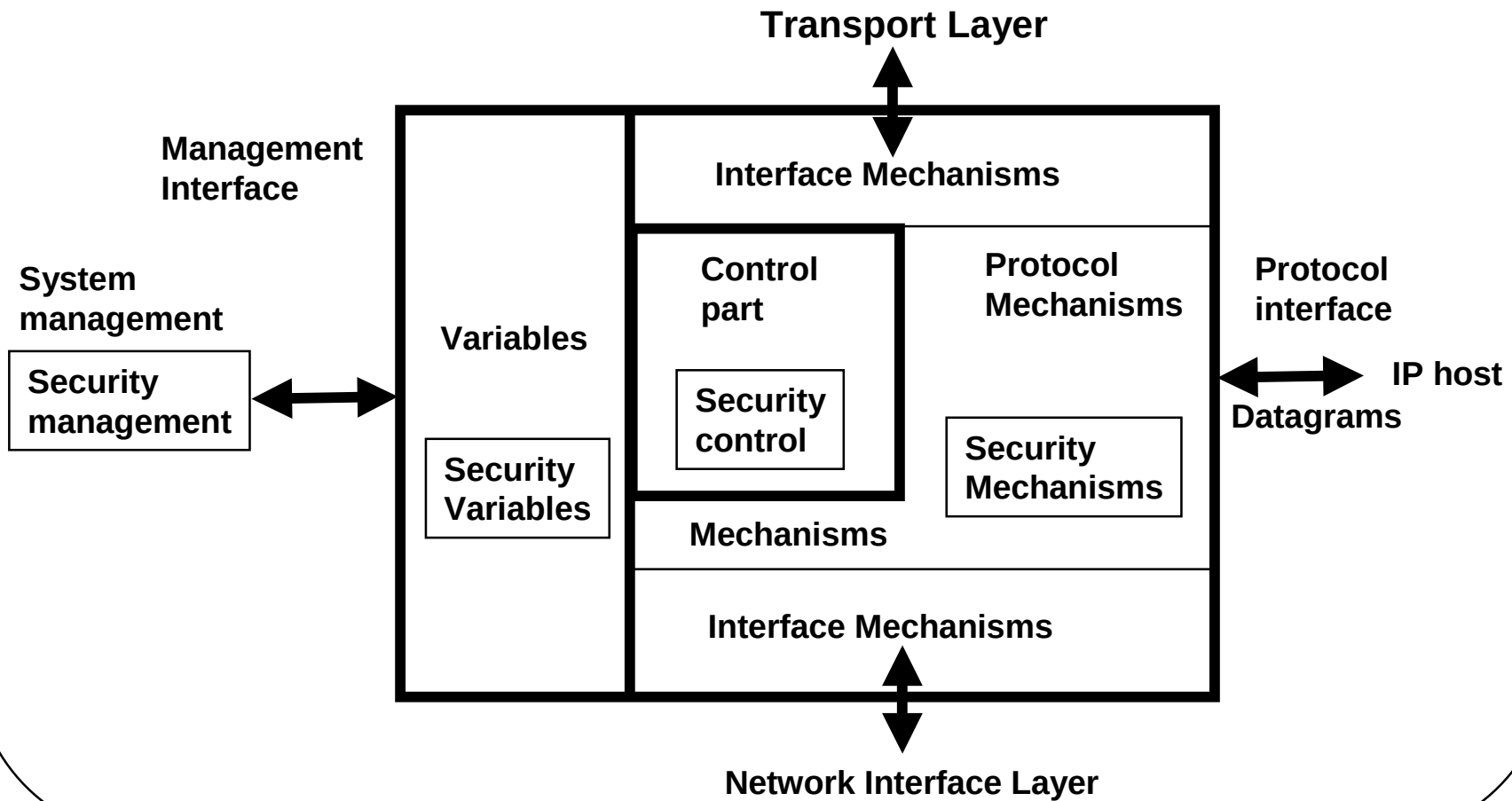


# Architecture of IPSec(I)

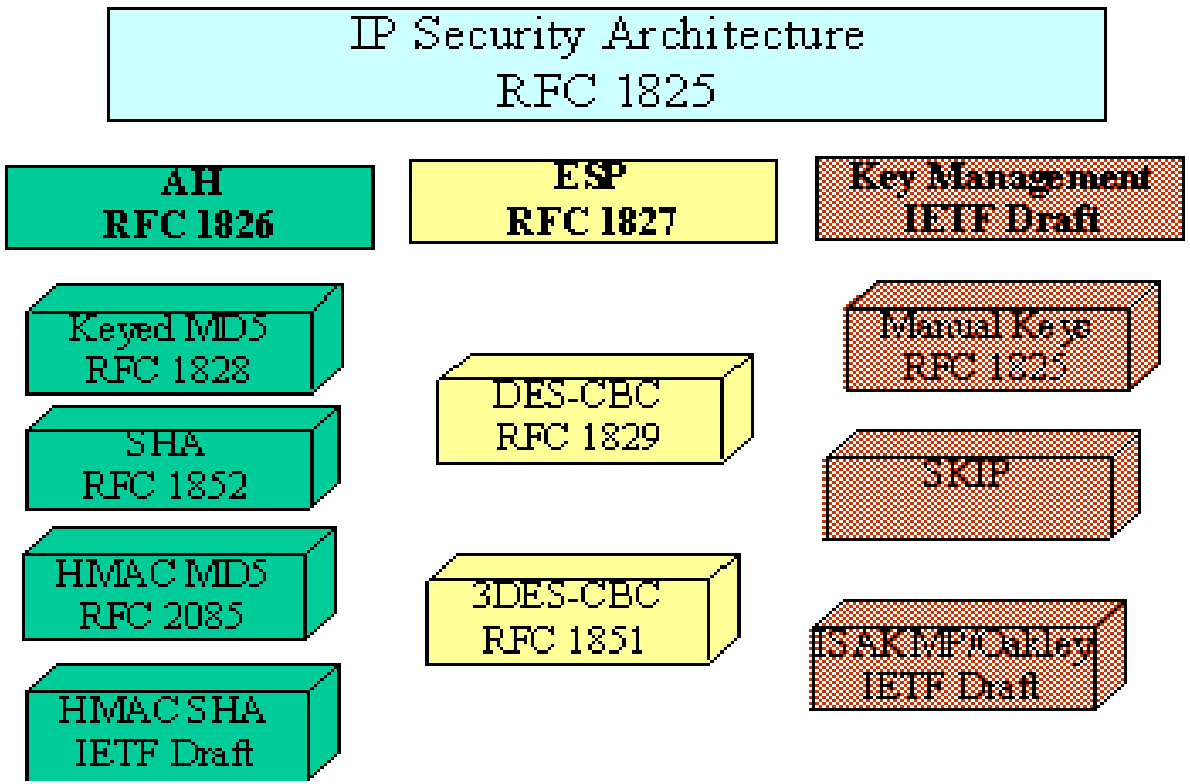



AH : Authentication Header
ESP : Encapsulating Security Payload

# Architecture of IPSec(II)



# Overview of IPSec protocol



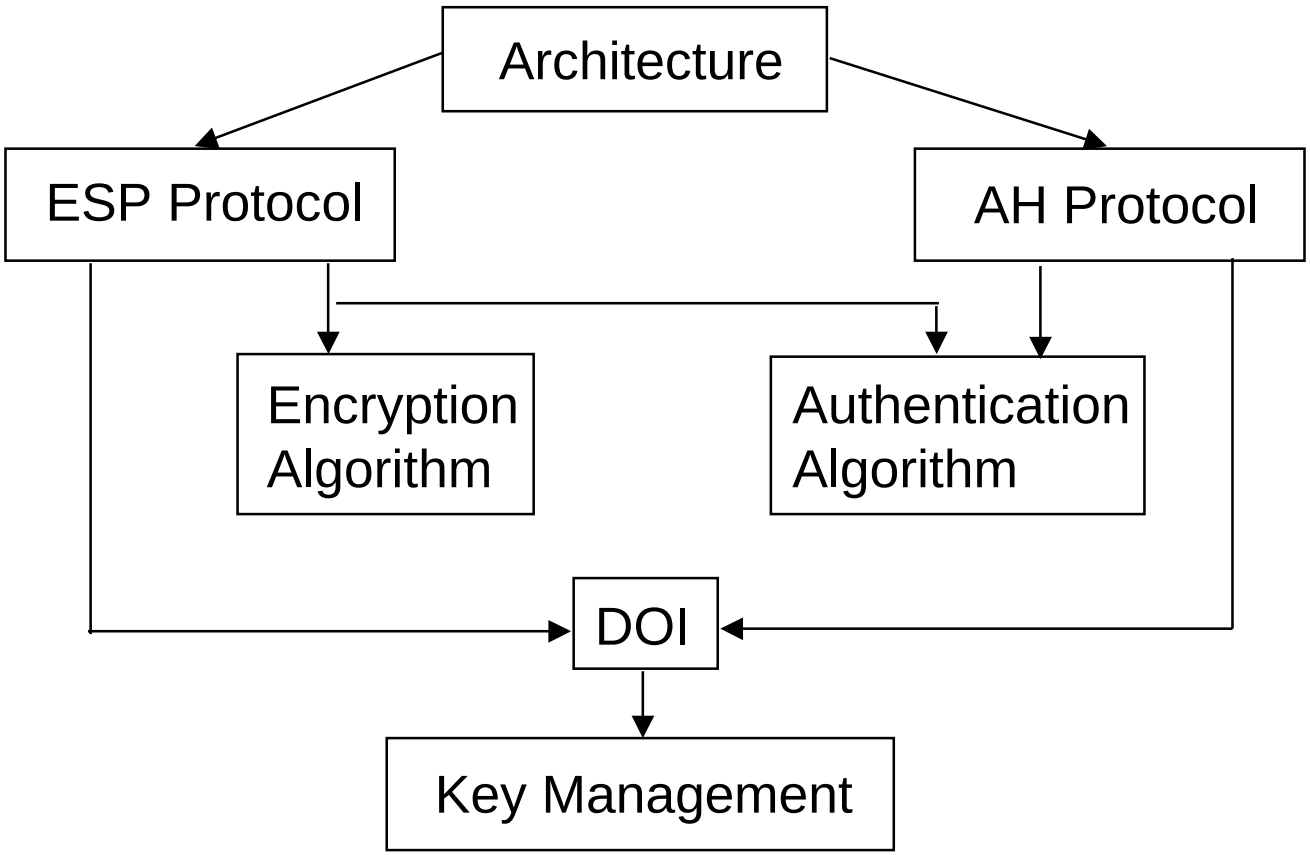
# Applications of IPSec

- Secure branch office connectivity over the Internet : VPN
- Secure remote access over the Internet via ISP
- Establishing extranet and intranet connectivity with partners :+SSL
- Enhancing electronic commerce security : SET

# IPSec Document

- RFC1636 : Report of IAB Workshop on Security in the Internet Architecture, Feb. 8-10,'94
- RFC1825 : Security architecture for the Internet Protocol
- RFC1826 : IP Authentication Header
- RFC1827 : IP Encapsulating Security Payload
- RFC1828 : IP Authentication using Keyed MD5
- RFC1829 : The ESP DES-CBC Transform
- RFC1851 : The ESP Triple DES Transform
- RFC1852 : IP Authentication using Keyed SHA
- RFC2085 : HMAC-MD5 IP Authentication with Replay Prevention
- RFC2104 : HMAC : Keyed-hashing for Message Authentication
- I-D : Internet Security Association and Key Management Protocol (ISAKMP) etc 23 documents

# IPSec Document Overview(I)




**DOI : Domain of Interpretation**

# IPSec document overview(II)

- **Architecture : general concepts, security req't, definitions and mechanisms defining IPsec tech.**
- **Encapsulating Security Payload (ESP) : covers packet format and general issues for packet encryption**
- **Authentication Header (AH) : packet authentication**
- **Encryption Algorithm : various algorithms for ESP**
- **Authentication Algorithm: various algorithms for AU**
- **Key Management : key management**
- **Domain of Interpretation (DOI) : values for the other documents to relate to each other**

# Security Association(I)

- Sender/receiver security info
- SA for each direction
- Maintained by kernel
- Uniquely identify
  - ✓ SPI (Security Parameter Index)
  - ✓ IP destination address
  - ✓ Security Protocol Identifier
- Specifies
  - ✓ encryption key, IV, algorithm
  - ✓ authentication algorithm
  - ✓ key lifetimes
  - ✓ SA lifetime
  - ✓ security labels

# Security Association(II)

| Security Parameter | Example value |
|---|---|
| SPI(Security Parameter Index) | 2916 |
| AH Algorithm | MD5 |
| AH Algorithm Mode | Keyed |
| AH Transform | RFC1828 |
| AH Key(s) | a 128 bit MD5 Key |
| AH Mode | Entire Datagram |
| ESP Algorithm | DES |
| ESP Algorithm Mode | CBC |
| ESP Transform | RFC1829 |
| ESP Key(s) | a 56 bit DES key |
| ESP Mode | Transport |
| ESP Synch/Init. Vector Size | 64 |
| Lifetime | an absolute time in Unix time format |

# Security Policy Record

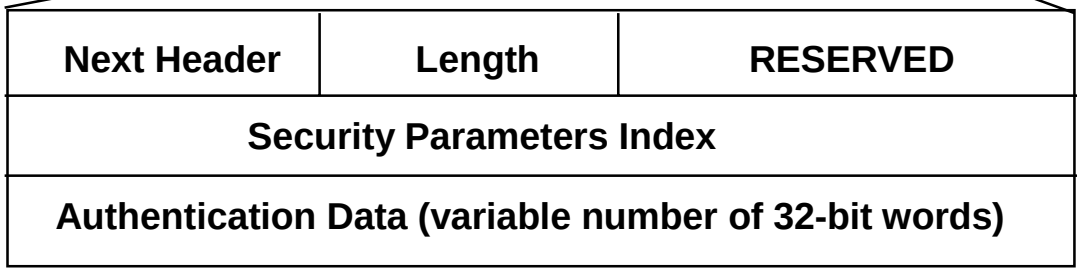
| Security Parameter | Example Values |
|---|---|
| SPI(Security Parameter Index) | 2916 |
| IP Destination Address | 128 bit IPv6 address value |
| IP Source Address | 128 bit IPv6 address value |
| Protocol | TCP |
| TCP/UDP Destination Port | 23 |
| TCP/UDP Source Port | 1234 |
| UserID | Unix UID or other credentials |

# AH format

Inbound datagram

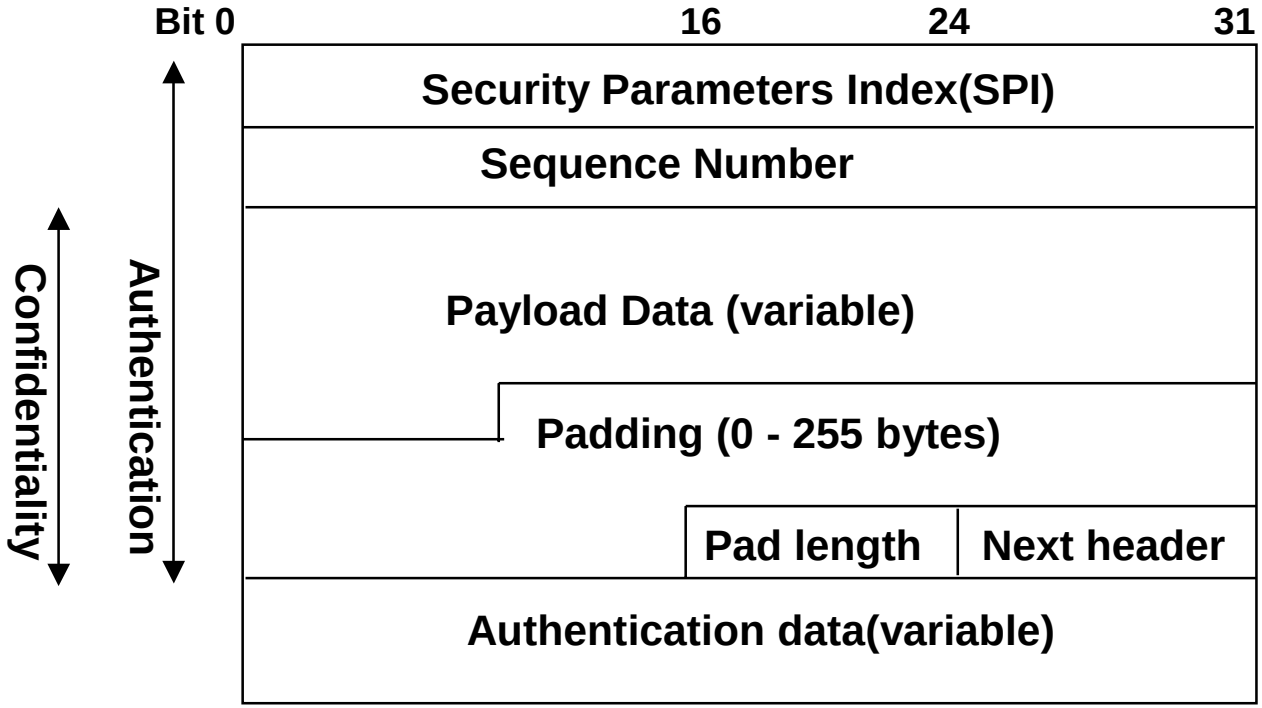

AH calculation


AH Syntax




**8bit Next header : next payload after Authentication payload**
**8 bit length : length of authentication data in 32 bit word**
**16 bit reserved field**
**32 bit SPI : SA of this datagram**
**Aut. Data : variable length depending on specification of auth. transfrom**

# ESP format




**SPI (32bit): Identifies SA**
**S.N. (32 bit) : decreasing counter values**
**P.D. (var.) : transport-level segment (transport m.) or IP packet (tunnel m.)**
**P. : for encryption of CBC mode**

# Algorithms

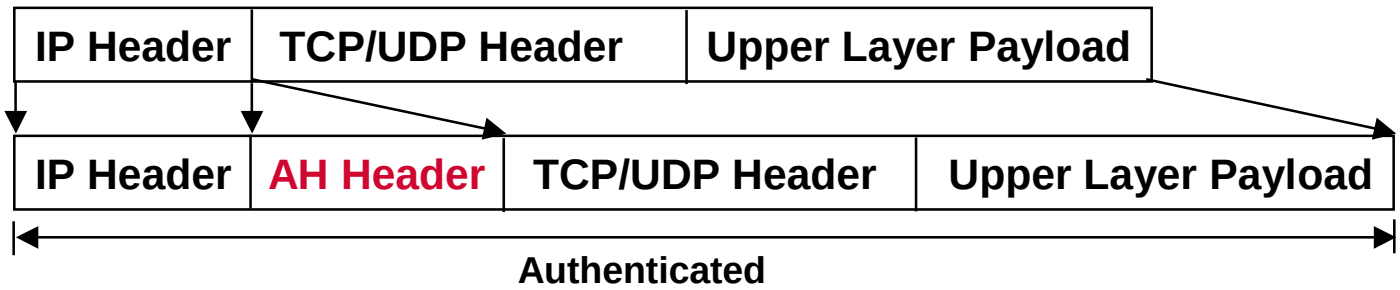
- Confidentiality and authentication
  - 3DES
  - RC5
  - IDEA
  - CAST
  - Blowfish
- MIC (Message Integrity Check)
  - HMAC-MD5-96
  - HMAC-SHA-1-96

# Modes(I)

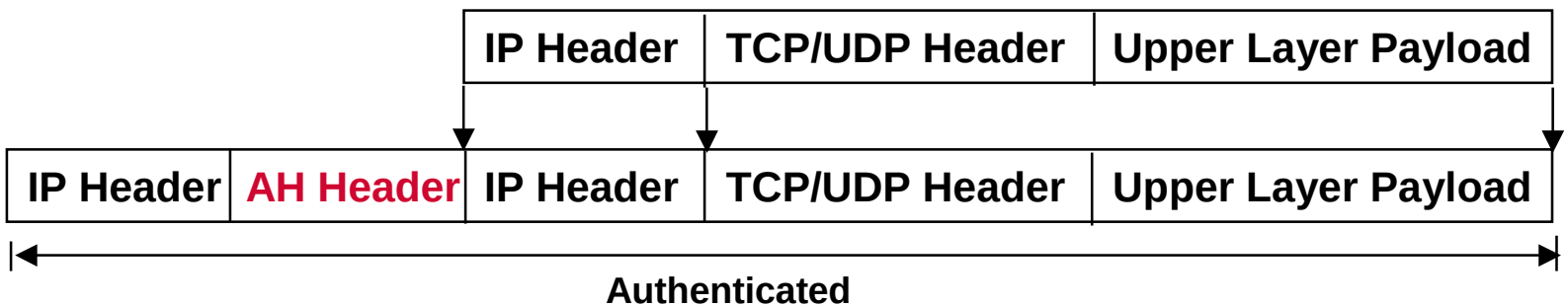
- **Transport Mode**
  - protection for upper-layer protocol like TCP, UDP or ICMP packet
  - end-to-end btw 2 hosts (e.g. C/S, or 2 W/S)
- **Tunnel Mode**
  - protect entire IP packet
  - host-to-subnet or subnet-to-subnet

# Modes(II)

AH Transformation



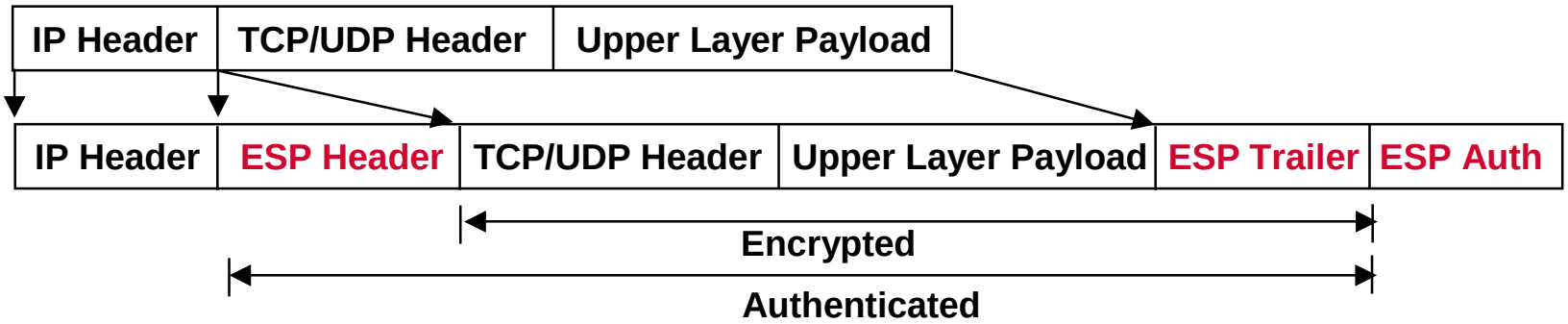

(1) transport mode



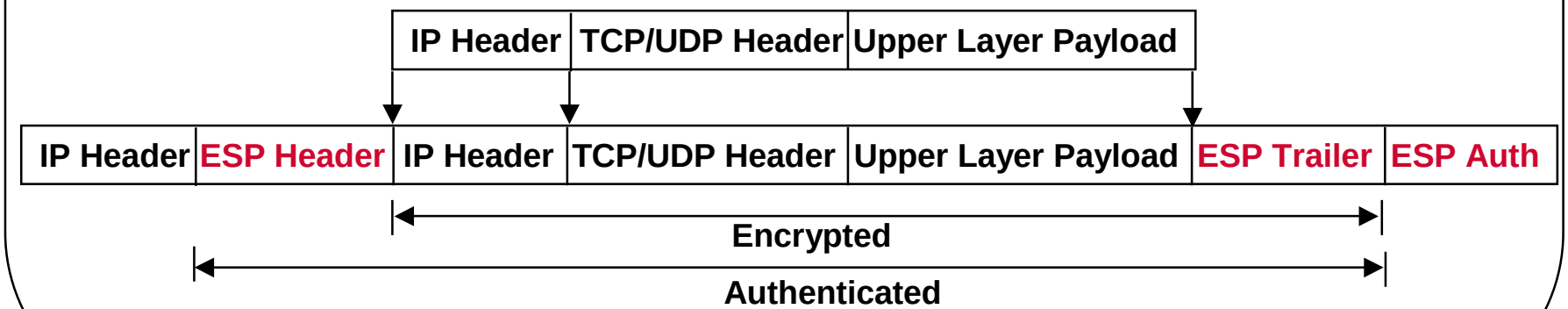

(2) tunnel mode

# Modes(III)

ESP transformation




(1) transport mode




(2) tunnel mode

# Modes(IV)

| | Transport Mode SA | Tunnel Mode SA |
|---|---|---|
| AH | Authenticates IP payload and selected portions of IP header and IPv6 extension headers. | Authenticate entire inner IP packet (inner header plus IP payload) plus selected portions of outer IP header and outer. |
| ESP | Encrypts IP payload and any IPv6 extension headers following the ESP header. | IPv6 extension headers. Encrypts inner IP packets |
| ESP with Authentication | Encrypts IP payload and any IPv6 extension headers following the ESP header. Authenticates IP payload but not IP header. | Encrypts inner IP packet. Authenticate inner IP packet. |

# IPSec Services

- Access control
- Connectionless integrity
- Data origin authentication
- Rejection for replayed packets (a form of partial sequence integrity)
- Confidentiality (encryption)
- Limited traffic flow confidentiality

# IPSec Services

| | AH | ESP(e. only) | ESP (e. + a.) |
|---|---|---|---|
| Access Control | X | X | X |
| Connectionless Integrity | X | | X |
| Data origin authentication | X | | X |
| Rejection of replayed packets | X | X | X |
| Confidentiality | | X | X |
| Limited Traffic flow confidentiality | | X | X |

# IP Sec benefits

- Implemented in firewall/router, provides strong security
- Traffic can’t bypass firewall with IPsec
- Below transport layer (TCP, UDP) and transparent to applications
- Transparent to end users
- Provide security for individual users if needed.

# Limitations

- Don’t provide traffic analysis
- Don’t provide non-repudiation
- Don’t provide denial-of-service attack

# key/SA management

**active research, not standard**

- **manual keying**
- **proposals (SKIP, ISAKMP, Photuris )**
  - **SKIP (Simple Key Interchange Protocol)**
    - **light-weight**
    - **in-band**
    - **Diffie-Hellman (signed public keys)**
  - **ISAKMP (Internet Security Association and Key Management Protocol)**
    - **out-of band, daemon**
    - **negotiate (Oakley)**
    - **Diffie-Hellman, public keys**

# Group key parameter by Oakley

- Modular exp. (a=2) with p
  - 768bit
  - 1024bit
- Elliptic curves over
  - $2^{155}$
  - $2^{185}$

# Features of Oakley

- employ mechanism known as cookies* to thwart clogging attack
- enable 2 parties to negotiate a group
- use nonces to ensure against replay attack
- enable to exchange DH public key values
- authenticate DH exchange to thwart man-in-the-middle attack

* cookie : low level ID carrying in each packet to drive classification or electronic tags placed on your computer by web site.

# Example of Oakley(I)

**I -> R : $CKY_I$, OK_KEYX, GRP, $g^x$, EHAO, NIDP, $ID_I$, $ID_R$, $N_I$,**
**$S_{KI}[ID_I \| ID_R \| N_I \| GRP \| g^x \| EHAO]$**

**R -> I : $CKY_R$, $CKY_I$, OK_KEYX, GRP, $g^y$, EHAS, NIDP, $ID_R$, $ID_I$, $N_R$, $N_I$,**
**$S_{KR}[ID_R \| ID_I \| N_R \| N_I \| GRP \| g^y \| g^x \| EHAS]$**

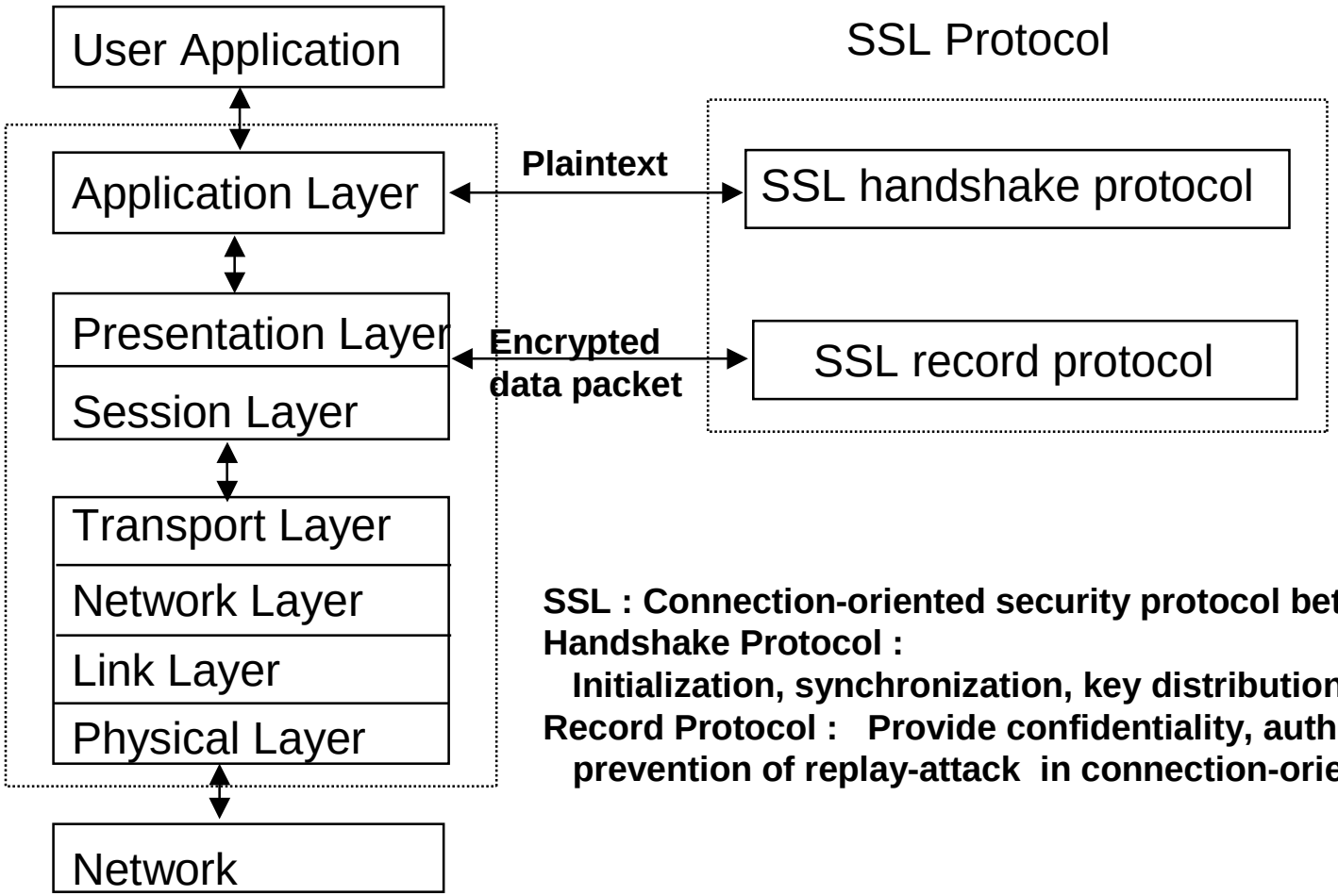
**I -> R : $CKY_I$, $CKY_R$, OK_KEYX, GRP, $g^x$, EHAS, NIDP, $ID_I$, $ID_R$, $N_I$, $N_R$,**
**$S_{KI}[ID_I \| ID_R \| N_I \| N_R \| GRP \| g^y \| g^x \| EHAS]$**

**I : Initiator, R:Responder**
**$CKY_I$, $CKY_R$ : Initiator, responder cookies, OK_KEYX : Key exchange message type**
**GRP : Name of DH group for this exchange**
**EHAO, EHAS : Encryption, hash, authentication functions, offered and selected**
**NIDP : Indicates encryption is not used for remainder of this message**
**$ID_I$, $ID_R$ : Identifier for initiator, responder**
**NI, NR : Random nonce supplied by initiator, responder for this exchange**
**$S_{KI}[X]$, $S_{KR}[X]$ : Indicates the signature over X using private key (signing key) of initiator, responder**

# Example of Oakley(II)

- (step1) transmit cookie, group to be used, I's public key and others
- (step2) R verifies signature using I's public key and echoing adding signature
- (step 3) verifies R's signature, check nonce against replay attack
- (step 4) complete the exchange, I send message back to R to verify that I have received R's public key

# SSL(I)




**SSL : Connection-oriented security protocol between C/S**
**Handshake Protocol :**
**Initialization, synchronization, key distribution**
**Record Protocol : Provide confidentiality, authentication, prevention of replay-attack in connection-oriented TCP**

# SSL(II)

- **Handshake Protocol**
  - **(Step 1) Selection of algorithm, distribution of master key, authentication of server**
  - **(Step 2)  Authentication of client if necessary**
- **Record Protocol**
  - **If no use session ID, no need authentication of client**
  - **If use of Session ID, no need authentication of client**
  - **If use of Session ID, need authentication of client**

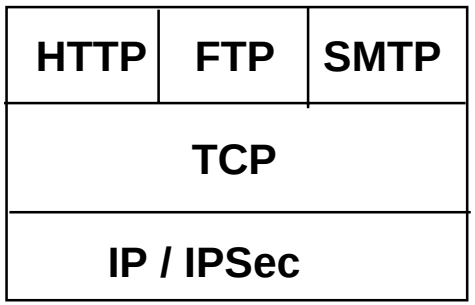
# SSL(III)

- Confidentiality : Fortezza, IDEA, RC2-40, RC4-40, DES, 3DES
- Anti-traffic attack
- Message Authentication : HMAC-MD5

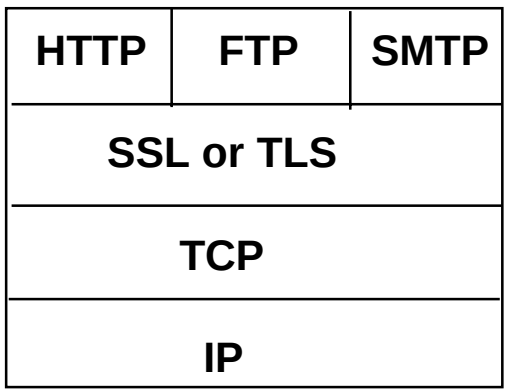
# Comparison of IPv6 and SSL

| Classification | | IPv6 | SSL |
|---|---|---|---|
| Layer | | • Network layer<br>• Applicable to transport layer | • Transport layer<br>• Limited privacy and authentication serivices |
| Style of usage | | • host-to-host<br>• host-to-subnet<br>• subnet-to-subnet | host-to-host |
| Key exchange | | • IKMP<br>• Hard to define exchange mechanism for large network | • Server key exchange message<br>• Client key exchange message<br>• secure WWW-based |
| Algorithm | Privacy | • No limitation<br>• DES, 3DES, IDEA, Blowfish, RC5 | •No limitation<br>•Fortezza, IDEA, RC2, RC4, DES, 3DES |
| | Authentication | • Keyed MD5, SHA-1<br>• packet authentication on network layer<br>• origin and destination address | • MD5<br>• Packet authentication on transpor t layer |
| | Integrity | • Tunnel mode ESP<br>• Transparent mode ESP | • Protocol (HTTP, NNTP, SMTP) dependent |

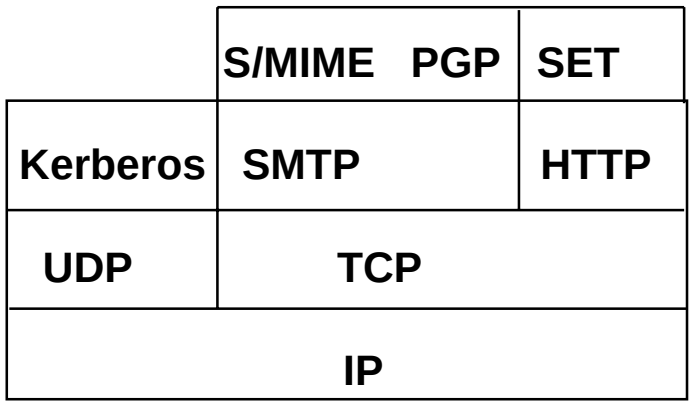
# Security Facilities in TCP/IP




(a) Network level




(a) transport level




(c) application level