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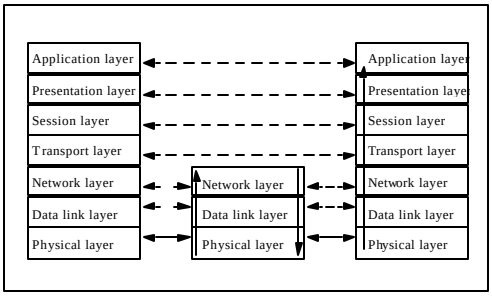
Network Security

EECE 412
Session 8

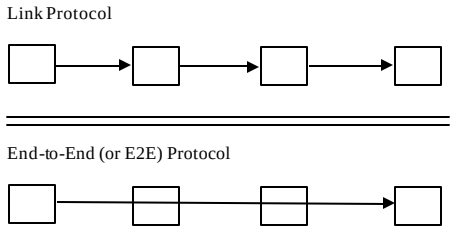
Outline

- Link & end-to-end protocols
- SSL
- IPSec

Networks



Link and End-to-End Protocols



Examples

- Telnet protocol
  - Messages between client, server enciphered, and encipherment, decipherment occur only at these hosts
  - End-to-end protocol
- PPP Encryption Control Protocol
  - Host gets message, deciphers it
    - Figures out where to forward it
    - Enciphers it in appropriate key and forwards it
  - Link protocol

Link vs. End-to-end protection

Link encryption

- Can protect headers of packets
- Possible to hide source and destination
  - Note: may be able to deduce this from traffic flows

End-to-end encryption

- Cannot hide packet headers
- Attacker can read source, destination

Example Protocols

- Privacy-Enhanced Electronic Mail (PEM)
  - Applications layer protocol
- Secure Socket Layer (SSL)
  - Transport layer protocol
- IP Security (IPSec)
  - Network layer protocol

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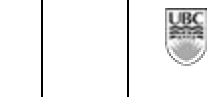

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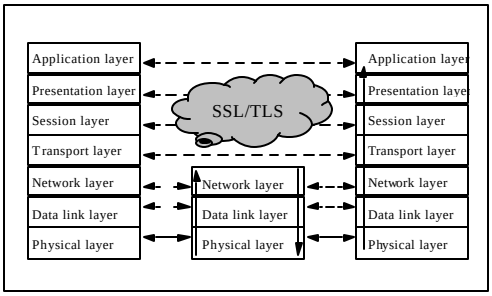
Secure Socket Layer (SSL) a.k.a. Transport Layer Security (TLS)

Networks



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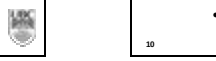

SSL Session

Association between two peers

- Two peers may have several sessions
- Information for each association:
  - Unique session identifier
  - Peer's X.509v3 certificate, if needed
  - Compression method
  - Cipher spec for cipher and MAC
  - "Master secret" shared with peer
    - 48 bits

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SSL Connection

Describes how data exchanged with peer in a session

- Several connections per session
- Information for each connection
  - Random data
  - Write keys (used to encipher data)
  - Write MAC key (used to compute MAC)
  - Initialization vectors for ciphers, if needed
  - Sequence numbers

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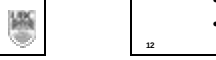

Supporting Crypto

- All parts of SSL use them
- Initial phase: public key system exchanges keys
  - Messages enciphered using classical ciphers, and MACed
  - Only certain combinations allowed
    - Depends on algorithm for key exchange cipher
  - Key exchange (a.k.a., interchange) algorithms:
    - RSA
    - Diffie-Hellman
    - Fortezza

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RSA: Cipher, MAC Algorithms

Interchange cipher	*Classical cipher*	*MAC Algorithm*
RSA, key = 512 bits	*none*	MD5, SHA
	RC4, 40-bit key	MD5
	RC2, 40-bit key, CBC mode	MD5
	DES, 40-bit key, CBC mode	SHA
RSA	*None*	MD5, SHA
	RC4, 128-bit key	MD5, SHA
	IDEA, CBC mode	SHA
	DES, CBC mode	SHA
	DES, EDE mode, CBC mode	SHA

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D-H: Cipher, MAC Algorithms

Interchange cipher	*Classical cipher*	*MAC Algorithm*
Diffie-Hellman, DSS Certificate	DES, 40-bit key, CBC mode	SHA
	DES, CBC mode	SHA
	DES, EDE mode, CBC mode	SHA
Diffie-Hellman, key = 512 bits RSA Certificate	DES, 40-bit key, CBC mode	SHA
	DES, CBC mode	SHA
	DES, EDE mode, CBC mode	SHA

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Fortezza: Cipher, MAC Algorithms

Interchange cipher	*Classical cipher*	*MAC Algorithm*
Fortezza key exchange	*none*	SHA
	RC4, 128-bit key	MD5
	Fortezza, CBC mode	SHA

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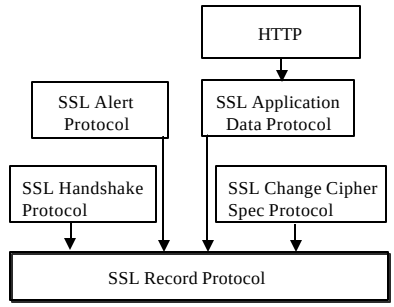
SSL Protocols



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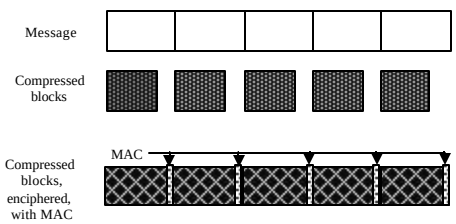
SSL Record Layer



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Overview of Handshake Rounds

1. Create SSL connection between client, server
2. Server authenticates itself
3. Client validates server, begins key exchange
4. Acknowledgments all around

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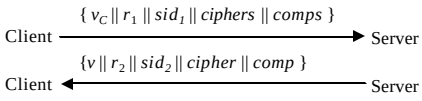
Handshake Round 1

Purpose: Create SSL connection between client, server



v_C	Client's version of SSL
v	Highest version of SSL that Client, Server both understand
r_1, r_2	nonces (timestamp and 28 random bytes)
sid_1	Current session id (0 if new session)
sid_2	Current session id (if s1 = 0, new session id)
ciphers	Ciphers that client understands
comps	Compression algorithms that client understand
cipher	Cipher to be used
comp	Compression algorithm to be used

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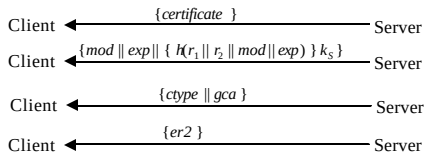
Handshake Round 2

Purpose: Server authenticates itself



Note: if Server not to authenticate itself, only last message sent; third step omitted if Server does not need Client certificate

mod	*public key modulus*
exp	*public key exponent*
k_S	Server's private key
ctype	Certificate type requested (by cryptosystem)
gca	"Good" certification authorities
er2	End round 2 message

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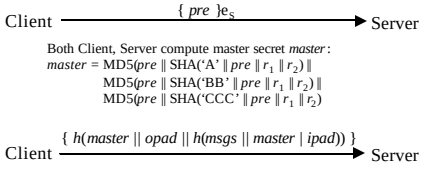
Handshake Round 3

Purpose: Client validates server, begins key exchange



Both Client, Server compute master secret *master*:
master = MD5(*pre* || SHA('A' || *pre* || r_1 || r_2) ||
MD5(*pre* || SHA('BB' || *pre* || r_1 || r_2) ||
MD5(*pre* || SHA('CCC' || *pre* || r_1 || r_2)

msgs	Concatenation of previous messages sent/received this handshake
opad, *ipad*	As above

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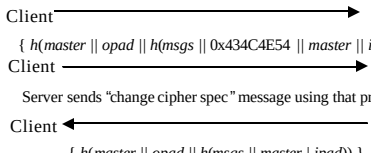
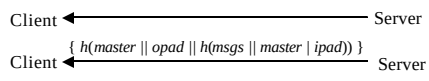
Handshake Round 4

Client sends "change cipher spec" message using that protocol



Server sends "change cipher spec" message using that protocol



msgs	Concatenation of messages sent/received this handshake in *previous* rounds (does notinclude these messages)
opad, *ipad*, *master*	As above

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SSL Change Cipher Spec Protocol

- Send single byte
- In handshake, new parameters considered "pending" until this byte received

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SSL Alert Protocol

- Closure alert
  - Sender will send no more messages
- Error alerts
  - Warning
    - connection remains open
  - Fatal error
    - connection torn down as soon as sent or received

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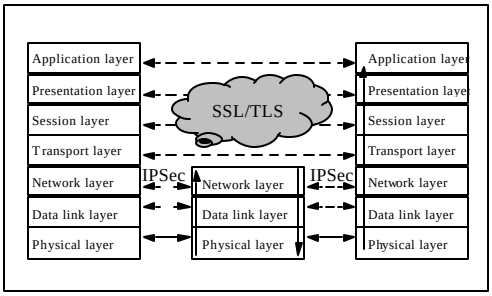
IPSec

Networks



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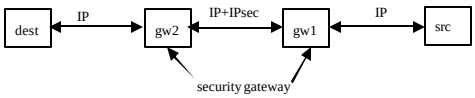
IPsec

Provides
- message confidentiality
- message integrity
- authentication of endpoints
- replay detection



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Transport Mode

- Encapsulate IP packet data
- Use IP to send IPsec-wrapped data packet
- Note: IP header not protected

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Tunnel Mode

- Encapsulate whole IP packet (header *and* data)
- Use IP to send IPsec-wrapped packet
- Note: IP header protected

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IPsec Protocols

- Authentication Header (AH) protocol
  - Message integrity
  - Origin authentication
  - Anti-replay
- Encapsulating Security Payload (ESP) protocol
  - Confidentiality
  - Others provided by AH

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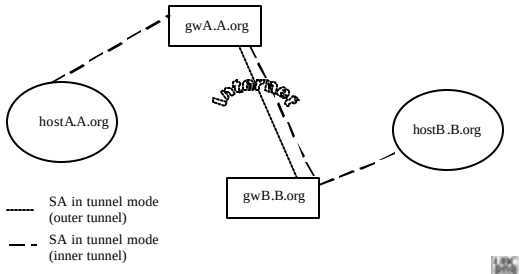
Example: Systems



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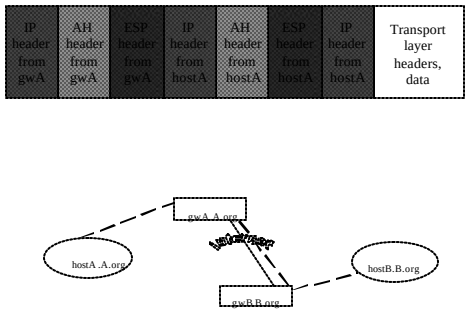
Example: Packets



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IPsec Architecture

Security Policy Database (SPD)

- rules to handle messages
  - discard, add security services, forward unchanged
- associated with network interface
- determines appropriate rule(s) based on IP packet attributes
  - source, destination, transport protocol

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Example

- Goals
  - Discard SMTP packets from host 192.168.2.9
  - Forward SMTP packets from 192.168.19.7 without change
  - "Secure" all other SMTP packets to 10.1.2.3-103
- SPD entries

src 192.168.2.9, dest 10.1.2.3 to 10.1.2.103, port 25, discard
src 192.168.19.7, dest 10.1.2.3 to 10.1.2.103, port 25, bypass
dest 10.1.2.3 to 10.1.2.103, port 25, applyIPsec

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IPsec Architecture

Security Association (SA)

- Association between peers for security services
  - Identified by
    1. dest address
    2. security protocol (AH or ESP)
    3. unique 32-bit number (security parameter index, SPI)
- Unidirectional
- SA database (SAD)

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Which to Use: PEM, SSL, IPsec?