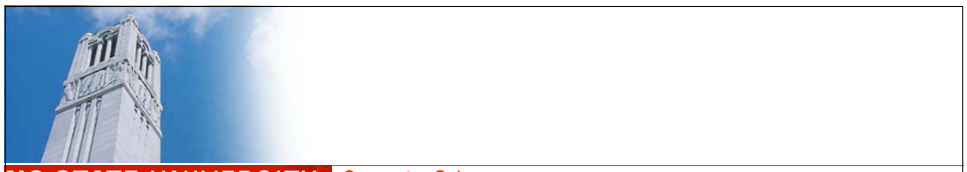


NC STATE UNIVERSITY Computer Science

CSC 474/574
Information Systems Security

Topic 5.6 Transport Layer Security

Transport Layer Security Protocols

- Secure Socket Layer (SSL)
  - Originally developed to secure http
  - Version 3 was developed with public review
  - Application independent
    - Can be used for any application protocol
    - Examples: telnet, pop3, imap, ftp, etc.
- Transport Layer Security (TLS)
  - TLS 1.0 very close to SSL 3.1
  - Backward compatible with SSL v3.

SSL Architecture

- A two-layered protocol.
- Rely on TCP for a reliable communication.

SSL Handshake Protocol	SSL Change Cipher Spec Protocol	SSL Alert Protocol	HTTP and other protocols
SSL Record Protocol			
TCP			
IP			

SSL Protocol Stack

SSL Services

- Peer entity and data authentication
- Data confidentiality
- Data integrity
- Compression/decompression
- Generation/distribution of session keys
  - Integrated to protocol
  - A different approach from IPSec
- Security parameter negotiation.

SSL Connection and Session

- Each SSL session can be used for multiple SSL connections.
- SSL Session
  - An association between a client and a server.
  - Created by handshake protocol.
  - Are used to avoid negotiation of new security parameters for each connection.
- SSL Connection
  - A connection is a transport that provides a suitable type of service.
  - Peer-to-peer, transient
  - Each connection is associate with one session.

SSL Session

- We can view an SSL session as an SSL security association.
- A SSL session consists of
  - Session ID
  - X.509 public-key certificate of peer (could be null)
  - Compression algorithm
  - Cipher spec:
    - Encryption algorithm, message digest algorithm, etc.
  - Master secret: 48 byte secret shared between the client and server
  - Is reusable

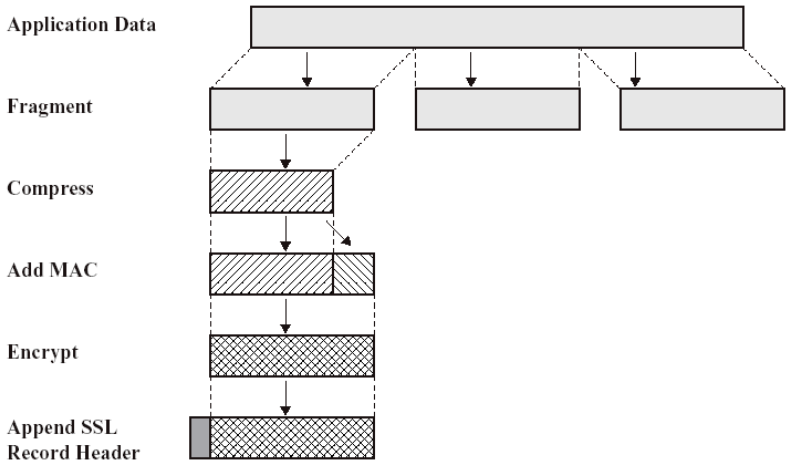
SSL Connection

- An SSL Connection consists of
  - Server and client random
  - Server write MAC secret
  - Client write MAC secret
  - Server write key
  - Client write key
  - Server IV
  - Client IV
  - Sequence number

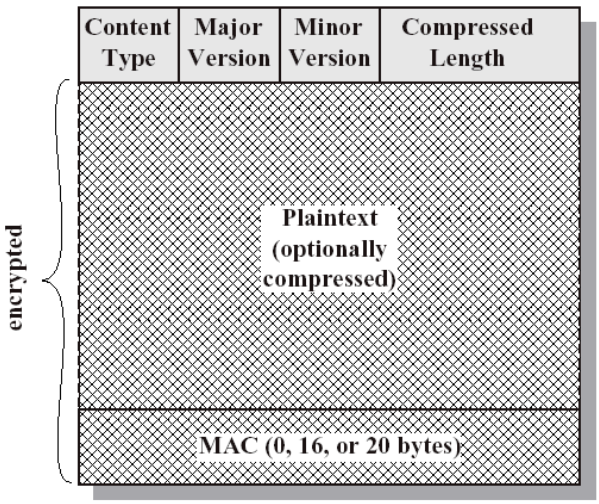
SSL Record Protocol

- Four steps by sender (reversed by receiver)
  - Fragmentation
    - 2^{14} bytes
  - Compression (optional)
  - MAC
  - Encryption

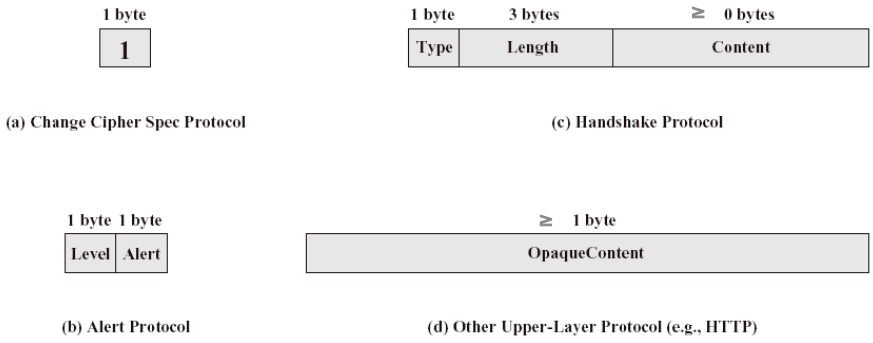
SSL Record Protocol Operation



SSL Record Format



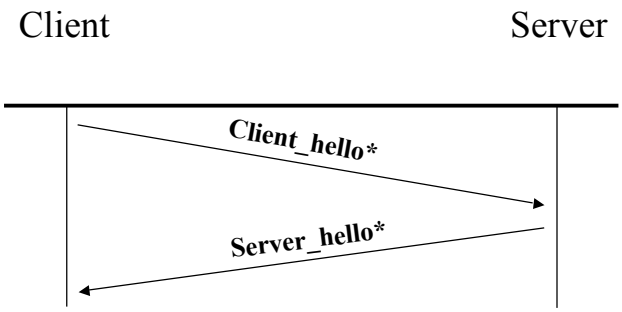
SSL Record Protocol Payload



Handshake Protocol

- Initially SSL session has null compression and encryption algorithm.
- Both are set by the handshake protocol at the beginning of session.
- Handshake protocol may be repeated during the session.
- Four phases
  - Establish Security Capabilities
  - Server Authentication and Key Exchange
  - Client Authentication and Key Exchange
  - Finish

Phase 1. Establish Security Capabilities



Message marked by * are mandatory;
Other messages are optional.

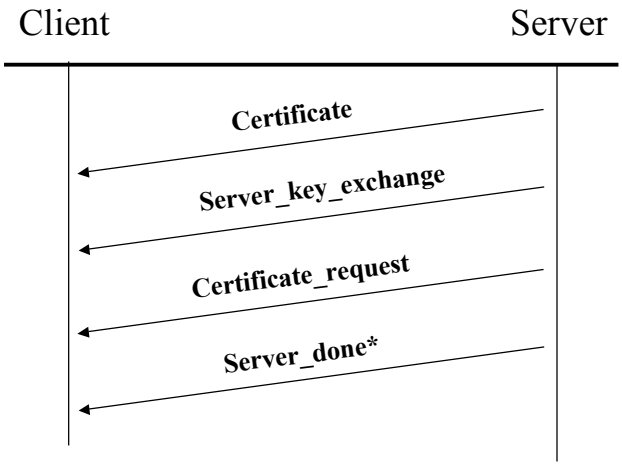
Phase 1 (Cont'd)

- Client_hello
  - Version: The highest SSL version understood by the client
  - Random: 4-byte timestamp + 28-byte random number.
  - Session ID: zero for new session, non-zero for a previous session
  - CipherSuite: list of supported algorithms
  - Compression Method: list of supported compression methods

Phase 1 (Cont'd)

- Server_hello
  - Version: min (client_hello version, highest version supported by the server)
  - Random: 4-byte timestamp + 28-byte random number.
    - Generated by the server
  - Session ID:
  - CipherSuite: selected from the client's list by the server
  - Compression method: selected from the client's list by the server

Phase 2: Server Authentication and Key Exchange



Certificate is almost always used.

Certificate message

- Required for any agreed-on key exchange method except for anonymous Diffie-Hellman.
  - Anonymous D-H
    - Problem?
- Contains one or a chain of X.509 certificates.

Server_key_exchange message

- Not required if
  - The server has sent a certificate with fixed D-H parameters, or
  - RSA key exchange is to be used.
- Needed for
  - Anonymous D-H
  - Ephemeral D-H
  - RSA key exchange, in which the server is using RSA but has a signature-only RSA key.
  - Fortezza

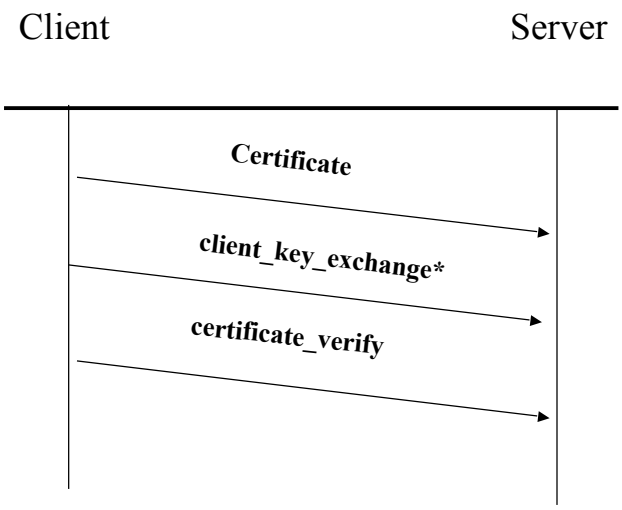
Certificate_request message

- Request a certificate from the client
- Two parameters
  - Certificate_type
    - RSA, signature only
    - DSS, signature only
    - …
  - Certificate_authorities

Server_done message

- Indicate the end of server hello and associated messages.

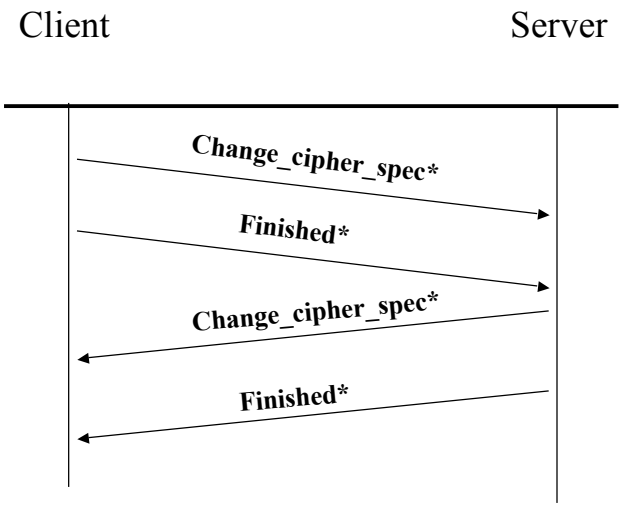
Phase 3. Client Authentication and Key Exchange



Phase 3. Client Authentication and Key Exchange

- Certificate
  - One or a chain of certificates.
- Client_key_exchange
  - RSA: encrypted pre-master secret with the server's public key.
  - D-H: client's public key.
- Certificate_verify
  - Only sent following any client certificate that has signing capability
  - Proves the client is the valid owner of the certificate.

Phase 4. Finish



Master Secret Creation

- The master secret is a one-time 48-byte value.
  - Pre-master secret: by RSA or D-H
  - Master secret is computed from the pre-master secret, client random and server random.

Generation of Cryptographic Parameters

- Generated from the master secret, client random, and server random.
  - Client write MAC secret
  - Server write MAC secret
  - Client write key
  - Server write key
  - Client write IV
  - Server write IV

Change Cipher Spec Protocol

- Session State
  - Current state
    - The session state in effect
  - Pending state
    - The session being negotiated.
- Change Cipher Spec Protocol
  - Cause the pending state to be copied into the current state.

Alert Protocol

- Convey SSL related alerts to the peer.
- Compressed and encrypted.
- Two types of alerts
  - Fatal
    - SSL immediately terminates the connection.
    - Examples
      - Unexpected message
      - Bad_record_mac
  - Warning
    - Examples
      - Close_notify
      - No_certificate

Application Ports Used with SSL

- https 443
- smtps 465
- nntps 563
- ldaps 636
- pop3s 995
- ftp-datas 889
- ftps 990
- imaps 991