



CSC 774 -- Network Security

Topic 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

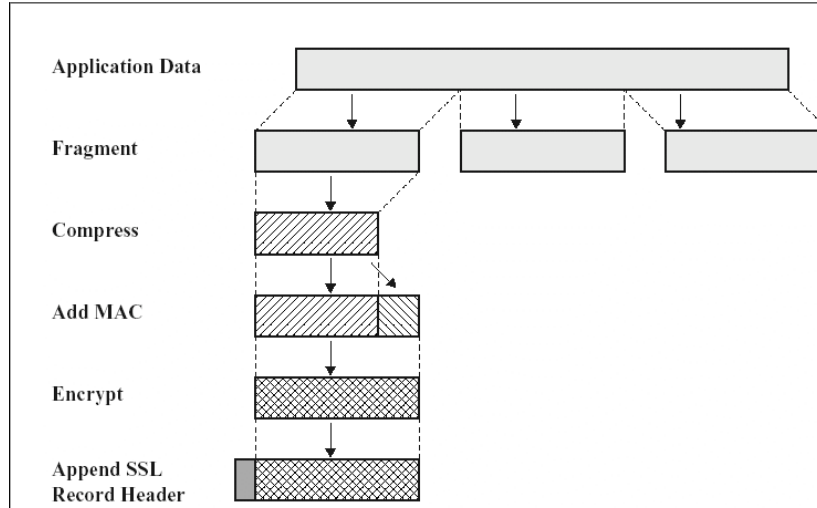
SSL Connection

- 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

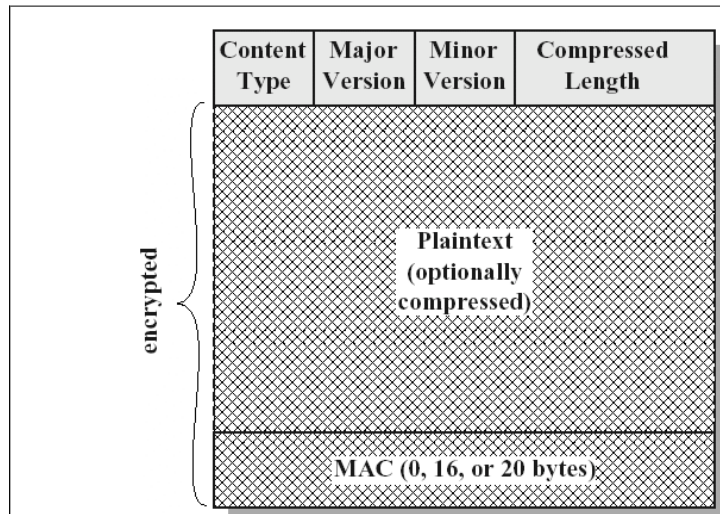
SSL Record Protocol

- Four steps by sender (reversed by receiver)
 - Fragmentation
 - 214 bytes
 - Compression (optional)
 - MAC
 - Encryption

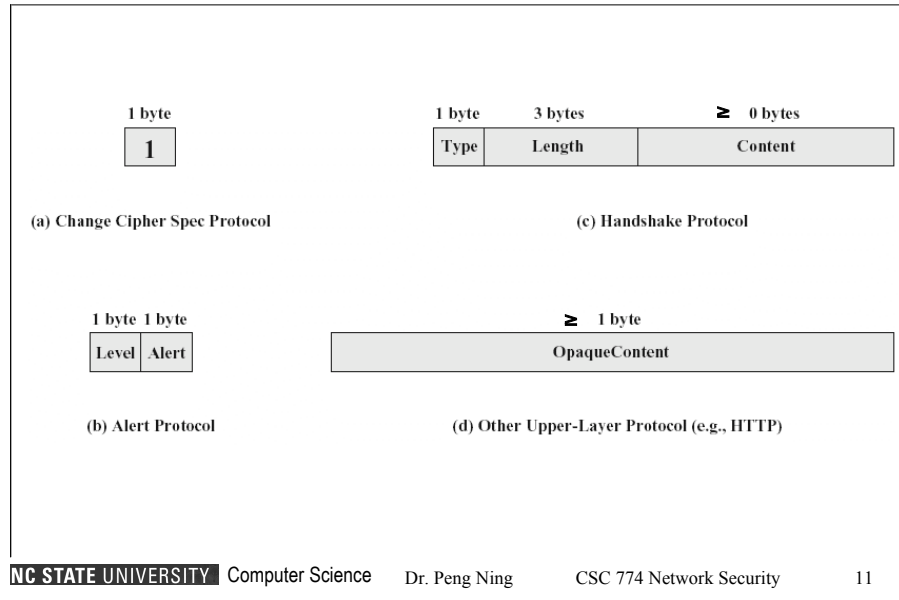
SSL Record Protocol Operation



SSL Record Format



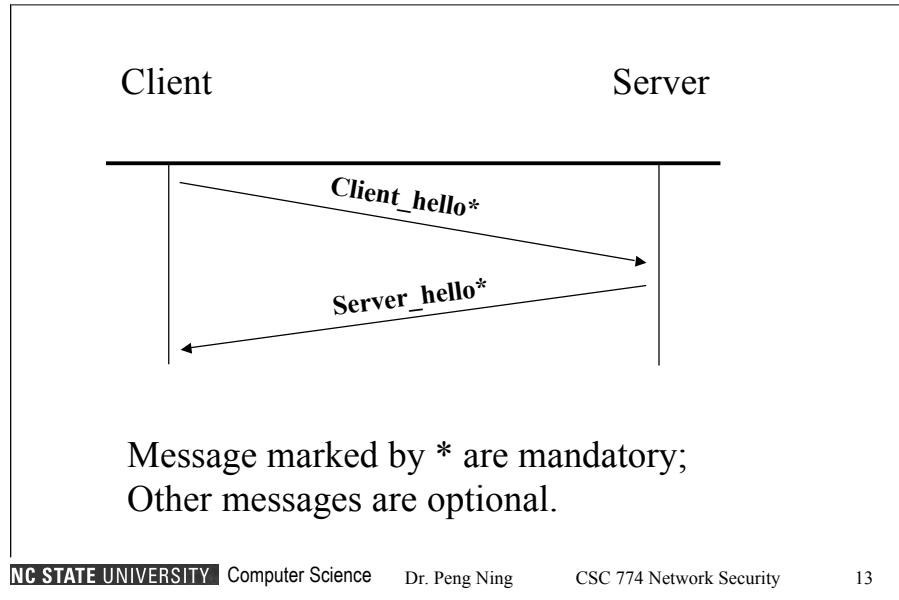
SSL Record Protocol Payload



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



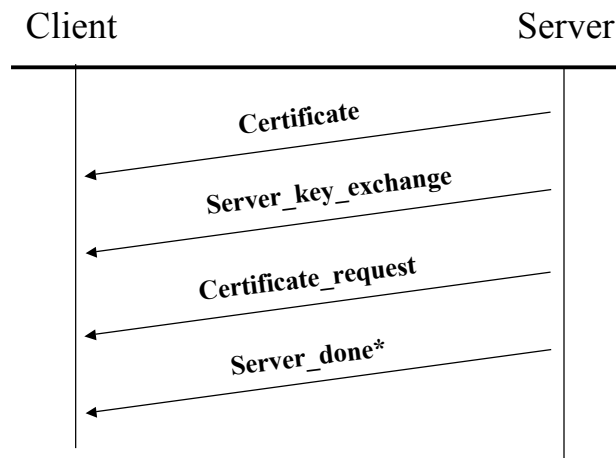
Phase 1 (Cont'd)

- **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

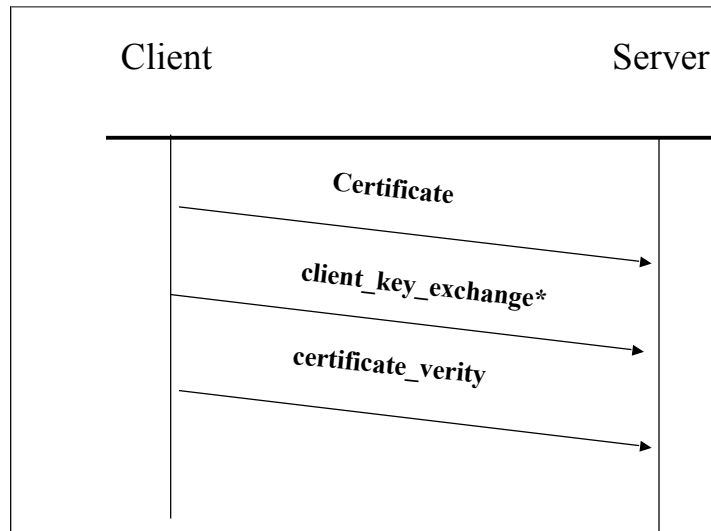
Certificate_request message

- 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.

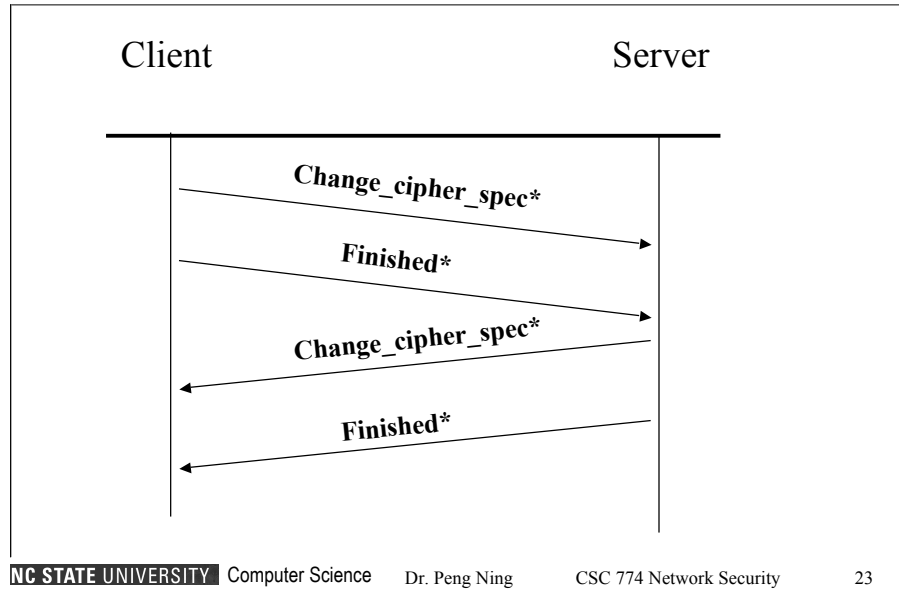
Phase 3. Client Authentication and Key Exchange



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