

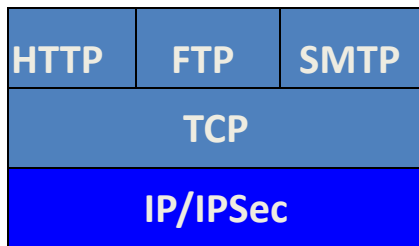
WEB Security: Secure Socket Layer

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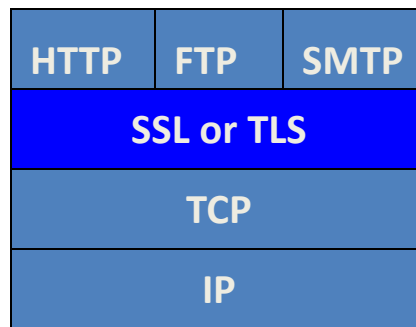
Outline of this Lecture

- Brief Information on SSL and TLS
- Secure Socket Layer (SSL)
- Transport Layer Security (TLS)
- Recommended Reading

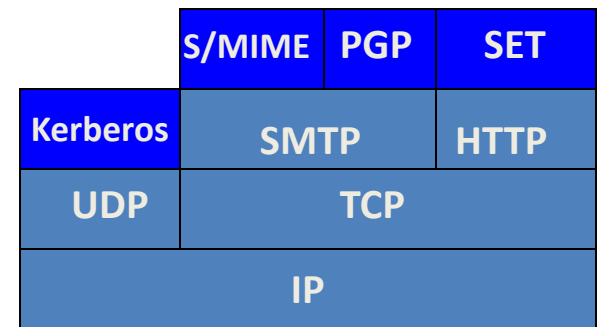
Security Facilities in the TCP/IP Protocol Stack



(a) Network level



(b) Transport level



(c) Application level

SSL and TLS: Information

- SSL was originated by Netscape, Version 1.0, 2.0, 3.0, 3.1
- TLS is an IETF protocol.
- TLS 1.0 (SSL 3.1), TLS 1.1 (SSL 3.2), TLS 1.2 (SSL 3.3), TLS 1.3 released 2018
- They are the most popular transport layer security protocols
- https: http over SSL or TLS (Web secu.)

SSL: Brief Introduction

- Based on connection-oriented and reliable service (e.g., TCP)
- Able to provide security services for any TCP-based application protocol, e.g., HTTP, FTP, TELNET, etc.
 - Application independent

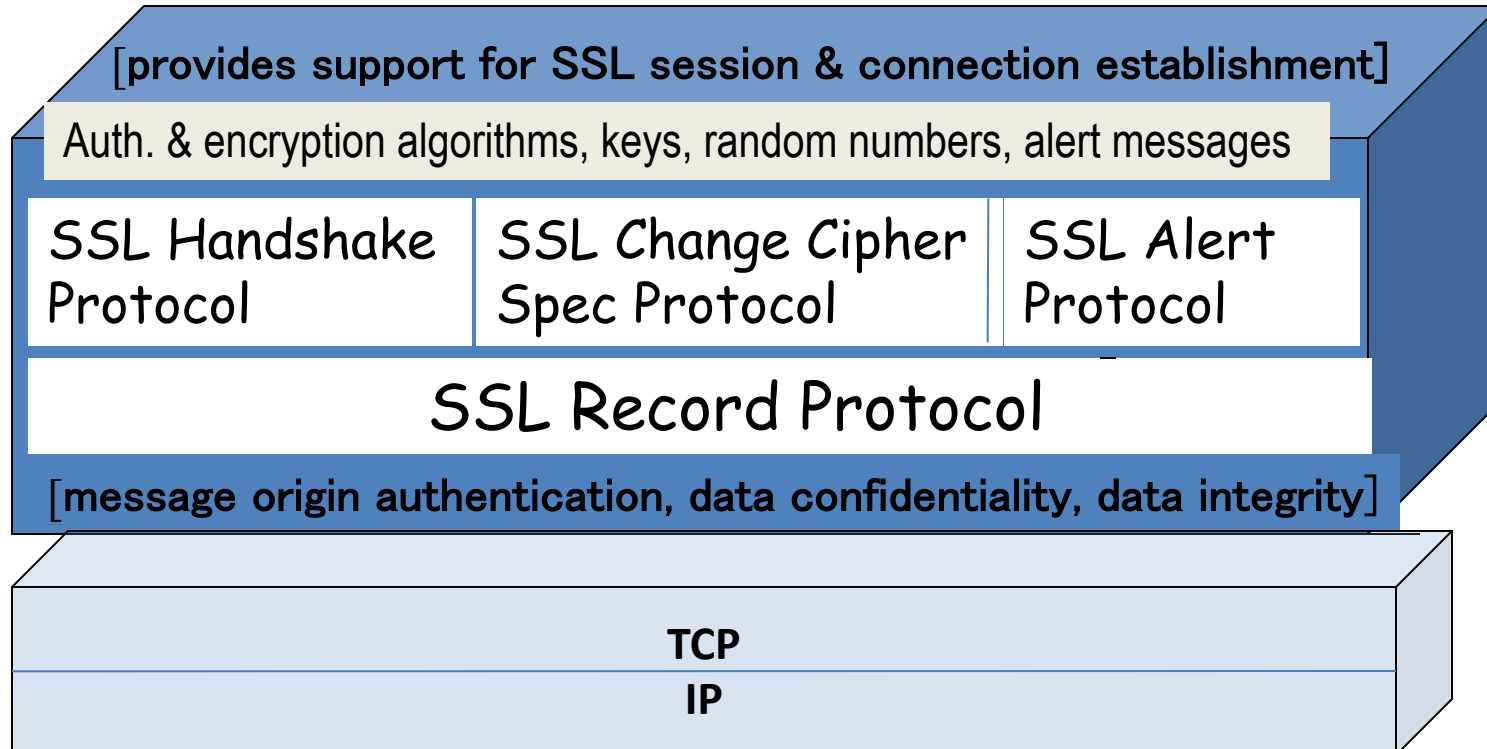
SSL Services

- Client- server authentication
- Data confidentiality
- Data origin authentication
- Data integrity

SSL Architecture

SSL Protocol Structure

It makes use of TCP to provide reliable end-to-end secure service.



SSL Protocol

Components:

- SSL Record Protocol
 - Layered on top of a connection-oriented and reliable transport layer service
 - Provides message origin authentication, data confidentiality, and data integrity
- SSL sub-protocols
 - Layered on top of the SSL Record Protocol
 - Provides support for SSL session and connection establishment

SSL Connection and Session

- **Connection:**

- a transport (in the OSI layering model definition) that provides a suitable service.
- For SSL, such connections are peer-to-peer relationships.
- Every connection is associated with one "session".

- **Session:**

- an association between a client and a server.
- Defines a set of cryptographic parameters, which can be shared among multiple connections.
- Is used to avoid the expensive negotiation of new security parameters for each connection.

SSL State Information

- SSL session is stateful
 - SSL protocol must initialize and maintain session state information on either side of the session
 - SSL state information is used by both sides
- SSL session can be used for a number of connections (i.e., it has a lifetime)
 - connection state information

SSL Session State Information Elements

- Session ID: An arbitrary byte sequence chosen by the server to identify an active or resumable session state.
- Peer certificate: X509.v3 certificate of the peer
- Compression method: algorithm to compress data before encryption
- Cipher spec: specification of data encryption and Message Authentication Code (MAC) algorithms
- Master secret: 48-byte secret shared between client and server
- Is resumable: flag that indicates whether the session can be used to initiate new connections

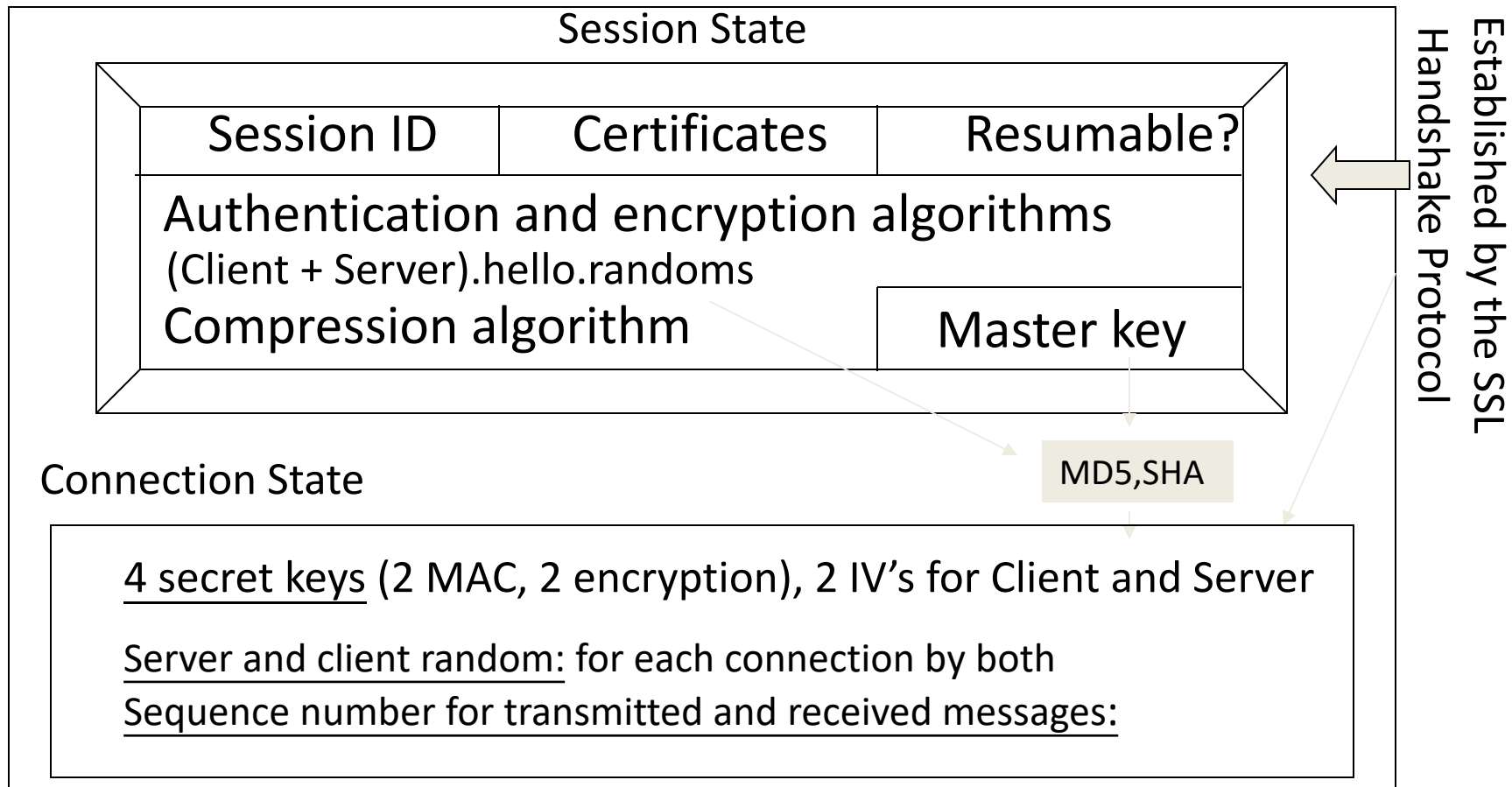
More on SSL Session State

- A previous session may be resumed (use Session ID and its session cache)
- A new session may be negotiated (use Session ID and the Handshake Protocol)

SSL Connection State Information Elements

- Server and client random: byte sequences that are chosen by server and client for each connection.
- Server write MAC secret: secret used for MAC on data written by server
- Client write MAC secret: secret used for MAC on data written by client [different from server write MAC key]
- Server write key: key used for data encryption by server and decryption by client
- Client write key: key used for encryption by client and decryption by server [different from server write key]
- Initialization vectors: for CBC mode (two are different!)
- Sequence number: for both transmitted and received messages, maintained by each party.

Session & Connection State: Pictorial Description



Current and Pending State

- Current state: There is a current operating state for both read and write (i.e., receive and send).
- Pending state: In addition, during the Handshake Protocol, pending read and write states are created.
- Updating: Upon successful conclusion of the Handshake protocol, the pending states become the current states.

Connection and Session

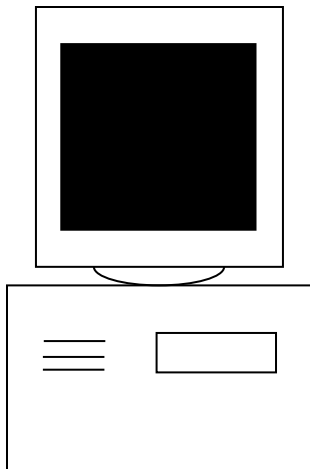
Establishing a session by the Handshake protocol

Master key, hash algor.
Encryption algorithm,
session keys, IV's, etc.

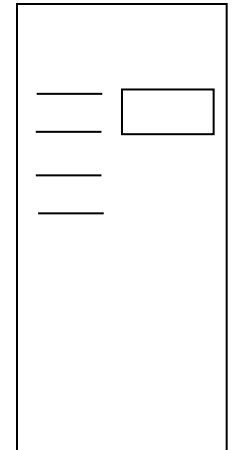
Change cipher
Spec protocol

Copying pending state into current state

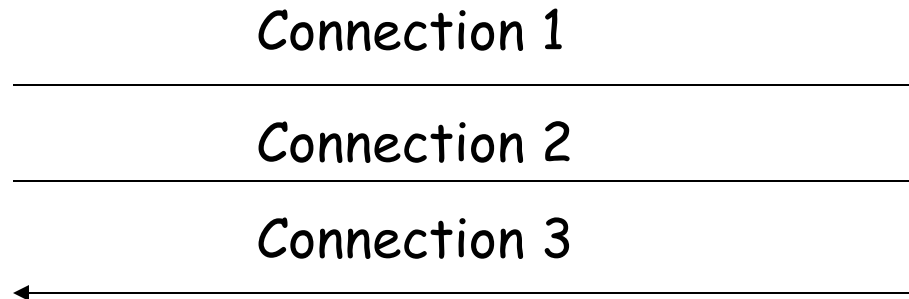
Now ready for connections in this session



Client

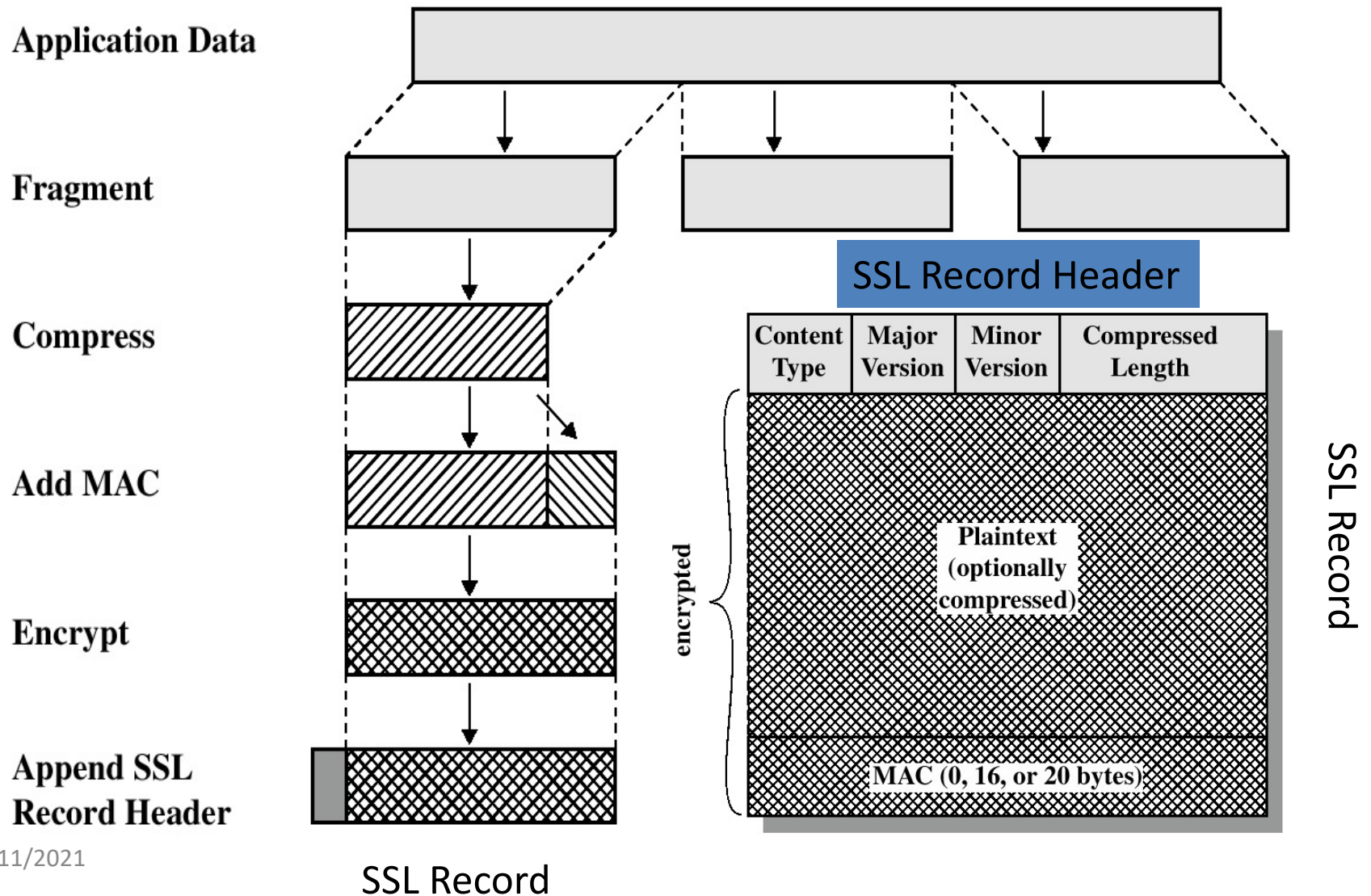


Server



SSL Record Protocol

SSL Record Protocol Operation



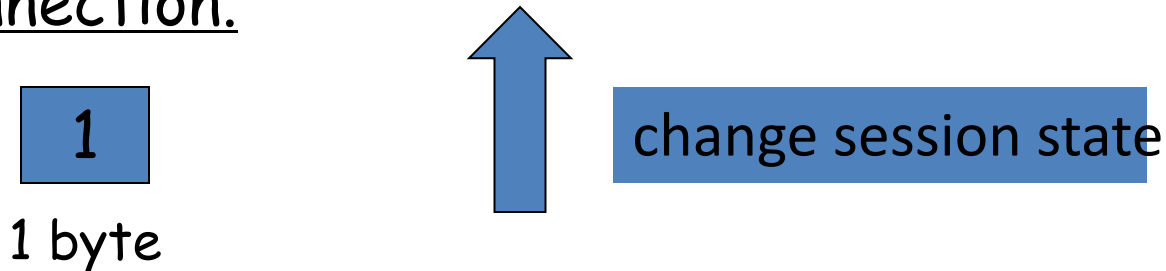
SSL Record Content

- **Content type (8 bits)**
 - Defines higher layer protocol that must be used to process the payload data (which may be handshake, alert, or change_cipher_spec messages).
- **Protocol version number (major & Minor) (8 bits)**
 - Defines SSL version in use. (3, 0) for SSLv3
- **Length (16 bits):** length in bytes of (compressed) plaintext.
- **Data payload**
 - Optionally compressed and encrypted
 - Encryption and compression requirements are defined during SSL handshake
- **MAC (0, 16, or 20 bytes)**
 - Appended for each record for message origin authentication and data integrity verification

Change Cipher Spec Protocol

Change Cipher Spec Protocol

- It is one of the three SSL-specific protocols that use the SSL Record Protocol.
- It consists of a single message, which consists of a single byte with value 1.
- The sole purpose of this message is to cause the pending state to be copied into the current state, which updates the cipher suite to be used on this connection.



Alert Protocol

Alert Protocol

- Used to transmit alerts via SSL Record Protocol to peer entity.
 - Alert message: (alert level, alert description)
 - Alert messages are compressed and encrypted, as specified by the current state.
 - Format of the message in this protocol:

Level	Alert
-------	-------

1 byte 1 byte

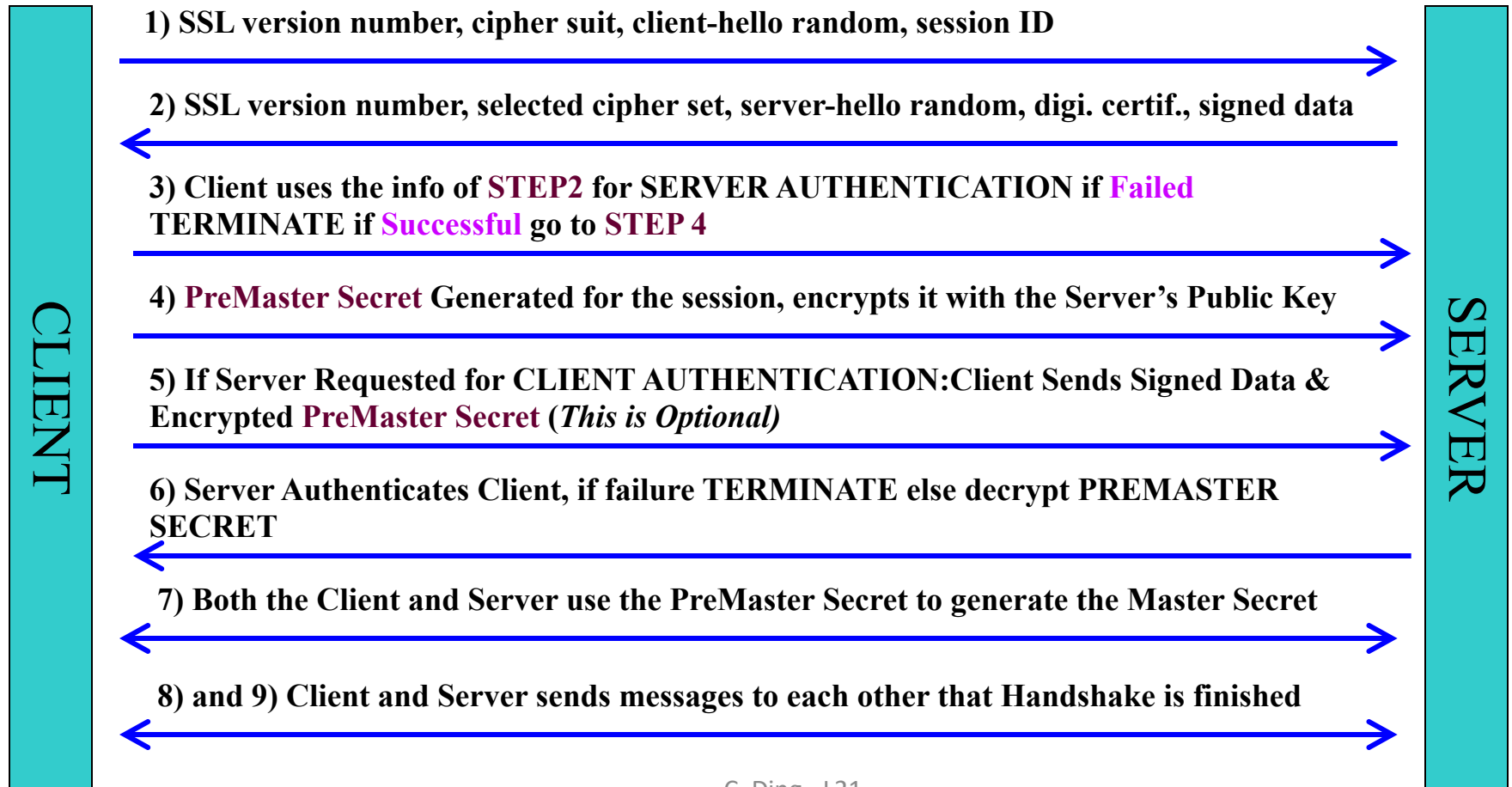
<==> errors occurred during handshaking
<=== errors occurred during processing at
the sever

Handshake Protocol

Handshake Protocol

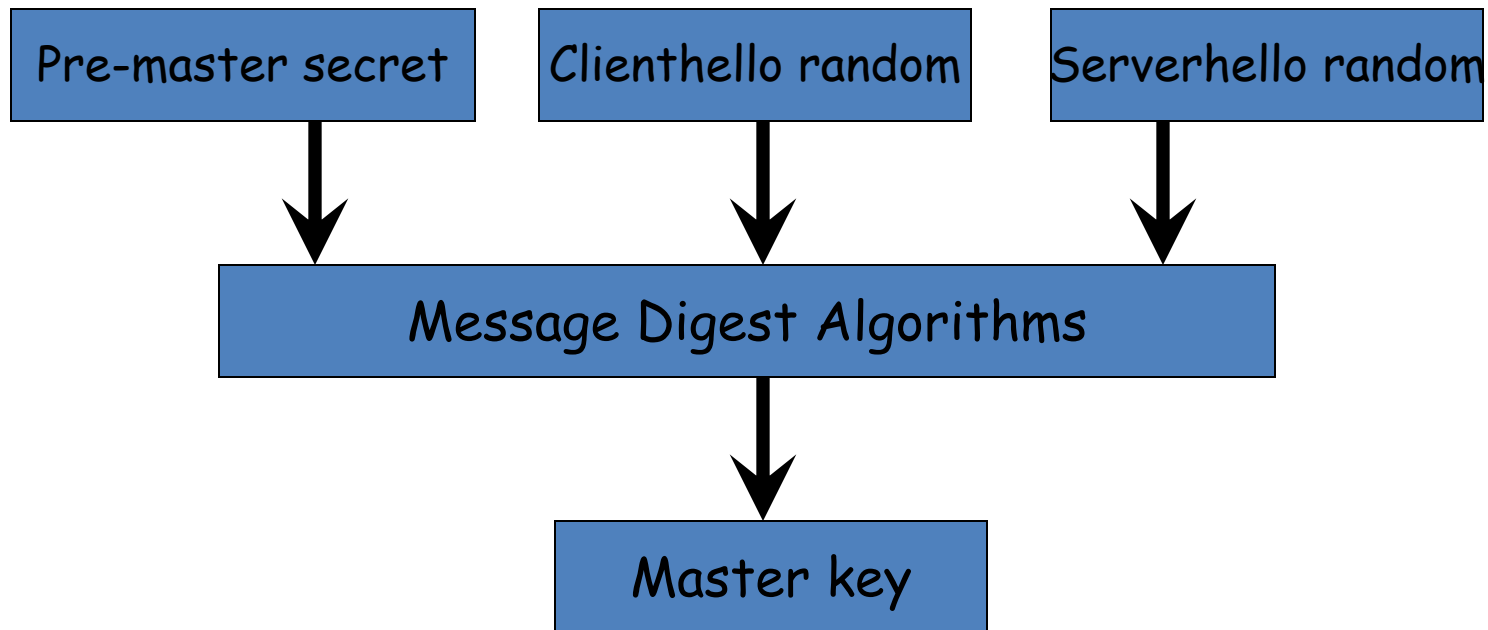
- The most complex part of SSL.
- Allows the server and client to authenticate each other.
- Negotiate encryption, MAC algorithm and cryptographic keys.
- Used before any application data is transmitted.

SSL Handshake



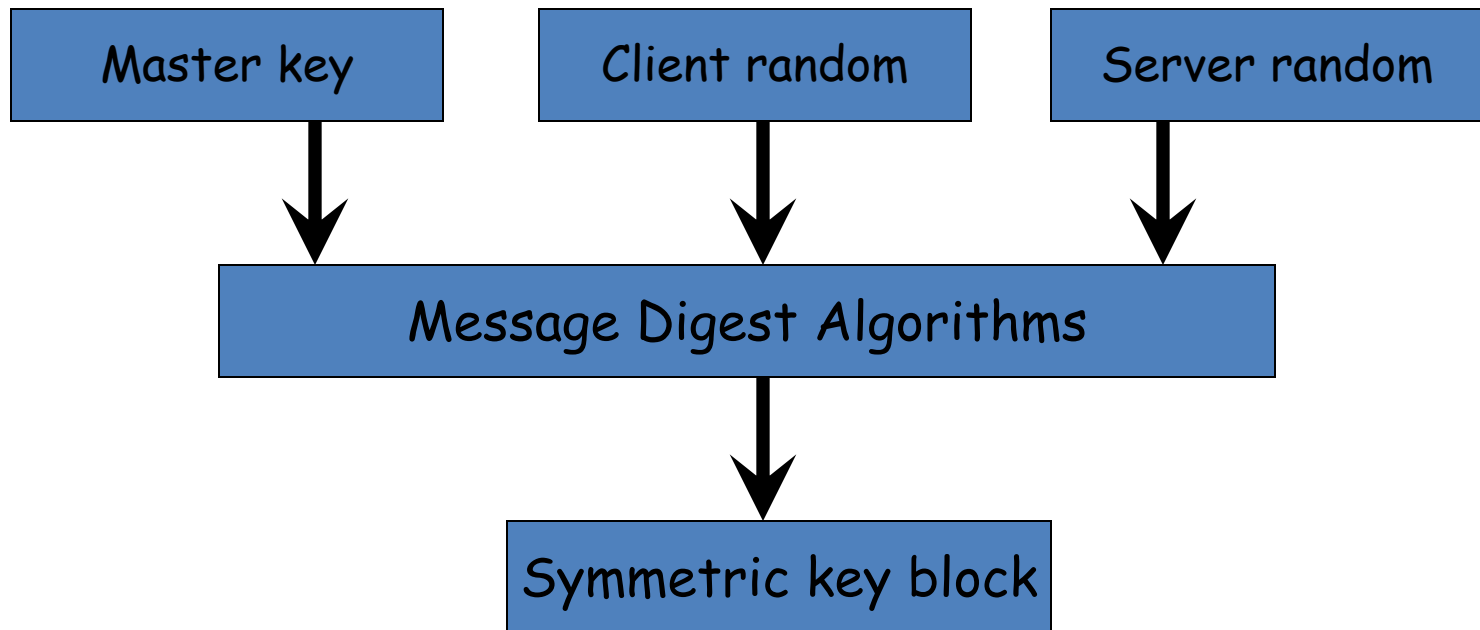
Pre-master secret, master secret, and symmetric key

The three words “A”, “BB” and “CCC” are also given as input values here



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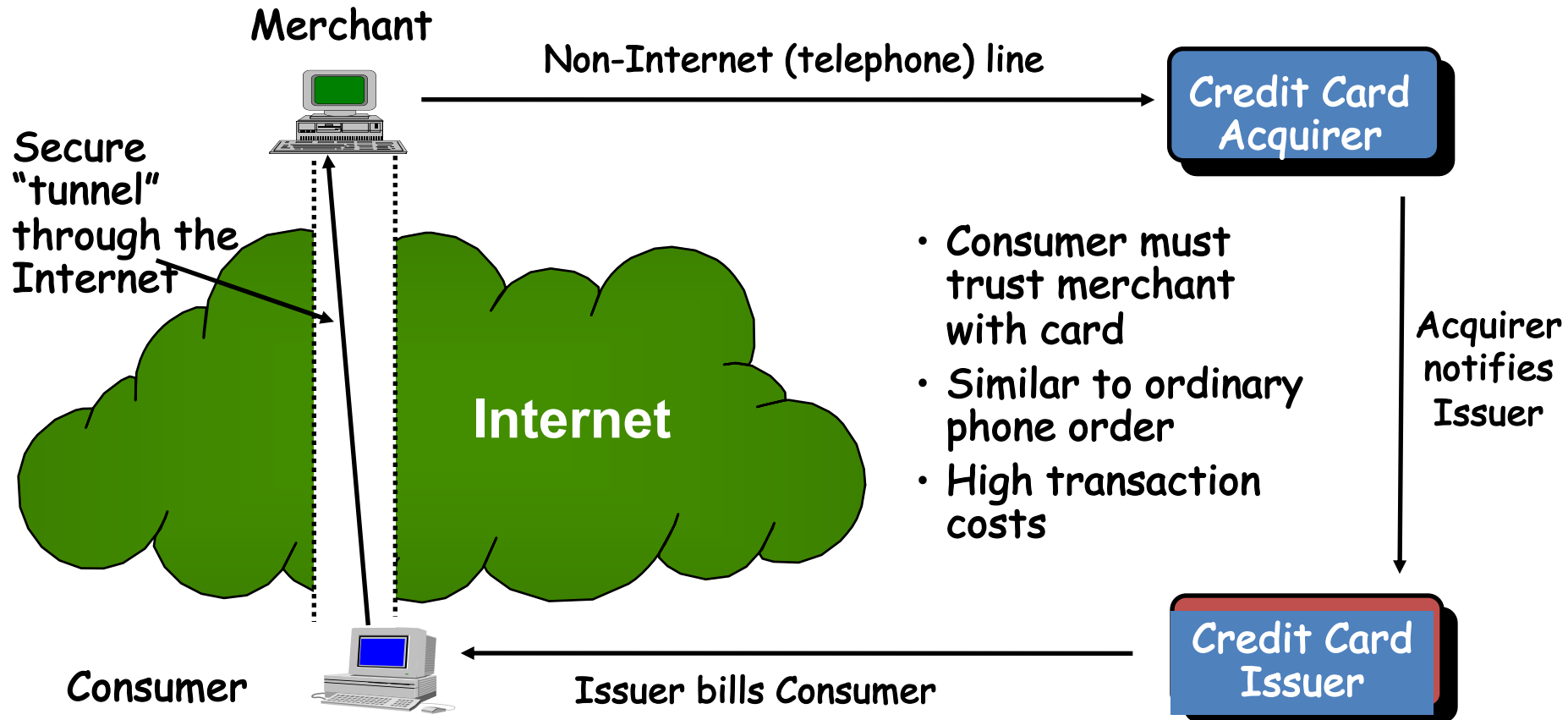
Symmetric key block = client write MAC secret, server write MAC secret, client write key, server write key, client write IV, and server write IV

Details Omitted in the Handshake Protocol

- Pre-master secret exchange methods:
 - RSA: A 48-byte pre-master key generated by client, and encrypted by the server's public key. The encrypted one is sent to server.
 - Diffie-Hellman: (three variants of DH) omitted.
- Cipher algorithm: RC4, RC2, DES, 3DES, AES, ...
- Server authentication: (using digital certificates)
- Client authentication: (using digital certificates)

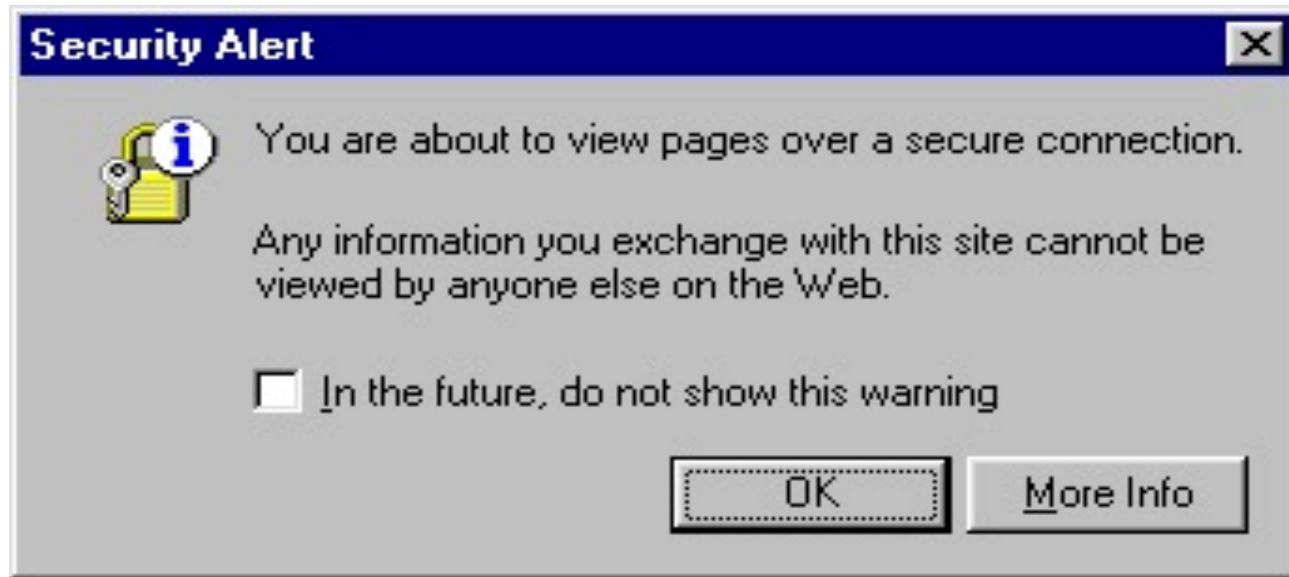
SSL Applications

The Main Usage of SSL



The Main Usage of SSL

After the SSL Handshaking



“If you want people to buy from your site, you must provide an order form with Secure Sockets Layer (SSL) encryption technology”

O’Brien (2000)

Transport Layer Security (Protocol)

- Similar to SSLv3.
- Differences in the:
 - version number
 - message authentication code
 - pseudorandom function
 - alert codes
 - cipher suites
 - client certificate types
 - certificate_verify and finished message
 - cryptographic computations
 - padding

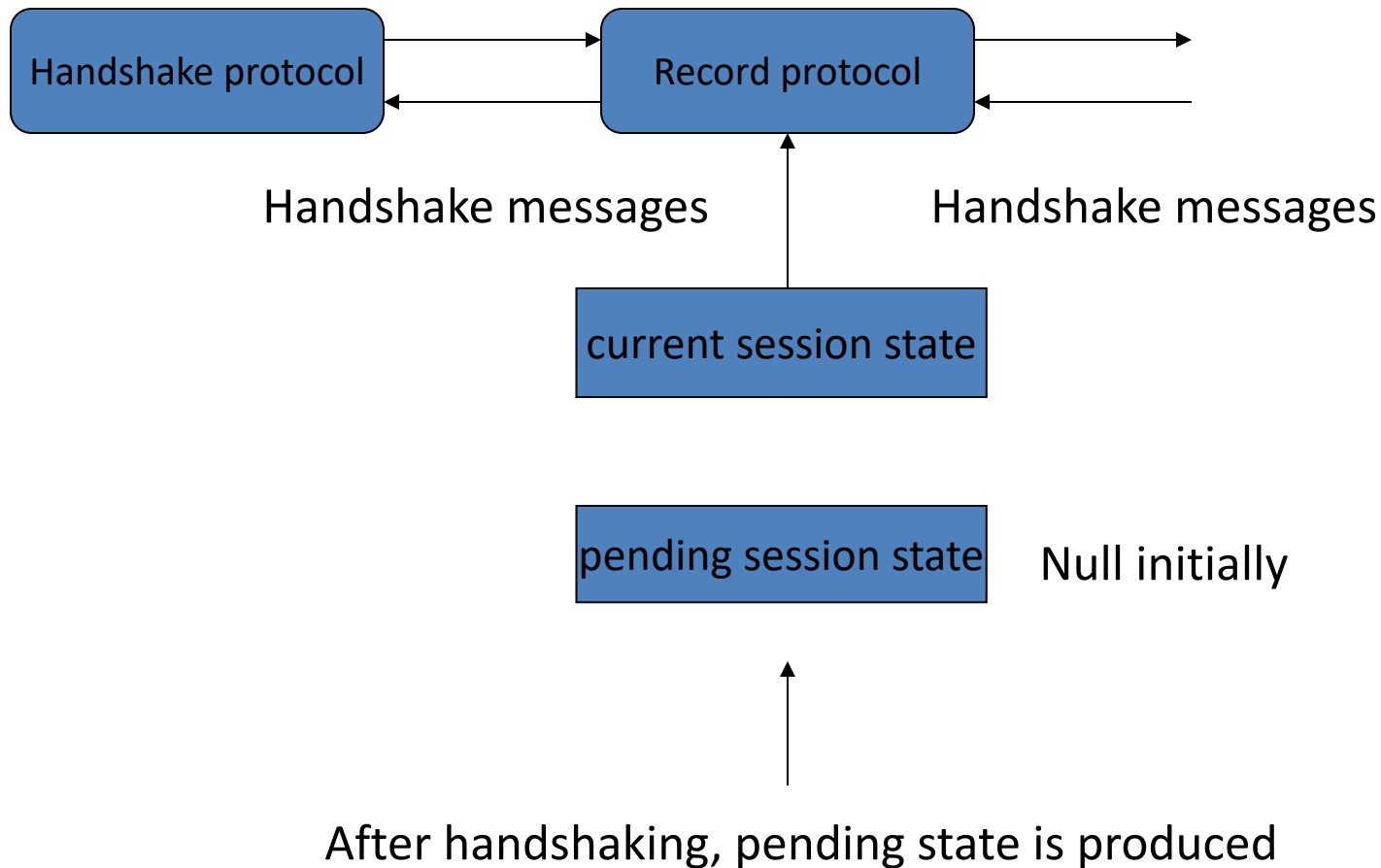
Recommended Reading

- W. Stallings, Cryptography and Network Security, 2nd, 3rd Edition, Prentice Hall
- B.A. Forouzan, Cryptography and Network Security, McGraw-Hill.
- Garfinkel, S., and Spafford, G. Web Security & Commerce. O'Reilly and Associates, 1997
- The SSL Protocol Version 3.0 Transport Layer Security Working Group RFC-2246
- <http://wp.netscape.com/eng/ssl3/ssl-toc.html>
- OpenSSL website: www.openssl.org

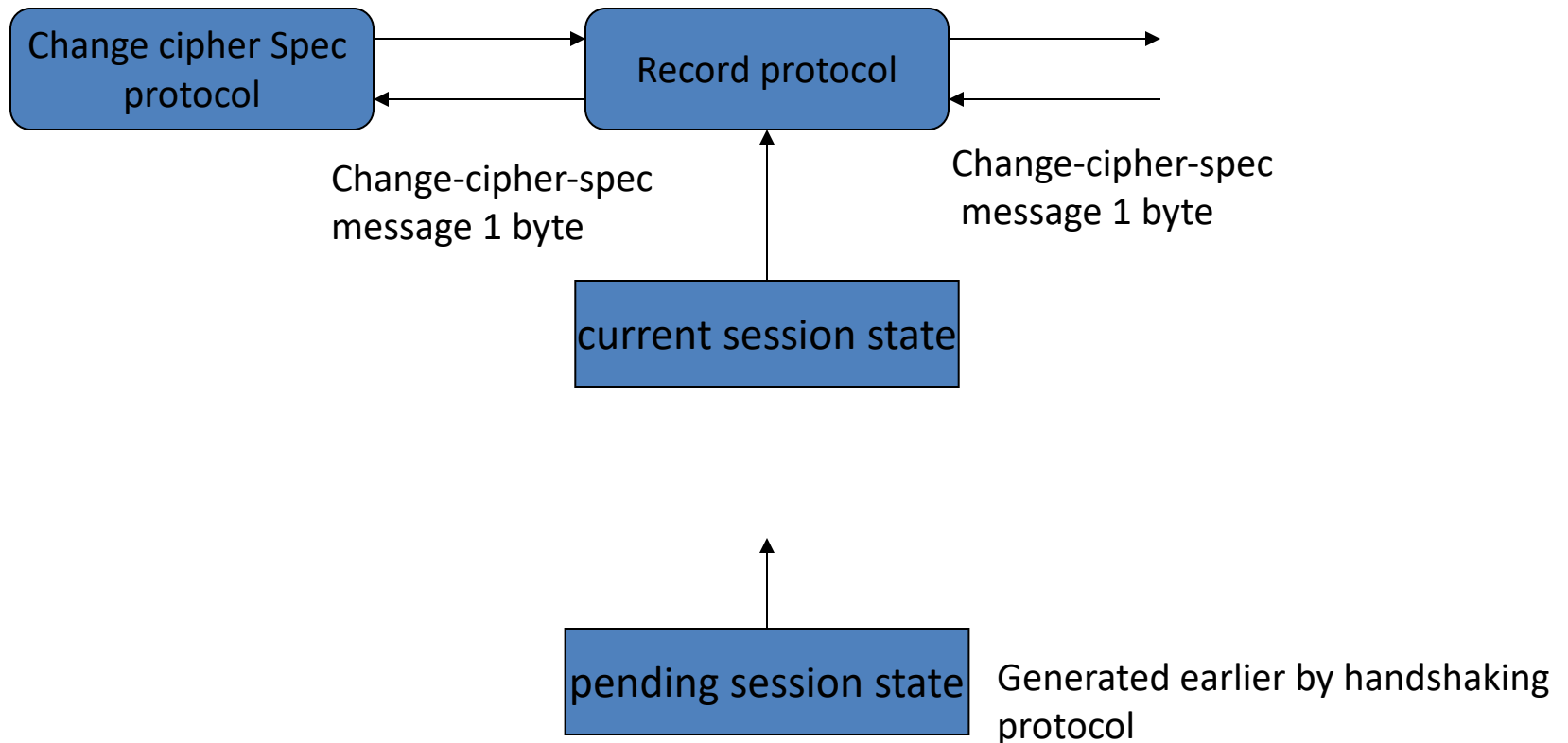
Appendix

Pictorial description of SSL protocols

SSL Procedure: Protocol 1



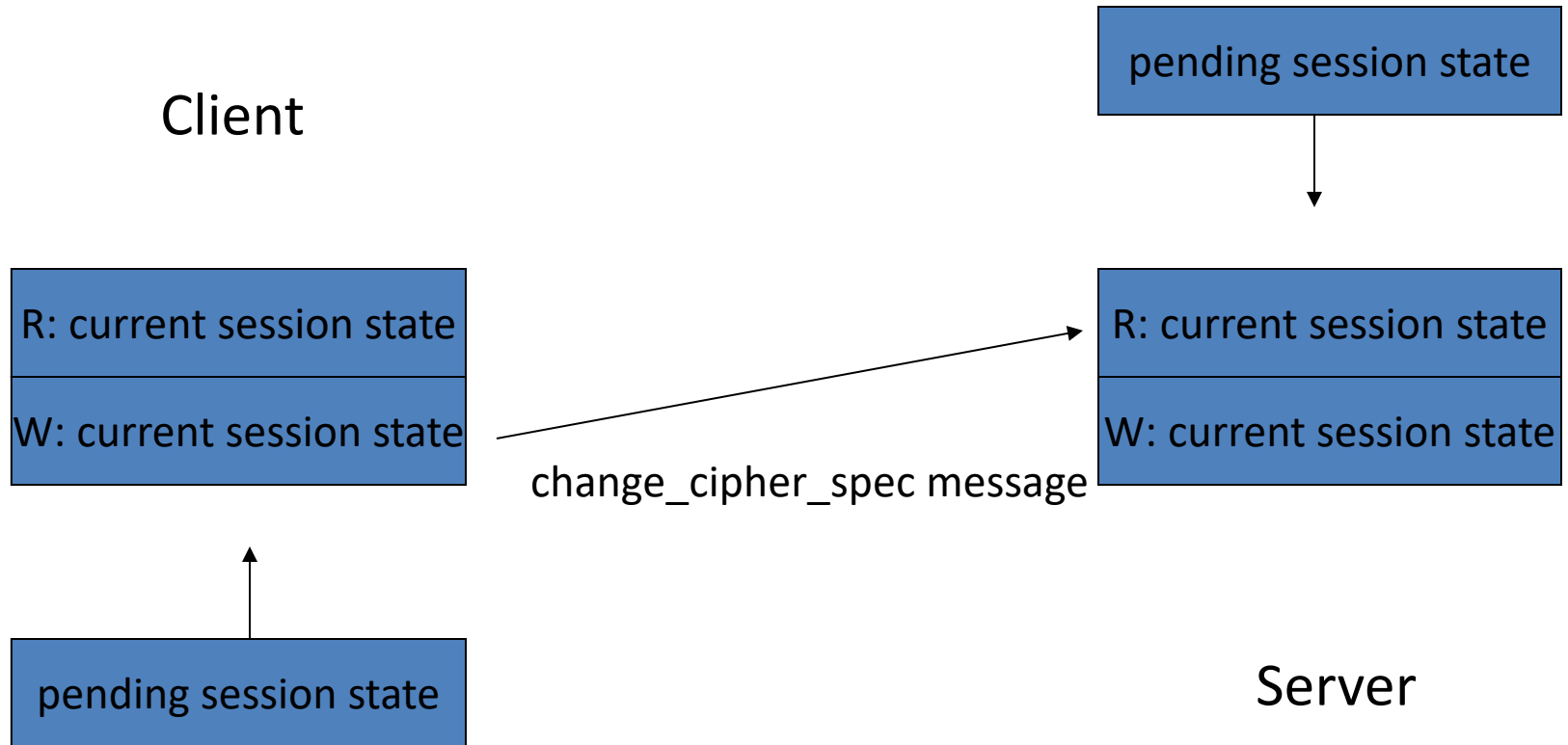
SSL Procedure: Protocol 2



Copy the pending state into current state, after finishing the change cipher protocol

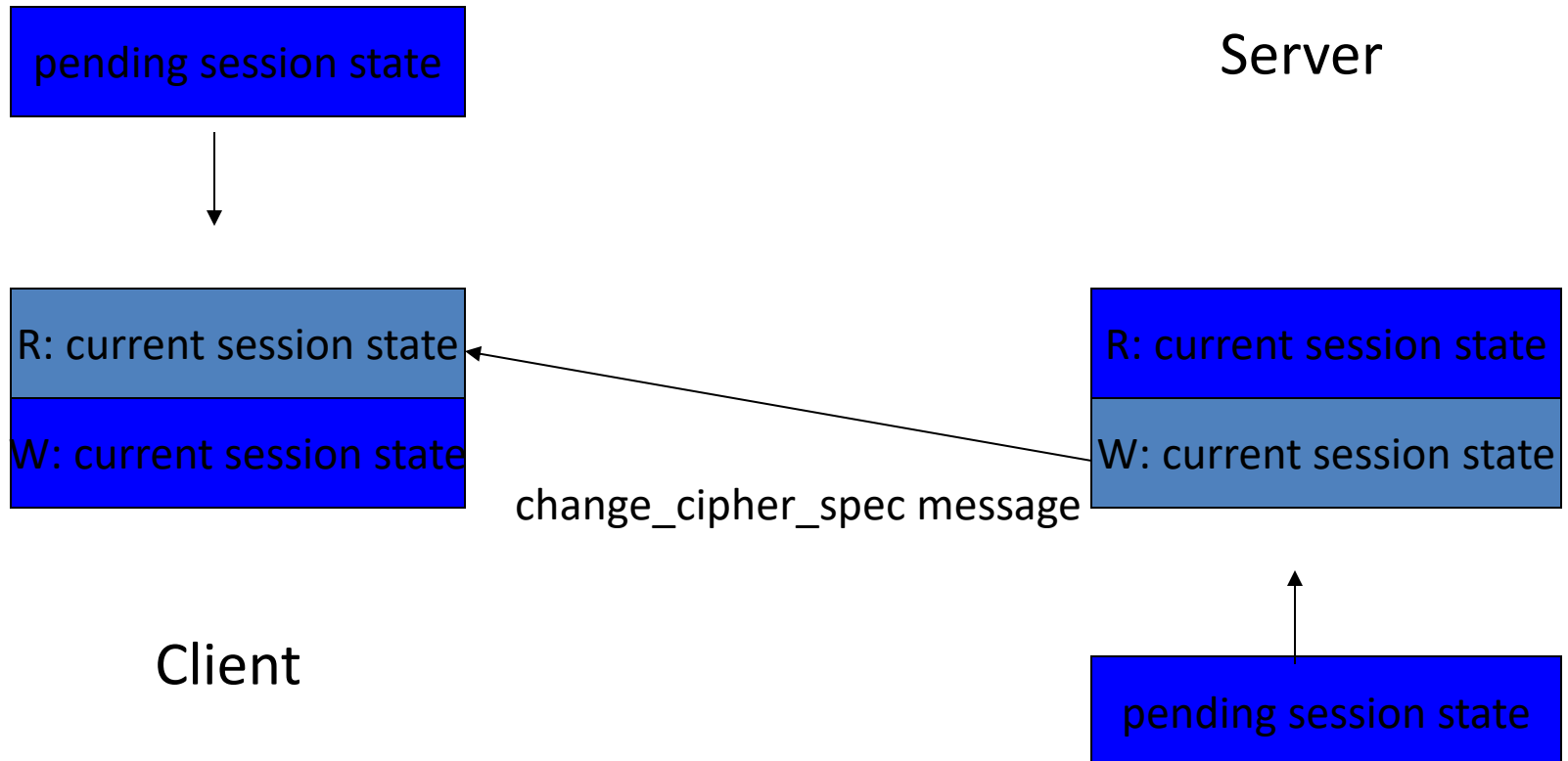
SSL Procedure: Protocol 2

more detailed information

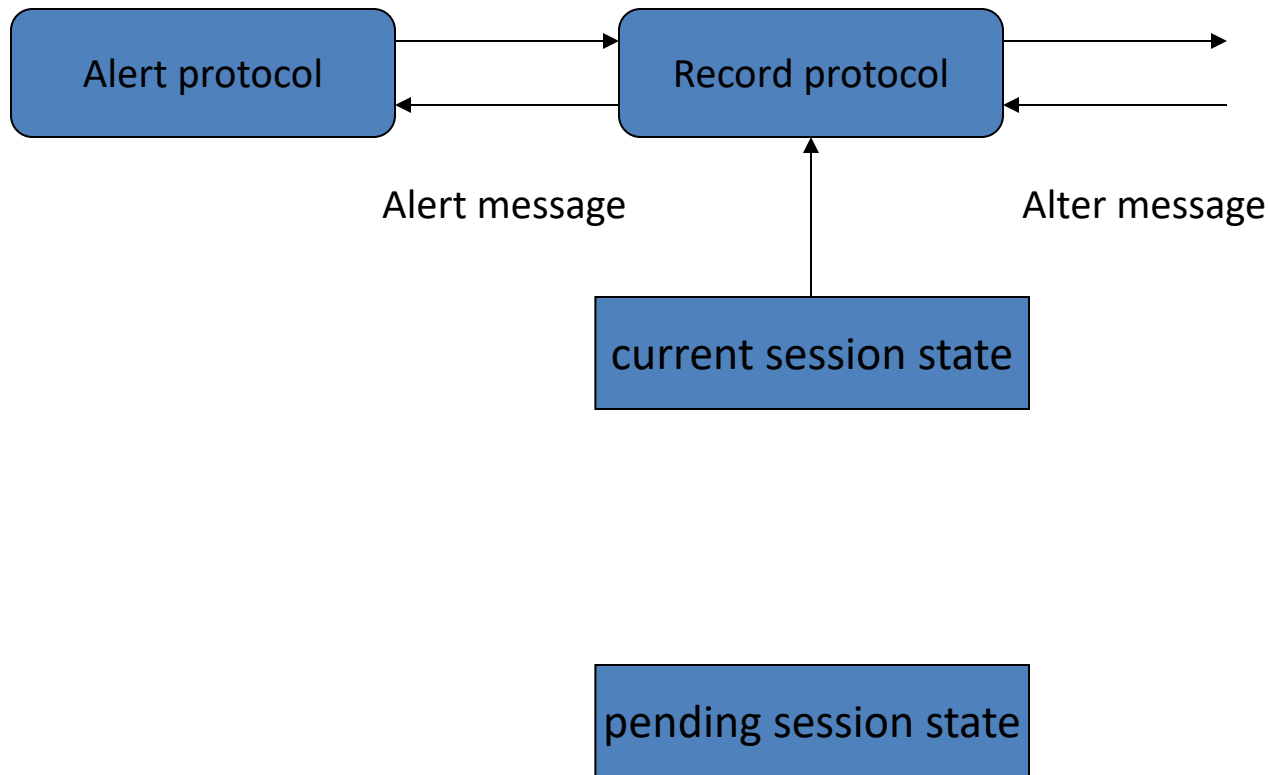


SSL Procedure: Protocol 2

more detailed information



SSL Procedure: Protocol 3



After this protocol, whether this connection should be terminated

SSL Procedure: Protocol 4

