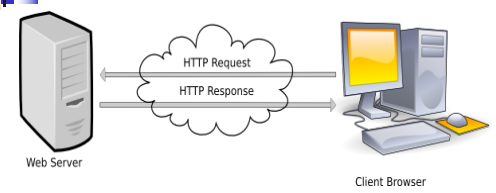
CS458/CS558
Introduction to Computer Security

Chapter 17.2
Secure Socket Layer (SSL)
http://en.wikipedia.org/wiki/Transport_Layer_Security

Web Security

- World Wide Web is fundamentally a client/server application running over internet and TCP/IP intranet.
- Web now widely used by business, government, individuals
- But Web is vulnerable

HTTP Protocol



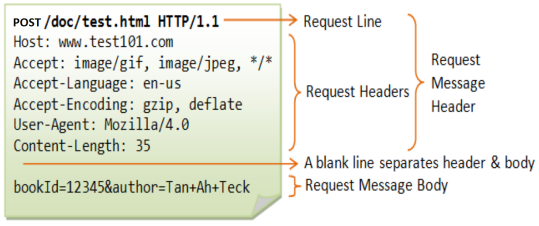
- HTTP (Hyper Text Transfer Protocol): specifies the communication between Browsers and Web Servers.
- HTTP is a stateless protocol (server maintains no information about past client requests.)

HTTP Request

- HTTP request
  - HTTP header
    - Request line (e.g. GET /images/logo.png HTTP/1.1,)
    - Request header (e.g., Accept-Language: en)
    - .....
  - HTTP body (optional)

HTTP Request: An Example

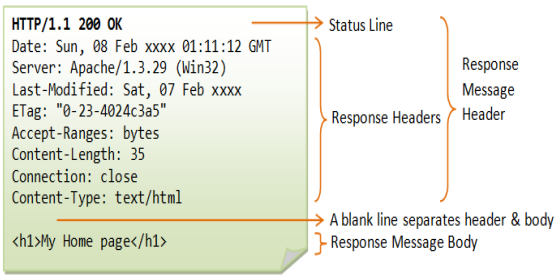
- E.g. the browser translated the URL http://www.test101.com/doc/test.html into the following http request:



HTTP Response

- HTTP Response is composed of a header and a body, separated by an empty line.
  - Header
    - Protocol version (e.g., HTTP/1.0 or HTTP/1.1)
    - Status code (e.g. 404)
    - Reason Phrase (e.g. Not Found)
    - .....
  - Body: a byte stream

HTTP Response: Example

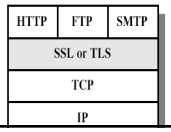


Hypertext Transfer Protocol Secure (Https)

- A combination of the http protocol and a network security protocol
- Also known as Hypertext Transfer Protocol over Secure Socket Layer
- The administrator must create a public key certificate for the Web server.
- This certificate must be signed by a certificate authority.
  - SSL certificate providers: Verisign, Thawte, InstantSSL, Entrust, Baltimore, Geotrust etc.
- Web browsers are distributed with the public key of major certificate authorities so that they can verify certificates signed by them.

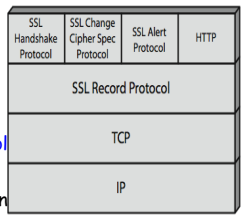
SSL (Secure Socket Layer)

- A cryptographic protocol that provides security for communications over networks.
- One of the most widely used Web security mechanism.
- Transport layer security service - designed to make use of TCP to provide a reliable end-to-end security service.
- Originally developed by Netscape
- Subsequently became Internet standard known as TLS (Transport Layer Security)



SSL Architecture

- Has two layers of protocols
  - Level 1:
    - SSL Record Protocol: provides basic security services to various higher-layer protocols.
  - Level 2:
    - Hypertext Transfer Protocol (HTTP): which provides the transfer service for Web client/server interaction, can operate on top of SSL.
    - Three higher-layer protocols: used in the management of SSL exchanges.



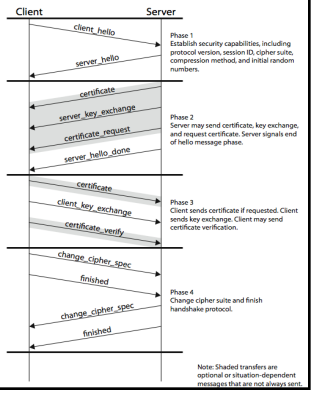
SSL Handshake Protocol

- Allows server and client to:
  - Authenticate each other
  - To negotiate encryption & MAC algorithms
  - To negotiate cryptographic keys to be used to protect data sent in an SSL record.

SSL Handshake Protocol

Comprises a series of messages in phases

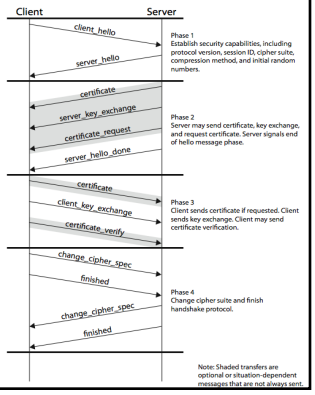
1. Establish Security Capabilities:
   (a) The client initiates a logical connection and establish the security capabilities : protocol version, session ID, cipher suite (cryptographic algorithms supported by the client), compression method.



SSL Handshake Protocol

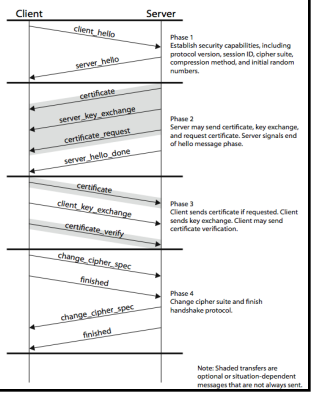
Comprises a series of messages in phases

1. Establish Security Capabilities:
   (b) the server picks the strongest cipher and hash function that it also supports and notifies the client of the decision



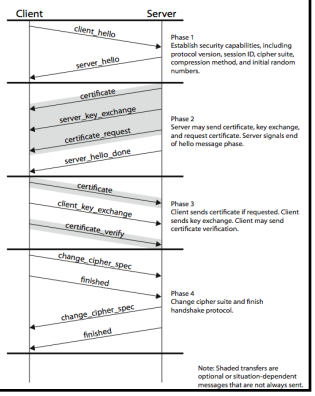
SSL Handshake Protocol

2. Server Authentication and Key Exchange: 1) sends certificate if it needs to be authenticated; 2) sends a server_key_exchange message, and request certificate; 3) signals the end of hello message phase.



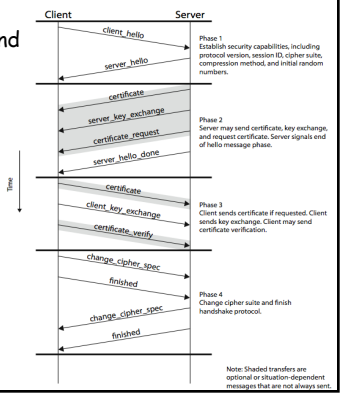
SSL Handshake Protocol

3. Client Authentication and Key Exchange: sends certificate if requested and encrypts a random key with the server's public key, and sends the result to the server.



SSL Handshake Protocol

4. Change cipher suite and finish handshake protocol.



SSL Change Cipher Spec Protocol

- Notify the receiving party that subsequent records will be protected under the just-negotiated cipherspec and keys.
- Consists of a single message, which consists of a single byte with the value 1.
- Causes pending state to become current - updating the cipher suite in use

1 byte

1

SSL Alert Protocol

- Conveys SSL-related alerts to peer entity
- Consists of two bytes – the first takes the value: warning (1) or fatal (2); the second contains a code that indicates the specific alert.

1 byte	1 byte
Level	Alert

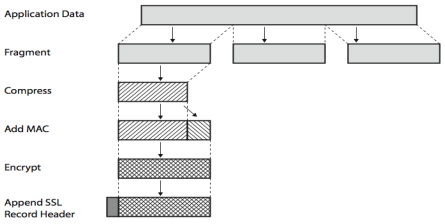
  - Fatal: unexpected message, decompression failure, handshake failure, illegal parameter
    - SSL immediately terminates the connection
  - Warning: close notify (the sender will not send any more message of this connection), bad certificate, unsupported certificate, certificate revoked, certificate expired, certificate unknown.

SSL Record Protocol Services

- Provides two services for SSL connections
  - Confidentiality:
    - encrypt SSL payloads
  - Message integrity:
    - use a shared secret key to form MAC.

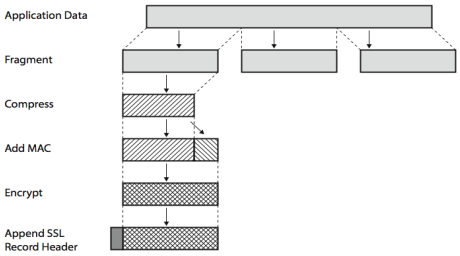
SSL Record Protocol Operation

- Fragmentation: message is fragmented into blocks of 2^{14} bytes or less
- Compression (optional): lossless and may not increase the content length by more than 1024 byte (for very short block, it is possible that the output is longer)



SSL Record Protocol Operation

- MAC: Compute the message authentication code over the compressed data.
- Encryption: the compressed message plus the MAC are encrypted using symmetric encryption.



Assignment 3

- Due: March 28th (Wed.)
- Done individually or by a group of 2 students

SSL

- Implement a client and a server using Secure Socket Layer (SSL).
- Upon connection, the client prompts the user to enter his/her ID and password.
- After the user enters the ID and the password, the client sends the ID and password to the server through SSL connection.

SSL

- After the server receives the ID and the password, the server computes the hash of the password, and prints the ID, the password, and the hashed password.
- The server then compares that hashed password against the password stored in file password.
  - If the two passwords match, the server sends a string "OK" to the client and the client prints "the password is correct" and terminates
  - otherwise, the client prints "the password is incorrect" and terminates.

SSL

- The server maintains a file *password* which has the following format:

<user ID> <hashed password> <date and time when the password is stored>

- The password can be hashed using SHA1 or MD5. You can use the existing implementation of SHA1 and MD5

SSL

- You will need to write a program gen-pass to generate file *password*.

./gen-pass (C/C++)
java Gen-pass (Java)

- When gen-pass is invoked, it prompts the person who invokes gen-pass to enter each user's ID and password.
- Your program then saves ID, the hashed password, and the date and time when the password is saved, to file password.
- Your program should also check whether the ID is already in password. If so, your program displays "the ID already exists".

SSL

- The server is invoked as

sslserv <*server_port*> (C/C++)
java SslServ <*server_port* > (Java)

<*server_port*>: the port number on which the server listens for the connection.

- The client is invoked as

sslcli <*server_domain*> <*server_port*> (C/C++)
java SslCli <*server_domain*> <*server_port*> (Java)

<*server_domain*>: the domain name of the server, i.e., bingsuns.binghamton.edu

SSL

- You can use any code available on the web for SSL socket programming and for hashing the password.
- However, you must write your own code for the rest part of the assignment (e.g. enter and verify ID and password, open/read/write files)
- You should also generate the certificate by yourself. Please use one of your group members' name when generating the certificate (other information can be forged).

Grading guideline

- Correct execution format: 2'
- Readme: 2'
- Makefile: 6'
- Correct implementation of gen-pass/Gen-pass: 35'
- Correct implementation of SSL server and client: 55'

Submission guideline

- Create a directory with a unique name (e.g. p3-[userid]), which contains the source codes, makefile, and a README file.

- README
  - The name and email address of your group members.
  - Whether your code was tested on bingsuns.
  - How to execute your program.
  - (Optional) Briefly describe your algorithm or anything special about your submission that the TA should take note of.

Submission guideline

- Tar the contents of this directory using
  tar –cvf [directory_name].tar [directory_name]
  E.g. tar -cvf p3-pyang.tar p3-pyang/

- Upload the tared file you create above to mycourses.