Cryptography and Network Security
Chapter 16

Fifth Edition

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Chapter 16 – Transport-Level Security

Use your mentality

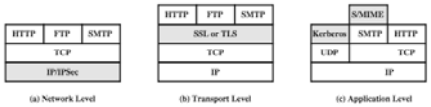
Wake up to reality

—From the song, "I've Got You under My Skin" by Cole Porter

Web Security

- Web now widely used by business, government, individuals
- but Internet & Web are vulnerable
- have a variety of threats
  - integrity
  - confidentiality
  - denial of service
  - authentication
- need added security mechanisms

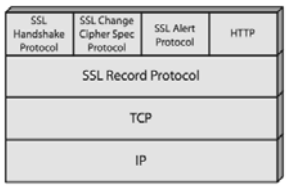
Web Traffic Security Approaches



SSL (Secure Socket Layer)

- transport layer security service
- originally developed by Netscape
- version 3 designed with public input
- subsequently became Internet standard known as TLS (Transport Layer Security)
- uses TCP to provide a reliable end-to-end service
- SSL has two layers of protocols

SSL Architecture



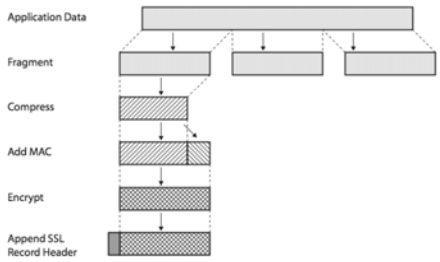
SSL Architecture

- **SSL connection**
  - a transient, peer-to-peer, communications link
  - associated with 1 SSL session
- **SSL session**
  - an association between client & server
  - created by the Handshake Protocol
  - define a set of cryptographic parameters
  - may be shared by multiple SSL connections

SSL Record Protocol Services

- **confidentiality**
  - using symmetric encryption with a shared secret key defined by Handshake Protocol
  - AES, IDEA, RC2-40, DES-40, DES, 3DES, Fortezza, RC4-40, RC4-128
  - message is compressed before encryption
- **message integrity**
  - using a MAC with shared secret key
  - similar to HMAC but with different padding

SSL Record Protocol Operation



SSL Change Cipher Spec Protocol

- one of 3 SSL specific protocols which use the SSL Record protocol
- a single message
- causes pending state to become current
- hence updating the cipher suite in use

(a) Change Cipher Spec Protocol

SSL Alert Protocol

- conveys SSL-related alerts to peer entity
- severity
  - warning or fatal
- specific alert
  - fatal: unexpected message, bad record mac, decompression failure, handshake failure, illegal parameter
  - warning: close notify, no certificate, bad certificate, unsupported certificate, certificate revoked, certificate expired, certificate unknown
- compressed & encrypted like all SSL data

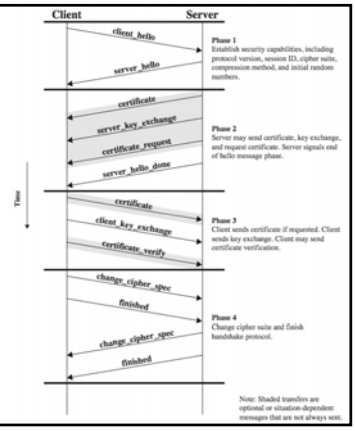
(b) Alert Protocol

SSL Handshake Protocol

- allows server & client to:
  - authenticate each other
  - to negotiate encryption & MAC algorithms
  - to negotiate cryptographic keys to be used
- comprises a series of messages in phases
  1. Establish Security Capabilities
  2. Server Authentication and Key Exchange
  3. Client Authentication and Key Exchange
  4. Finish

(c) Handshake Protocol

SSL Handshake Protocol



Cryptographic Computations

- master secret creation
  - a one-time 48-byte value
  - generated using secure key exchange (RSA / Diffie-Hellman) and then hashing info
- generation of cryptographic parameters
  - client write MAC secret, a server write MAC secret, a client write key, a server write key, a client write IV, and a server write IV
  - generated by hashing master secret

TLS (Transport Layer Security)

- IETF standard RFC 2246 similar to SSLv3
- with minor differences
  - in record format version number
  - uses HMAC for MAC
  - a pseudo-random function expands secrets
    - based on HMAC using SHA-1 or MD5
  - has additional alert codes
  - some changes in supported ciphers
  - changes in certificate types & negotiations
  - changes in crypto computations & padding

HTTPS

- HTTPS (HTTP over SSL)
  - combination of HTTP & SSL/TLS to secure communications between browser & server
    - documented in RFC2818
    - no fundamental change using either SSL or TLS
- use https:// URL rather than http://
  - and port 443 rather than 80
- encrypts
  - URL, document contents, form data, cookies, HTTP headers

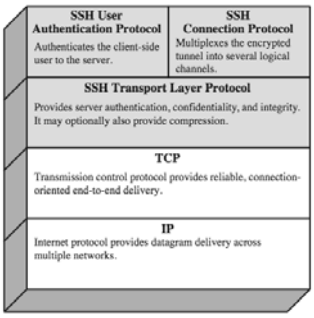
HTTPS Use

- connection initiation
  - TLS handshake then HTTP request(s)
- connection closure
  - have "Connection: close" in HTTP record
  - TLS level exchange close_notify alerts
  - can then close TCP connection
  - must handle TCP close before alert exchange sent or completed

Secure Shell (SSH)

- protocol for secure network communications
  - designed to be simple & inexpensive
- SSH1 provided secure remote logon facility
  - replace TELNET & other insecure schemes
  - also has more general client/server capability
- SSH2 fixes a number of security flaws
- documented in RFCs 4250 through 4254
- SSH clients & servers are widely available
- method of choice for remote login/ X tunnels

SSH Protocol Stack



SSH Transport Layer Protocol

- server authentication occurs at transport layer, based on server/host key pair(s)
  - server authentication requires clients to know host keys in advance
- packet exchange
  - establish TCP connection
  - can then exchange data
    - identification string exchange, algorithm negotiation, key exchange, end of key exchange, service request
  - using specified packet format

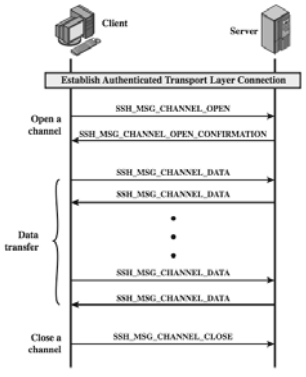
SSH User Authentication Protocol

- authenticates client to server
- three message types:
  - SSH_MSG_USERAUTH_REQUEST
  - SSH_MSG_USERAUTH_FAILURE
  - SSH_MSG_USERAUTH_SUCCESS
- authentication methods used
  - public-key, password, host-based

SSH Connection Protocol

- runs on SSH Transport Layer Protocol
- assumes secure authentication connection
- used for multiple logical channels
  - SSH communications use separate channels
  - either side can open with unique id number
  - flow controlled
  - have three stages:
    - opening a channel, data transfer, closing a channel
  - four types:
    - session, x11, forwarded-tcpip, direct-tcpip.

SSH Connection Protocol Exchange



Port Forwarding

- convert insecure TCP connection into a secure SSH connection
  - SSH Transport Layer Protocol establishes a TCP connection between SSH client & server
  - client traffic redirected to local SSH, travels via tunnel, then remote SSH delivers to server
- supports two types of port forwarding
  - local forwarding – hijacks selected traffic
  - remote forwarding – client acts for server

Summary

- have considered:
  - need for web security
  - SSL/TLS transport layer security protocols
  - HTTPS
  - secure shell (SSH)