Cryptography and Network Security

Chapter 7

Transport-Level Security

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Outline

- Web Security Issues
- Security Socket Layer (SSL)
- Transport Layer Security (TLS)
- HTTPS
- Secure Shell (SSH)

Overview (1/2)

- Secure Socket Layer (SSL) provides ***security services between*** **TCP** and **applications** that use TCP.
- The Internet standard version is called Transport Layer Service (TLS).
- SSL/TLS provides ***confidentiality*** using ***symmetric encryption*** and message ***integrity*** using a ***message authentication code***.
- SSL/TLS includes ***protocol mechanisms*** to enable two ***TCP users*** to determine the security mechanisms and ***services*** they will use.

Overview (2/2)

- **HTTPS** (HTTP over SSL) ***refers to*** the ***combination of*** **HTTP** and **SSL** to implement ***secure communication*** ***between*** a **Web browser** and a **Web server**.

- Secure Shell (**SSH**) provides ***secure remote logon*** and ***other*** secure client/server ***facilities***.

Web Security

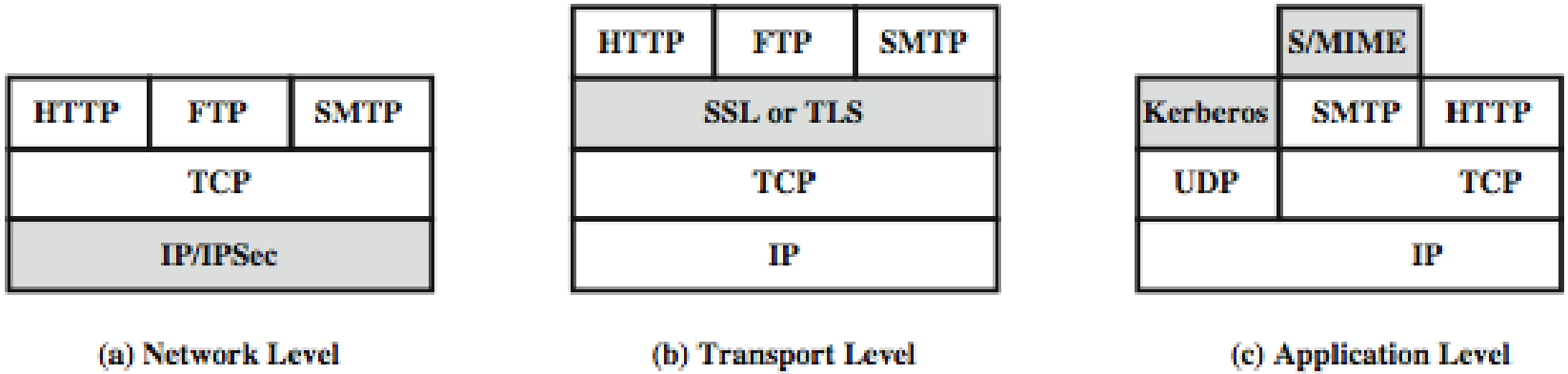
- Web now widely used by business, government, individuals
- but ***Internet & Web are vulnerable***
- have a ***variety of threats***
  - integrity
  - confidentiality
  - denial of service
  - authentication

➔ need ***added security mechanisms***

Web Security

- One way to group these threats is in terms of ***passive*** and ***active*** attacks.
- Passive attacks include ***eavesdropping*** on network traffic between browser and server and gaining access to information on a Web site that is supposed to be restricted.
- Active attacks include ***impersonating*** another user, ***altering messages*** in transit between client and server, and ***altering information*** on a website
- Another way to classify Web security threats ***is in terms of the location*** of the threat: **Web server**, **Web browser**, and **network traffic** between browser and server

Web Traffic Security Approaches



- One way to provide Web security is to use IP security (IPsec) (Figure a). The advantage of using IPsec is that it is ***transparent*** to end users and applications and provides a general-purpose solution.
- Furthermore, IPsec includes a ***filtering capability*** so that only ***selected*** traffic need incur the overhead of IPsec processing.

Web Traffic Security Approaches

- Another relatively general-purpose solution is to implement security just above TCP (Figure b). The foremost example of this approach is the Secure Sockets Layer (**SSL**) and the follow-on Internet standard known as Transport Layer Security (**TLS**).
- At this level, there are two implementation choices. For full generality, SSL (or TLS) could be provided as part of the underlying protocol suite and therefore be ***transparent*** to applications.
- Alternatively, *SSL can be embedded in specific packages*. For example, Netscape and Microsoft Explorer browsers come equipped with SSL, and most Web servers have implemented the protocol

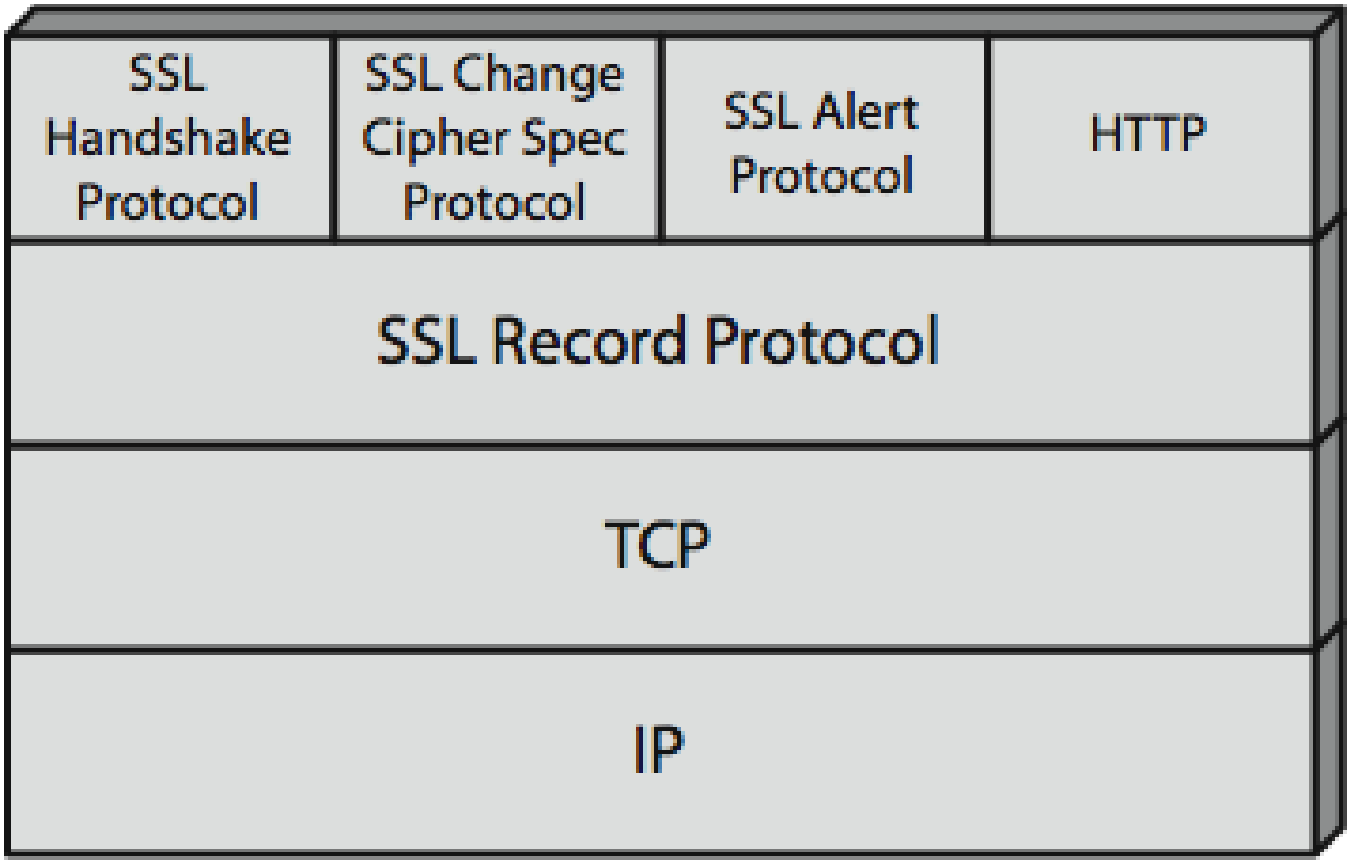
SSL

- Netscape originated SSL.
- Version 3 of the protocol was designed with public review and input from industry and was published as an Internet draft document.
- Subsequently, when a consensus was reached to submit the protocol for Internet standardization, the TLS working group was formed within IETF to develop a common ***standard***.

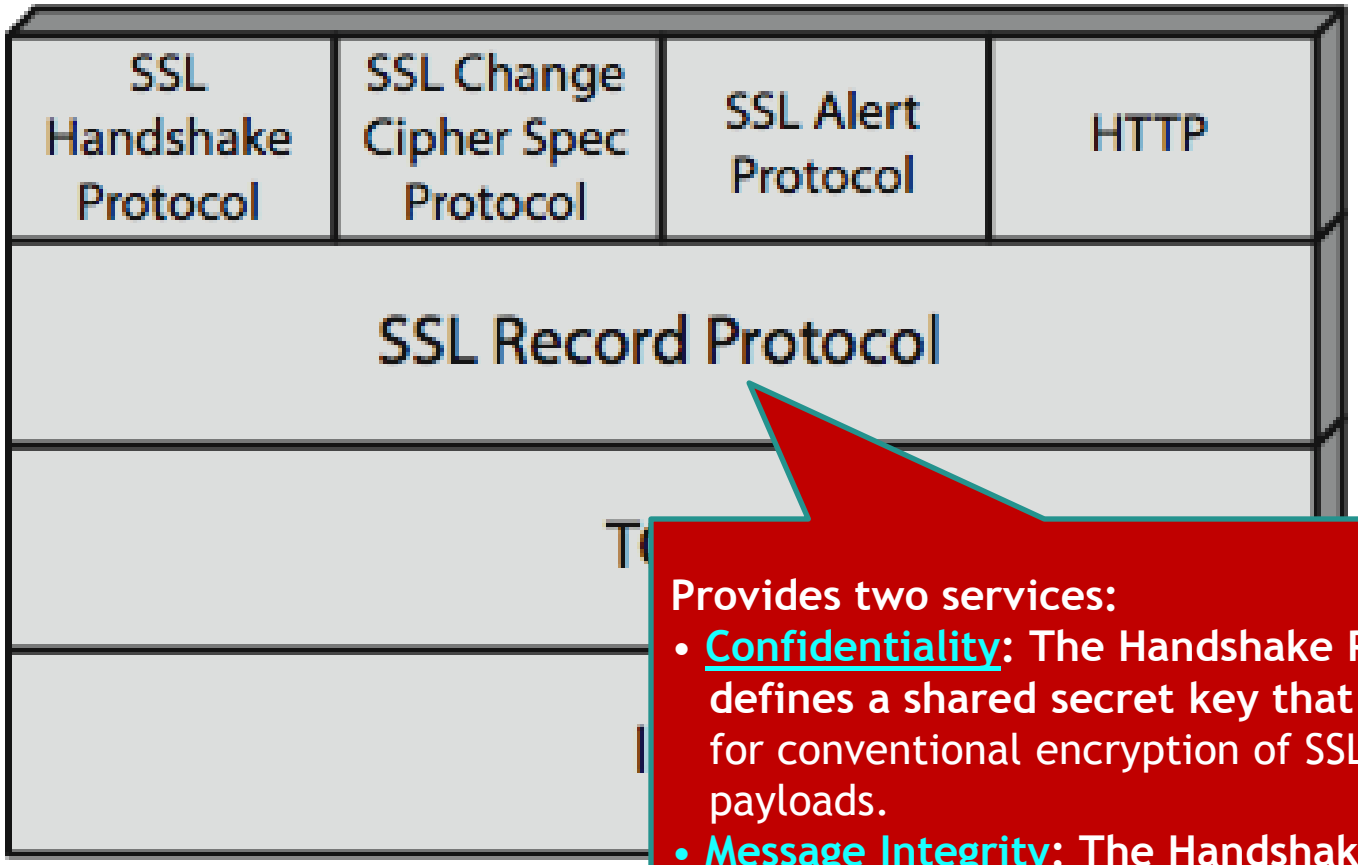
SSL Architecture

- SSL is designed to make use of TCP to provide a ***reliable end-to-end secure service***.
- SSL is not a single protocol but rather ***two layers*** of protocols,

SSL Architecture



SSL Architecture



Provides two services:

- **Confidentiality: The Handshake Protocol defines a shared secret key that is** used for conventional encryption of SSL payloads.
- **Message Integrity: The Handshake Protocol also defines a shared secret key** that is used to form a message authentication code (MAC).

SSL Architecture

- Two important SSL concepts are the ***SSL session*** and the ***SSL connection***, which are defined in the specification as follows.
  - **Connection:**
    - connections are **peer-to-peer** relationships.
    - The connections are transient.
    - Every connection is associated with one session.
  - **Session:**
    - between a client and a server.
    - Sessions are created by the Handshake Protocol.
    - Sessions define a set of cryptographic security parameters which can be shared among multiple connections.

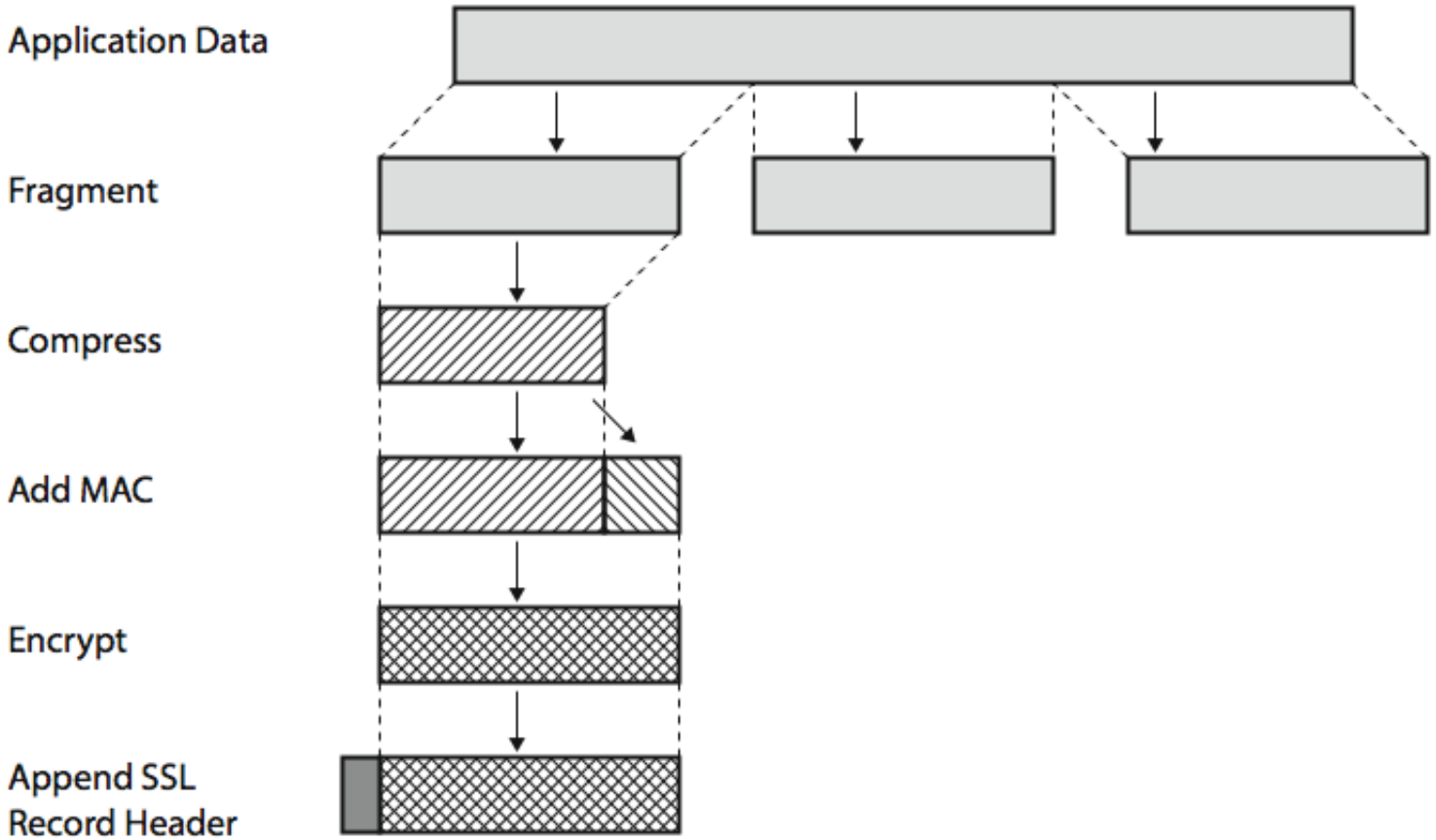
SSL Record Protocol

- The SSL Record Protocol provides two services for SSL connections:
  - **Confidentiality**: The Handshake Protocol defines a shared secret key that is used for conventional encryption of SSL payloads.
  - **Message Integrity**: The Handshake Protocol also defines a shared secret key that is used to form a message authentication code (MAC).

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



Change Cipher Spec Protocol

- The Change Cipher Spec Protocol is ***one of the three*** SSL-specific protocols that use the SSL Record Protocol, and it is ***the simplest***.

- 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.

SSL Alert Protocol

- The Alert Protocol is used to ***convey*** SSL-related alerts ***to the peer entity***.
- As with other applications that use SSL, ***alert messages are compressed*** and ***encrypted***, as specified by the current state.

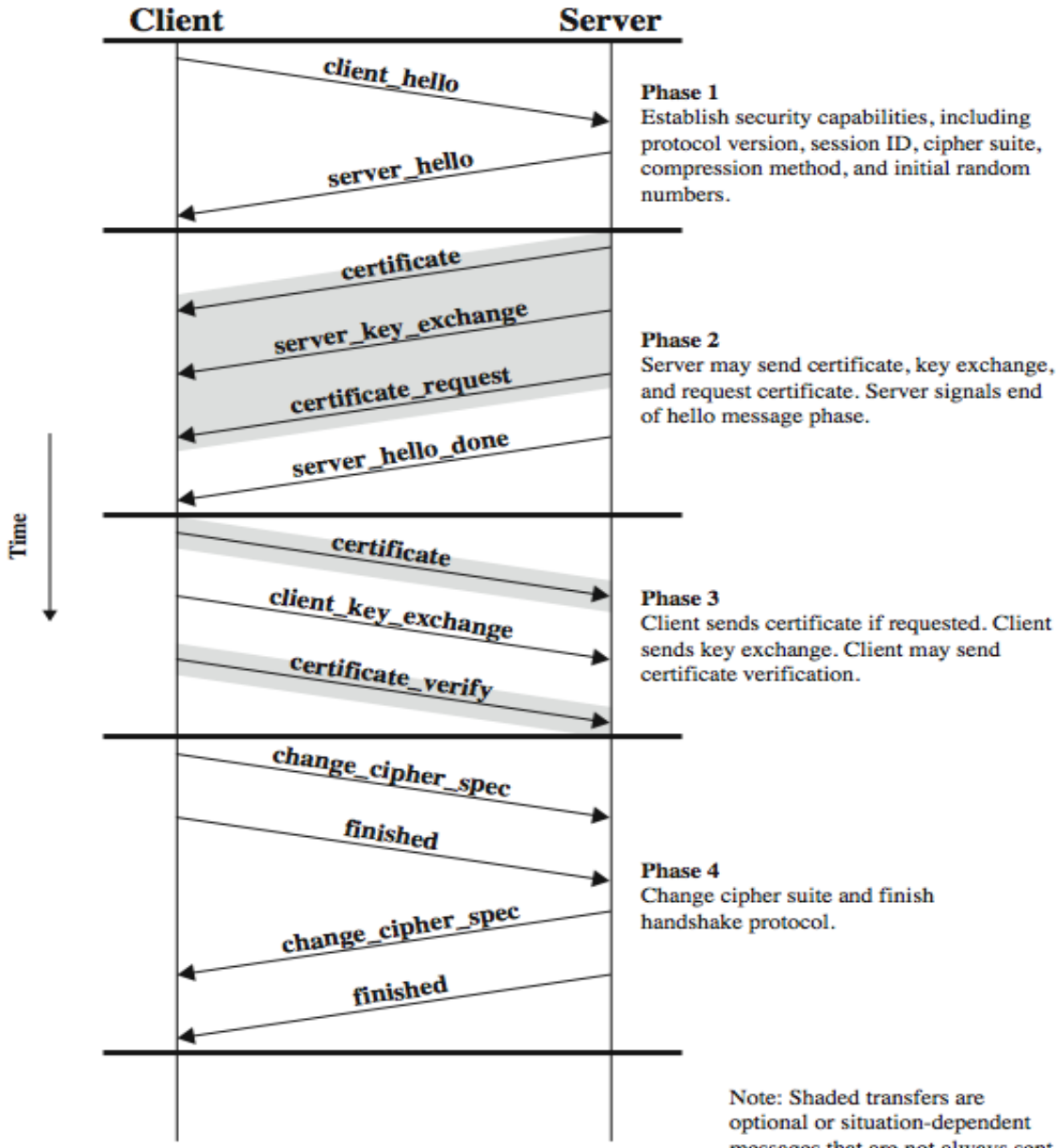
SSL Handshake Protocol

- The ***most complex*** part of SSL is the Handshake Protocol.
- This protocol allows the ***server*** and ***client***
  - to *authenticate each other* and
  - to *negotiate an* ***encryption*** *and* ***MAC algorithm*** and
  - To *negotiate cryptographic keys* to be used to protect data sent in an SSL record.
- The Handshake Protocol is used ***before*** any application data is transmitted

SSL Handshake Protocol

- Comprises a ***series of messages*** in phases
  - Establish Security Capabilities
  - Server Authentication and Key Exchange
  - Client Authentication and Key Exchange
  - Finish

SSL Handshake Protocol



Cryptographic Computations

Two further items are of interest:

- the ***creation of a shared master secret*** by means of the key exchange and
  - a one-time 48-byte value
  - generated using secure key exchange (RSA / Diffie-Hellman) and then hashing info

- the ***generation of cryptographic parameters*** from the master secret.
  - 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

- TLS is an IETF standardization initiative whose goal is to produce an Internet standard version of SSL
- 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

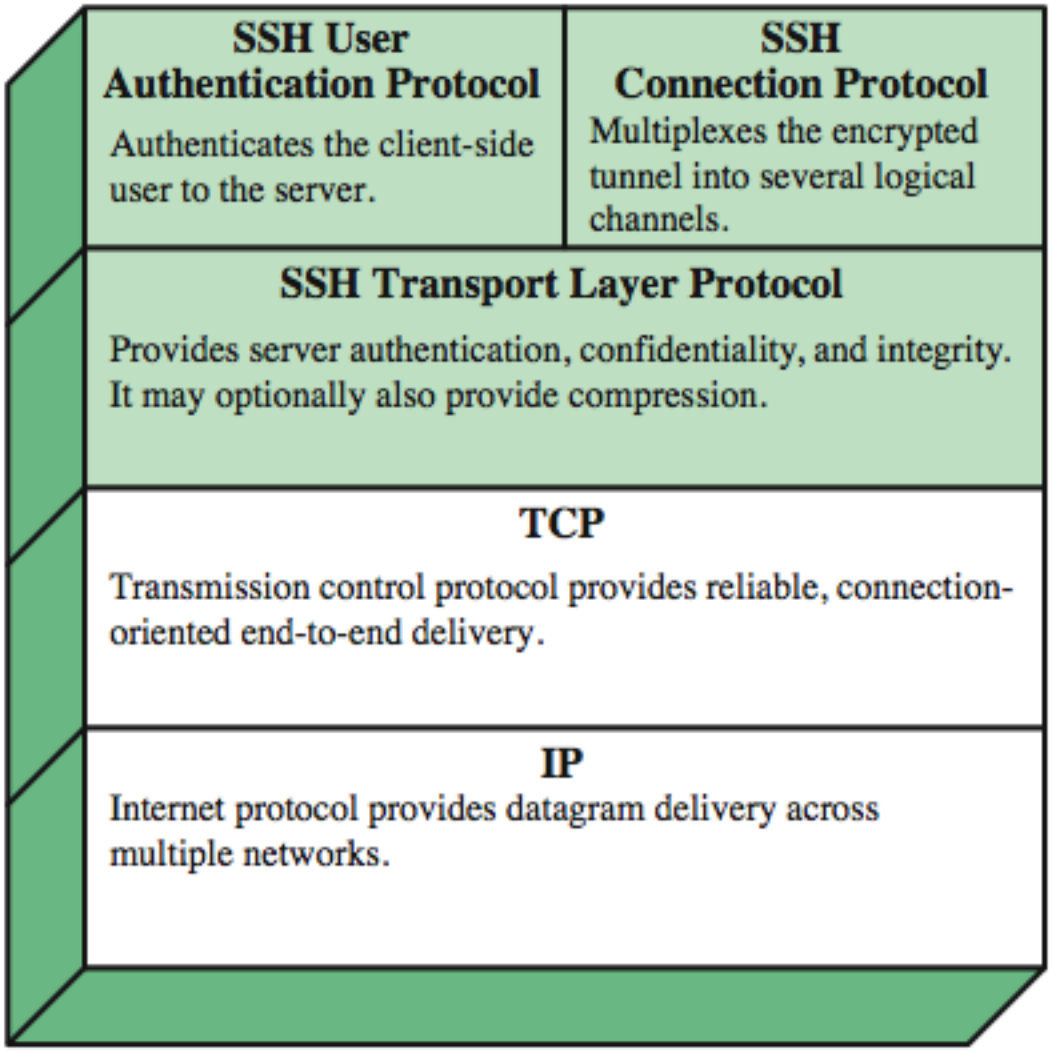
HTTPS Use

- 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

SSH (Secure Shell)

- ***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

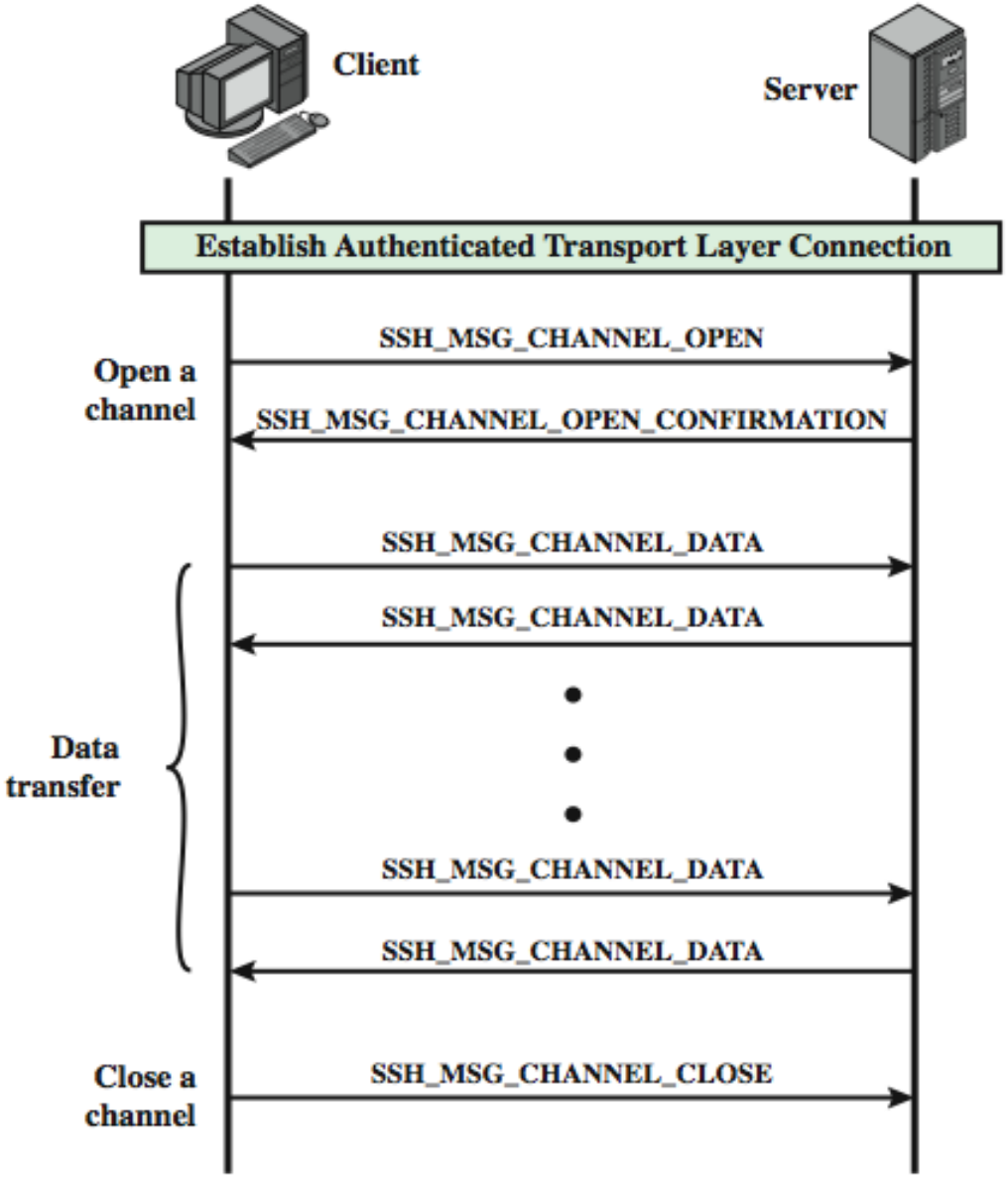
SSH User Authentication Protocol

- 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

We have discussed:

- Web Security Issues
- Security Socket Layer (SSL)
- Transport Layer Security (TLS)
- HTTPS
- Secure Shell (SSH)

References

1. Cryptography and Network Security, Principles and Practice, William Stallings, Prentice Hall, Sixth Edition, 2013