

Web Security

ITS335: IT Security

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Contents

Web Browsing

Web Applications

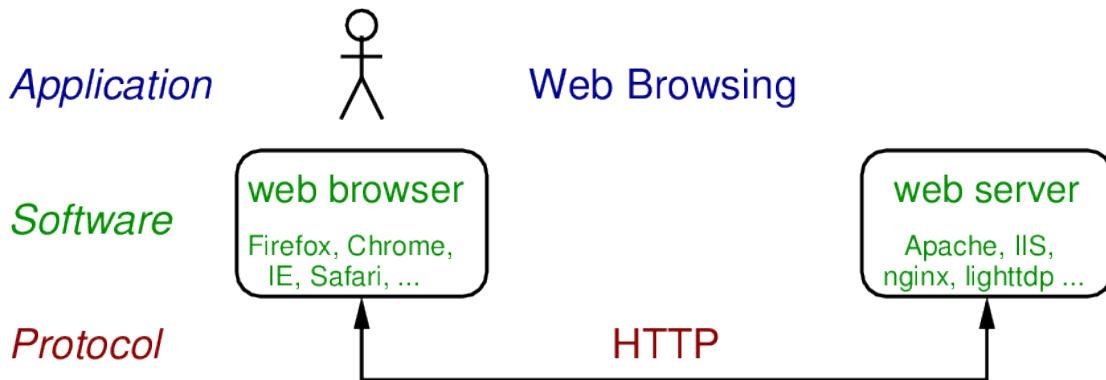
Confidential Web Communications with HTTPS

Digital Certificates

Summary

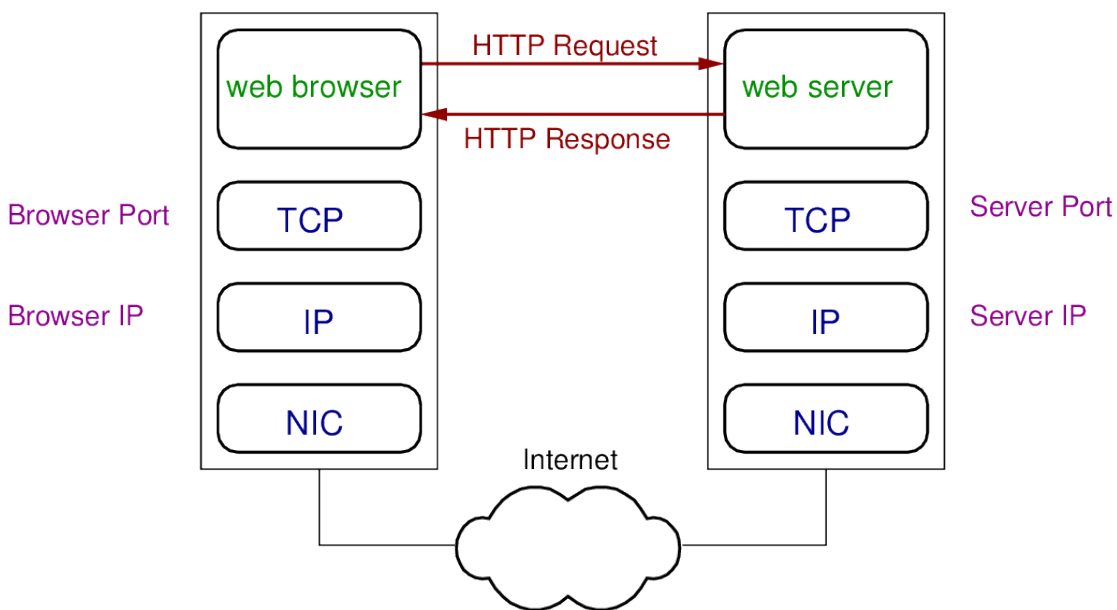
- Browsing
- Applications
- HTTPS
- Certificates
- Summary

Web Browsing with HTTP



- Browsing
- Applications
- HTTPS
- Certificates
- Summary

Web Browsing with HTTP

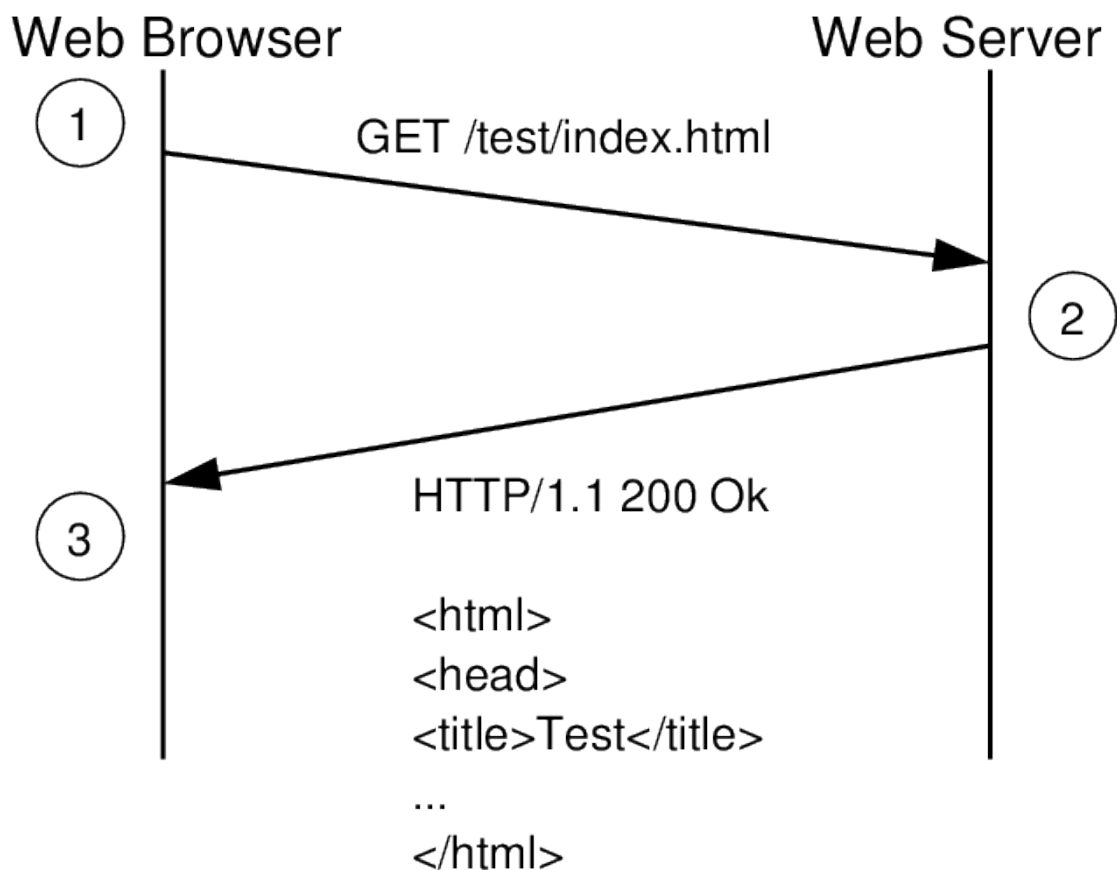


Web Access with Hypertext Transfer Protocol

- ▶ HTTP is a request/response protocol for web browsing
- ▶ HTTP is stateless; no dependence between a request and previous request
- ▶ User Agent (client) sends HTTP Request message
- ▶ Server responds with HTTP Response message
- ▶ Default server port number: 80
- ▶ Generic HTTP message format:
 - Start line
 - Optional header lines
 - <empty line>
 - Optional message body
- ▶ Start line differs for request and response
- ▶ Header format: field-name: value

5

HTTP Example



6

HTTP Request Messages

- ▶ Start line: Method URL Version
- ▶ Methods:
 - ▶ GET: retrieve the resource at the specific URL
 - ▶ HEAD: same as GET, except do not return message body (only header)
 - ▶ OPTIONS: retrieve options available for resource or server
 - ▶ POST: asks server to accept and process the attached data at the resource
 - ▶ ...
- ▶ Version: version of HTTP, e.g. HTTP/1.0, HTTP/1.1

7

HTTP Response Messages

- ▶ Start line: Version StatusCode StatusReason
- ▶ Status Codes and Reasons:
 - ▶ 100: Continue (the client should continue with its request)
 - ▶ 200: OK (the request succeeded)
 - ▶ 301: Moved Permanently (the requested resource has a new URL)
 - ▶ 304: Not Modified (resource hasn't changed since last request, client should use cached copy)
 - ▶ 401: Unauthorized (request must include user authentication)
 - ▶ 403: Forbidden (request was understood, but server refuses to process it)
 - ▶ 404: Not Found (server cannot find resource at requested URL)
 - ▶ 503: Service Unavailable (server currently unable to handle request, e.g. server is too busy)

8

HTTP Headers

- ▶ Date: data and time of message generation
- ▶ Host: domain name of host of resource (means relative URLs can be used)
- ▶ Accept-Charset, Accept-Encoding, Accept-Language: indicate the character sets, encodings and languages that client can accept
- ▶ Authorization: include user credentials (e.g. username, password) if authorization is required
- ▶ User-Agent: indicates information about the client (user agent), e.g. web browser
- ▶ Referrer: URL from which this request came from
- ▶ Content-Encoding: encoding or compression, e.g. gzip
- ▶ Content-Length: length of message body on bytes
- ▶ Content-Type: the type of content in message body
- ▶ Last-Modified: indicates data/time when content was last modified on server

9

Contents

Web Browsing

Web Applications

Confidential Web Communications with HTTPS

Digital Certificates

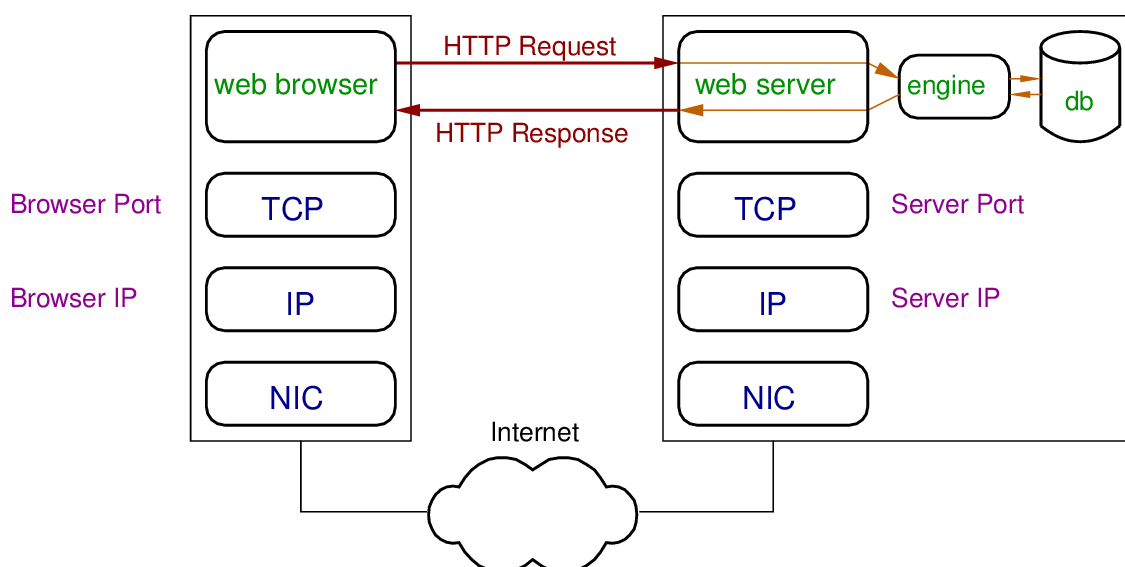
Summary

Web Applications

- ▶ Plain, static web pages: HTML, images and other files served to browser
- ▶ But many applications use dynamic content
 - ▶ Content server to browse changes depending on request
 - ▶ Provides interactive, tailored content
 - ▶ Client-side: JavaScript, Flash, Silverlight, Java
 - ▶ Server-side: CGI, ASP, PHP, Coldfusion, Java, ...
 - ▶ Content stored in databases

11

Dynamic Content with Server-Side Processing



12

What are the security issues?

- ▶ Data transmitted between browser and server is confidential: encryption with HTTPS
- ▶ Browser sure it is communicating with intended server: digital certificates
- ▶ Server sure it is communicating with intended user: password authentication, session management
- ▶ Actions performed by server (engine) are appropriate: authentication, access control
- ▶ Actions of user (of browser) are kept private: anonymity services

13

Contents

Web Browsing

Web Applications

Confidential Web Communications with HTTPS

Digital Certificates

Summary

14

HTTPS

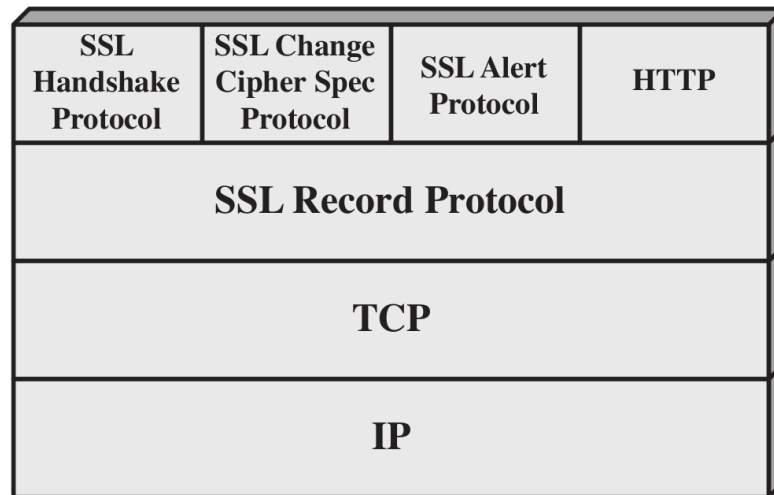
- ▶ HTTPS: HTTP over SSL (or TLS)
- ▶ URL uses https://
- ▶ Web server listens on port 443
- ▶ Encrypt: URL of requested document, contents of document, contents of browser forms, cookies, contents of HTTP header
- ▶ Server is authenticated using certificate (using SSL)
- ▶ Client is authenticated using password (using HTTP)

15

SSL and TLS

- ▶ Secure Sockets Layer (SSL) originated in Netscape web browser
- ▶ Transport Layer Security (TLS) standardised by IETF
- ▶ SSLv3 and TLS are almost the same
- ▶ SSL provides security services to application layer protocols using TCP
- ▶ SSL architecture consists of multiple protocols

16



Record: provides confidentiality and message integrity

Handshake: authenticate entities, negotiate parameter values

Change Cipher: change cipher for use in connection

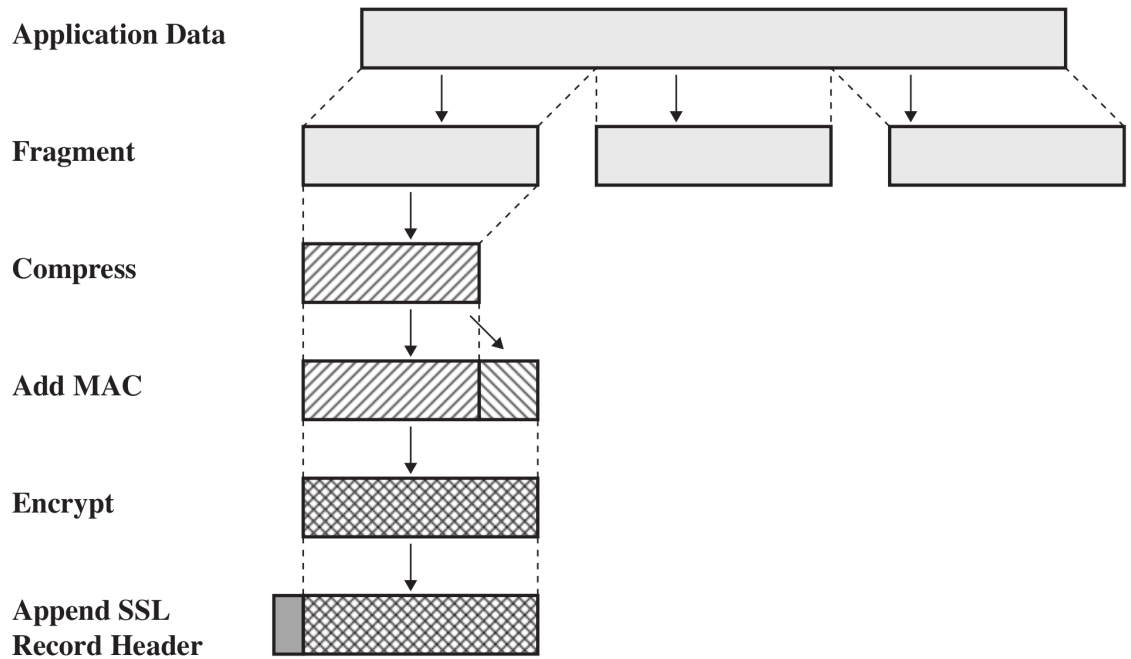
Alert: alert peer entity of status/warning/error

17

- ▶ SSL connection corresponds with TCP connection
 - ▶ Client and server may have multiple connections
- ▶ SSL session is association between client and server
 - ▶ Session created with Handshake protocol
 - ▶ Multiple connections can be associated with one session
 - ▶ Security parameters for session can be shared for connections
- ▶ State information is stored after Handshake protocol
 - ▶ Session: ID, certificate, compression, cipher spec, master secret, ...
 - ▶ Connection: random values, encrypt keys, MAC secrets, IV, sequence numbers, ...

18

SSL Record Protocol Operation



19

SSL Handshake Protocol

- ▶ Allow client and server to authenticate each other
- ▶ Negotiate encryption and MAC algorithms, exchange keys
 - ▶ Key Exchange: RSA, Diffie-Hellman
 - ▶ MAC: HMAC using SHA or MD5
 - ▶ Encryption: RC4, RC2, DES, 3DES, IDEA, AES
- ▶ Multiple phases:
 1. Establish security capabilities: client proposes algorithms, server selects one
 2. Server authentication and key exchange
 3. Client authentication and key exchange
 4. Finish setting up connection

20

Contents

Web Browsing

Web Applications

Confidential Web Communications with HTTPS

Digital Certificates

Summary

21

Authentication and Encryption in Web Browsing

- ▶ Browser and server do not have pre-shared secrets
- ▶ Use public key cryptography to securely exchange secret key
 - ▶ RSA/DSA
 - ▶ Diffie-Hellman key exchange
 - ▶ Elliptic curve cryptography
- ▶ Once a secret key is exchanged, use symmetric key encryption
 - ▶ AES, RC4, 3DES, ...
- ▶ E.g. with RSA: if a server sends browser its RSA public key, how does browser know it is indeed RSA public key of server?
 - ▶ Get a trusted third party to confirm it is the servers RSA public key

22

Public Key for Key Exchange, Symmetric for Data

Browsing

Applications

HTTPS

Certificates

Summary

Man-in-the-Middle Attack

Browsing

Applications

HTTPS

Certificates

Summary

Digital Certificates

Step 1: Server Obtains Digital Certificate

- ▶ Server (owner) creates key pair: (PU_s, PR_s)
- ▶ Server confirms identity, ID_s , with trusted third party called Certificate Authority
- ▶ CA issues server with a digital certificate by signing relevant info:

$$C_s = ID_s || PU_s || T, E(PR_{CA}, H(ID_s || PU_s || T))$$

- ▶ A timestamp, T , can be used to determine how long the certificate is valid
- ▶ X.509 specifies standard format of certificates

25

Digital Certificates

Step 2: Server Sends Digital Certificate to Browser

- ▶ When browser initiates communications with server, server responds with C_s
- ▶ Browser verifies signature using PU_{CA}
 - ▶ Assumes browser already knows and trusts PU_{CA}
 - ▶ PU_{CA} is stored in self-signed certificate:

$$C_{CA} = ID_{CA} || PU_{CA} || T, E(PR_{CA}, H(ID_{CA} || PU_{CA} || T))$$

- ▶ Once verified, browser can choose secret value and send it encrypted using PU_s to server

26

Key Exchange with Certificates

Browsing

Applications

HTTPS

Certificates

Summary

Attacks on Certificates

Browsing

Applications

HTTPS

Certificates

Summary

X.509 Certificates

- ▶ X.509 certificate format includes:
 - ▶ Version of X.509 certificate
 - ▶ Serial number unique to the issuer (CA)
 - ▶ Signature algorithm
 - ▶ Issuer's name and unique identifier
 - ▶ Period of validity (start time, end time)
 - ▶ Subject's name and unique identifier
 - ▶ Subject's public key information: algorithm, parameters, key
 - ▶ Signature
- ▶ Certificates may be revoked before expiry
 - ▶ CA signs a Certificate Revocation List (CRL), which is publicly available

29

Digital Certificates in Practice

How does a server obtain a certificate?

- ▶ Prove identity to CA by:
 - ▶ Domain validation
 - ▶ Extended validation
- ▶ Free and commercial services

How does browser obtain CA certificate?

- ▶ Pre-loaded into browsers
- ▶ Hierarchy of certificates is supported

What if CA certificate is not in browser?

- ▶ Browsers commonly present warning to user

30

Security Issues with Digital Certificates

- ▶ Identity verification of server (owners)
- ▶ Security of CA private key
- ▶ Pre-loaded certificates by browser publisher
- ▶ Response when invalid certificate received
- ▶ Algorithms used in certificates should be strong

31

Contents

Web Browsing

Web Applications

Confidential Web Communications with HTTPS

Digital Certificates

Summary

32

Key Points

- ▶ Web browsing uses HTTP over TCP
- ▶ Secure web browsing inserts SSL in between HTTP and TCP; HTTPS
- ▶ Secret key exchange between browser and server using public key crypto
- ▶ For browser to trust server public key, must be signed by trusted third party (certificate authority)
- ▶ X.509 digital certificates used in web browsing, email and many networked applications

33

Security Issues

- ▶ Digital certificates rely on trustworthiness of certificate authorities
- ▶ Also rely on action by users: response with invalid certificate received; trusting browser CA list
- ▶ Man-in-the-middle interception/modification attacks on web browsing are easy *if* certificates are compromised

34

Areas To Explore

- ▶ Public key distribution methods
- ▶ PGP and GPG for email
- ▶ Securing web applications, OWASP