香港中文大學
The Chinese University of Hong Kong

CSCI2720 - Building Web Applications

Lecture 16: Web Security

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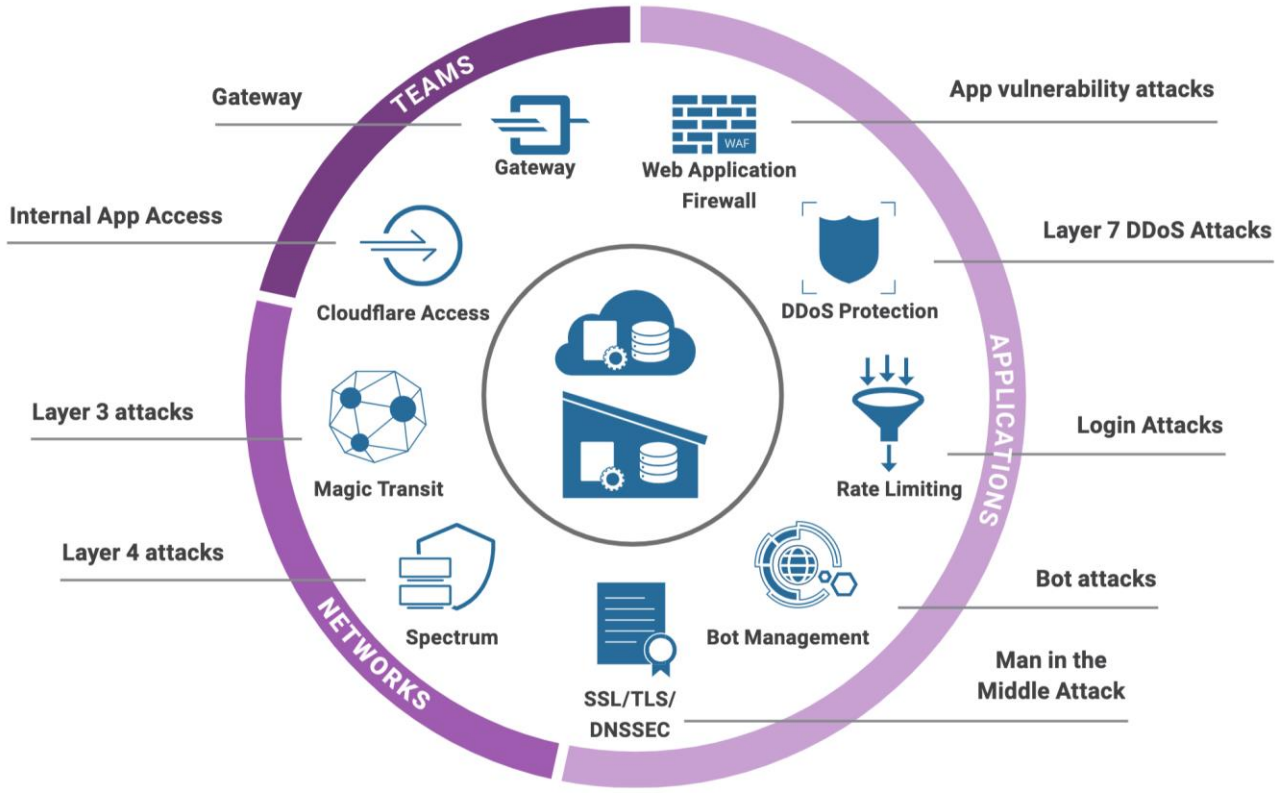
Outline

- Important terms in cyber security
- Top 10 web application security risks\
- Mitigation to threats
- Authentication methods
- HTTPS
- DDoS

Cyber security

- Application security:
  - Assets at the software level
  - Database, documents
- Network security
  - Infrastructure of network level
  - Connection, hardware



- See: https://www.cloudflare.com/en-gb/security/
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Important terms

- Validation
  - To check if something (e.g., an account) is valid or existing
- Verification
  - To check if something (e.g., account ownership) is real
- Authentication
  - To verify a user with credentials (e.g., password) as the correct person
- Authorization
  - To determine the permission on what a user can access (e.g., change a file)

Top 10 of OWASP

- Open Web Application Security Project

1. Broken access control
2. Cryptographic failures Failed encryption
3. Injection
4. Insecure design
5. Security misconfiguration
6. Vulnerable and outdated components
7. Identification and authentication failures
8. Software and data integrity failures
9. Security logging and monitoring failures
10. Server-side request forgery (SSRF)

- See: https://www.reflectiz.com/blog/owasp-top-ten-2023/

Common access control vulnerabilities

- Access granted to *more than necessary* capabilities, roles, or users
- *Bypassing* access control checks possible with URL / state modification
  - E.g., access with an admin link without proper authentication
- Permitting access to someone else's account with *unique identifier*
- *Metadata manipulation* with cookies or security tokens
- *CORS misconfiguration* giving rise to access from unauthorized origins

- More on: https://owasp.org/Top10/A01_2021-Broken_Access_Control/

Bad implementation

- There may be *carelessness* or *ignorance* to threats
  - Including sensitive data in URL
  - Password not encrypted in storage or transit
  - Storing credentials in public code repositories
  - Permitting brute force attacks
  - Running application in development/debug mode for production
  - Session timeout unhandled
  - Missing access control to functions
  - Using components with known vulnerabilities
- *Using security frameworks instead might be helpful*
- Test the application thoroughly and rigorously

Mitigation to attacks

- Plan carefully for authentication and authorization
- Combination of multiple layers of security measures
- Sanitize all untrusted data
  - All user input should be considered untrusted, and should go through:
    - *Validation*: check if the string format is as expected
    - *Escaping*: special characters such as **<** or **>** should be changed to **<** and **&gt**; to prevent injection of HTML code To avoid hackers inject <script>
    - *Sanitization*: if needed, only allow certain code in a whitelist
- Enforce same-site requirements:
  - Allow *cross-site only if needed*, with only minimal possibilities

Authentication for web apps

- Membership is one important features in apps and services.
- Three major ways to check the identity of users:

HTTP Authentication	Session/token based	Delegating/Decentralizing
• HTTP Basic/Bearer/Digest authentication • User/password pairs to be checked • Stateless: resending all data in every request	• Authenticated with user/password pairs • Stateful: user info stored on server or client	• OpenID Connect / OAuth 2.0 • User identity being checked by a ***third party***, e.g., "Sign in with Google" • More robust if set up properly
Well supported, not preferred	***Currently most preferred***	Outsourcing – is it good?

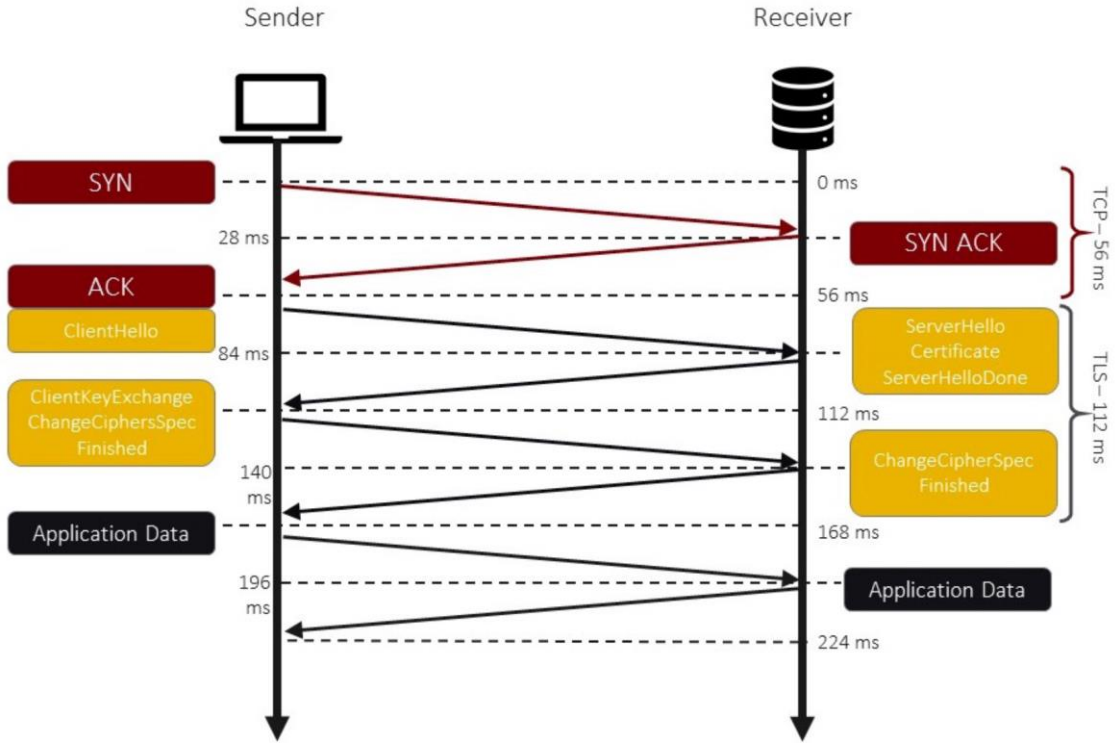
- More on: https://testdriven.io/blog/web-authentication-methods/

HTTPS

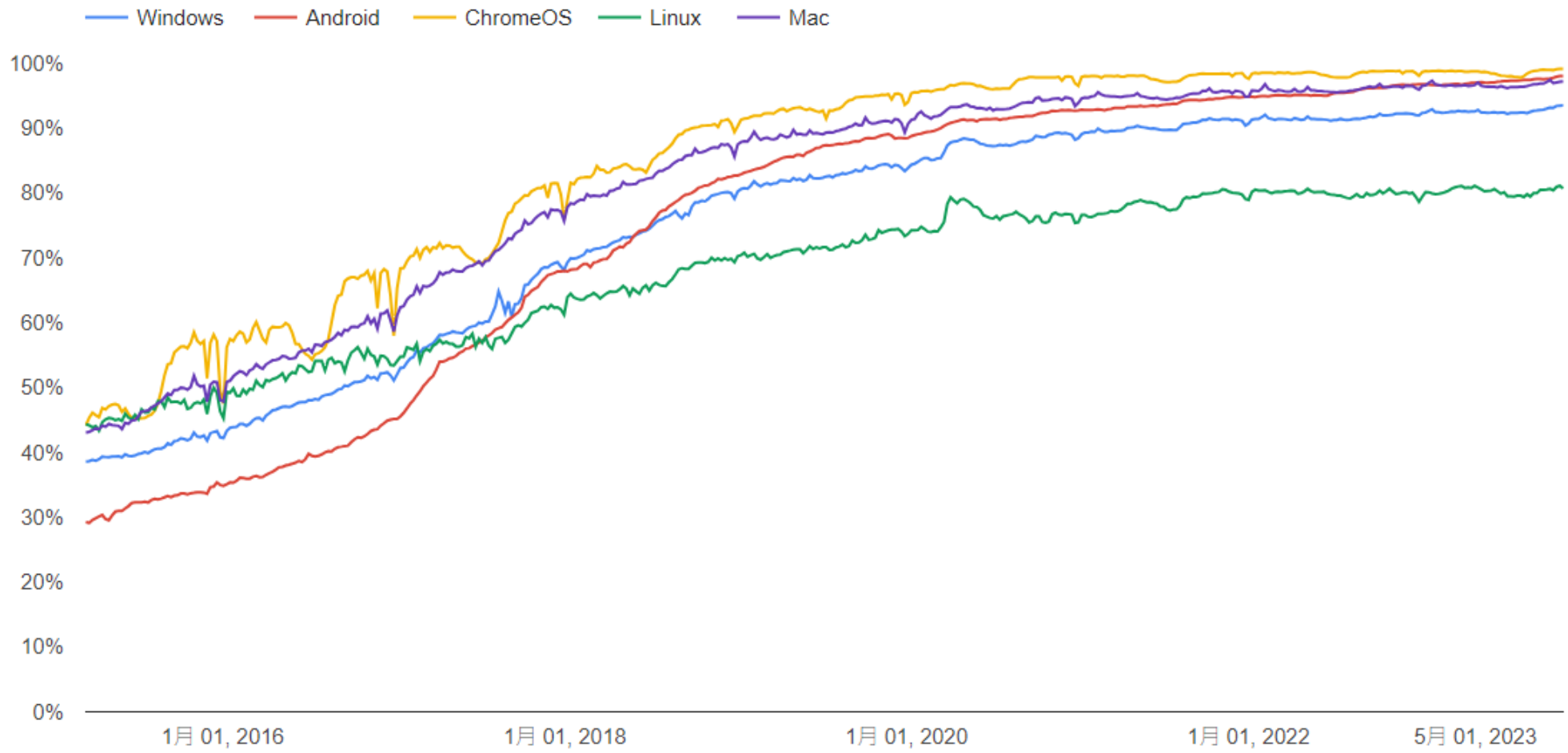
- By design, HTTP transfers everything in plain text.
- *HTTP Secure* is an extension to HTTP
  - *Authentication*: to prove its identity, visited website must present a valid digital certificate signed by an authority
  - *Encryption*: HTTP requests and responses are transmitted over an added layer of SSL/TLS, so all messages are transferred in *ciphertext*
- Transport Layer Security (TLS)
  - Private connection with symmetric cryptography
    - A key is used for encryption of plain text and decryption of ciphertext
    - A unique session key are generated at the beginning of each connection during handshake

The HTTPS connection

- See: https://love2dev.com/blog/how-https-works/



Trend of HTTPS page loads in Chrome



Certificates

- To verify identity, signed by a Certificate Authority (CA)
- Server certificates
  - *Domain verification*: owning the domain name with DNS records
  - *Organization verification*: company name and public address
  - *Extended verification*: existence and location of a legal entity
- Browsers and Oses maintain trusted list of CAs
  - If a cert is issued by these Cas, the cert is trusted

Certificates

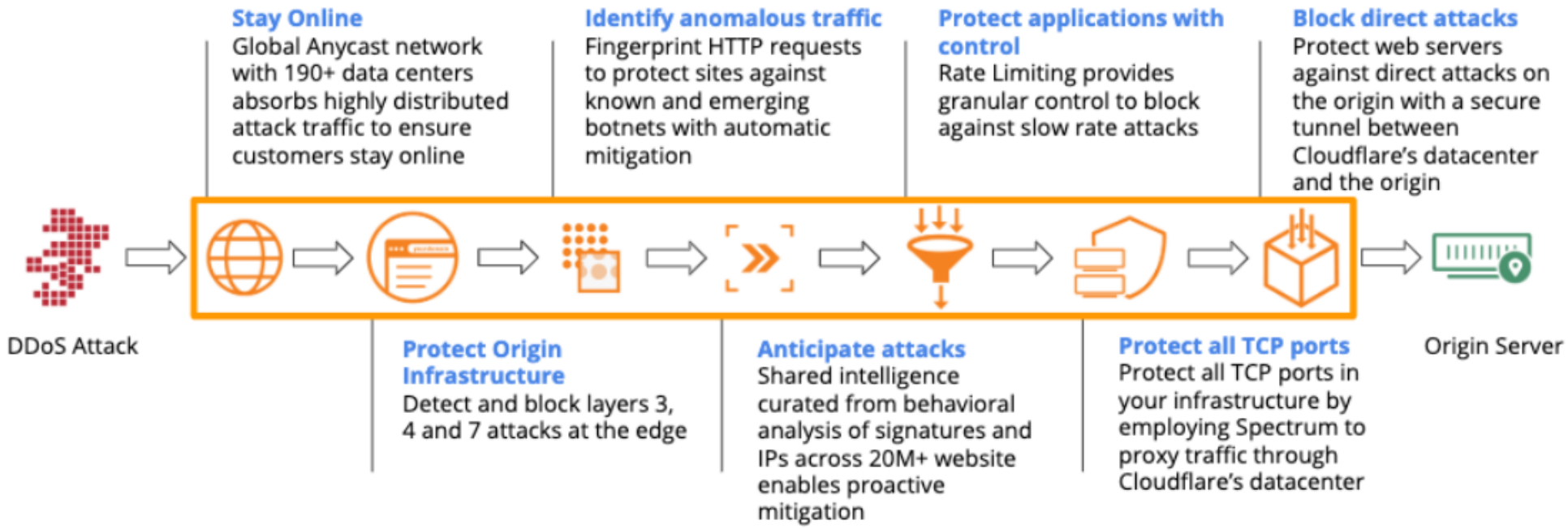
- Commercial Cas
  - Paid service for verification
  - Recognized Cas in HK: https://www.ogcio.gov.hk/en/our_work/regulation/eto/ordinance/ca_in_hk/
- Let's Encrypt
  - Free of charge, supported by sponsors
  - DV only – fully automated
- Self-signed certificates / private CA
  - Browsers need to trust the certificate manually
- More on: https://www.digitalocean.com/community/tutorials/a-comparison-of-let-s-encrypt-commercial-and-private-certificate-authorities-and-self-signed-ssl-certificates

DDoS attack

- Distributed Denial-of-Service attack
  - Exhausting the resource of the target, e.g., consuming all the available bandwidth, or computation power
  - Distributed: not a single source of attack, usually using bots
- Layer 7 DDoS
  - Flooding with application requests (e.g., HTTP requests)
- Layer 3 or 4 DDoS
  - Protocol attacks (e.g., SYN flood)
  - Volumetric attacks (e.g., DNS amplification)
- See: https://www.cloudflare.com/en-gb/learning/ddos/what-is-a-ddos-attack/

Cloud solutions for DDoS

- Distributed an intelligent systems to mitigate attacks
  - E.g., Cloudflare, AWS Shield, Nexuguard
  - See: https://www.cloudflare.com/ddos/



A lot of hard work ahead …

- The internet evolves with improving concern on security
- Cyber security depends heavily on
  - The developers
  - The system administrators
  - The users
- Wish you god luck
- Check out OWASP cheat sheets: https://cheatsheetseries.owasp.org/

Further readings

- All links on “OWASP top ten” :
  - https://owasp.org/Top10/
- 10 most common web security vulnerabilities:
  - https://www.toptal.com/security/10-most-common-web-security-vulnerabilities
- Web security on MDN:
  - https://developer.mozilla.org/en-US/docs/Web/Security