Sichere Software-Entwicklung für Java Entwickler

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AGENDA

1. OWASP and the top 10 project
2. A closer look at the current top 10
3. Raise interest in secure programming

Every developer needs secure programming knowledge

- Applications must be protected from the beginning
  - A security fix does not bring back stolen data
  - The problem may be caused by the architecture
    - Not fixable with a couple of simple code changes
- 100% secure software will never exist
  - But we can stop making it that easy for attackers
  - Secure software is not developed accidentally
    - Test web applications for vulnerabilities before deployment

If you don't do this, the attackers will be happy to do it for you...

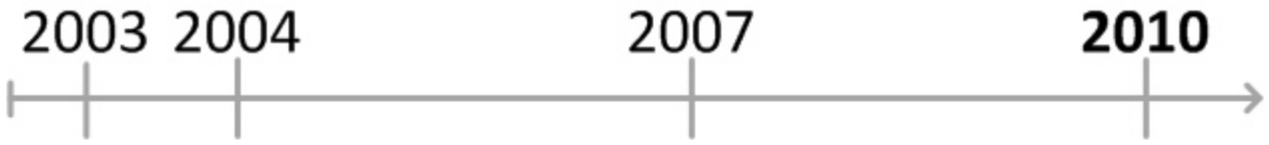
Improving the security of (web) application software

- Open Web Application Security Project (OWASP)
  - Not-for-profit worldwide charitable organization since 2001
  - All material available for free

- Top 10
- Cheat Sheets to avoid most of the top 10 risks
- Development guides

- **ESAPI** - OWASP Enterprise Security API
- **WebScarab** - analyze applications that communicate using HTTP(S)
- **WebGoat** - deliberately insecure JEE web application to teach web application security

Awareness for developers – the OWASP TOP 10 project



- Lists the 10 most critical web application security risks
  - Focus changed from weaknesses/ vulnerabilities to risks in 2010
  - Not a security guide
  - Consider it as a starter
- There are more than 10 risks for web applications
  - Focus on secure development first and train all developers
  - Document secure coding conventions
  - Think about a Software Development Lifecycle (SDLC) later

The Enterprise Security API (ESAPI) addresses the top 10 risks

- Addresses the OWASP Top 10 risks
  - Good Java library, but project is not really active
- Easy to use open source web application security library
  - Collection of security building blocks, not a framework
  - Centralized access to all security related functionality
    - One access point for all security functionality
    - Much easier for developers
- Provides authentication, access control, input validation, **output escaping**, encryption, random numbers, ...

https://www.owasp.org/index.php/Category:OWASP_Enterprise_Security_API

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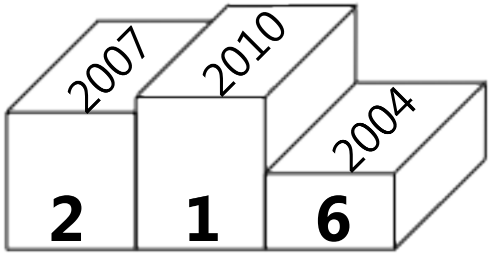
Top 10 2010

- A1: Injection
- A2: Cross-Site Scripting (XSS)
- A3: Broken Authentication and Session Management
- A4: Insecure Direct Object References
- A5: Cross Site Request Forgery (CSRF)
- A6: Security Misconfiguration
- A7: Insecure Cryptographic Storage
- A8: Failure to Restrict URL Access
- A9: Insufficient Transport Layer Protection
- A10: Unvalidated Redirects and Forwards

http://owasptop10.googlecode.com/files/OWASP_Top_10_-_2010%20Presentation.pptx

A1 – Injection



- The famous (and least necessary) **SQL injection**
  - Simple to avoid with **prepared statements**
    - Use an OR-Mapper like Hibernate
    - Use Spring JDBCTemplate
    - Dynamic queries may still be misused and made vulnerable
  - Limit database user permissions
- **Other injections** (like LDAP injection, XPath injection)
  - **White list validation** for all user supplied input

Always validate in
front- and backend

A2 – Cross Site Scripting (XSS)

- Execute code in victim's browser
  - Steal users' session, sensitive data
  - Redirect to phishing sites
- Often injected due to missing input validation
  - **<script …>**
  - **<… onclick="" …>**
- Different XSS types
  - Stored
  - Reflected ←
  - DOM based

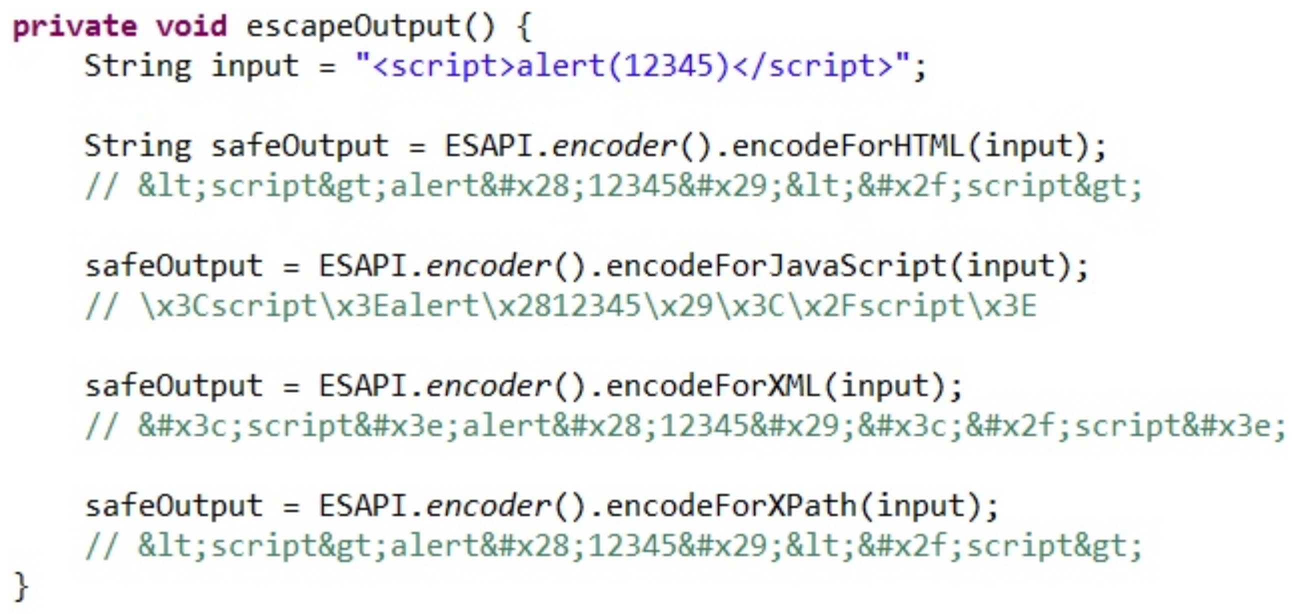
Basic browser protection – Internet Explorer 8 detects some patterns/ Firefox with NoScript

Server side attacks stored/ reflected, client side DOM based

- Stored
  - Injected code stored permanently on target servers
    - Often into a database via forum, guestbook, comment field, …
- Reflected
  - Injected code is reflected off the web server
    - Search results, error messages, or other response which contain (parts of) the input
- DOM based
  - Attack payload is executed because of DOM environment modification in the victim's browser
    - Page itself (HTTP response) does not change, only client side code

A2 – Cross Site Scripting (XSS) (cont'd.)

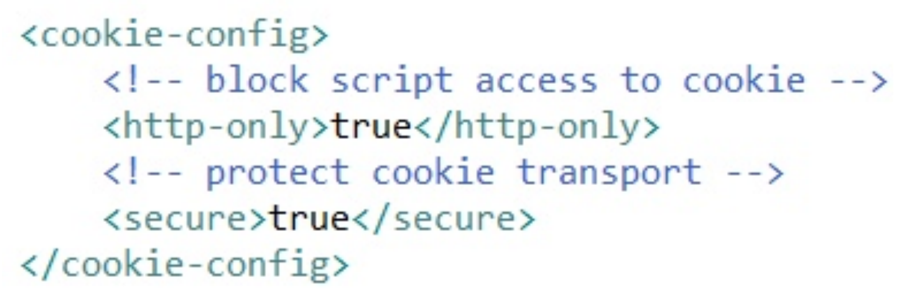
- Every time an application accepts user input
  - **Validate** all user supplied input with a white list
  - Output **escape** (output encode) all user supplied input



```
private void escapeOutput() {
    String input = "<script>alert(12345)</script>";

    String safeOutput = ESAPI.encoder().encodeForHTML(input);
    // &lt;script&gt;alert&#x28;12345&#x29;&lt;&#x2f;script&gt;

    safeOutput = ESAPI.encoder().encodeForJavaScript(input);
    // \x3Cscript\x3Ealert\x2812345\x29\x3C\x2Fscript\x3E

    safeOutput = ESAPI.encoder().encodeForXML(input);
    // &#x3c;script&#x3e;alert&#x28;12345&#x29;&#x3c;&#x2f;script&#x3e;

    safeOutput = ESAPI.encoder().encodeForXPath(input);
    // &lt;script&gt;alert&#x28;12345&#x29;&lt;&#x2f;script&gt;
}
```

A2 – Cross Site Scripting (XSS) (cont'd.)

- Prevent scripts from accessing cookie with **http-only**
  - No session cookie theft and other session-based attacks



```
<cookie-config>
    <!-- block script access to cookie -->
    <http-only>true</http-only>
    <!-- protect cookie transport -->
    <secure>true</secure>
</cookie-config>
```

A3 – Broken Authentication and Session Management

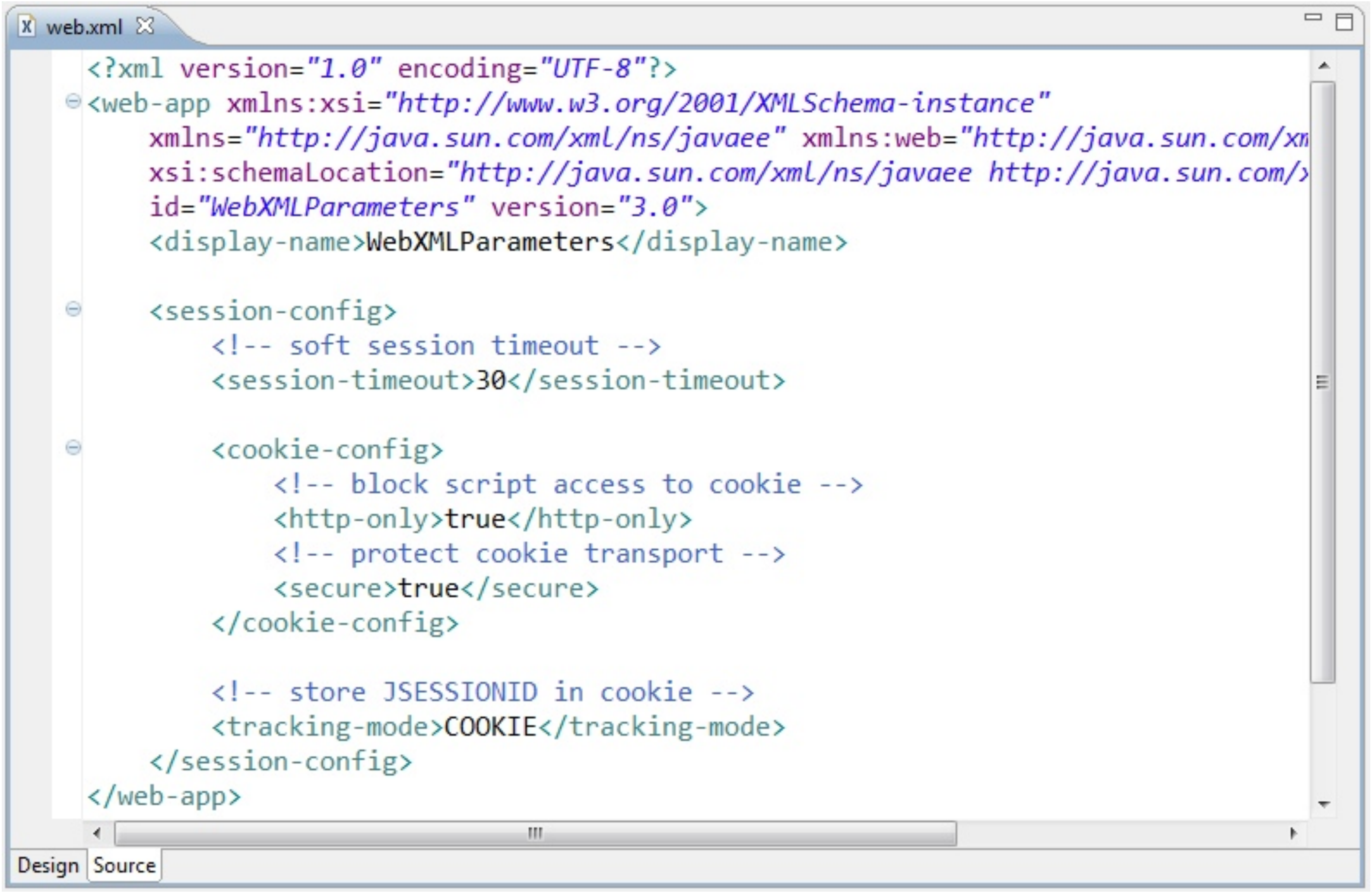
- One of the most complicated parts to develop
  - Simply: Don't invent it again, use existing frameworks
    - Spring Security http://static.springsource.org/spring-security/site
    - Apache Shiro http://shiro.apache.org
- Centralize in one place and reuse code application wide
  - Try to use one library only
  - Know exactly how to use it

But: HTTP is a stateless protocol →
credentials (session id) are included in every request

A3 – Broken Authentication and Session Management (cont'd.)

- Protect all connections with authentication data with TLS
  - Session id and credentials must be protected at all times
    - Session id is as valuable as username and password
    - Unprotected connection does expose the session id
- Don't include session information (like session id) in URLs
  - Shows up in referrer and other logs
  - Included in copied links (send via email, twitter, …)
- Make sure logoff/timeout completely destroys the session

Servlet specification 3.0 makes secure configuration easier



```
<?xml version="1.0" encoding="UTF-8"?>
<web-app xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns="http://java.sun.com/xml/ns/javaee" xmlns:web="http://java.sun.com/xn
    xsi:schemaLocation="http://java.sun.com/xml/ns/javaee http://java.sun.com/x
    id="WebXMLParameters" version="3.0">
    <display-name>WebXMLParameters</display-name>

    <session-config>
        <!-- soft session timeout -->
        <session-timeout>30</session-timeout>

        <cookie-config>
            <!-- block script access to cookie -->
            <http-only>true</http-only>
            <!-- protect cookie transport -->
            <secure>true</secure>
        </cookie-config>

        <!-- store JSESSIONID in cookie -->
        <tracking-mode>COOKIE</tracking-mode>
    </session-config>
</web-app>
```

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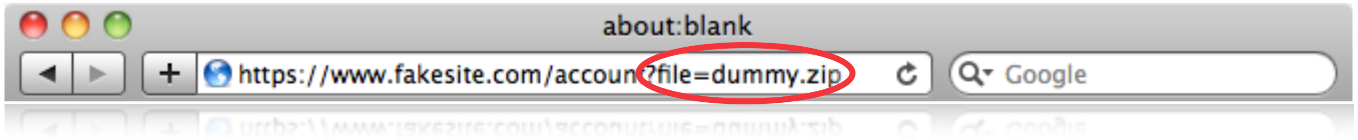
A4 – Insecure Direct Object References



- Presentation layer access control
  - User notices a direct reference in the URL
    - e.g. a file, account, database record, …
  - No enforcement of these restrictions on server side

1. User 57894 logs in with username/ password
   URL is https://www.myfakewebsite.com/account?**no=57894**
2. User experiments with URL *no* parameter, e.g. 57895
   URL is https://www.myfakewebsite.com/account?**no=57895**
3. User can view/ change other accounts

Reference map samples with ESAPI

```java
private Set<Object> fileSet;
private File fileA = new File("/temp/dummyA.txt");
private File fileB = new File("/temp/dummyB.txt");
private File fileC = new File("/temp/dummyC.txt");
private File fileD = new File("/temp/dummyD.txt");

public FileService() {
    fileSet = new HashSet<Object>();

    fileSet.add(fileA);
    fileSet.add(fileB);
    fileSet.add(fileC);
    fileSet.add(fileD);
}
```

```java
public void accessMap() throws AccessControlException {
    IntegerAccessReferenceMap map = new IntegerAccessReferenceMap(fileSet);
    String indRef = map.getIndirectReference(fileB);

    System.out.println("indRef " + indRef);

    String mapRef = indRef; // e.g. accessed via request parameter
    File file = (File) map.getDirectReference(mapRef);

    System.out.println("file " + file.getAbsolutePath());
}
```

indRef **3**
file **C:\temp\dummyC.txt**

```java
public void accessRandomMap() throws AccessControlException {
    RandomAccessReferenceMap map = new RandomAccessReferenceMap(fileSet);
    String indRef = map.getIndirectReference(fileA);

    System.out.println("indRef " + indRef);

    String mapRef = indRef; // e.g. accessed via request parameter
    File file = (File) map.getDirectReference(mapRef);

    System.out.println("file " + file.getAbsolutePath());
}
```

indRef **hUDXFM**
file **C:\temp\dummyA.txt**

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A4 – Insecure Direct Object References (cont'd.)

- Replace the direct object references with an **access reference map** (indirect object references)
  - Replace account number with *no=1*, *no=2*, … for current user
  - Mapping reference <-> real object on server **for this user**
    - Map is stored somewhere safe, e.g. session
  - No way for an attacker to break out
    - Using no=100 results in an error
    - Only resources in this map are accessible

ESAPI only

- Useable for files, database records, accounts, …
  - Use random numbers for more protection

A5 – Cross Site Request Forgery (CSRF)

- Often a vulnerable standard intranet (rarely web) application
  - Not accessible externally
  - Victim's browser is tricked into issuing commands via XSS
    - Acts as a proxy
- Browser **with authenticated user** must send credentials
  - Attacker causes request to vulnerable application
    - Uses credentials to execute his own request

A5 – Cross Site Request Forgery (CSRF) (cont'd.)

- Calculate a **random secret token** at beginning of session
  - May not be automatically submitted like session cookie
  - Add this token as hidden field to **all forms (and links)**
    ```
    <input name="token" value="abekdil873843944"
    type="hidden"/>
    ```
  - Check token before executing selected action
- Configure a low soft **session timeout**
  - Makes attack more complicated, not impossible

A6 – Security Misconfiguration

- Some other guys job
  - Patches for app-/web-server, databases, operating system, …
  - App-/web-server/ database configuration, firewall, user rights
    - Turn off unnecessary features, disable ports, services, …
- Developer’s job
  - Inform admins about project requirements (document them)
  - Configure logging, exception handling
    - No technical errors in frontend
    - Never serve log over web application in a production environment
  - Framework security configuration
    - Security related settings in all used frameworks
    - Security updates, new library versions

A7 – Insecure Cryptographic Storage

- Most of the time, the problem is not the algorithm
  - The data isn’t protected at all
    - Identify and protect all sensitive data in all places
  - The real threats are not identified
    - DB encryption protects data from DBA/ stolen disks, not SQL injection
- Never log any sensitive data **unencrypted**
- Store key(s) and data in different locations
  - Prepare key exchange and revocation
  - Change keys periodically

How do I select a strong algorithm?

- Never invent your own algorithms
- There is more than just the algorithm name
  - Size, padding, mode, and don't forget the salt
    - Symmetric
      AES/CBC/PKCS5Padding with 192 bit, Blowfish
    - Asymmetric
      RSA, DSA with > 1024 bit
    - Hash
      SHA-256, RIPEMD-160

if in doubt, choose the stronger key (negative impact on performance)

- Follow the news, replace weak algorithms in next project

Encryption does not have to be complicated

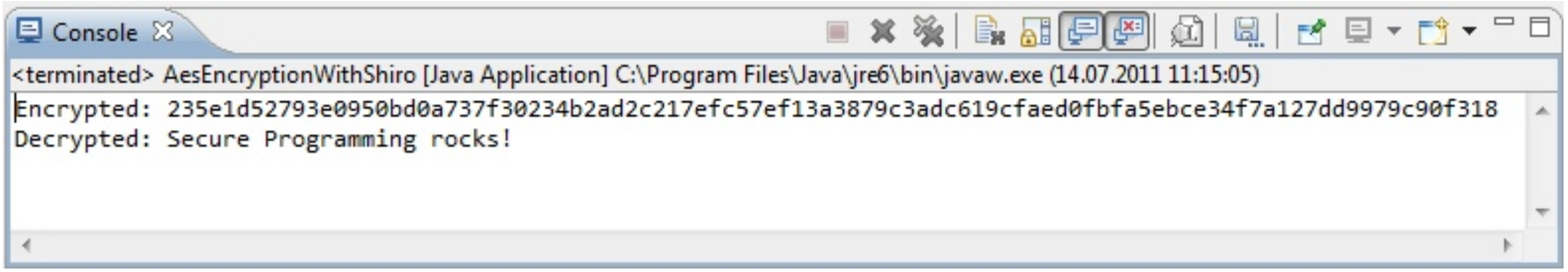
But key handling...

```java
/**
 * Symmetric AES (CBC, 128 bits) encryption sample with Apache Shiro.
 */
private void encryptAndDecryptAES() {
    AesCipherService cipher = new AesCipherService();

    byte[] key = cipher.generateNewKey().getEncoded();

    byte[] encrypted = cipher.encrypt("Secure Programming rocks!".getBytes(), key).getBytes();
    System.out.println("Encrypted: " + asHex(encrypted));

    byte[] decrypted = cipher.decrypt(encrypted, key).getBytes();
    System.out.println("Decrypted: " + new String(decrypted));
}
```



```
<terminated> AesEncryptionWithShiro [Java Application] C:\Program Files\Java\jre6\bin\javaw.exe (14.07.2011 11:15:05)
Encrypted: 235e1d52793e0950bd0a737f30234b2ad2c217efc57ef13a3879c3adc619cfaed0fbfa5ebce34f7a127dd9979c90f318
Decrypted: Secure Programming rocks!
```

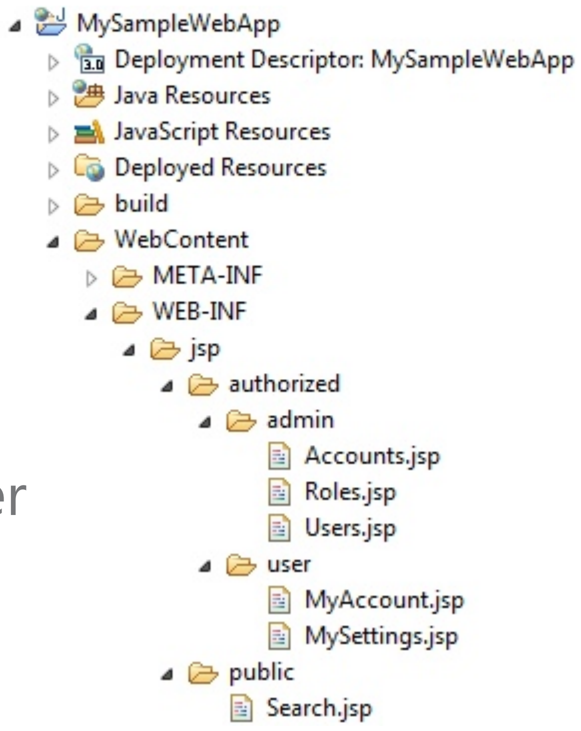
A8 – Failure to Restrict URL Access

- Presentation layer access control
  - GUI only shows authorized buttons/ links/ ...
  - User notices his role in the URL and changes it
    - e.g. user, editor, admin, ...
  - No enforcement of these restrictions on server side

1. User 57894 logs in with username/ password
   URL is https://www.myfakewebsite.com/**user**/account
2. User experiments with role part in URL, e.g. admin
   URL is https://www.myfakewebsite.com/**admin**/account
3. User has access to other accounts

A8 – Failure to Restrict URL Access (cont'd.)

- Enforce all restrictions on server side
  - Access for authorized users only
- **Think about roles from the beginning**
  - Store view files (JSP, JSF, …) in different folders based on their roles
  - Makes role/ filter configuration much easier
- Avoid combining user and admin roles in one application
  - Public application with user role only accessible via internet
  - Separate admin application only accessible in the intranet



```
MySampleWebApp
  Deployment Descriptor: MySampleWebApp
  Java Resources
  JavaScript Resources
  Deployed Resources
  build
  WebContent
    META-INF
    WEB-INF
      jsp
        authorized
          admin
            Accounts.jsp
            Roles.jsp
            Users.jsp
          user
            MyAccount.jsp
            MySettings.jsp
        public
          Search.jsp
```

A9 – Insufficient Transport Layer Protection

- Identify all routes where sensitive data is broadcasted
- Correct SSL/TLS **configuration** is difficult
  - Ask an administrator
- Protect all ~~*(or nothing)*~~
  - Don't mix protected with unprotected content
  - Secure the input form for log-in credentials
  - Secure the (session) cookie

$\left.\begin{array}{l}\text{Don't mix protected with unprotected content}\\ \text{Secure the input form for log-in credentials}\end{array}\right\}$ less vulnerable for Man-in-the-Middle attacks

Some Secure Sockets Layer and Transport Layer Security basics

- **SSL v2** is insecure and must not be used
  - Disable it
- **SSL v3** and **TLS v1.0** are most common
  - Do not have any major security flaws up to now
  - TLS v1.0 is sometimes referred to as SSL v3.1
- **TLS v1.1** and **TLS v1.2** are the best selection
  - Do not have any security flaws up to now
  - Widely unsupported, choose in case server supports it
    - Older clients will automatically fall back to TLS v1.0

https://www.ssllabs.com

Set the HTTP Strict Transport Security (HSTS) header

```
HttpServletResponse response ...;
response.setHeader("Strict-Transport-Security",
 "max-age=8640000; includeSubdomains");
```

- HTTP Strict Transport Security is currently an IETF draft
- Application forces browser to only use HTTPS when visiting
  - For specified time, renewed with every response
  - Access is blocked if communication is insecure
    - Invalid certificate results into error page, not a strange certificate warning dialog
- Browser support required, no backwards compatibility issues
  - Supported in Firefox and Chrome

http://tools.ietf.org/html/draft-ietf-websec-strict-transport-sec

A10 – Unvalidated Redirects and Forwards

- **Redirects** send request to different page
  - Often include user supplied parameters in destination URL
  - **Target:** Phishing and pharming (malware installation)
- **Forwards** send request to new page in same application
  - Sometimes include user supplied parameters in destination URL
  - **Target:** Bypass authentication/ authorization checks

A10 – Unvalidated Redirects and Forwards (cont'd.)

- **Avoid** redirects and forwards wherever possible
- **Don't allow** user parameters for the target URL

- In case you need parameters in the target URL
  - Use a server side mapping to translate the values shown to the user into valid URL parts
    - That's the access reference map from before...
  - **Validate the final target URL**
  - Call the access controller

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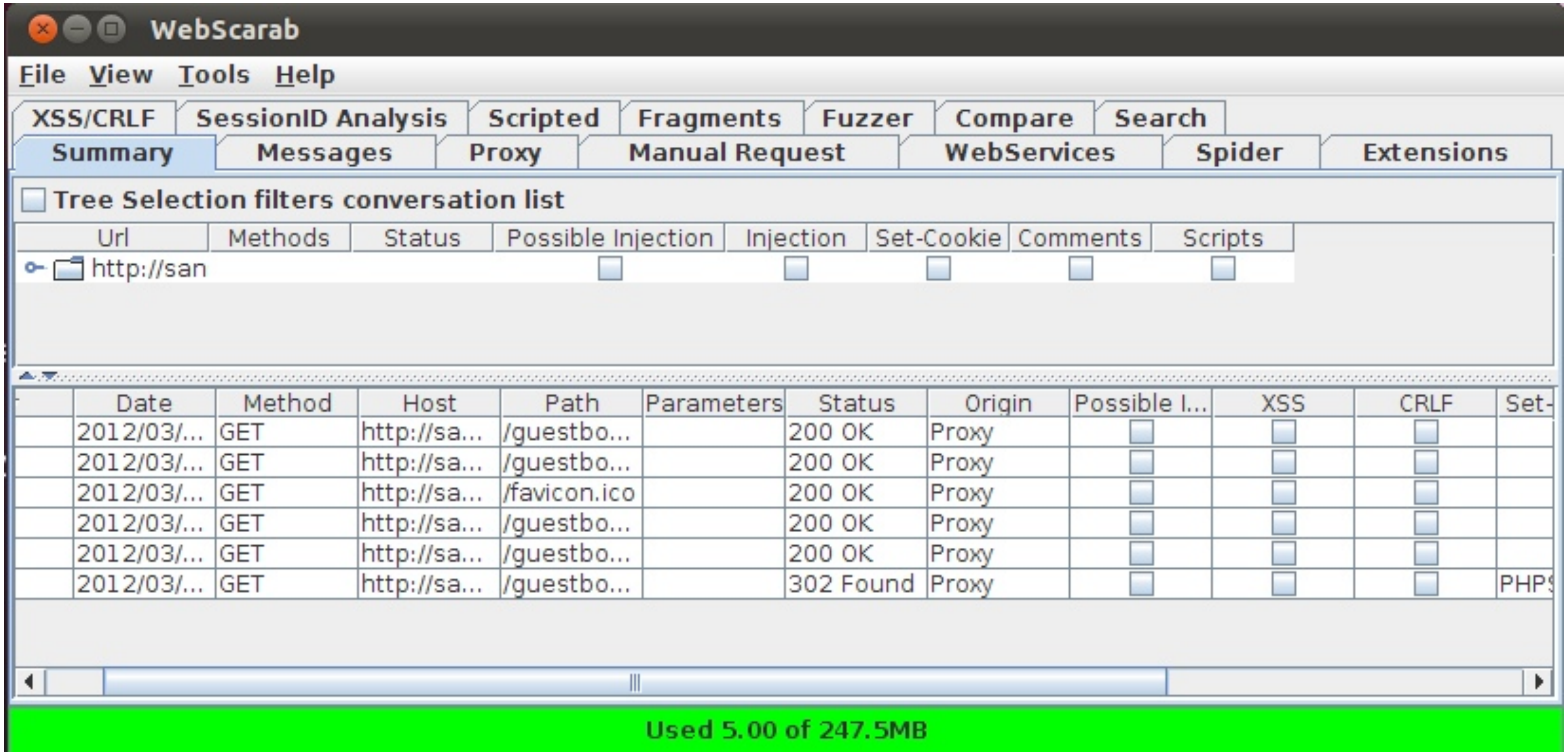
Use tools to examine/ manipulate your web application (data)


WebScarab
File View Tools Help
XSS/CRLF SessionID Analysis Scripted Fragments Fuzzer Compare Search
Summary Messages Proxy Manual Request WebServices Spider Extensions

Tree Selection filters conversation list

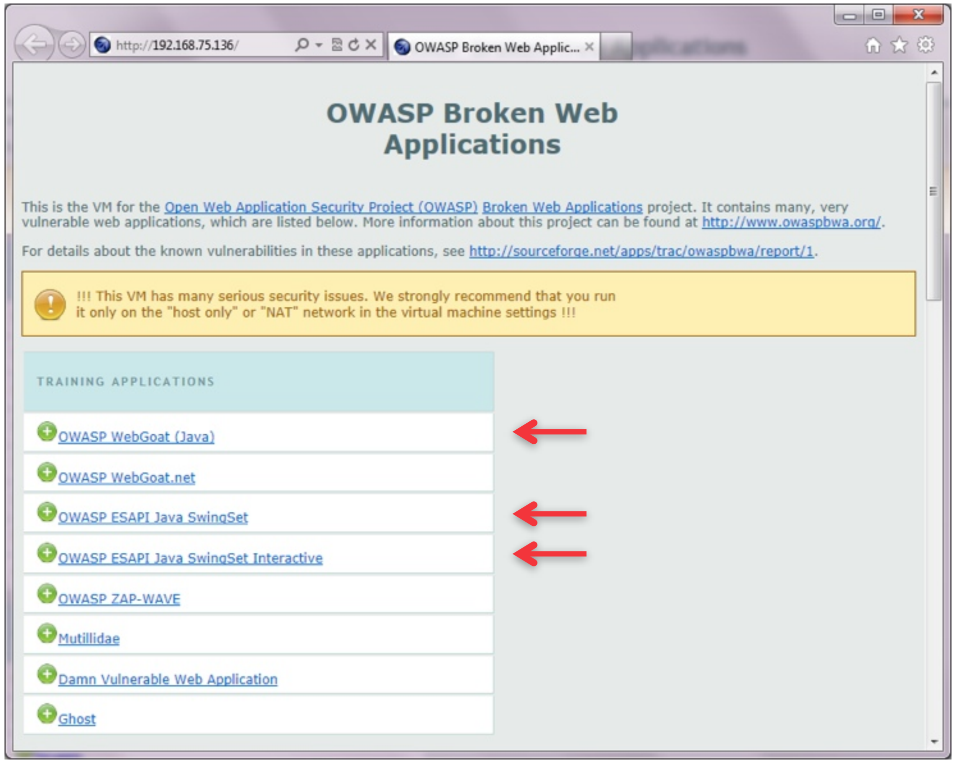
Url	Methods	Status	Possible Injection	Injection	Set-Cookie	Comments	Scripts
http://san			☐	☐	☐	☐	☐

	Date	Method	Host	Path	Parameters	Status	Origin	Possible I...	XSS	CRLF	Set-
	2012/03/...	GET	http://sa...	/guestbo...		200 OK	Proxy	☐	☐	☐	
	2012/03/...	GET	http://sa...	/guestbo...		200 OK	Proxy	☐	☐	☐	
	2012/03/...	GET	http://sa...	/favicon.ico		200 OK	Proxy	☐	☐	☐	
	2012/03/...	GET	http://sa...	/guestbo...		200 OK	Proxy	☐	☐	☐	
	2012/03/...	GET	http://sa...	/guestbo...		200 OK	Proxy	☐	☐	☐	
	2012/03/...	GET	http://sa...	/guestbo...		302 Found	Proxy	☐	☐	☐	PHPS

Used 5.00 of 247.5MB

https://www.owasp.org/index.php/Category:OWASP_WebScarab_Project
with Firefox QuickProxy https://addons.mozilla.org/de/firefox/addon/quickproxy

The OWASP Broken Web Applications project


http://192.168.75.136/

OWASP Broken Web Applic...

OWASP Broken Web Applications

This is the VM for the Open Web Application Security Project (OWASP) Broken Web Applications project. It contains many, very vulnerable web applications, which are listed below. More information about this project can be found at http://www.owaspbwa.org/.

For details about the known vulnerabilities in these applications, see http://sourceforge.net/apps/trac/owaspbwa/report/1.

!!! This VM has many serious security issues. We strongly recommend that you run it only on the "host only" or "NAT" network in the virtual machine settings !!!

TRAINING APPLICATIONS

- OWASP WebGoat (Java)
- OWASP WebGoat.net
- OWASP ESAPI Java SwingSet
- OWASP ESAPI Java SwingSet Interactive
- OWASP ZAP-WAVE
- Mutillidae
- Damn Vulnerable Web Application
- Ghost

- Download the VM
- **Run it with NAT virtual machine settings!!!**
- Launch your host's browser with the IP address shown

https://www.owasp.org/index.php/OWASP_Broken_Web_Applications_Project

One security aware developer is not enough

- Developing with security awareness is a good start
  - Make sure the environment is configured properly
  - Inform administrators about your requirements
- Design security in from the beginning
  - Think about security needs before starting to code
  - Much harder/ more expensive to secure an existing application

Security must be a natural part of the development process

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THANK YOU.

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Resources

- OWASP www.owasp.org
  - Developer's Guide, Testing Guide, Code Review Guide
  - **Cheat Sheets**
- OWASP Guide Project https://www.owasp.org/index.php/Category:OWASP_Guide_Project
- ESAPI http://esapi.org
- Java Secure Coding Guidelines http://www.oracle.com/technetwork/java/seccodeguide-139067.html
- Qualys SSL Labs https://www.ssllabs.com