Secure Programming and Common Errors

brought to you by Michele “antisnatchor” Orru’
Computer System Security course lead by Prof. Ozalp Babaoglu
5 May 2009

Who am I ?

- Bachelor Degree in Internet Sciences
- Independent Security Researcher
- Owner of http://antisnatchor.com security advisory blog
- Collaborator of Apache OFBiz (ofbiz.apache.org) and OpenTaps(www.opentaps.com)
- JEE developer

Seminar Objectives

- Discuss the most relevant SANS top 25 errors that concern Web Applications
- Practical demonstrations of some vulnerable Real World web applications (my totally independent security research)
- Understand the impact of these threats on the most valuable web-app assets

What we’ll discuss

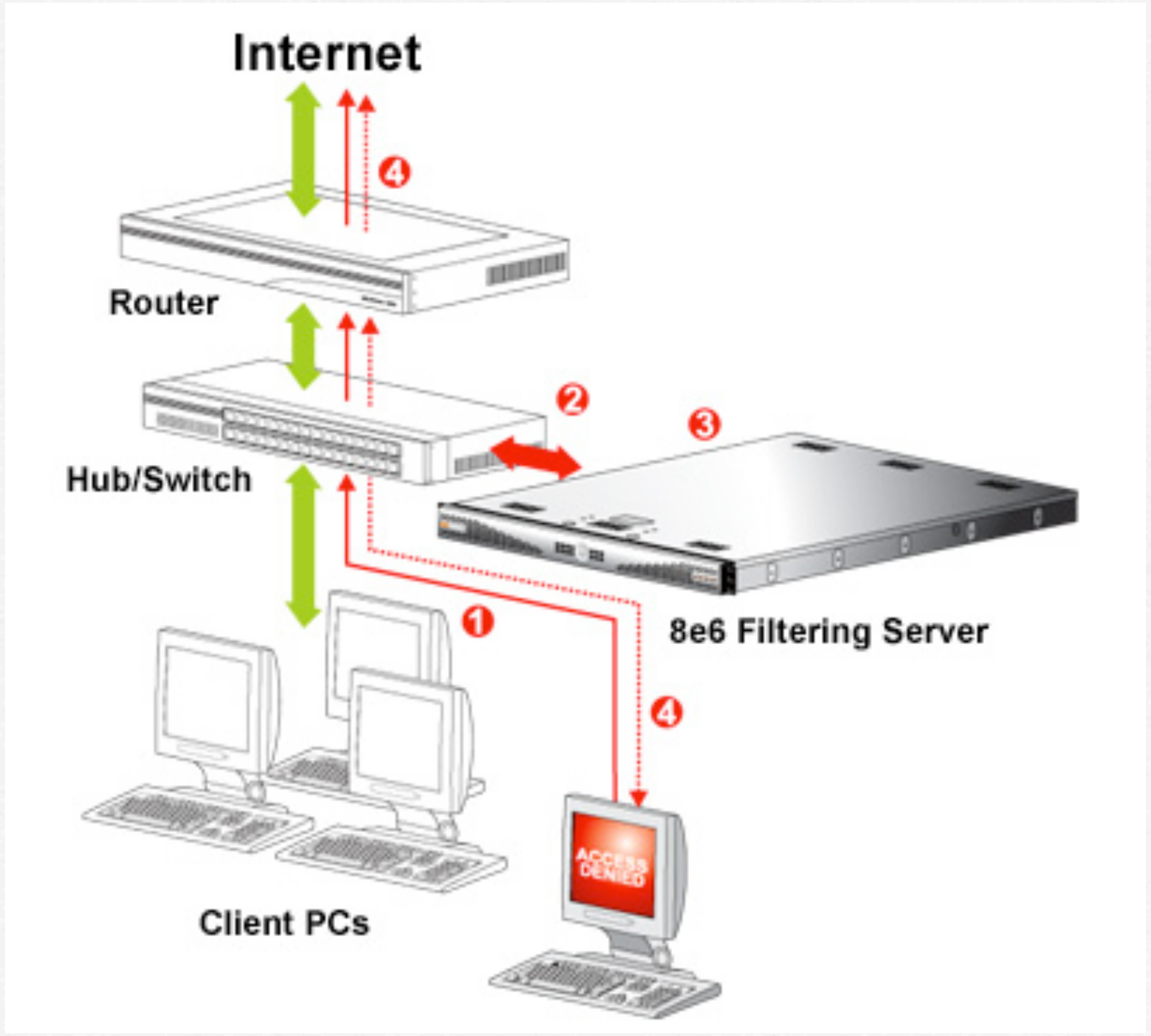
- CWE-20: Improper Input Validation
- CWE-116: Improper Encoding or Escaping of Output
- CWE-209: Error Message Information Leak
- CWE-89: Failure to Preserve SQL Query Structure (SQL injection)
- CWE-79: Failure to Preserve Web Page Structure (XSS)
- CWE-352: Cross-Site Request Forgery (XSRF)

CWE-20: Improper Input Validation

- The biggest issues on today’s Internet Applications (not just WebApps)
- Improper Input Validation can lead to security vulnerabilities when attackers can modify input in unexpected ways for the application
- The only way to protect our applications is by understanding that all input can be malicious

CWE-20: Example

- **8e6 R3000 Internet Filter** (commercial HTTP(s) Proxy filter solution)



CWE-20: Example

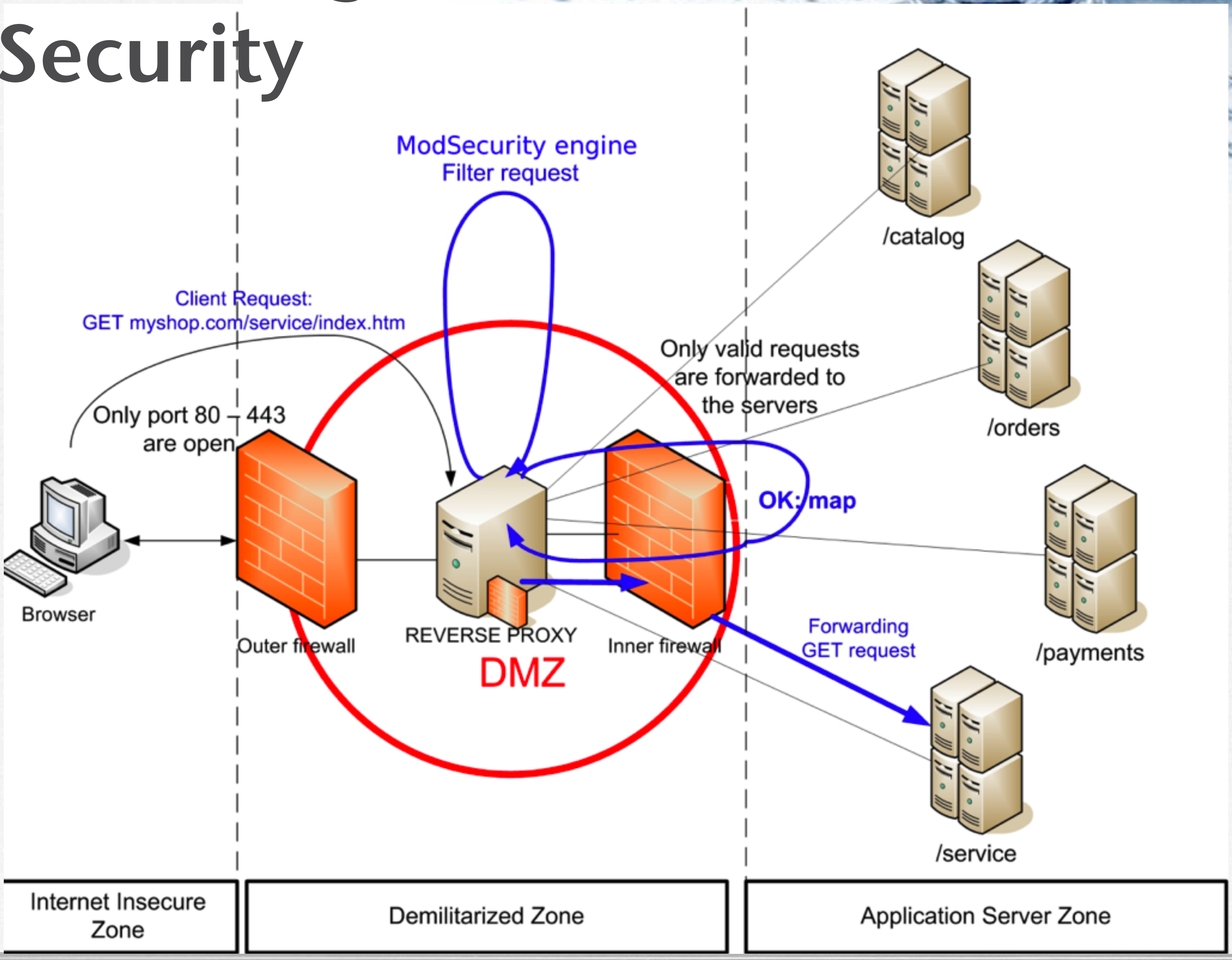
- Credits: *nnposter*
- DNS based website blacklist can be bypassed by providing a forged request with custom HTTP header

```
GET / HTTP/1.1
X-DecoyHost: www.milw0rm.org
Host: www.blocked.org
```

CWE-20: Mitigation

- Understand every potential attacks areas: parameters, arguments, cookies, headers, files, databases...
- **Whitelist approach** instead of blacklist (you’re gonna certainly miss some character encoding variants)
- WebApp case: use a WebApp Firewall (ModSecurity/F5) or an Input Validation Framework for your language.

CWE-20: Mitigation ModSecurity



CWE-20:Mitigation OWASP ESAPI

A common set of interfaces for security controls such as:

- Authentication
- Access Control
- **Input Validation**
- Output Encoding
- Cryptography (secure Java implementation of md5/sha*/BlowFish/AES)
- Error handling/logging

CWE-20:Mitigation PHPIDS

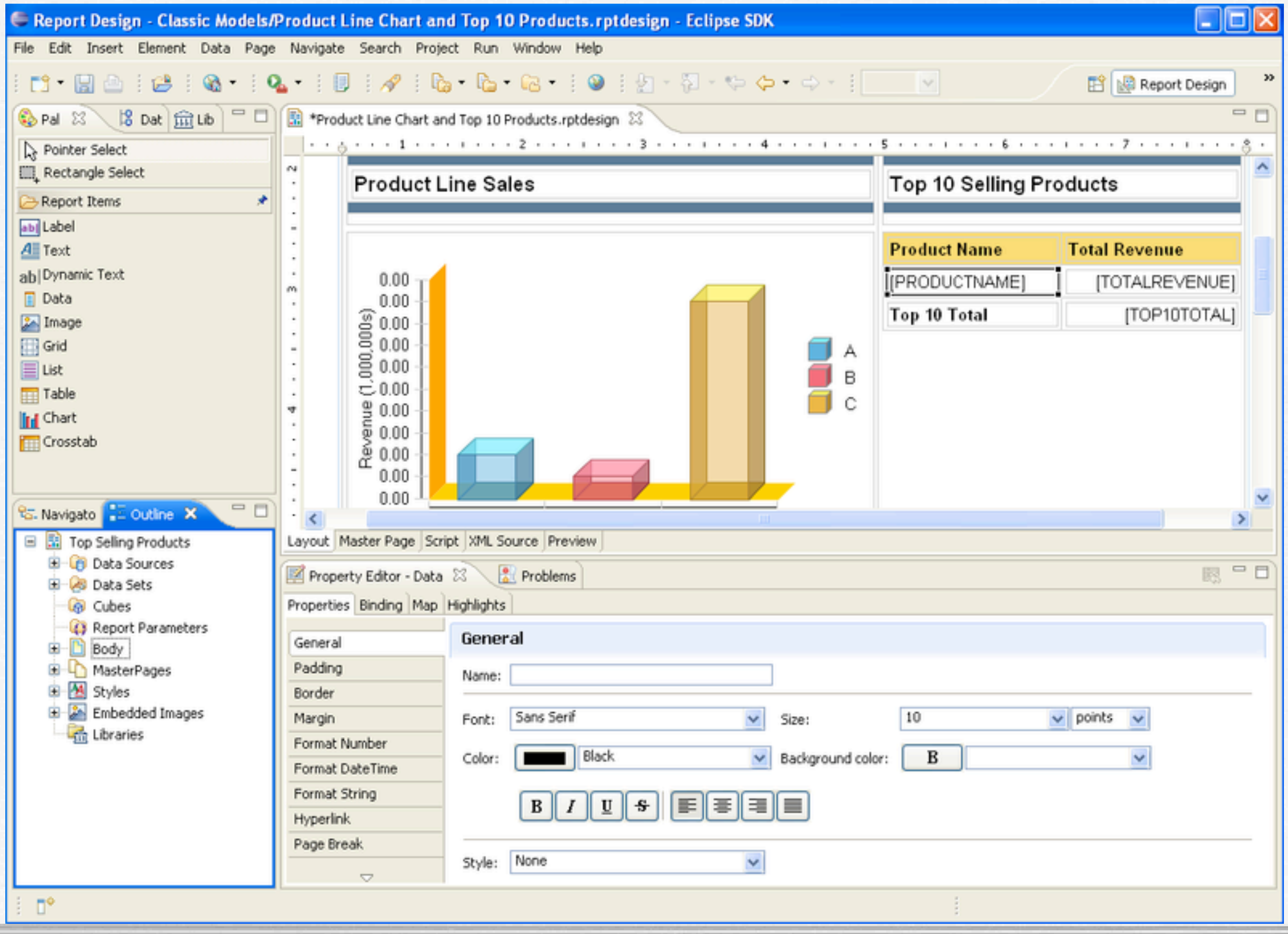
- Input validation framework for PHP based applications
- Developed by skilled hackers (Mario Heiderich - .mario on sla.ckers.org)
- Try their demo with your nasty attack vectors here: http://demo.php-ids.org/

CWE-116: Improper Encoding/Escaping of Output

- Insufficient output encoding is the often-ignored sibling to poor input validation
- Even if input has been filtered, application output could not be safe: it need to be encoded too
- Common examples: HTML/JavaScript injection on web based applications

CWE-116: Example

- **Eclipse BIRT** (reporting system that integrates with Java/JEE applications)



CWE-116: Example

- Credits: *antisnatchor*
  [http://antisnatchor.com/2008/12/18/eclipse-birt-reflected-xss]
- Java Exception stack trace was not HTML-encoded, so we can inject an iframe

```
GET

/birt-viewer/run?__report='"><iframe
%20src=javascript:alert(666)>&r=-703171660 HTTP/1.1

Host: localhost:8780
```

- Our code was executed correctly in the application output

CWE-116: Mitigation

- Always encode Java stack traces (better to don’t show them to prevent Information Leakage)
- Always encode application output, especially if it contains previously user-supplied input
- WebApp firewall and ESAPI/PHPIDS (*you lazy developers :)*)

CWE-209: Error Message Information Leak

- Chatty or debug error messages could disclose important important informations to attackers
- This information is used in the Penetration Testing phase called *“Reconnaissance”*
- Even these little secrets can greatly simplify a more concerted attack that yields much bigger rewards

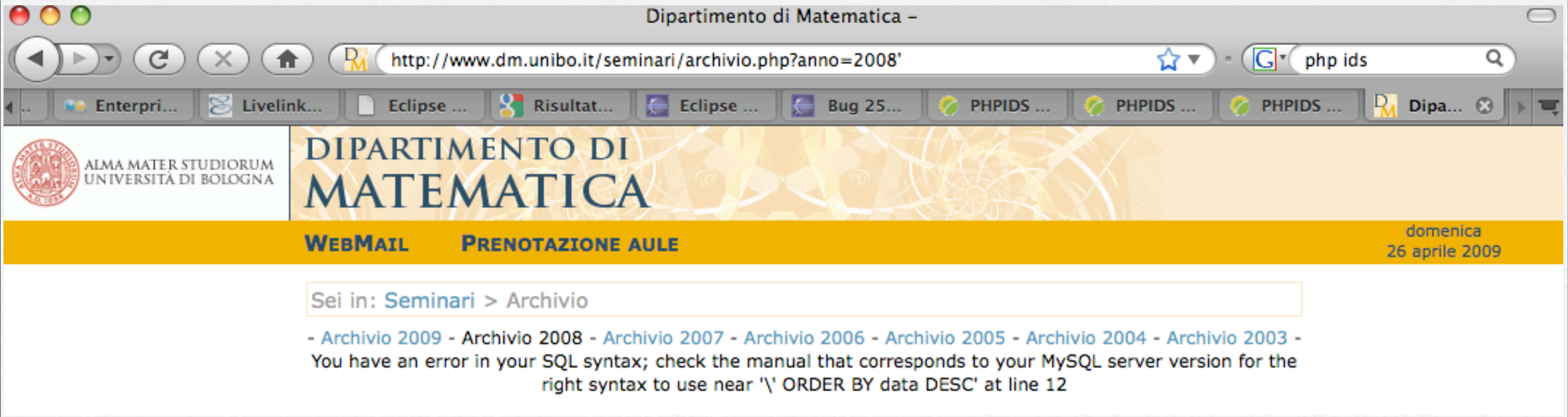
CWE-209: Examples
1. www.dm.unibo.it

- Credits: *antisnatchor*
- MySQL error when forging a malicious request altering the *anno* parameter

```
GET /seminari/archivio.php?anno=2008%27 HTTP/1.1
Host: www.dm.unibo.it
[...]
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7
Keep-Alive: 300
Proxy-Connection: keep-alive
Cookie: dm=[...]
```

CWE-209: Examples
1. www.dm.unibo.it

- Application response:


Dipartimento di Matematica –
http://www.dm.unibo.it/seminari/archivio.php?anno=2008'
php ids
Enterpri... Livelink... Eclipse ... Risultat... Eclipse ... Bug 25... PHPIDS ... PHPIDS ... PHPIDS ... Dipa...
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DIPARTIMENTO DI MATEMATICA
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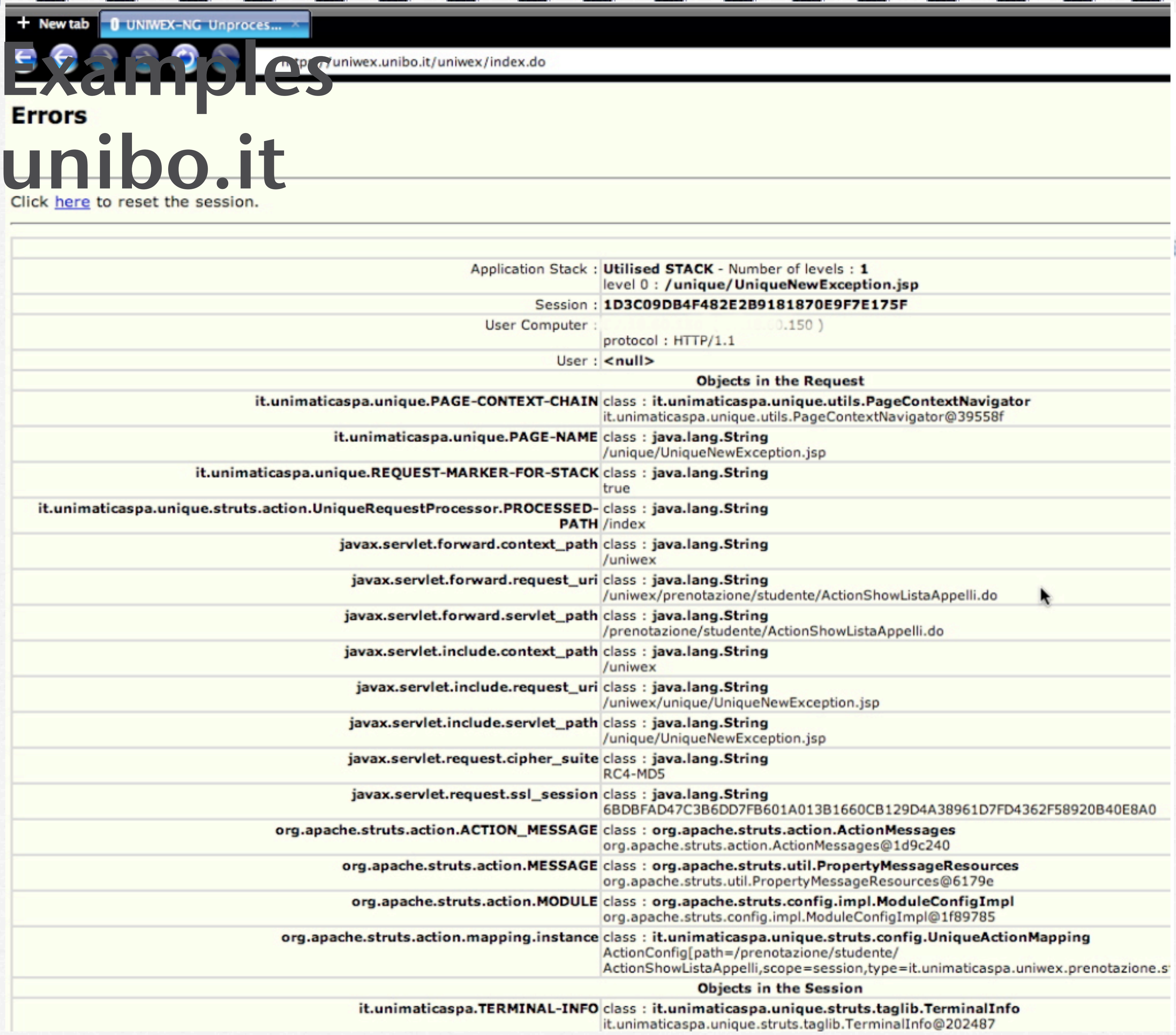
```
You have an error in your SQL syntax; check the manual that corresponds to your MySQL server version for the
right syntax to use near '\' ORDER BY data DESC' at line 12
```

- Causing an SQL syntax error we discovered that the DB backend is **MySQL**
- We can now run **more targeted attacks**

CWE-209: Examples
2. uniwex.unibo.it

- Credits: *antisnatchor*
- Session Management was (IS actually) broken and can be manipulated
- If we are the hacker **riding** the victim’s session, and the victim then logout from Uniwex, his session (and ours, because is the same) is invalidated.
- If we invalidate a session and then we try to submit the previously “*invalid*” session token... MAGICALLY ...

CWE-209: Examples
2. uniwex.unibo.it



New tab | UNIWEX-NG Unproces...

https://uniwex.unibo.it/uniwex/index.do

Errors

Click here to reset the session.

Application Stack :	**Utilised STACK** - Number of levels : **1** level 0 : **/unique/UniqueNewException.jsp**
Session :	**1D3C09DB4F482E2B9181870E9F7E175F**
User Computer :	[redacted].150) protocol : HTTP/1.1
User :	**<null>**
	Objects in the Request
it.unimaticaspa.unique.PAGE-CONTEXT-CHAIN	class : **it.unimaticaspa.unique.utils.PageContextNavigator** it.unimaticaspa.unique.utils.PageContextNavigator@39558f
it.unimaticaspa.unique.PAGE-NAME	class : **java.lang.String** /unique/UniqueNewException.jsp
it.unimaticaspa.unique.REQUEST-MARKER-FOR-STACK	class : **java.lang.String** true
it.unimaticaspa.unique.struts.action.UniqueRequestProcessor.PROCESSED-PATH	class : **java.lang.String** /index
javax.servlet.forward.context_path	class : **java.lang.String** /uniwex
javax.servlet.forward.request_uri	class : **java.lang.String** /uniwex/prenotazione/studente/ActionShowListaAppelli.do
javax.servlet.forward.servlet_path	class : **java.lang.String** /prenotazione/studente/ActionShowListaAppelli.do
javax.servlet.include.context_path	class : **java.lang.String** /uniwex
javax.servlet.include.request_uri	class : **java.lang.String** /uniwex/unique/UniqueNewException.jsp
javax.servlet.include.servlet_path	class : **java.lang.String** /unique/UniqueNewException.jsp
javax.servlet.request.cipher_suite	class : **java.lang.String** RC4-MD5
javax.servlet.request.ssl_session	class : **java.lang.String** 6BDBFAD47C3B6DD7FB601A013B1660CB129D4A38961D7FD4362F58920B40E8A0
org.apache.struts.action.ACTION_MESSAGE	class : **org.apache.struts.action.ActionMessages** org.apache.struts.action.ActionMessages@1d9c240
org.apache.struts.action.MESSAGE	class : **org.apache.struts.util.PropertyMessageResources** org.apache.struts.util.PropertyMessageResources@6179e
org.apache.struts.action.MODULE	class : **org.apache.struts.config.impl.ModuleConfigImpl** org.apache.struts.config.impl.ModuleConfigImpl@1f89785

org.apache.struts.action.mapping.instance	class : **it.unimaticaspa.unique.struts.config.UniqueActionMapping**
	ActionConfig[path=/prenotazione/studente/
	ActionShowListaAppelli,scope=session,type=it.unimaticaspa.uniwex.prenotazione.s

	Objects in the Session
it.unimaticaspa.TERMINAL-INFO	class : **it.unimaticaspa.unique.struts.taglib.TerminalInfo** it.unimaticaspa.unique.struts.taglib.TerminalInfo@202487

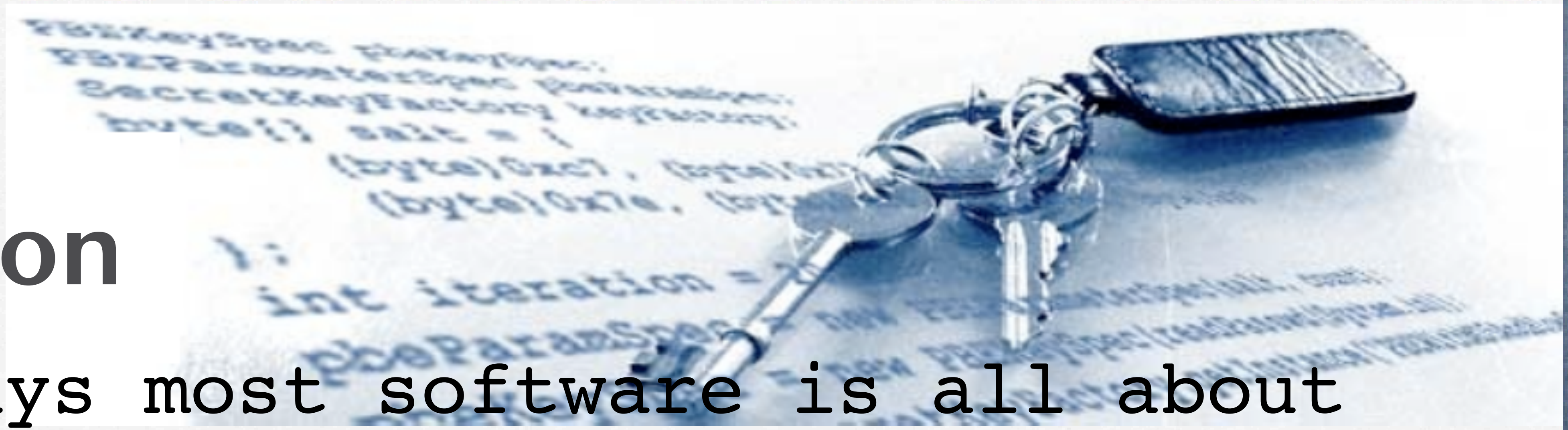
CWE-209: Examples
2. uniwex.unibo.it

- The JSP page `/unique/UniqueNewException.jsp` is clearly leaved there for debug purposes
- It shouldn't be there in production!!!
- This revealed us that Tomcat is used as Application Server, and we've also obtained the specific version of a few frameworks on which the application was built:

```
/home/unimatica/uniwex/uniwexng-4.4.0/WEB-INF/lib/struts-1.1.jar

/home/unimatica/uniwex/uniwexng-4.4.0/WEB-INF/lib/myfaces-api-1.1.4.jar
```

CWE-89: SQL Injection



- These days most software is all about the data and how it can be served to maximize user and business needs
- The most common storage solution is a Relation Database(Oracle, MySQL, Postgres, MS-SQL, Sybase)
- If attackers can influence the SQL that you use to communicate with your database, then they can do nasty things for fun and profit

CWE-89: SQL Injection

- Discovering which web application parameters/cookie/headers are querying the DB, we can test if input is properly escaped or not
- The previous example on www.dm.unibo.it demonstrates that input is not being escaped at all
- After we discovered the SQL injection we can fire-up our favorite injection tool to retrieve useful informations

CWE-89:Example 1. www.dm.unibo.it

- Credits: *antisnatchor*
- Confirmed unescaped numeric injection on GET parameter “*anno*”
- We were able to obtain details about the application stack:Apache 2.2.3, PHP 5.2.0, MySQL >= 5.0
- For demonstration we retrieved the exact name of the database name to which the web app is bounded: *dipartimento*

CWE-89:Example
1. www.virtus.it

- Credits: *antisnatchor*
- Confirmed unescaped numeric injection on GET parameter "*ID*" (SPNewsDettaglio.asp)
- We were able to obtain details about the application stack:Microsoft IIS 6, ASP and SQL Server 2000
- We retrieved the exact name of the database name to which the web app is bounded: *ServizioNews (and a few tables too)*

CWE-89: Mitigation

- Implement a validation framework (previously discussed) to protect your application
- Use stored procedures
- Hibernate on JEE, NHibernate on .NET
- DB specific: Oracle DBMS_ASSERT directive, MySQL real_escape_string() function
- Use a whitelist approach, permitting only “known good input”

CWE-89: Dangers

- As you can see SQL injection can be devastating for the integrity of your data
- Data loss is probably the most negative consequence for an Enterprise
- If the web application is storing web page content inside the DB, we can **deface** the site too

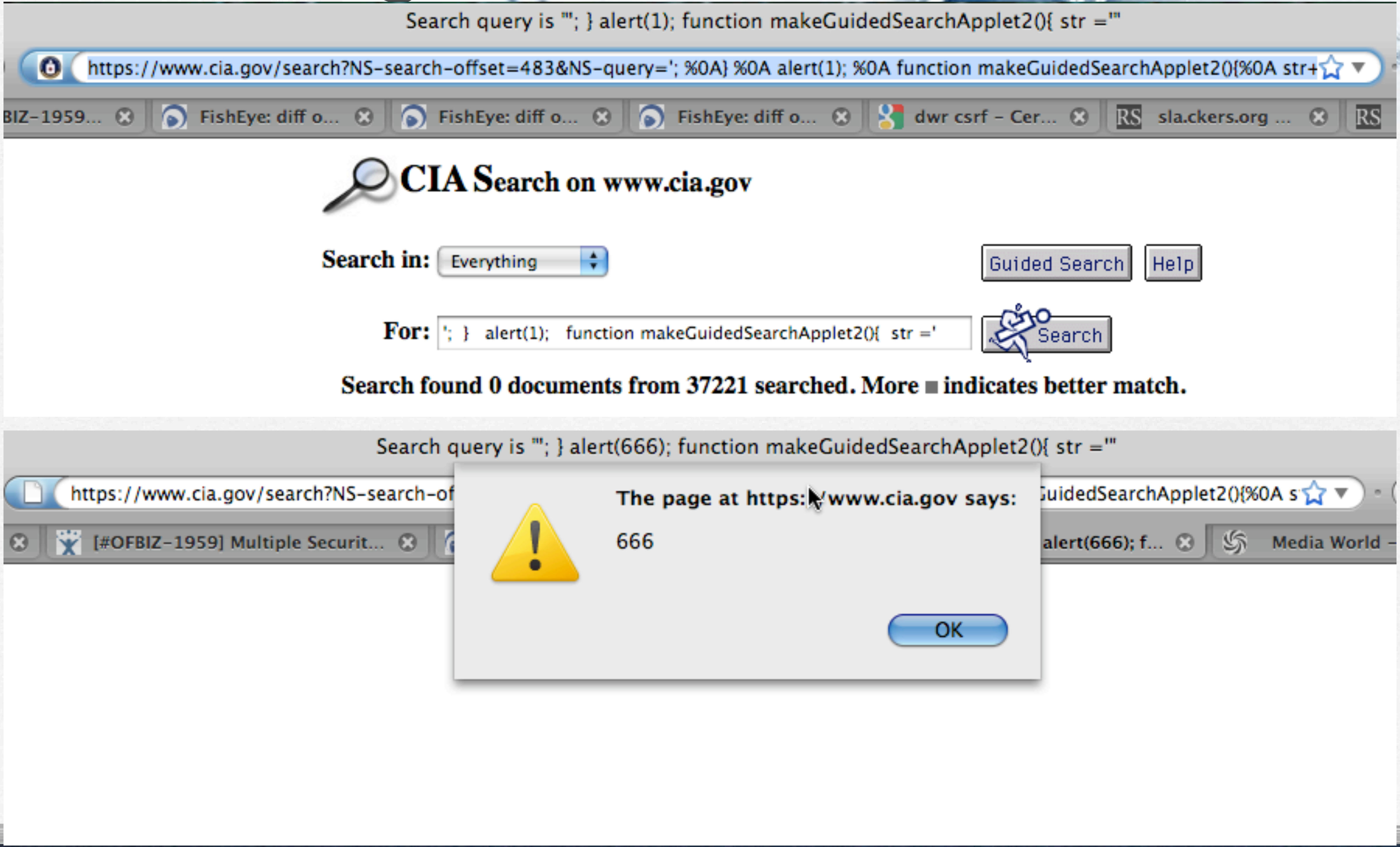
CWE-79: The Plague of Cross Site Scripting

- We can inject JavaScript,HTML,VBscript or other browser-executable content into a pages generated by the application
- The page is then accessed by other users, whose browsers execute that malicious script as if it came from the legitimate user (the victim)

CWE-79: Examples
1. www.cia.gov

- Credits: *PaPPY*
- *search* URI: *NS-query* parameter is not properly escaping malicious input, leading to reflected XSS
- https://www.cia.gov/search?NS-search-offset=483&***NS-query=%27;%20%0A}%20%0A%20alert(666);%20%0A%20function%20makeGuidedSearchApplet2(){%0A%20str+=%27***&NS-search-type=NS-boolean-query&NS-max-records=20&NS-collection=Everything&x=0&y=0&NS-search-page=results&

CWE-79: Examples
1. www.cia.gov



Search query is "'; } alert(1); function makeGuidedSearchApplet2(){ str ='"

```
https://www.cia.gov/search?NS-search-offset=483&NS-query='; %0A} %0A alert(1); %0A function makeGuidedSearchApplet2(){%0A str+
```

CIA Search on www.cia.gov

Search in: Everything

For: '; } alert(1); function makeGuidedSearchApplet2(){ str ='

Search found 0 documents from 37221 searched. More ■ indicates better match.

Search query is "'; } alert(666); function makeGuidedSearchApplet2(){ str ='"

```
https://www.cia.gov/search?NS-search-of ... uidedSearchApplet2(){%0A s
```

The page at https://www.cia.gov says:

666

CWE-79: Examples
2. compraonline.mediaworld.it

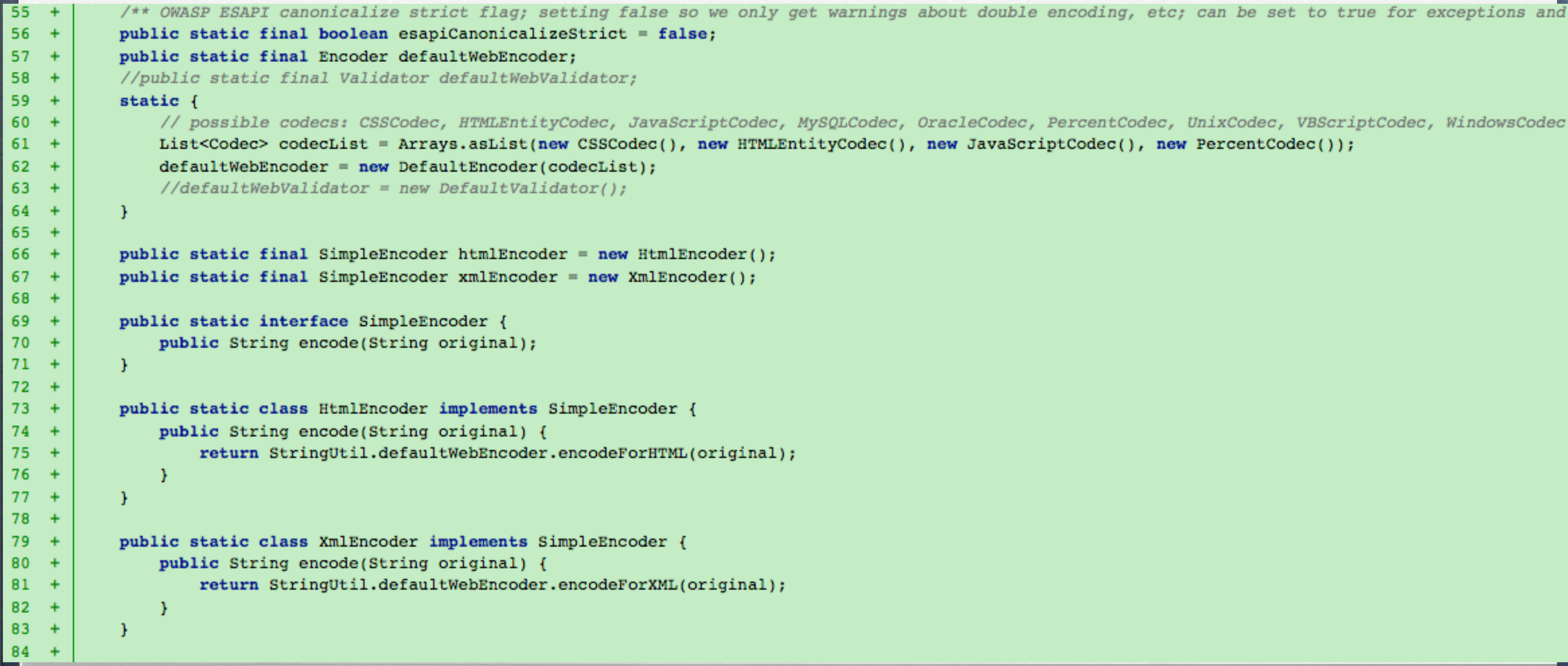
- Credits: *antisnatchor*
- *search* URI: *NS-query* parameter is not properly escaping malicious input, leading to reflected XSS
- https://www.cia.gov/search?NS-search-offset=483&***NS-query=%27;%20%0A}%20%0A%20alert(666);%20%0A%20function%20makeGuidedSearchApplet2(){%0A%20str+=%27***&NS-search-type=NS-boolean-query&NS-max-records=20&NS-collection=Everything&x=0&y=0&NS-search-page=results&

CWE-79: Mitigation

- A real world case example: **Apache OFBiz** implementation of ESAPI toolkit.
- After my JIRA issue they started to take really care of security (I’m glad to)
- See http://fisheye6.atlassian.com/changelog/ofbiz?cs=746409 and http://antisnatchor.com/2008/12/11/apache-ofbiz-multiple-security-vulnerabilities

CWE-79: Mitigation

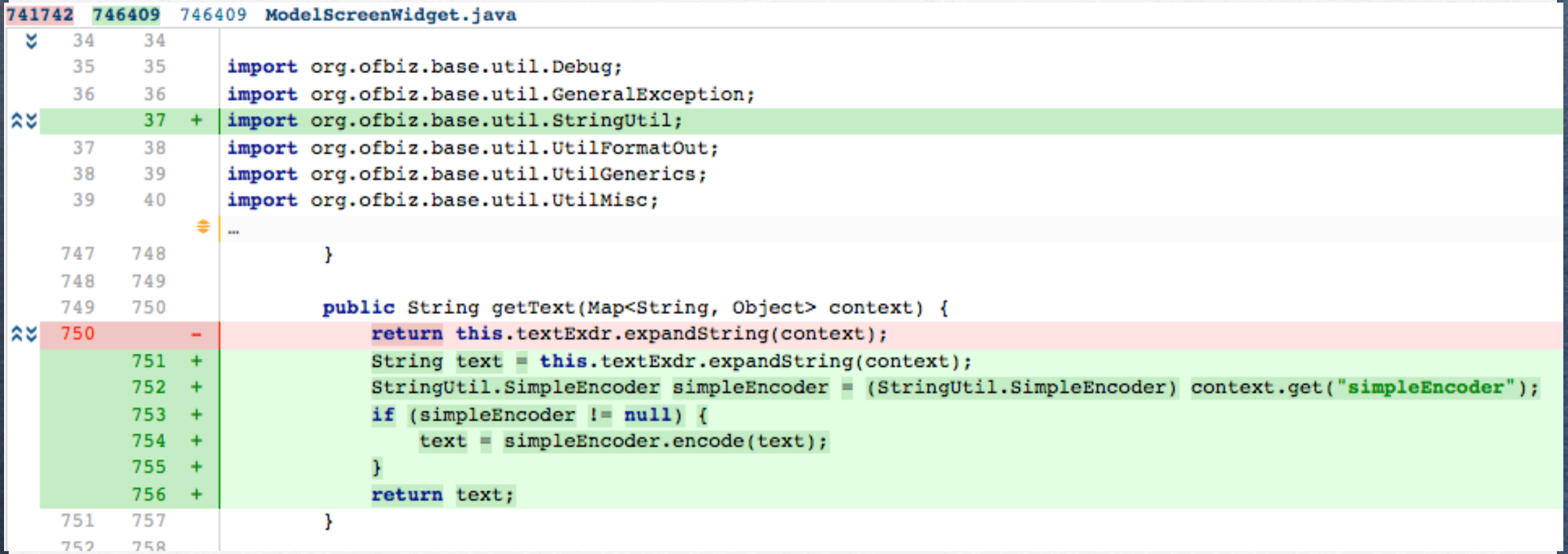
- The changes of StringUtil.java class:



```
+    /** OWASP ESAPI canonicalize strict flag; setting false so we only get warnings about double encoding, etc; can be set to true for exceptions and
+    public static final boolean esapiCanonicalizeStrict = false;
+    public static final Encoder defaultWebEncoder;
+    //public static final Validator defaultWebValidator;
+    static {
+        // possible codecs: CSSCodec, HTMLEntityCodec, JavaScriptCodec, MySQLCodec, OracleCodec, PercentCodec, UnixCodec, VBScriptCodec, WindowsCodec
+        List<Codec> codecList = Arrays.asList(new CSSCodec(), new HTMLEntityCodec(), new JavaScriptCodec(), new PercentCodec());
+        defaultWebEncoder = new DefaultEncoder(codecList);
+        //defaultWebValidator = new DefaultValidator();
+    }
+
+    public static final SimpleEncoder htmlEncoder = new HtmlEncoder();
+    public static final SimpleEncoder xmlEncoder = new XmlEncoder();
+
+    public static interface SimpleEncoder {
+        public String encode(String original);
+    }
+
+    public static class HtmlEncoder implements SimpleEncoder {
+        public String encode(String original) {
+            return StringUtil.defaultWebEncoder.encodeForHTML(original);
+        }
+    }
+
+    public static class XmlEncoder implements SimpleEncoder {
+        public String encode(String original) {
+            return StringUtil.defaultWebEncoder.encodeForXML(original);
+        }
+    }
+
```

CWE-79: Mitigation

- The changes of ModelScreenWidget.java:



741742 746409 746409 ModelScreenWidget.java

```diff
 
 import org.ofbiz.base.util.Debug;
 import org.ofbiz.base.util.GeneralException;
+import org.ofbiz.base.util.StringUtil;
 import org.ofbiz.base.util.UtilFormatOut;
 import org.ofbiz.base.util.UtilGenerics;
 import org.ofbiz.base.util.UtilMisc;
 …
         }
 
         public String getText(Map<String, Object> context) {
-            return this.textExdr.expandString(context);
+            String text = this.textExdr.expandString(context);
+            StringUtil.SimpleEncoder simpleEncoder = (StringUtil.SimpleEncoder) context.get("simpleEncoder");
+            if (simpleEncoder != null) {
+                text = simpleEncoder.encode(text);
+            }
+            return text;
         }
```

CWE-79: Mitigation

- Validate every parameter/cookie/header/input that can be manipulated by a potential attacker and then displayed on the page
- **Do not create your own filters:** you'll probably miss some attack vectors or encodings
- Use well known Encoding/Validation frameworks such as ESAPI,PHPIDS,Microsoft Anti-XSS (yes, Microsoft, don't laugh :))

CWE-352: Cross Site Request Forgery

- It exploits the trust that a website has for the currently authenticated user and executes unwanted actions on a web application on his behalf
- Once the request gets to the application, it looks as if it came from the user, not the attacker
- If the victim has admin privileges on the application: GAME OVER

CWE-352: XSRF Concrete Consequences

- Performing illegal actions such as using victim's shopping cart, executing stock trades
- Changing DNS settings of home routers (thanks pdp & GNUCITIZEN)
- Performing a Denial Of Service attack on the application
- Combining it with XSS to build WORMS

CWE-352: XSRF Concrete Consequences

1. Find a page with a lost-password form inside and find out which fields would be updated

2. **Trick the administrator** to load a hacker page with a malicious request on it that submits a new email

3. Administrator's e-mail is now changed to the email submitted by hacker

4. A hacker performs a lost-password request and **receives a new password**

CWE-352: XSRF
Who has been vulnerable?

- ING direct [We discovered CSRF vulnerabilities in ING's site that allowed an attacker to open additional accounts on behalf of a user and transfer funds from a user's account to the attacker's account.]
- Youtube
- New York Times
- Gmail [http://directwebremoting.org/blog/joe/2007/01/01/csrf_attacks_or_how_to_avoid_exposing_your_gmail_contacts.html]

CWE-352: XSRF Example

- A simple practical attack:

  `http://x.x.x.x/account/doTransfer?from=666&to=667`

  where 666 is a potential victim account and 667 the attacker one.

  Tricking the victim to load that URL will transfer money from one account to another one.

CWE-352: XSRF
1. Apache OFBiz

- Read my advisory here: https://issues.apache.org/jira/browse/OFBIZ-1959
- We can create a malicious form that will add a product (eventually with some JS inside) to the Catalog
- If the victim is already authenticated she will not even realize what she did

CWE-352: XSRF
1. Apache OFBiz

```
<form method="POST" id="xsrf" name="xsrf"

action="https://127.0.0.1:8443/catalog/control/
createProduct">

<input type=hidden name="isCreate" value="true">

<input type=hidden name="productId" value="hack02">

<input type=hidden name="productTypeId" value="DIGITAL_GOOD">

<input type=hidden name="internalName"
value="hack02<script>alert(document.cookie)</script>">

</form>

<script>document.xsrf.submit(); </script>
```

CWE-352: XSRF Mitigation

- Add a unique randomly-generated token to each request (maybe as an hidden form value): this n bit token is changed for every request and is verified by the application

```
<input id="fkey" name="fkey"
type="hidden" value="df8652852f139" />
```

CWE-352: XSRF Mitigation

- Use a secure framework such as ESAPI to add random token to your requests
- Implement AJAX functionalities with secure libraries such as DWR-2.0 (Direct Web Remoting) that automatically prevent XSRF

Thanks for your attention!

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5 May 2009