Fortify Security Report

Oct 24, 2018

Executive Summary

Issues Overview

On Oct 24, 2018, a source code review was performed over the api code base. 1,839 files, 54,288 LOC (Executable) were scanned and reviewed for defects that could lead to potential security vulnerabilities. A total of 3703 reviewed findings were uncovered during the analysis.

Issues by Fortify Priority Order	
Low	2856
High	708
Critical	129
Medium	10

Recommendations and Conclusions

The Issues Category section provides Fortify recommendations for addressing issues at a generic level. The recommendations for specific fixes can be extrapolated from those generic recommendations by the development group.

Project Summary

Code Base Summary

Code location: C:/eclipse/git/openmrs-core-master/openmrs-core-master/api
Number of Files: 1839
Lines of Code: 54288
Build Label: <No Build Label>

Scan Information

Scan time: 43:57
SCA Engine version: 17.10.0156
Machine Name: win10ent
Username running scan: ajain28

Results Certification

Results Certification Valid

Details:

Results Signature:

SCA Analysis Results has Valid signature

Rules Signature:

There were no custom rules used in this scan

Attack Surface

Attack Surface:
Command Line Arguments:
org.openmrs.test.MigrateDataSet.main

Environment Variables:
java.lang.System.getenv

File System:
java.io.FileInputStream.FileInputStream
java.util.jar.JarFile.entries
java.util.jar.JarFile.getEntry

GUI Form:
javax.swing.JPasswordField.getPassword
javax.swing.JPasswordField.getText
javax.swing.text.JTextComponent.getText

Private Information:
null.null.null
java.security.Provider.getProperty
java.util.Properties.getProperty

javax.crypto.KeyGenerator.generateKey
javax.swing.JPasswordField.getPassword
javax.swing.JPasswordField.getText
org.openmrs.util.Security.decrypt

Java Properties:
java.lang.System.getProperties
java.util.Properties.load
org.springframework.orm.hibernate4.LocalSessionFactoryBean.getHibernateProperties

Stream:
java.io.BufferedReader.read
java.io.FileInputStream.read
java.io.FilterInputStream.read
java.io.InputStream.read
java.io.Reader.read

System Information:
null.null.null
ca.uhn.hl7v2.HL7Exception.getMessage
java.awt.HeadlessException.getMessage
java.io.File.listFiles
java.lang.ClassLoader.getResource
java.lang.ClassLoader.getResources
java.lang.Runtime.freeMemory
java.lang.Runtime.maxMemory
java.lang.Runtime.totalMemory
java.lang.System.getProperty
java.lang.Throwable.getMessage
java.net.InetAddress.getLocalHost
java.net.URISyntaxException.getMessage
java.net.URLClassLoader.findResource
java.net.URLClassLoader.findResources
java.rmi.RemoteException.getMessage
java.util.regex.PatternSyntaxException.getMessage
javax.xml.transform.TransformerFactoryConfigurationError.getMessage
liquibase.exception.MigrationFailedException.getMessage
org.apache.commons.lang3.exception.ExceptionUtils.getStackTrace
org.apache.commons.lang3.exception.ExceptionUtils.getThrowables
org.apache.velocity.exception.MethodInvocationException.getMessage
org.apache.velocity.runtime.parser.ParseException.getMessage
org.hibernate.QueryException.getMessage
org.openmrs.module.ModuleClassLoader.findResource
org.openmrs.module.ModuleClassLoader.findResources
org.openmrs.util.OpenmrsClassLoader.findResource
org.openmrs.util.OpenmrsClassLoader.findResources
org.openmrs.util.OpenmrsClassLoader.getResources
org.springframework.core.NestedRuntimeException.getMessage
org.springframework.core.env.MissingRequiredPropertiesException.getMessage
org.springframework.validation.BindException.getMessage
org.xml.sax.SAXException.getMessage

Filter Set Summary

Current Enabled Filter Set:
Security Auditor View

Filter Set Details:

Folder Filters:
If [fortify priority order] contains critical Then set folder to Critical
If [fortify priority order] contains high Then set folder to High
If [fortify priority order] contains medium Then set folder to Medium
If [fortify priority order] contains low Then set folder to Low

Audit Guide Summary

Audit guide not enabled

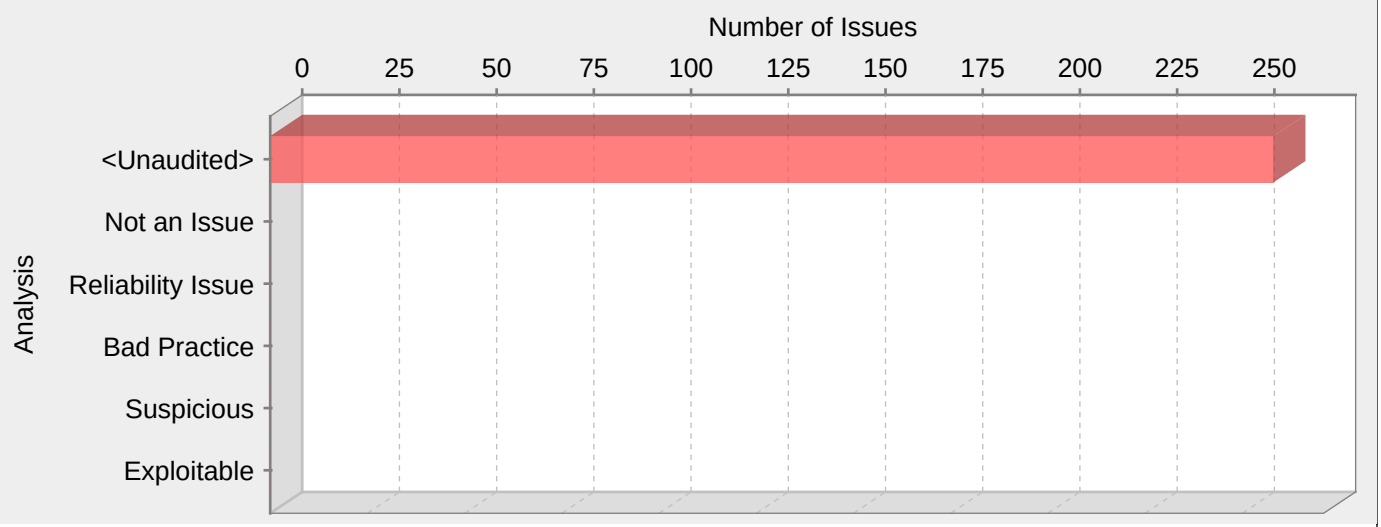
Results Outline

Overall number of results

The scan found 3703 issues.

Vulnerability Examples by Category

Category: Log Forging (258 Issues)



Abstract:

The method becomeUser() in Context.java writes unvalidated user input to the log on line 334. An attacker could take advantage of this behavior to forge log entries or inject malicious content into the log.

Explanation:

Log forging vulnerabilities occur when:

1. Data enters an application from an untrusted source.

2. The data is written to an application or system log file.

Applications typically use log files to store a history of events or transactions for later review, statistics gathering, or debugging. Depending on the nature of the application, the task of reviewing log files may be performed manually on an as-needed basis or automated with a tool that automatically culls logs for important events or trending information.

Interpretation of the log files may be hindered or misdirected if an attacker can supply data to the application that is subsequently logged verbatim. In the most benign case, an attacker may be able to insert false entries into the log file by providing the application with input that includes appropriate characters. If the log file is processed automatically, the attacker may be able to render the file unusable by corrupting the format of the file or injecting unexpected characters. A more subtle attack might involve skewing the log file statistics. Forged or otherwise, corrupted log files can be used to cover an attacker's tracks or even to implicate another party in the commission of a malicious act [1]. In the worst case, an attacker may inject code or other commands into the log file and take advantage of a vulnerability in the log processing utility [2].

Example 1: The following web application code attempts to read an integer value from a request object. If the value fails to parse as an integer, then the input is logged with an error message indicating what happened.

```
...
String val = request.getParameter("val");
try {
int value = Integer.parseInt(val);
}
catch (NumberFormatException nfe) {
log.info("Failed to parse val = " + val);
}
...
```

If a user submits the string "twenty-one" for val, the following entry is logged:

```
INFO: Failed to parse val=twenty-one
```

However, if an attacker submits the string "twenty-one%0a%0aINFO:+User+logged+out%3dbadguy", the following entry is logged:

INFO: Failed to parse val=twenty-one

INFO: User logged out=badguy

Clearly, attackers may use this same mechanism to insert arbitrary log entries.

Some think that in the mobile world, classic web application vulnerabilities, such as log forging, do not make sense -- why would the user attack themself? However, keep in mind that the essence of mobile platforms is applications that are downloaded from various sources and run alongside each other on the same device. The likelihood of running a piece of malware next to a banking application is high, which necessitates expanding the attack surface of mobile applications to include inter-process communication.

Example 2: The following code adapts Example 1 to the Android platform.

```
...
String val = this.getIntent().getExtras().getString("val");
try {
int value = Integer.parseInt();
}
catch (NumberFormatException nfe) {
Log.e(TAG, "Failed to parse val = " + val);
}
...
```

Recommendations:

Prevent log forging attacks with indirection: create a set of legitimate log entries that correspond to different events that must be logged and only log entries from this set. To capture dynamic content, such as users logging out of the system, always use server-controlled values rather than user-supplied data. This ensures that the input provided by the user is never used directly in a log entry.

Example 1 can be rewritten to use a pre-defined log entry that corresponds to a NumberFormatException as follows:

```
...
public static final String NFE = "Failed to parse val. The input is required to be an integer value."
...
String val = request.getParameter("val");
try {
int value = Integer.parseInt(val);
}
catch (NumberFormatException nfe) {
log.info(NFE);
}
..
```

And here is an Android equivalent:

```
...
public static final String NFE = "Failed to parse val. The input is required to be an integer value."
...
String val = this.getIntent().getExtras().getString("val");
try {
int value = Integer.parseInt();
}
catch (NumberFormatException nfe) {
Log.e(TAG, NFE);
}
...
```

In some situations this approach is impractical because the set of legitimate log entries is too large or complicated. In these situations, developers often fall back on blacklisting. Blacklisting selectively rejects or escapes potentially dangerous characters before using the input. However, a list of unsafe characters can quickly become incomplete or outdated. A better approach is to create a whitelist of characters that are allowed to appear in log entries and accept input composed exclusively of characters in the approved set. The most critical character in most log forging attacks is the '\n' (newline) character, which should never appear on a log entry whitelist.

Tips:

1. Many logging operations are created only for the purpose of debugging a program during development and testing. In our experience, debugging will be enabled, either accidentally or purposefully, in production at some point. Do not excuse log forging vulnerabilities simply because a programmer says "I don't have any plans to turn that on in production".

2. A number of modern web frameworks provide mechanisms for performing validation of user input. Struts and Spring MVC are two examples. To highlight the unvalidated sources of input, the Fortify Secure Coding Rulepacks dynamically re-prioritize the issues reported by Fortify Static Code Analyzer by lowering their probability of exploit and providing pointers to the supporting evidence whenever the framework validation mechanism is in use. We refer to this feature as Context-Sensitive Ranking. To further assist the Fortify user with the auditing process, the Fortify Software Security Research group makes available the Data Validation project template that groups the issues into folders based on the validation mechanism applied to their source of input.

Context.java, line 334 (Log Forging)

Fortify Priority:	High	**Folder**	High
Kingdom:	Input Validation and Representation		
Abstract:	The method becomeUser() in Context.java writes unvalidated user input to the log on line 334. An attacker could take advantage of this behavior to forge log entries or inject malicious content into the log.		

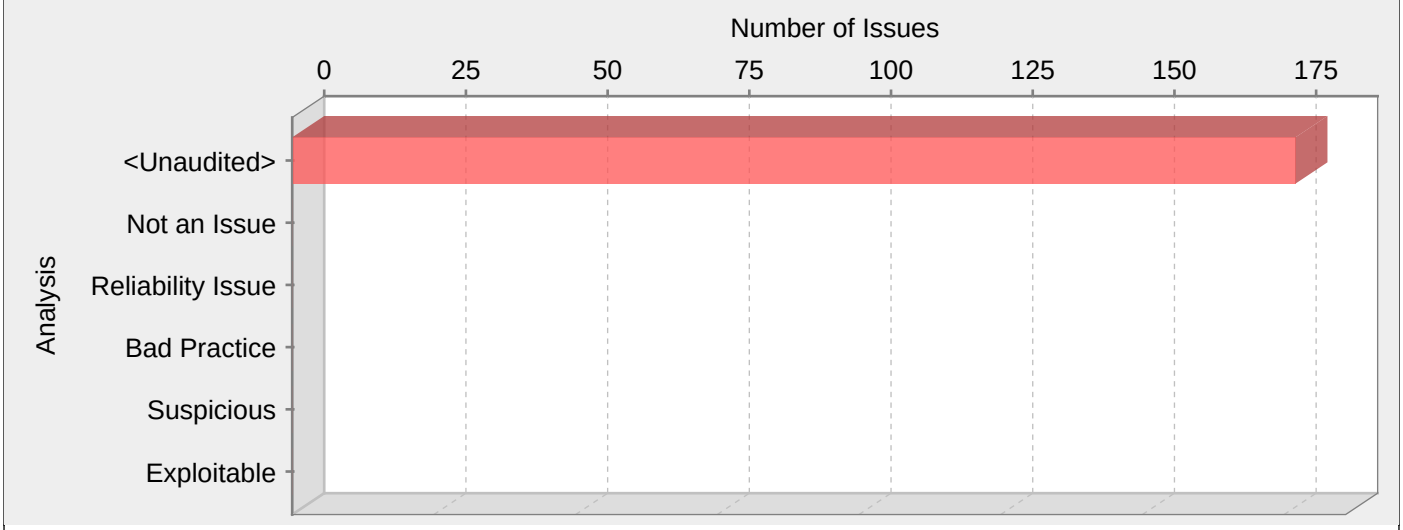
Source: HibernateUserDAO.java:100 org.hibernate.Query.list()

```
98    query.setString(0, username);
99    query.setString(1, username);
100   List<User> users = query.list();
101
102   if (users == null || users.isEmpty()) {
```

Sink: Context.java:334 org.slf4j.Logger.info()

```
332   public static void becomeUser(String systemId) throws ContextAuthenticationException {
333     if (log.isInfoEnabled()) {
334       log.info("systemId: " + systemId);
335     }
```

Category: Access Control: Database (177 Issues)



Abstract:

Without proper access control, the method getCohort() in HibernateCohortDAO.java can execute a SQL statement on line 52 that contains an attacker-controlled primary key, thereby allowing the attacker to access unauthorized records.

Explanation:

Database access control errors occur when:

1. Data enters a program from an untrusted source.

2. The data is used to specify the value of a primary key in a SQL query.

Example 1: The following code uses a parameterized statement, which escapes metacharacters and prevents SQL injection vulnerabilities, to construct and execute a SQL query that searches for an invoice matching the specified identifier [1]. The identifier is selected from a list of all invoices associated with the current authenticated user.

```
...
id = Integer.decode(request.getParameter("invoiceID"));
String query = "SELECT * FROM invoices WHERE id = ?";
PreparedStatement stmt = conn.prepareStatement(query);
stmt.setInt(1, id);
ResultSet results = stmt.execute();
...
```

The problem is that the developer has failed to consider all of the possible values of id. Although the interface generates a list of invoice identifiers that belong to the current user, an attacker may bypass this interface to request any desired invoice. Because the code in this example does not check to ensure that the user has permission to access the requested invoice, it will display any invoice, even if it does not belong to the current user.

Some think that in the mobile world, classic web application vulnerabilities, such as database access control errors, do not make sense -- why would the user attack themself? However, keep in mind that the essence of mobile platforms is applications that are downloaded from various sources and run alongside each other on the same device. The likelihood of running a piece of malware next to a banking application is high, which necessitates expanding the attack surface of mobile applications to include inter-process communication.

Example 2: The following code adapts Example 1 to the Android platform.

```
...
String id = this.getIntent().getExtras().getString("invoiceID");
String query = "SELECT * FROM invoices WHERE id = ?";
SQLiteDatabase db = this.openOrCreateDatabase("DB", MODE_PRIVATE, null);
Cursor c = db.rawQuery(query, new Object[]{id});
...
```

A number of modern web frameworks provide mechanisms for performing validation of user input. Struts and Spring MVC are among them. To highlight the unvalidated sources of input, the rulepacks dynamically re-prioritize the issues reported by Fortify Static Code Analyzer by lowering their probability of exploit and providing pointers to the supporting evidence whenever the framework validation mechanism is in use. We refer to this feature as Context-Sensitive Ranking. To further assist the Fortify user with the auditing process, the Fortify Software Security Research group makes available the Data Validation project template that groups the issues into folders based on the validation mechanism applied to their source of input.

Recommendations:

Rather than relying on the presentation layer to restrict values submitted by the user, access control should be handled by the application and database layers. Under no circumstances should a user be allowed to retrieve or modify a row in the database without the appropriate permissions. Every query that accesses the database should enforce this policy, which can often be accomplished by simply including the current authenticated username as part of the query.

Example 3: The following code implements the same functionality as Example 1 but imposes an additional constraint requiring that the current authenticated user have specific access to the invoice.

```
...
userName = ctx.getAuthenticatedUserName();
id = Integer.decode(request.getParameter("invoiceID"));
String query =
"SELECT * FROM invoices WHERE id = ? AND user = ?";
PreparedStatement stmt = conn.prepareStatement(query);
stmt.setInt(1, id);
stmt.setString(2, userName);
ResultSet results = stmt.execute();
...
```

And here is an Android equivalent:

```
...
PasswordAuthentication pa = authenticator.getPasswordAuthentication();
String userName = pa.getUserName();
String id = this.getIntent().getExtras().getString("invoiceID");
String query = "SELECT * FROM invoices WHERE id = ? AND user = ?";
SQLiteDatabase db = this.openOrCreateDatabase("DB", MODE_PRIVATE, null);
Cursor c = db.rawQuery(query, new Object[]{id, userName});
...
```

HibernateCohortDAO.java, line 52 (Access Control: Database)

Fortify Priority:	High	**Folder**	High
Kingdom:	Security Features		
Abstract:	Without proper access control, the method getCohort() in HibernateCohortDAO.java can execute a SQL statement on line 52 that contains an attacker-controlled primary key, thereby allowing the attacker to access unauthorized records.		

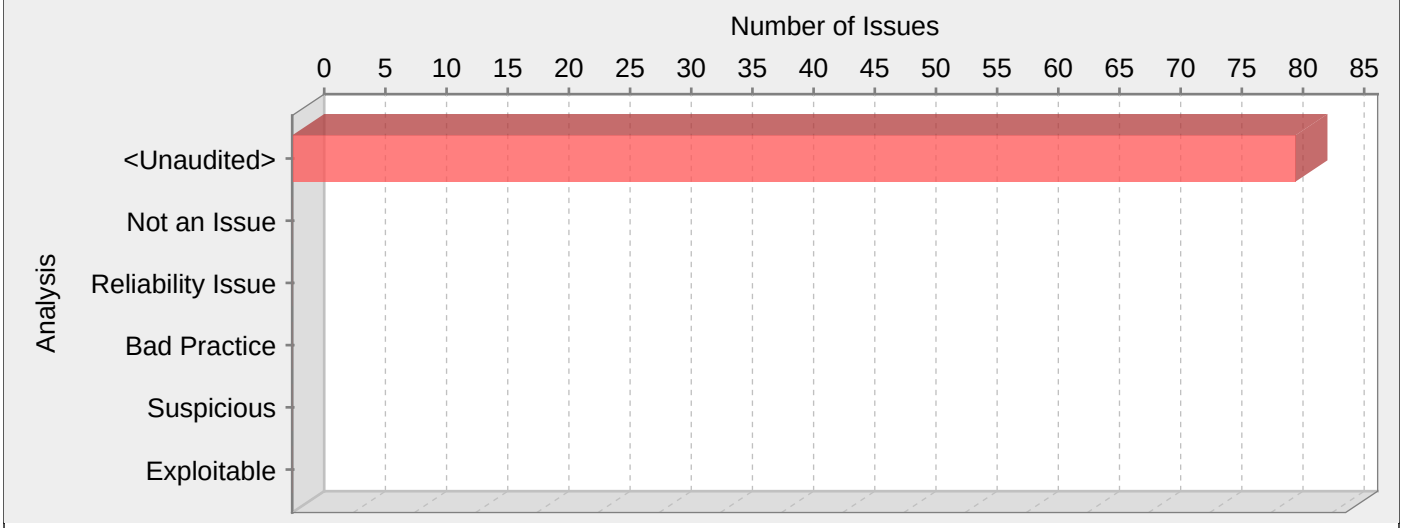
Source: HibernateCohortDAO.java:97 org.hibernate.Query.uniqueResult()

```
95    return (CohortMembership) sessionFactory.getCurrentSession()
96      .createQuery("from CohortMembership m where m.uuid = :uuid")
97      .setString("uuid", uuid).uniqueResult();
98   }
```

Sink: HibernateCohortDAO.java:52 org.hibernate.Session.get()

```
50   @Override
51   public Cohort getCohort(Integer id) throws DAOException {
52    return (Cohort) sessionFactory.getCurrentSession().get(Cohort.class, id);
53   }
```

Category: Path Manipulation (82 Issues)



Abstract:

Attackers are able to control the file system path argument to File() at HL7ServiceImpl.java line 1146, which allows them to access or modify otherwise protected files.

Explanation:

Path manipulation errors occur when the following two conditions are met:

1. An attacker is able to specify a path used in an operation on the file system.

2. By specifying the resource, the attacker gains a capability that would not otherwise be permitted.

For example, the program may give the attacker the ability to overwrite the specified file or run with a configuration controlled by the attacker.

Example 1: The following code uses input from an HTTP request to create a file name. The programmer has not considered the possibility that an attacker could provide a file name such as "../../tomcat/conf/server.xml", which causes the application to delete one of its own configuration files.

```
String rName = request.getParameter("reportName");
File rFile = new File("/usr/local/apfr/reports/" + rName);
...
rFile.delete();
```

Example 2: The following code uses input from a configuration file to determine which file to open and echo back to the user. If the program runs with adequate privileges and malicious users can change the configuration file, they can use the program to read any file on the system that ends with the extension .txt.

```
fis = new FileInputStream(cfg.getProperty("sub")+".txt");
amt = fis.read(arr);
out.println(arr);
```

Some think that in the mobile world, classic vulnerabilities, such as path manipulation, do not make sense -- why would the user attack themself? However, keep in mind that the essence of mobile platforms is applications that are downloaded from various sources and run alongside each other on the same device. The likelihood of running a piece of malware next to a banking application is high, which necessitates expanding the attack surface of mobile applications to include inter-process communication.

Example 3: The following code adapts Example 1 to the Android platform.

```
...
String rName = this.getIntent().getExtras().getString("reportName");
File rFile = getBaseContext().getFileStreamPath(rName);
...
rFile.delete();
...
```

Recommendations:

The best way to prevent path manipulation is with a level of indirection: create a list of legitimate resource names that a user is allowed to specify, and only allow the user to select from the list. With this approach the input provided by the user is never used directly to specify the resource name.

In some situations this approach is impractical because the set of legitimate resource names is too large or too hard to keep track of. Programmers often resort to blacklisting in these situations. Blacklisting selectively rejects or escapes potentially dangerous characters before using the input. However, any such list of unsafe characters is likely to be incomplete and will almost certainly become out of date. A better approach is to create a whitelist of characters that are allowed to appear in the resource name and accept input composed exclusively of characters in the approved set.

Tips:

1. If the program is performing custom input validation you are satisfied with, use the Fortify Custom Rules Editor to create a cleanse rule for the validation routine.

2. Implementation of an effective blacklist is notoriously difficult. One should be skeptical if validation logic requires blacklisting. Consider different types of input encoding and different sets of meta-characters that might have special meaning when interpreted by different operating systems, databases, or other resources. Determine whether or not the blacklist can be updated easily, correctly, and completely if these requirements ever change.

3. A number of modern web frameworks provide mechanisms for performing validation of user input. Struts and Spring MVC are among them. To highlight the unvalidated sources of input, the Fortify Secure Coding Rulepacks dynamically re-prioritize the issues reported by Fortify Static Code Analyzer by lowering their probability of exploit and providing pointers to the supporting evidence whenever the framework validation mechanism is in use. We refer to this feature as Context-Sensitive Ranking. To further assist the Fortify user with the auditing process, the Fortify Software Security Research group makes available the Data Validation project template that groups the issues into folders based on the validation mechanism applied to their source of input.

HL7ServiceImpl.java, line 1146 (Path Manipulation)

Fortify Priority:	High	**Folder**	High
Kingdom:	Input Validation and Representation		
Abstract:	Attackers are able to control the file system path argument to File() at HL7ServiceImpl.java line 1146, which allows them to access or modify otherwise protected files.		

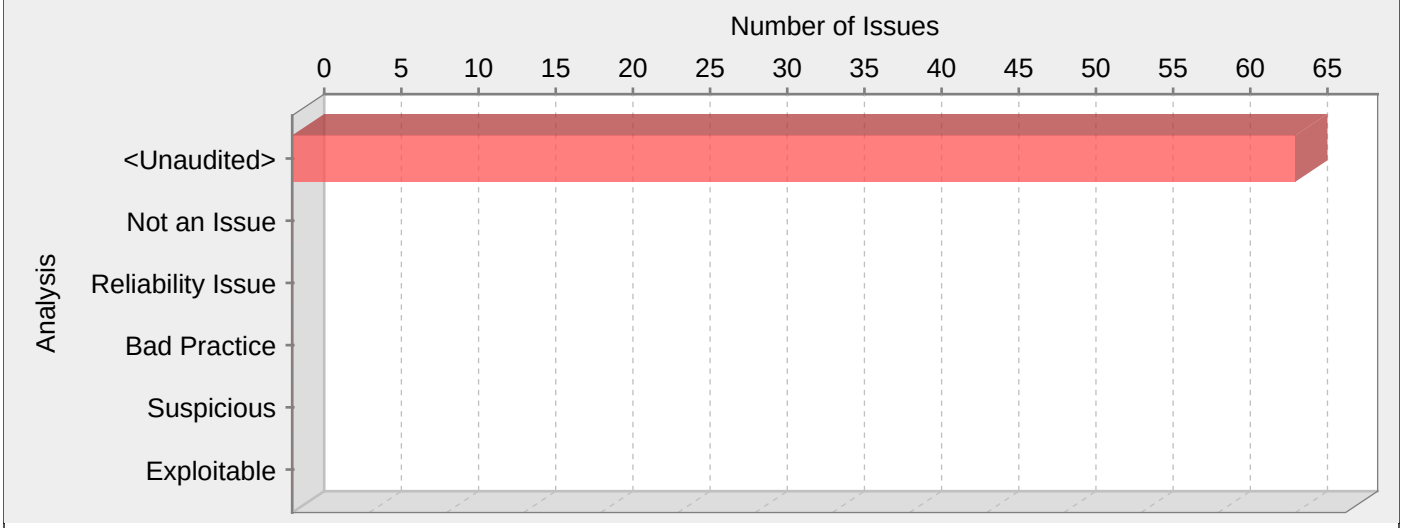
Source: HibernateHL7DAO.java:369 org.hibernate.Criteria.list()

```
367    crit.add(Restrictions.lt("dateCreated", cal.getTime()));
368   }
369   return crit.list();
370  }
371
```

Sink: HL7ServiceImpl.java:1146 java.io.File.File()

```
1144
1145    //resolve the year folder from the date of creation of the archive
1146    File yearDir = new File(destinationDir,
Integer.toString(calendar.get(Calendar.YEAR)));
1147    if (!yearDir.isDirectory()) {
1148     yearDir.mkdirs();
```

Category: Privacy Violation (65 Issues)



Abstract:

The method authenticate() in Context.java mishandles confidential information, which can compromise user privacy and is often illegal.

Explanation:

Privacy violations occur when:

1. Private user information enters the program.

2. The data is written to an external location, such as the console, file system, or network.

Example 1: The following code contains a logging statement that tracks the contents of records added to a database by storing them in a log file. Among other values that are stored, the getPassword() function returns the user-supplied plain text password associated with the account.

```
pass = getPassword();
...
dbmsLog.println(id+":"+pass+":"+type+":"+tstamp);
```

The code in the example above logs a plain text password to the file system. Although many developers trust the file system as a safe storage location for data, it should not be trusted implicitly, particularly when privacy is a concern.

Privacy is one of the biggest concerns in the mobile world for a couple of reasons. One of them is a much higher chance of device loss. The other has to do with inter-process communication between mobile applications. The essence of mobile platforms is applications that are downloaded from various sources and run alongside each other on the same device. The likelihood of running a piece of malware next to a banking application is high, which is why application authors need to be careful about what information they include in messages addressed to other applications running on the device. Sensitive information should never be part of inter-process communication between mobile applications.

Example 2: The code below reads username and password for a given site from an Android WebView store and broadcasts them to all the registered receivers.

```
...
webview.setWebViewClient(new WebViewClient() {
public void onReceivedHttpAuthRequest(WebView view,
HttpAuthHandler handler, String host, String realm) {
String[] credentials = view.getHttpAuthUsernamePassword(host, realm);
String username = credentials[0];
String password = credentials[1];
Intent i = new Intent();
i.setAction("SEND_CREDENTIALS");
i.putExtra("username", username);
i.putExtra("password", password);
view.getContext().sendBroadcast(i);
}
});
...
```

There are several problems with this example. First of all, by default, WebView credentials are stored in plain text and are not hashed. So if a user has a rooted device (or uses an emulator), she is able to read stored passwords for given sites. Second, plain text credentials are broadcast to all the registered receivers, which means that any receiver registered to listen to intents with the SEND_CREDENTIALS action will receive the message. The broadcast is not even protected with a permission to limit the number of recipients, even though in this case, we do not recommend using permissions as a fix.

Private data can enter a program in a variety of ways:

- Directly from the user in the form of a password or personal information

- Accessed from a database or other data store by the application

- Indirectly from a partner or other third party

Typically, in the context of the mobile world, this private information would include (along with passwords, SSNs and other general personal information):

- Location

- Cell phone number

- Serial numbers and device IDs

- Network Operator information

- Voicemail information

Sometimes data that is not labeled as private can have a privacy implication in a different context. For example, student identification numbers are usually not considered private because there is no explicit and publicly-available mapping to an individual student's personal information. However, if a school generates identification numbers based on student social security numbers, then the identification numbers should be considered private.

Security and privacy concerns often seem to compete with each other. From a security perspective, you should record all important operations so that any anomalous activity can later be identified. However, when private data is involved, this practice can create risk.

Although there are many ways in which private data can be handled unsafely, a common risk stems from misplaced trust. Programmers often trust the operating environment in which a program runs, and therefore believe that it is acceptable to store private information on the file system, in the registry, or in other locally-controlled resources. However, even if access to certain resources is restricted, this does not guarantee that the individuals who do have access can be trusted. For example, in 2004, an unscrupulous employee at AOL sold approximately 92 million private customer e-mail addresses to a spammer marketing an offshore gambling web site [1].

In response to such high-profile exploits, the collection and management of private data is becoming increasingly regulated. Depending on its location, the type of business it conducts, and the nature of any private data it handles, an organization may be required to comply with one or more of the following federal and state regulations:

- Safe Harbor Privacy Framework [3]

- Gramm-Leach Bliley Act (GLBA) [4]

- Health Insurance Portability and Accountability Act (HIPAA) [5]

- California SB-1386 [6]

Despite these regulations, privacy violations continue to occur with alarming frequency.

Recommendations:

When security and privacy demands clash, privacy should usually be given the higher priority. To accomplish this and still maintain required security information, cleanse any private information before it exits the program.

To enforce good privacy management, develop and strictly adhere to internal privacy guidelines. The guidelines should specifically describe how an application should handle private data. If your organization is regulated by federal or state law, ensure that your privacy guidelines are sufficiently strenuous to meet the legal requirements. Even if your organization is not regulated, you must protect private information or risk losing customer confidence.

The best policy with respect to private data is to minimize its exposure. Applications, processes, and employees should not be granted access to any private data unless the access is required for the tasks that they are to perform. Just as the principle of least privilege dictates that no operation should be performed with more than the necessary privileges, access to private data should be restricted to the smallest possible group.

For mobile applications, make sure they never communicate any sensitive data to other applications running on the device. When private data needs to be stored, it should always be encrypted. For Android, as well as any other platform that uses SQLite database, SQLCipher is a good alternative. SQLCipher is an extension to the SQLite database that provides transparent 256-bit AES encryption of database files. Thus, credentials can be stored in an encrypted database.

Example 3: The code below demonstrates how to integrate SQLCipher into an Android application after downloading the necessary binaries, and store credentials into the database file.

```
import net.sqlcipher.database.SQLiteDatabase;
```

```
...
SQLiteDatabase.loadLibs(this);
File dbFile = getDatabasePath("credentials.db");
dbFile.mkdirs();
dbFile.delete();
SQLiteDatabase db = SQLiteDatabase.openOrCreateDatabase(dbFile, "credentials", null);
db.execSQL("create table credentials(u, p)");
db.execSQL("insert into credentials(u, p) values(?, ?)", new Object[]{username, password});
...
```

Note that references to android.database.sqlite.SQLiteDatabase are substituted with those of net.sqlcipher.database.SQLiteDatabase.

To enable encryption on the WebView store, WebKit has to be re-compiled with the sqlcipher.so library.

Example 4: The code below reads username and password for a given site from an Android WebView store and instead of broadcasting them to all the registered receivers, it only broadcasts internally so that the broadcast can only be seen by other parts of the same app.

```
...
webview.setWebViewClient(new WebViewClient() {
public void onReceivedHttpAuthRequest(WebView view,
HttpAuthHandler handler, String host, String realm) {
String[] credentials = view.getHttpAuthUsernamePassword(host, realm);
String username = credentials[0];
String password = credentials[1];
Intent i = new Intent();
i.setAction("SEND_CREDENTIALS");
i.putExtra("username", username);
i.putExtra("password", password);
LocalBroadcastManager.getInstance(view.getContext()).sendBroadcast(i);
}
});
...
```

Tips:

1. As part of any thorough audit for privacy violations, ensure that custom rules have been written to identify all sources of private or otherwise sensitive information entering the program. Most sources of private data cannot be identified automatically. Without custom rules, your check for privacy violations is likely to be substantially incomplete.

2. The Fortify Java Annotations FortifyPassword, FortifyNotPassword, FortifyPrivate and FortifyNotPrivate can be used to indicate which fields and variables represent passwords and private data.

3. A number of modern web frameworks provide mechanisms for performing validation of user input. Struts and Spring MVC are two examples. To highlight the unvalidated sources of input, the Fortify Secure Coding Rulepacks dynamically re-prioritize the issues reported by Fortify Static Code Analyzer by lowering their probability of exploit and providing pointers to the supporting evidence whenever the framework validation mechanism is in use. We refer to this feature as Context-Sensitive Ranking. To further assist the Fortify user with the auditing process, the Fortify Software Security Research group makes available the Data Validation project template that groups the issues into folders based on the validation mechanism applied to their source of input.

Context.java, line 293 (Privacy Violation)

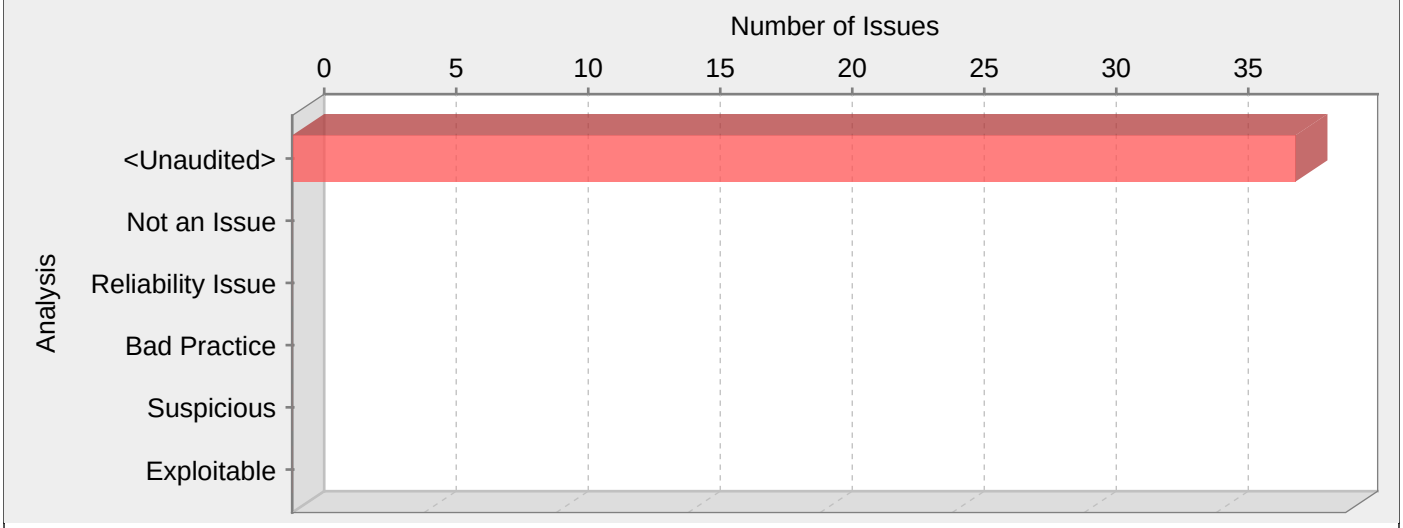
Fortify Priority:	Critical	**Folder**	Critical
Kingdom:	Security Features		
Abstract:	The method authenticate() in Context.java mishandles confidential information, which can compromise user privacy and is often illegal.		
Source:	BaseContextSensitiveTest.java:425 Read junitpassword()		

```
423         return;
424       } else
425         credentials = new String[] { junitusername, junitpassword };
426
427       // try to authenticate to the Context with either the runtime
```

Sink: Context.java:293 org.slf4j.Logger.debug()

```
291                     public static void authenticate(String username, String password) throws
                       ContextAuthenticationException {
292                       if (log.isDebugEnabled()) {
293                         log.debug("Authenticating with username: " + username);
294                       }
```

Category: Password Management: Password in Configuration File (38 Issues)



Abstract:

Storing a plain text password in a configuration file may result in a system compromise.

Explanation:

Storing a plain text password in a configuration file allows anyone who can read the file access to the password-protected resource. Developers sometimes believe that they cannot defend the application from someone who has access to the configuration, but this attitude makes an attacker's job easier. Good password management guidelines require that a password never be stored in plain text.

Recommendations:

A password should never be stored in plain text. Instead, the password should be entered by an administrator when the system starts. If that approach is impractical, a less secure but often adequate solution is to obfuscate the password and scatter the de-obfuscation material around the system so that an attacker has to obtain and correctly combine multiple system resources to decipher the password.

Some third-party products claim the ability to manage passwords in a more secure way. For example, WebSphere Application Server 4.x uses a simple XOR encryption algorithm for obfuscating values, but be skeptical about such facilities. WebSphere and other application servers offer outdated and relatively weak encryption mechanisms that are insufficient for security-sensitive environments. For a secure solution the only viable option is a proprietary one.

Tips:

1. Fortify Static Code Analyzer searches configuration files for common names used for password properties. Audit these issues by verifying that the flagged entry is used as a password and that the password entry contains plain text.

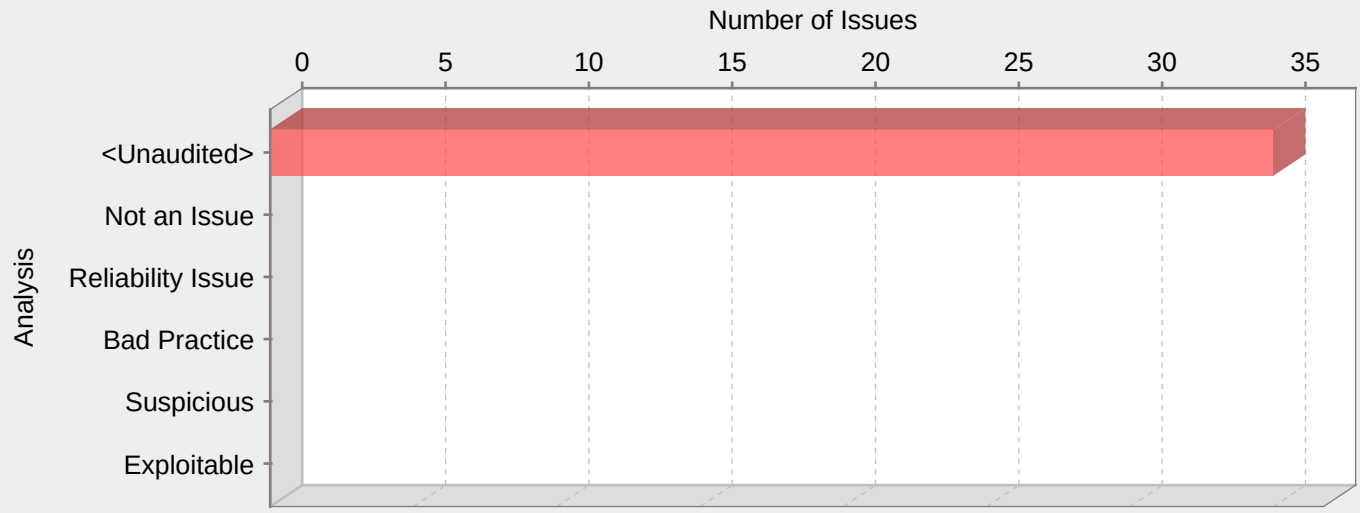
2. If the entry in the configuration file is a default password, require that it be changed in addition to requiring that it be obfuscated in the configuration file.

hibernate.default.properties, line 5 (Password Management: Password in Configuration File)

Fortify Priority:	High	**Folder**	High
Kingdom:	Environment		
Abstract:	Storing a plain text password in a configuration file may result in a system compromise.		
Sink:	hibernate.default.properties:5 hibernate.connection.password()		

```
3  # Connection Properties -->
4  hibernate.connection.username=test
5  hibernate.connection.password=******
6  hibernate.connection.driver_class=com.mysql.jdbc.Driver
7  hibernate.connection.url=jdbc:mysql://localhost:3306/openmrs?autoReconnect=true
```

Category: Null Dereference (35 Issues)



Abstract:

The method onFlushDirty() in ImmutableEntityInterceptor.java can crash the program by dereferencing a null pointer on line 109.

Explanation:

Null pointer exceptions usually occur when one or more of the programmer's assumptions is violated. A dereference-after-store error occurs when a program explicitly sets an object to null and dereferences it later. This error is often the result of a programmer initializing a variable to null when it is declared.

Most null pointer issues result in general software reliability problems, but if attackers can intentionally trigger a null pointer dereference, they can use the resulting exception to bypass security logic or to cause the application to reveal debugging information that will be valuable in planning subsequent attacks.

Example: In the following code, the programmer explicitly sets the variable foo to null. Later, the programmer dereferences foo before checking the object for a null value.

Foo foo = null;

...

foo.setBar(val);

...

}

Recommendations:

Implement careful checks before dereferencing objects that might be null. When possible, abstract null checks into wrappers around code that manipulates resources to ensure that they are applied in all cases and to minimize the places where mistakes can occur.

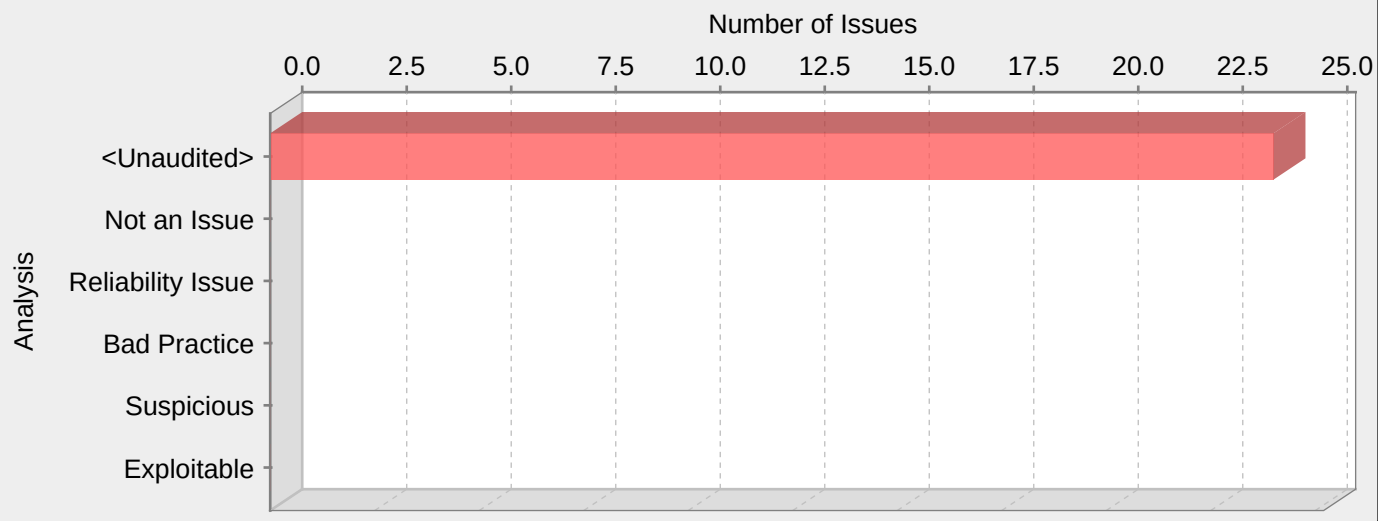
ImmutableEntityInterceptor.java, line 109 (Null Dereference)

Fortify Priority:	High	**Folder**	High
Kingdom:	Code Quality		
Abstract:	The method onFlushDirty() in ImmutableEntityInterceptor.java can crash the program by dereferencing a null pointer on line 109.		

Sink: ImmutableEntityInterceptor.java:109 Dereferenced : changedProperties()

```
107                 if (CollectionUtils.isNotEmpty(changedProperties)) {
108                  if (log.isDebugEnabled()) {
109                   log.debug("The following fields cannot be changed for " + getSupportedType() + ":" +
changedProperties);
110                  }
111
```

Category: Denial of Service: Regular Expression (24 Issues)



Abstract:

Untrusted data is passed to the application and used as a regular expression. This can cause the thread to overconsume CPU resources.

Explanation:

There is a vulnerability in implementations of regular expression evaluators and related methods that can cause the thread to hang when evaluating regular expressions that contain a grouping expression that is itself repeated. Additionally, any regular expression that contains alternate subexpressions that overlap one another can also be exploited. This defect can be used to execute a Denial of Service (DoS) attack.

Example:

(e+)+

([a-zA-Z]+)*

(e|ee)+

There are no known regular expression implementations which are immune to this vulnerability. All platforms and languages are vulnerable to this attack.

Recommendations:

Do not allow untrusted data to be used as regular expression patterns.

HibernatePatientDAO.java, line 866 (Denial of Service: Regular Expression)

Fortify Priority:	High	**Folder**	High
Kingdom:	Input Validation and Representation		
Abstract:	Untrusted data is passed to the application and used as a regular expression. This can cause the thread to overconsume CPU resources.		

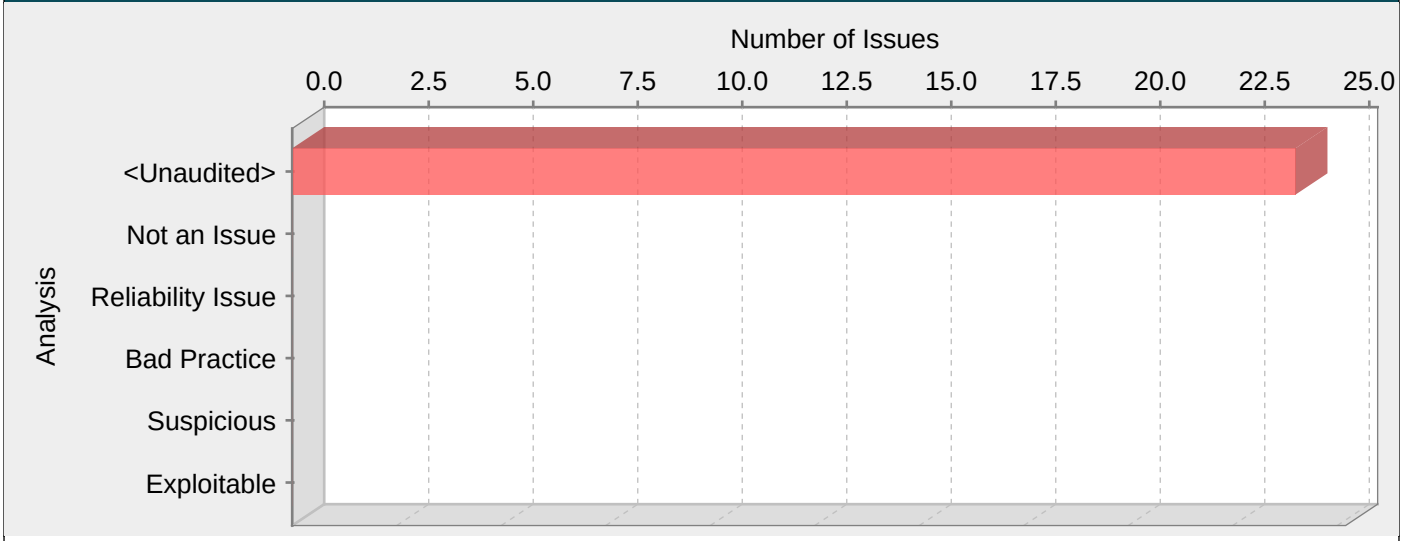
Source: HibernateAdministrationDAO.java:100 org.hibernate.Criteria.uniqueResult()

```
98    Criteria criteria = sessionFactory.getCurrentSession().createCriteria(GlobalProperty.class);
99    return (GlobalProperty) criteria.add(Restrictions.eq("property", propertyName).ignoreCase())
100           .uniqueResult();
101   } else {
102   return (GlobalProperty) sessionFactory.getCurrentSession().get(GlobalProperty.class, propertyName);
```

Sink: HibernatePatientDAO.java:866 java.util.regex.Pattern.compile()

```
864   if (Pattern.matches("^\\^.{1}\\*.*$", regex)) {
865   String padding = regex.substring(regex.indexOf("^") + 1, regex.indexOf("*"));
866   Pattern pattern = Pattern.compile("^" + padding + "+");
867   query = pattern.matcher(query).replaceFirst("");
868   }
```

Category: Password Management: Hardcoded Password (24 Issues)



Abstract:

Hardcoded passwords may compromise system security in a way that cannot be easily remedied.

Explanation:

It is never a good idea to hardcode a password. Not only does hardcoding a password allow all of the project's developers to view the password, it also makes fixing the problem extremely difficult. Once the code is in production, the password cannot be changed without patching the software. If the account protected by the password is compromised, the owners of the system will be forced to choose between security and availability.

Example 1: The following code uses a hardcoded password to connect to a database:

```
...
DriverManager.getConnection(url, "scott", "tiger");
...
```

This code will run successfully, but anyone who has access to it will have access to the password. Once the program has shipped, there is likely no way to change the database user "scott" with a password of "tiger" unless the program is patched. An employee with access to this information could use it to break into the system. Even worse, if attackers have access to the bytecode for the application they can use the javap -c command to access the disassembled code, which will contain the values of the passwords used. The result of this operation might look something like the following for the example above:

```
javap -c ConnMngr.class
22: ldc   #36; //String jdbc:mysql://ixne.com/rxsql
24: ldc   #38; //String scott
26: ldc   #17; //String tiger
```

In the mobile environment, password management is especially important given that there is such a high chance of device loss.

Example 2: The code below uses hardcoded username and password to setup authentication for viewing protected pages with Android's WebView.

```
...
webview.setWebViewClient(new WebViewClient() {
public void onReceivedHttpAuthRequest(WebView view,
HttpAuthHandler handler, String host, String realm) {
handler.proceed("guest", "allow");
}
});
...
```

Similar to Example 1, this code will run successfully, but anyone who has access to it will have access to the password.

Recommendations:

Passwords should never be hardcoded and should generally be obfuscated and managed in an external source. Storing passwords in plain text anywhere on the system allows anyone with sufficient permissions to read and potentially misuse the password. At the very least, passwords should be hashed before being stored.

Some third-party products claim the ability to manage passwords in a more secure way. For example, WebSphere Application Server 4.x uses a simple XOR encryption algorithm for obfuscating values, but be skeptical about such facilities. WebSphere and other application servers offer outdated and relatively weak encryption mechanisms that are insufficient for security-sensitive environments. For a secure generic solution, the best option today appears to be a proprietary mechanism that you create.

For Android, as well as any other platform that uses SQLite database, SQLCipher is a good alternative. SQLCipher is an extension to the SQLite database that provides transparent 256-bit AES encryption of database files. Thus, credentials can be stored in an encrypted database.

Example 3: The code below demonstrates how to integrate SQLCipher into an Android application after downloading the necessary binaries, and store credentials into the database file.

```
import net.sqlcipher.database.SQLiteDatabase;
...
SQLiteDatabase.loadLibs(this);
File dbFile = getDatabasePath("credentials.db");
dbFile.mkdirs();
dbFile.delete();
SQLiteDatabase db = SQLiteDatabase.openOrCreateDatabase(dbFile, "credentials", null);
db.execSQL("create table credentials(u, p)");
db.execSQL("insert into credentials(u, p) values(?, ?)", new Object[]{username, password});
...
```

Note that references to android.database.sqlite.SQLiteDatabase are substituted with those of net.sqlcipher.database.SQLiteDatabase.

To enable encryption on the WebView store, WebKit has to be re-compiled with the sqlcipher.so library.

Tips:

1. The Fortify Java Annotations FortifyPassword and FortifyNotPassword can be used to indicate which fields and variables represent passwords.

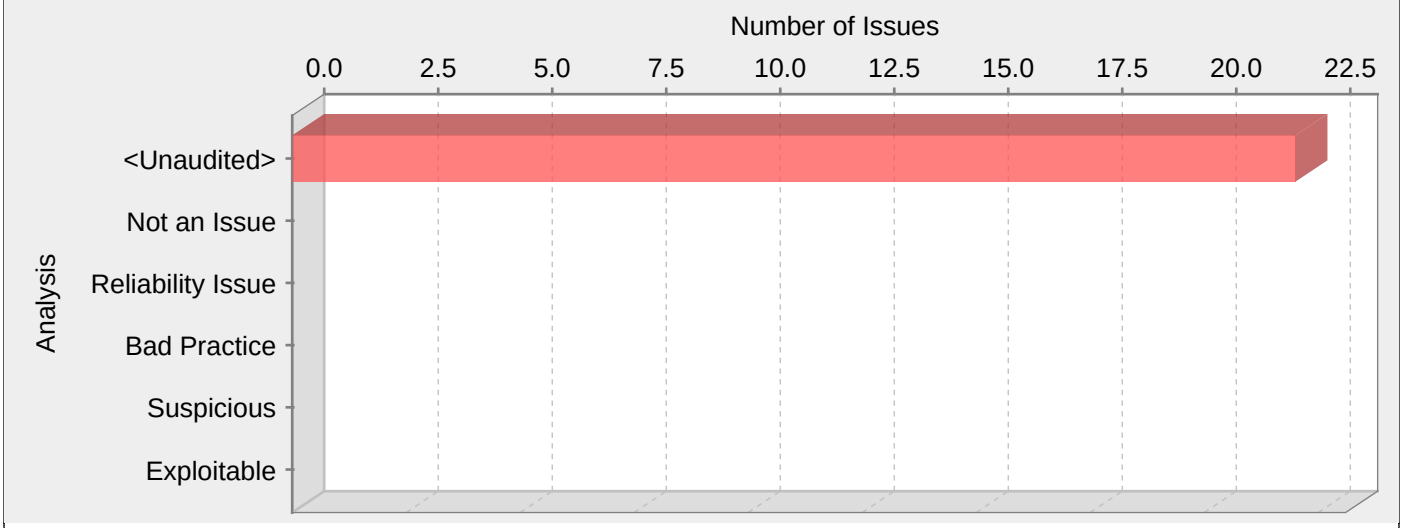
2. When identifying null, empty, or hardcoded passwords, default rules only consider fields and variables that contain the word password. However, the Fortify Custom Rules Editor provides the Password Management wizard that makes it easy to create rules for detecting password management issues on custom-named fields and variables.

SchedulerConstants.java, line 22 (Password Management: Hardcoded Password)

Fortify Priority:	High	**Folder**	High
Kingdom:	Security Features		
Abstract:	Hardcoded passwords may compromise system security in a way that cannot be easily remedied.		
Sink:	SchedulerConstants.java:22 FieldAccess: SCHEDULER_DEFAULT_PASSWORD()		

```
20  public static String SCHEDULER_DEFAULT_USERNAME = "admin";
21
22  public static String SCHEDULER_DEFAULT_PASSWORD =******
23
24  /** The default 'from' address for emails send by the schedule */
```

Category: Access Specifier Manipulation (22 Issues)



Abstract:

The call to method setAccessible() on line 317 changes an access specifier.

Explanation:

The AccessibleObject API allows the programmer to get around the access control checks provided by Java access specifiers. In particular it enables the programmer to allow a reflected object to bypass Java access controls and in turn change the value of private fields or invoke private methods, behaviors that are normally disallowed.

Recommendations:

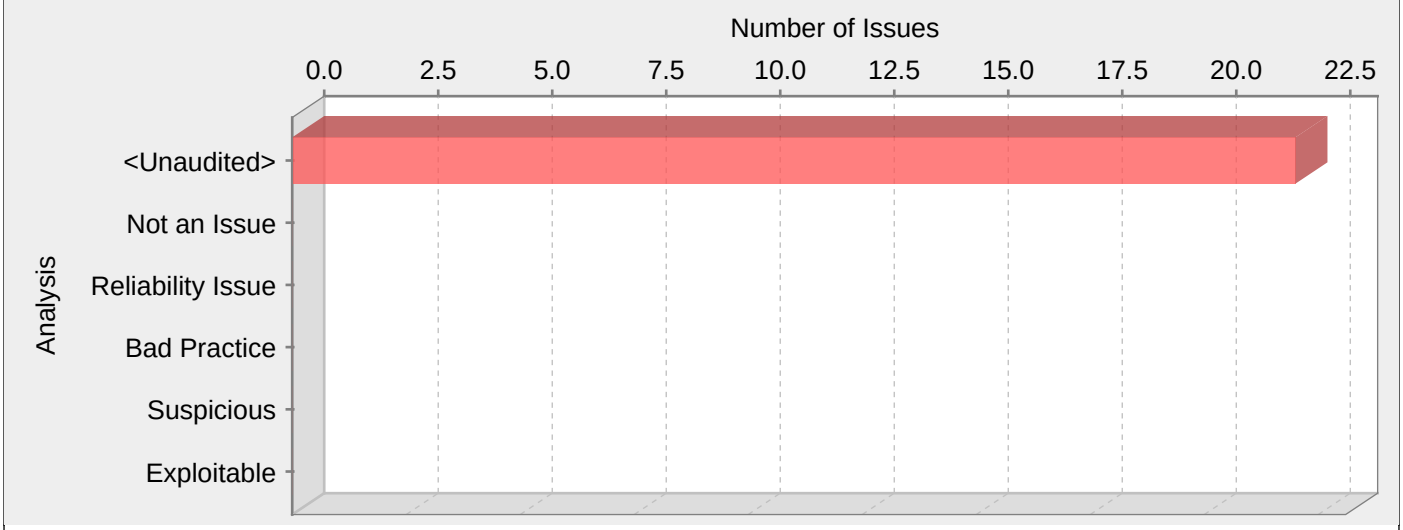
Access specifiers should only be changed by a privileged class using arguments that an attacker cannot set. All occurrences should be examined carefully.

RequiredDataAdvice.java, line 317 (Access Specifier Manipulation)

Fortify Priority:	High	**Folder**	High
Kingdom:	Input Validation and Representation		
Abstract:	The call to method setAccessible() on line 317 changes an access specifier.		
Sink:	RequiredDataAdvice.java:317 setAccessible()		

```
315
316                 boolean previousFieldAccessibility = field.isAccessible();
317                 field.setAccessible(true);
318                 Collection<OpenmrsObject> childCollection = (Collection<OpenmrsObject>)
field.get(openmrsObject);
319                 field.setAccessible(previousFieldAccessibility);
```

Category: Unreleased Resource: Streams (22 Issues)



Abstract:

The function runLiquibase() in ModuleFactory.java sometimes fails to release a system resource allocated by getResourceAsStream() on line 981.

Explanation:

The program can potentially fail to release a system resource.

Resource leaks have at least two common causes:

- Error conditions and other exceptional circumstances.

- Confusion over which part of the program is responsible for releasing the resource.

Most unreleased resource issues result in general software reliability problems, but if an attacker can intentionally trigger a resource leak, the attacker may be able to launch a denial of service attack by depleting the resource pool.

Example: The following method never closes the file handle it opens. The finalize() method for FileInputStream eventually calls close(), but there is no guarantee as to how long it will take before the finalize() method will be invoked. In a busy environment, this can result in the JVM using up all of its file handles.

```
private void processFile(String fName) throws FileNotFoundException, IOException {
FileInputStream fis = new FileInputStream(fName);
int sz;
byte[] byteArray = new byte[BLOCK_SIZE];
while ((sz = fis.read(byteArray)) != -1) {
processBytes(byteArray, sz);
}
}
```

Recommendations:

1. Never rely on finalize() to reclaim resources. In order for an object's finalize() method to be invoked, the garbage collector must determine that the object is eligible for garbage collection. Because the garbage collector is not required to run unless the JVM is low on memory, there is no guarantee that an object's finalize() method will be invoked in an expedient fashion. When the garbage collector finally does run, it may cause a large number of resources to be reclaimed in a short period of time, which can lead to "bursty" performance and lower overall system throughput. This effect becomes more pronounced as the load on the system increases.

Finally, if it is possible for a resource reclamation operation to hang (if it requires communicating over a network to a database, for example), then the thread that is executing the finalize() method will hang.

2. Release resources in a finally block. The code for the Example should be rewritten as follows:

```
public void processFile(String fName) throws FileNotFoundException, IOException {
FileInputStream fis;
try {
fis = new FileInputStream(fName);
int sz;
byte[] byteArray = new byte[BLOCK_SIZE];
while ((sz = fis.read(byteArray)) != -1) {
```

```
processBytes(byteArray, sz);
}
}
finally {
if (fis != null) {
safeClose(fis);
}
}
}

public static void safeClose(FileInputStream fis) {
if (fis != null) {
try {
fis.close();
} catch (IOException e) {
log(e);
}
}
}
```

This solution uses a helper function to log the exceptions that might occur when trying to close the stream. Presumably this helper function will be reused whenever a stream needs to be closed.

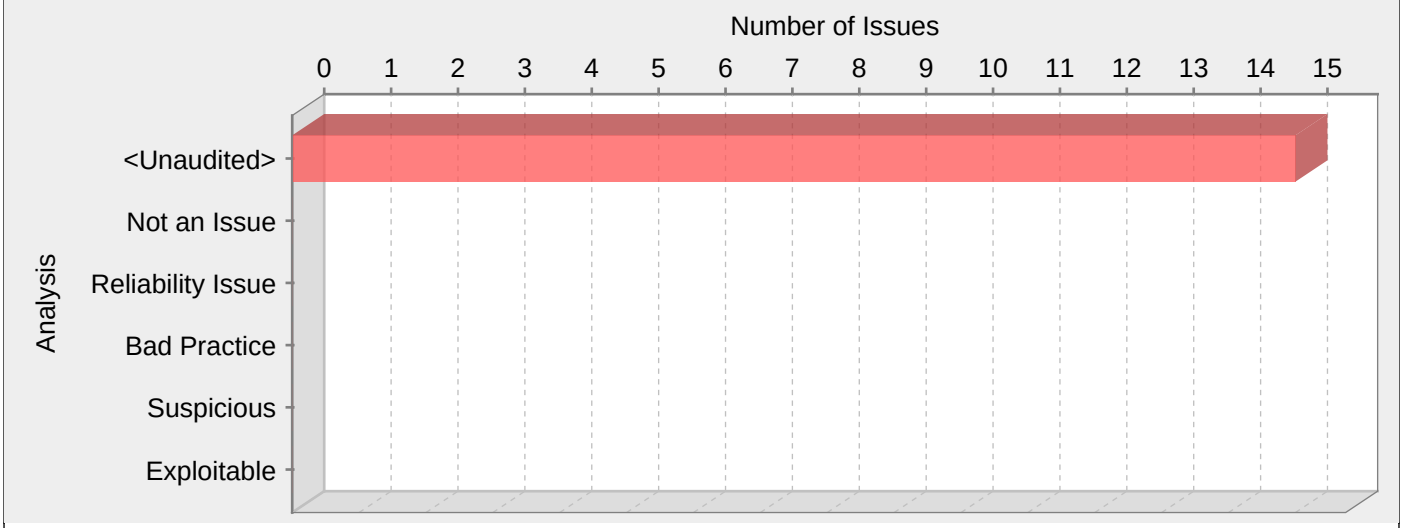
Also, the processFile method does not initialize the fis object to null. Instead, it checks to ensure that fis is not null before calling safeClose(). Without the null check, the Java compiler reports that fis might not be initialized. This choice takes advantage of Java's ability to detect uninitialized variables. If fis is initialized to null in a more complex method, cases in which fis is used without being initialized will not be detected by the compiler.

ModuleFactory.java, line 981 (Unreleased Resource: Streams)

Fortify Priority:	High	**Folder**	High
Kingdom:	Code Quality		
Abstract:	The function runLiquibase() in ModuleFactory.java sometimes fails to release a system resource allocated by getResourceAsStream() on line 981.		
Sink:	ModuleFactory.java:981 inStream = getResourceAsStream(...)		

```
979   private static void runLiquibase(Module module) {
980     ModuleClassLoader moduleClassLoader = ModuleFactory.getModuleClassLoader(module);
981     InputStream inStream =
      moduleClassLoader.getResourceAsStream(MODULE_CHANGELOG_FILENAME);
982     boolean liquibaseFileExists = (inStream != null);
983
```

Category: Race Condition: Singleton Member Field (15 Issues)



Abstract:

The class ServiceContext is a singleton, so the member field applicationContext is shared between users. The result is that one user could see another user's data.

Explanation:

Many Servlet developers do not understand that a Servlet is a singleton. There is only one instance of the Servlet, and that single instance is used and re-used to handle multiple requests that are processed simultaneously by different threads.

A common result of this misunderstanding is that developers use Servlet member fields in such a way that one user may inadvertently see another user's data. In other words, storing user data in Servlet member fields introduces a data access race condition.

Example 1: The following Servlet stores the value of a request parameter in a member field and then later echoes the parameter value to the response output stream.

```
public class GuestBook extends HttpServlet {

String name;

protected void doPost (HttpServletRequest req, HttpServletResponse res) {
name = req.getParameter("name");
...
out.println(name + ", thanks for visiting!");
}
}
```

While this code will work perfectly in a single-user environment, if two users access the Servlet at approximately the same time, it is possible for the two request handler threads to interleave in the following way:

Thread 1: assign "Dick" to name
Thread 2: assign "Jane" to name
Thread 1: print "Jane, thanks for visiting!"
Thread 2: print "Jane, thanks for visiting!"

Thereby showing the first user the second user's name.

Recommendations:

Do not use Servlet member fields for anything but constants. (i.e. make all member fields static final).

Developers are often tempted to use Servlet member fields for user data when they need to transport data from one region of code to another. If this is your aim, consider declaring a separate class and using the Servlet only to "wrap" this new class.

Example 2: The bug in the example above can be corrected in the following way:

```
public class GuestBook extends HttpServlet {

protected void doPost (HttpServletRequest req, HttpServletResponse res) {
GBRequestHandler handler = new GBRequestHandler();
handler.handle(req, res);
}
```

```
}
public class GBRequestHandler {
String name;
public void handle(HttpServletRequest req, HttpServletResponse res) {
name = req.getParameter("name");
...
out.println(name + ", thanks for visiting!");
}
}
```

Alternatively, a Servlet can utilize synchronized blocks to access servlet instance variables but using synchronized blocks may cause significant performance problems.

Please notice that wrapping the field access within a synchronized block will only prevent the issue if all read and write operations on that member are performed within the same synchronized block or method.

Example 3: Wrapping the Example 1 write operation (assignment) in a synchronized block will not fix the problem since the threads will have to get a lock to modify name field, but they will release the lock afterwards, allowing a second thread to change the value again. If, after changing the name value, the first thread resumes execution, the value printed will be the one assigned by the second thread:

```
public class GuestBook extends HttpServlet {
String name;
protected void doPost (HttpServletRequest req, HttpServletResponse res) {
synchronized(name) {
name = req.getParameter("name");
}
...
out.println(name + ", thanks for visiting!");
}
}
```

In order to fix the race condition, all the write and read operations on the shared member field should be run atomically within the same synchronized block:

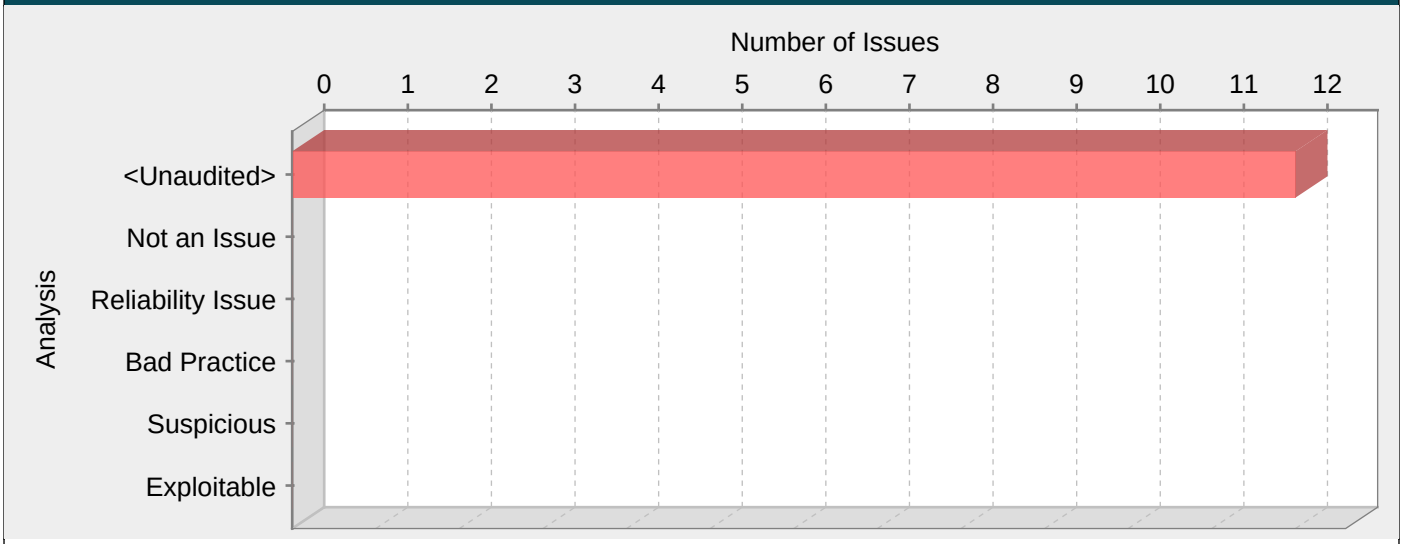
```
public class GuestBook extends HttpServlet {
String name;
protected void doPost (HttpServletRequest req, HttpServletResponse res) {
synchronized(name) {
name = req.getParameter("name");
...
out.println(name + ", thanks for visiting!");
}
}
}
```

ServiceContext.java, line 934 (Race Condition: Singleton Member Field)

Fortify Priority:	High	**Folder**	High
Kingdom:	Time and State		
Abstract:	The class ServiceContext is a singleton, so the member field applicationContext is shared between users. The result is that one user could see another user's data.		
Sink:	ServiceContext.java:934 AssignmentStatement()		

```
932  @Override
933  public void setApplicationContext(ApplicationContext applicationContext) {
934   this.applicationContext = applicationContext;
935  }
936
```

Category: Command Injection (12 Issues)



Abstract:

The method execCmd() in SourceMySqldiffFile.java calls exec() with a command built from untrusted data. This call can cause the program to execute malicious commands on behalf of an attacker.

Explanation:

Command injection vulnerabilities take two forms:

- An attacker can change the command that the program executes: the attacker explicitly controls what the command is.

- An attacker can change the environment in which the command executes: the attacker implicitly controls what the command means.

In this case we are primarily concerned with the first scenario, the possibility that an attacker may be able to control the command that is executed. Command injection vulnerabilities of this type occur when:

1. Data enters the application from an untrusted source.

2. The data is used as or as part of a string representing a command that is executed by the application.

3. By executing the command, the application gives an attacker a privilege or capability that the attacker would not otherwise have.

Example 1: The following code from a system utility uses the system property APPHOME to determine the directory in which it is installed and then executes an initialization script based on a relative path from the specified directory.

```
...
String home = System.getProperty("APPHOME");
String cmd = home + INITCMD;
java.lang.Runtime.getRuntime().exec(cmd);
...
```

The code in Example 1 allows an attacker to execute arbitrary commands with the elevated privilege of the application by modifying the system property APPHOME to point to a different path containing a malicious version of INITCMD. Because the program does not validate the value read from the environment, if an attacker can control the value of the system property APPHOME, then they can fool the application into running malicious code and take control of the system.

Example 2: The following code is from an administrative web application designed to allow users to kick off a backup of an Oracle database using a batch-file wrapper around the rman utility and then run a cleanup.bat script to delete some temporary files. The script rmanDB.bat accepts a single command line parameter, which specifies the type of backup to perform. Because access to the database is restricted, the application runs the backup as a privileged user.

```
...
String btype = request.getParameter("backuptype");
String cmd = new String("cmd.exe /K
\"c:\\util\\rmanDB.bat "+btype+"&&c:\\util\\cleanup.bat\"")
System.Runtime.getRuntime().exec(cmd);
...
```

The problem here is that the program does not do any validation on the backuptype parameter read from the user. Typically the Runtime.exec() function will not execute multiple commands, but in this case the program first runs the cmd.exe shell in order to run multiple commands with a single call to Runtime.exec(). Once the shell is invoked, it will allow for the execution of multiple commands separated by two ampersands. If an attacker passes a string of the form "&& del c:\\dbms*.*", then the application will execute this command along with the others specified by the program. Because of the nature of the application, it runs with the privileges necessary to interact with the database, which means whatever command the attacker injects will run with those privileges as well.

Example 3: The following code is from a web application that allows users access to an interface through which they can update their password on the system. Part of the process for updating passwords in certain network environments is to run a make command in the /var/yp directory, the code for which is shown below.

```
...
System.Runtime.getRuntime().exec("make");
...
```

The problem here is that the program does not specify an absolute path for make and fails to clean its environment prior to executing the call to Runtime.exec(). If an attacker can modify the $PATH variable to point to a malicious binary called make and cause the program to be executed in their environment, then the malicious binary will be loaded instead of the one intended. Because of the nature of the application, it runs with the privileges necessary to perform system operations, which means the attacker's make will now be run with these privileges, possibly giving the attacker complete control of the system.

Some think that in the mobile world, classic vulnerabilities, such as command injection, do not make sense -- why would a user attack him or herself? However, keep in mind that the essence of mobile platforms is applications that are downloaded from various sources and run alongside each other on the same device. The likelihood of running a piece of malware next to a banking application is high, which necessitates expanding the attack surface of mobile applications to include inter-process communication.

Example 4: The following code reads commands to be executed from an Android intent.

```
...
String[] cmds = this.getIntent().getStringArrayExtra("commands");
Process p = Runtime.getRuntime().exec("su");
DataOutputStream os = new DataOutputStream(p.getOutputStream());
for (String cmd : cmds) {
os.writeBytes(cmd+"\n");
}
os.writeBytes("exit\n");
os.flush();
...
```

On a rooted device, a malicious application can force a victim application to execute arbitrary commands with super user privileges.

Recommendations:

Do not allow users to have direct control over the commands executed by the program. In cases where user input must affect the command to be run, use the input only to make a selection from a predetermined set of safe commands. If the input appears to be malicious, the value passed to the command execution function should either default to some safe selection from this set or the program should decline to execute any command at all.

In cases where user input must be used as an argument to a command executed by the program, this approach often becomes impractical because the set of legitimate argument values is too large or too hard to keep track of. Developers often fall back on blacklisting in these situations. Blacklisting selectively rejects or escapes potentially dangerous characters before using the input. Any list of unsafe characters is likely to be incomplete and will be heavily dependent on the system where the commands are executed. A better approach is to create a whitelist of characters that are allowed to appear in the input and accept input composed exclusively of characters in the approved set.

An attacker may indirectly control commands executed by a program by modifying the environment in which they are executed. The environment should not be trusted and precautions should be taken to prevent an attacker from using some manipulation of the environment to perform an attack. Whenever possible, commands should be controlled by the application and executed using an absolute path. In cases where the path is not known at compile time, such as for cross-platform applications, an absolute path should be constructed from trusted values during execution. Command values and paths read from configuration files or the environment should be sanity-checked against a set of invariants that define valid values.

Other checks can sometimes be performed to detect if these sources may have been tampered with. For example, if a configuration file is world-writable, the program might refuse to run. In cases where information about the binary to be executed is known in advance, the program may perform checks to verify the identity of the binary. If a binary should always be owned by a particular user or have a particular set of access permissions assigned to it, these properties can be verified programmatically before the binary is executed.

Although it may be impossible to completely protect a program from an imaginative attacker bent on controlling the commands the program executes, be sure to apply the principle of least privilege wherever the program executes an external command: do not hold privileges that are not essential to the execution of the command.

Tips:

1. A number of modern web frameworks provide mechanisms for performing validation of user input. Struts and Spring MVC are two examples. To highlight the unvalidated sources of input, the Fortify Secure Coding Rulepacks dynamically re-prioritize the issues reported by Fortify Static Code Analyzer by lowering their probability of exploit and providing pointers to the supporting evidence whenever the framework validation mechanism is in use. We refer to this feature as Context-Sensitive Ranking. To further assist the Fortify user with the auditing process, the Fortify Software Security Research group makes available the Data Validation project template that groups the issues into folders based on the validation mechanism applied to their source of input.

2. Fortify RTA adds protection against this category.

SourceMySqldiffFile.java, line 207 (Command Injection)

Fortify Priority:	Critical	**Folder**	Critical
Kingdom:	Input Validation and Representation		
Abstract:	The method execCmd() in SourceMySqldiffFile.java calls exec() with a command built from untrusted data. This call can cause the program to execute malicious commands on behalf of an attacker.		

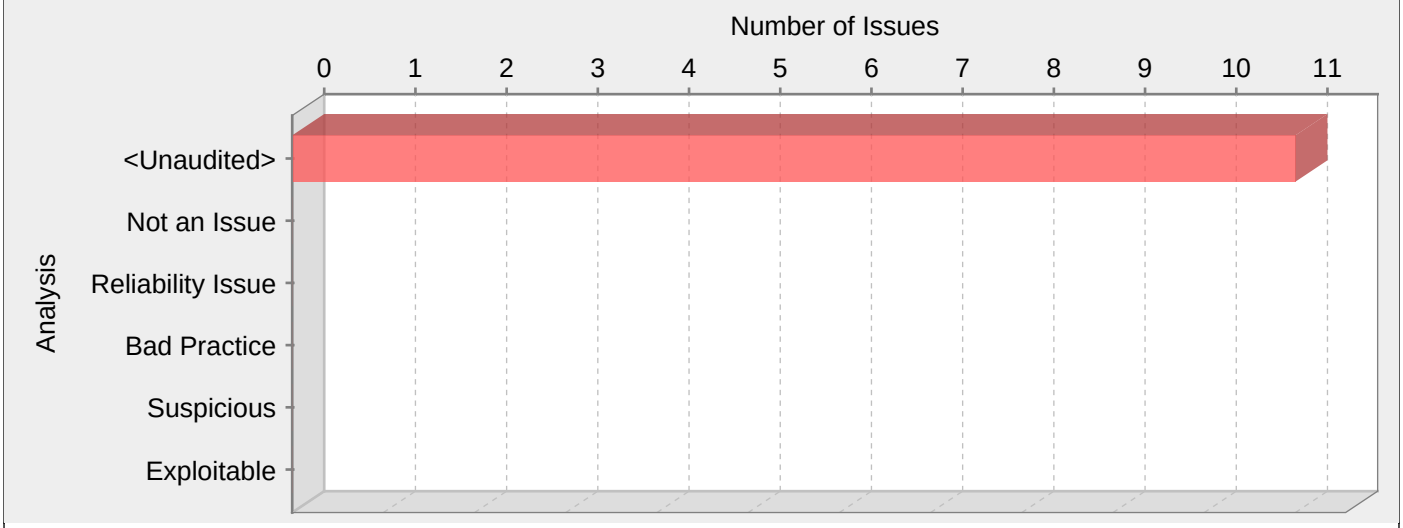
Source: SourceMySqldiffFile.java:76 java.lang.System.getProperty()

```
74
75                  if (username == null) {
76                   username = System.getProperty(CONNECTION_USERNAME);
77                  }
78                  if (password =****** null) {
```

Sink: SourceMySqldiffFile.java:207 java.lang.Runtime.exec()

```
205                 }
206
207                 Process p = (wd != null) ? Runtime.getRuntime().exec(cmdWithArguments, null, wd) :
Runtime.getRuntime().exec(
208                       cmdWithArguments);
209
```

Category: Insecure Randomness (11 Issues)



Abstract:

The random number generator implemented by nextInt() cannot withstand a cryptographic attack.

Explanation:

Insecure randomness errors occur when a function that can produce predictable values is used as a source of randomness in a security-sensitive context.

Computers are deterministic machines, and as such are unable to produce true randomness. Pseudorandom Number Generators (PRNGs) approximate randomness algorithmically, starting with a seed from which subsequent values are calculated.

There are two types of PRNGs: statistical and cryptographic. Statistical PRNGs provide useful statistical properties, but their output is highly predictable and form an easy to reproduce numeric stream that is unsuitable for use in cases where security depends on generated values being unpredictable. Cryptographic PRNGs address this problem by generating output that is more difficult to predict. For a value to be cryptographically secure, it must be impossible or highly improbable for an attacker to distinguish between the generated random value and a truly random value. In general, if a PRNG algorithm is not advertised as being cryptographically secure, then it is probably a statistical PRNG and should not be used in security-sensitive contexts, where its use can lead to serious vulnerabilities such as easy-to-guess temporary passwords, predictable cryptographic keys, session hijacking, and DNS spoofing.

Example: The following code uses a statistical PRNG to create a URL for a receipt that remains active for some period of time after a purchase.

```
String GenerateReceiptURL(String baseUrl) {
Random ranGen = new Random();
ranGen.setSeed((new Date()).getTime());
return (baseUrl + ranGen.nextInt(400000000) + ".html");
}
```

This code uses the Random.nextInt() function to generate "unique" identifiers for the receipt pages it generates. Since Random.nextInt() is a statistical PRNG, it is easy for an attacker to guess the strings it generates. Although the underlying design of the receipt system is also faulty, it would be more secure if it used a random number generator that did not produce predictable receipt identifiers, such as a cryptographic PRNG.

Recommendations:

When unpredictability is critical, as is the case with most security-sensitive uses of randomness, use a cryptographic PRNG. Regardless of the PRNG you choose, always use a value with sufficient entropy to seed the algorithm. (Values such as the current time offer only negligible entropy and should not be used.)

The Java language provides a cryptographic PRNG in java.security.SecureRandom. As is the case with other algorithm-based classes in java.security, SecureRandom provides an implementation-independent wrapper around a particular set of algorithms. When you request an instance of a SecureRandom object using SecureRandom.getInstance(), you can request a specific implementation of the algorithm. If the algorithm is available, then it is given as a SecureRandom object. If it is unavailable or if you do not specify a particular implementation, then you are given a SecureRandom implementation selected by the system.

Sun provides a single SecureRandom implementation with the Java distribution named SHA1PRNG, which Sun describes as computing:

"The SHA-1 hash over a true-random seed value concatenated with a 64-bit counter which is incremented by 1 for each operation. From the 160-bit SHA-1 output, only 64 bits are used [1]."

However, the specifics of the Sun implementation of the SHA1PRNG algorithm are poorly documented, and it is unclear what sources of entropy the implementation uses and therefore what amount of true randomness exists in its output. Although there is speculation on the Web about the Sun implementation, there is no evidence to contradict the claim that the algorithm is cryptographically strong and can be used safely in security-sensitive contexts.

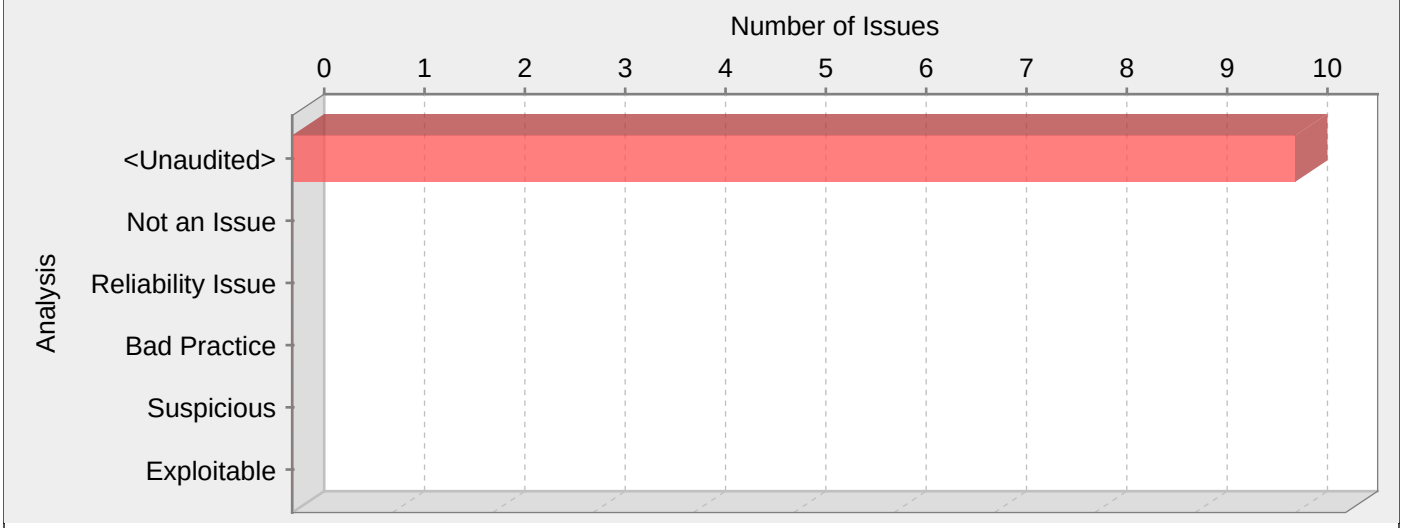
MigrationHelper.java, line 156 (Insecure Randomness)

Fortify Priority:	High	**Folder**	High
Kingdom:	Security Features		
Abstract:	The random number generator implemented by nextInt() cannot withstand a cryptographic attack.		

Sink: MigrationHelper.java:156 nextInt()

```
154    String pass;
155    {
156     int length = rand.nextInt(4) + 8;
157     char[] password =****** char[length];
158     for (int x = 0; x < length; x++) {
```

Category: Dynamic Code Evaluation: Unsafe XStream Deserialization (10 Issues)



Abstract:

The file SimpleXStreamSerializer.java deserializes unvalidated XML input using XStream on line 107. Deserializing user-controlled XML documents at run-time can allow attackers to execute malicious arbitrary code on the server.

Explanation:

XStream library provides the developer with an easy way to transmit objects, serializing them to XML documents. But XStream can by default deserialize dynamic proxies allowing an attacker to run arbitrary Java code on the server when the proxy's InvocationHandler is invoked.

Example 1: The following Java code shows an instance of XStream processing untrusted input.

```
XStream xstream = new XStream();
String body = IOUtils.toString(request.getInputStream(), "UTF-8");
Contact expl = (Contact) xstream.fromXML(body);
```

Example 2: The following XML document will instantiate a ProcessBuilder object and will invoke its static start() method to run the Windows calculator.

```
<dynamic-proxy>
<interface>com.company.model.Contact</interface>
<handler class="java.beans.EventHandler">
<target class="java.lang.ProcessBuilder">
<command><string>/Applications/Calculator.app/Contents/MacOS/Calculator</string></command>
</target>
<action>start</action>
</handler>
</dynamic-proxy>
```

Recommendations:

XStream implicitly prevents the deserialization of known bad classes such as java.beans.EventHandler that can be used by attackers to run arbitrary commands. In addition, starting with XStream 1.4.7, it is possible to define permissions for types. These permissions can be used to explicitly allow or deny the types that will be deserialized and so it is not possible to inject unexpected types into an object graph. Any application that deserializes data from an external source should use this feature to limit the danger of arbitrary command execution. Always use the whitelist approach (allowed types) since many classes can be used to achieve remote code execution and to bypass blacklists.

Example 3: The following Java code shows an instance of XStream securely processing untrusted input by defining the allowed types.

```
XStream xstream = new XStream();
// clear out existing permissions and set own ones
xstream.addPermission(NoPermissionType.NONE);
// allow some basics
xstream.addPermission(NullPermission.NULL);
xstream.addPermission(PrimitiveTypePermission.PRIMITIVES);
xstream.allowTypeHierarchy(Collection.class);
```

```
// allow any type from the same package
xstream.allowTypesByWildcard(new String[] {
Contact.class.getPackage().getName()+".*"
});
String body = IOUtils.toString(request.getInputStream(), "UTF-8");
Contact expl = (Contact) xstream.fromXML(body);
```

Note that any class allowed in the whitelist should be audited to make sure it is safe to deserialize.

If using XStream as the marshalling solution for a Spring project, use the "converters" property to set up a chain of custom converters starting with the org.springframework.oxm.xstream.CatchAllConverter converter as shown in the example below:

```
<bean id="marshallingHttpMessageConverter"
class="org.springframework.http.converter.xml.MarshallingHttpMessageConverter">
<property name="marshaller" ref="xstreamMarshaller"/>
<property name="unmarshaller" ref="xstreamMarshaller"/>
</bean>

<bean id="xstreamMarshaller" class="org.springframework.oxm.xstream.XStreamMarshaller">
<property name="aliases">
<props>
<prop key="contact">org.company.converters.Contact</prop>
</props>
</property>
<property name="converters">
<list>
<bean class="org.springframework.oxm.xstream.CatchAllConverter"/>
<bean class="org.company.converters.ContactConverter"/>
</list>
</property>
</bean>
```

SimpleXStreamSerializer.java, line 107 (Dynamic Code Evaluation: Unsafe XStream Deserialization)

Fortify Priority:	High	**Folder**	High
Kingdom:	Input Validation and Representation		
Abstract:	The file SimpleXStreamSerializer.java deserializes unvalidated XML input using XStream on line 107. Deserializing user-controlled XML documents at run-time can allow attackers to execute malicious arbitrary code on the server.		

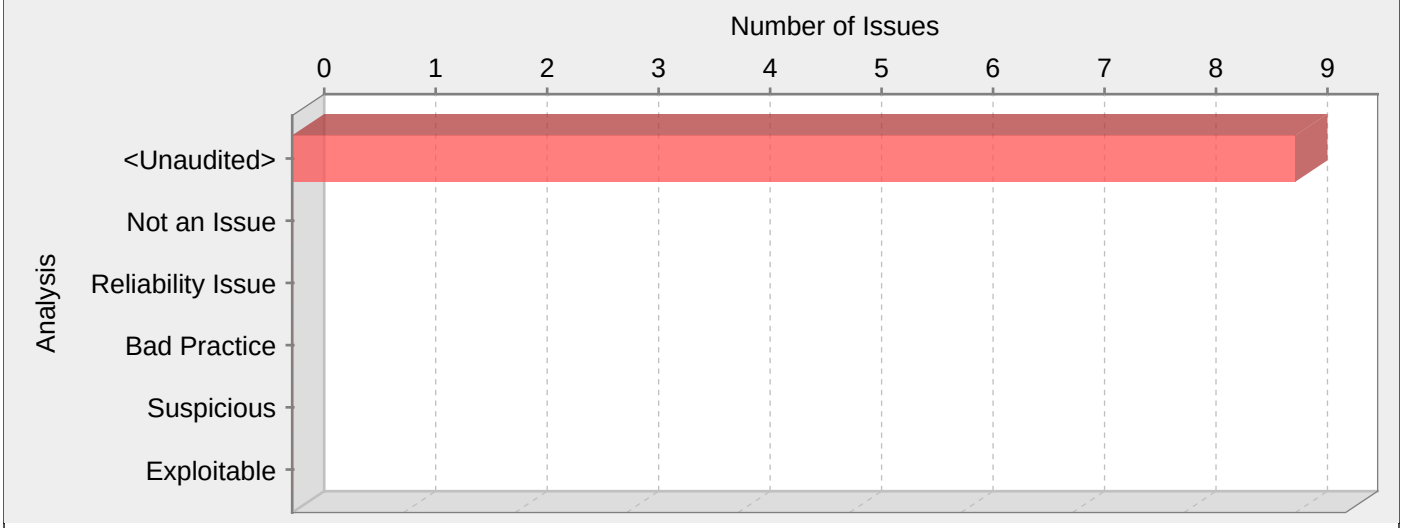
Source: HibernateSerializedObjectDAO.java:92 org.hibernate.Criteria.uniqueResult()

```
90    Criteria c =
sessionFactory.getCurrentSession().createCriteria(SerializedObject.class);
91    c.add(Restrictions.eq("uuid", uuid));
92    ret = (SerializedObject) c.uniqueResult();
93   }
94   return ret;
```

Sink: SimpleXStreamSerializer.java:107 com.thoughtworks.xstream.XStream.fromXML()

```
105
106   try {
107    return (T) xstream.fromXML(serializedObject);
108   }
109   catch (XStreamException e) {
```

Category: Unreleased Resource: Database (9 Issues)



Abstract:

The function execute() in DuplicateEncounterRoleNameChangeSet.java sometimes fails to release a database resource allocated by getConnection() on line 121.

Explanation:

Resource leaks have at least two common causes:

- Error conditions and other exceptional circumstances.

- Confusion over which part of the program is responsible for releasing the resource.

Most unreleased resource issues result in general software reliability problems, but if an attacker can intentionally trigger a resource leak, the attacker may be able to launch a denial of service attack by depleting the resource pool.

Example: Under normal conditions, the following code executes a database query, processes the results returned by the database, and closes the allocated statement object. But if an exception occurs while executing the SQL or processing the results, the statement object will not be closed. If this happens often enough, the database will run out of available cursors and not be able to execute any more SQL queries.

```
Statement stmt = conn.createStatement();
ResultSet rs = stmt.executeQuery(CXN_SQL);
harvestResults(rs);
stmt.close();
```

Recommendations:

1. Never rely on finalize() to reclaim resources. In order for an object's finalize() method to be invoked, the garbage collector must determine that the object is eligible for garbage collection. Because the garbage collector is not required to run unless the JVM is low on memory, there is no guarantee that an object's finalize() method will be invoked in an expedient fashion. When the garbage collector finally does run, it may cause a large number of resources to be reclaimed in a short period of time, which can lead to "bursty" performance and lower overall system throughput. This effect becomes more pronounced as the load on the system increases.

Finally, if it is possible for a resource reclamation operation to hang (if it requires communicating over a network to a database, for example), then the thread that is executing the finalize() method will hang.

2. Release resources in a finally block. The code for the Example should be rewritten as follows:

```
public void execCxnSql(Connection conn) {
Statement stmt;
try {
stmt = conn.createStatement();
ResultSet rs = stmt.executeQuery(CXN_SQL);
...
}
finally {
if (stmt != null) {
safeClose(stmt);
}
```

```
}
}
public static void safeClose(Statement stmt) {
if (stmt != null) {
try {
stmt.close();
} catch (SQLException e) {
log(e);
}
}
}
```

This solution uses a helper function to log the exceptions that might occur when trying to close the statement. Presumably this helper function will be reused whenever a statement needs to be closed.

Also, the execCxnSql method does not initialize the stmt object to null. Instead, it checks to ensure that stmt is not null before calling safeClose(). Without the null check, the Java compiler reports that stmt might not be initialized. This choice takes advantage of Java's ability to detect uninitialized variables. If stmt is initialized to null in a more complex method, cases in which stmt is used without being initialized will not be detected by the compiler.

Tips:

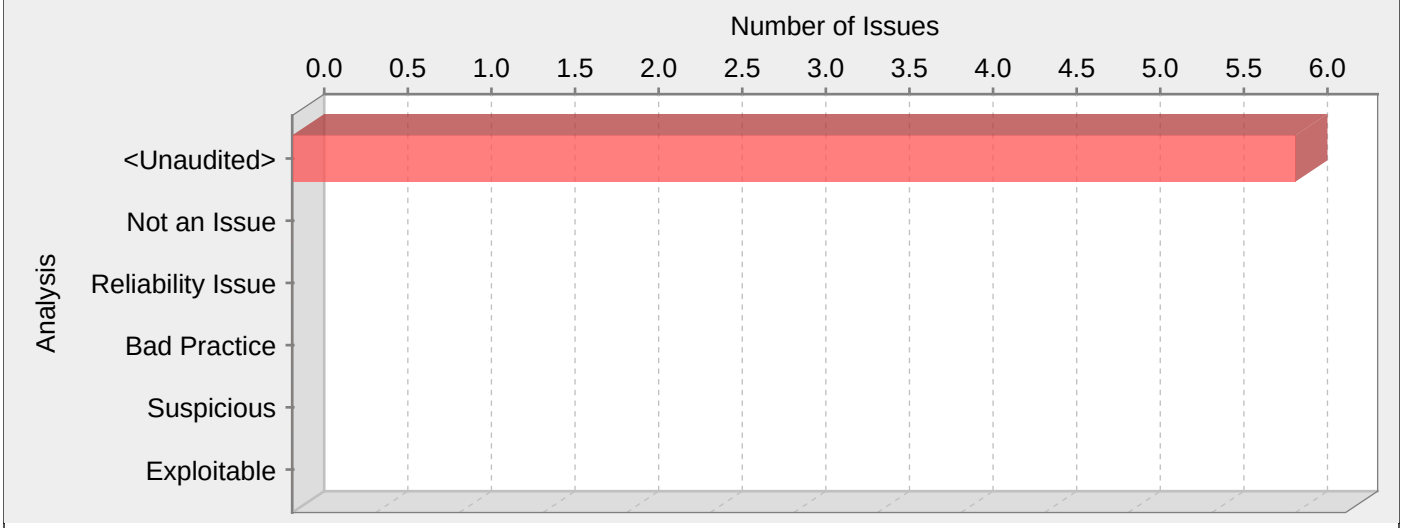
1. Be aware that closing a database connection may or may not automatically free other resources associated with the connection object. If the application uses connection pooling, it is best to explicitly close the other resources after the connection is closed. If the application is not using connection pooling, the other resources are automatically closed when the database connection is closed. In such a case, this vulnerability is invalid.

DuplicateEncounterRoleNameChangeSet.java, line 121 (Unreleased Resource: Database)

Fortify Priority:	High	**Folder**	High
Kingdom:	Code Quality		
Abstract:	The function execute() in DuplicateEncounterRoleNameChangeSet.java sometimes fails to release a database resource allocated by getConnection() on line 121.		
Sink:	DuplicateEncounterRoleNameChangeSet.java:121 con = getConnection()		

```
119                 List<List<Object>> duplicateResult;
120                 boolean duplicateName;
121                 Connection con = DatabaseUpdater.getConnection();
122                 do {
123                  String sqlValidatorString = "select * from encounter_role where name = '" + newName +
"'";
```

Category: Privacy Violation: Heap Inspection (6 Issues)



Abstract:

The method toString() in Result.java stores sensitive data in a String object, making it impossible to reliably purge the data from memory.

Explanation:

Sensitive data (such as passwords, social security numbers, credit card numbers etc) stored in memory can be leaked if memory is not cleared after use. Often, Strings are used store sensitive data, however, since String objects are immutable, removing the value of a String from memory can only be done by the JVM garbage collector. The garbage collector is not required to run unless the JVM is low on memory, so there is no guarantee as to when garbage collection will take place. In the event of an application crash, a memory dump of the application might reveal sensitive data.

Example 1: The following code converts a password from a character array to a String.

```
private JPasswordField pf;
...
final char[] password = pf.getPassword();
...
String passwordAsString = new String(password);
```

This category was derived from the Cigital Java Rulepack. http://www.cigital.com/

Recommendations:

Always be sure to clear sensitive data when it is no longer needed. Instead of storing sensitive data in immutable objects such as Strings, use byte arrays or character arrays that can be programmatically cleared.

Example 2: The following code clears memory after a password is used.

```
private JPasswordField pf;
...
final char[] password = pf.getPassword();
// use the password
...
// erase when finished
Arrays.fill(password, ' ');
```

Tips:

1. A number of modern web frameworks provide mechanisms for performing validation of user input. Struts and Spring MVC are among them. To highlight the unvalidated sources of input, the Fortify Secure Coding Rulepacks dynamically re-prioritize the issues reported by Fortify Static Code Analyzer by lowering their probability of exploit and providing pointers to the supporting evidence whenever the framework validation mechanism is in use. We refer to this feature as Context-Sensitive Ranking. To further assist the Fortify user with the auditing process, the Fortify Software Security Research group makes available the Data Validation project template that groups the issues into folders based on the validation mechanism applied to their source of input.

Result.java, line 631 (Privacy Violation: Heap Inspection)

Fortify Priority:	High	**Folder**	High
Kingdom:	Security Features		

Abstract:	The method toString() in Result.java stores sensitive data in a String object, making it impossible to reliably purge the data from memory.

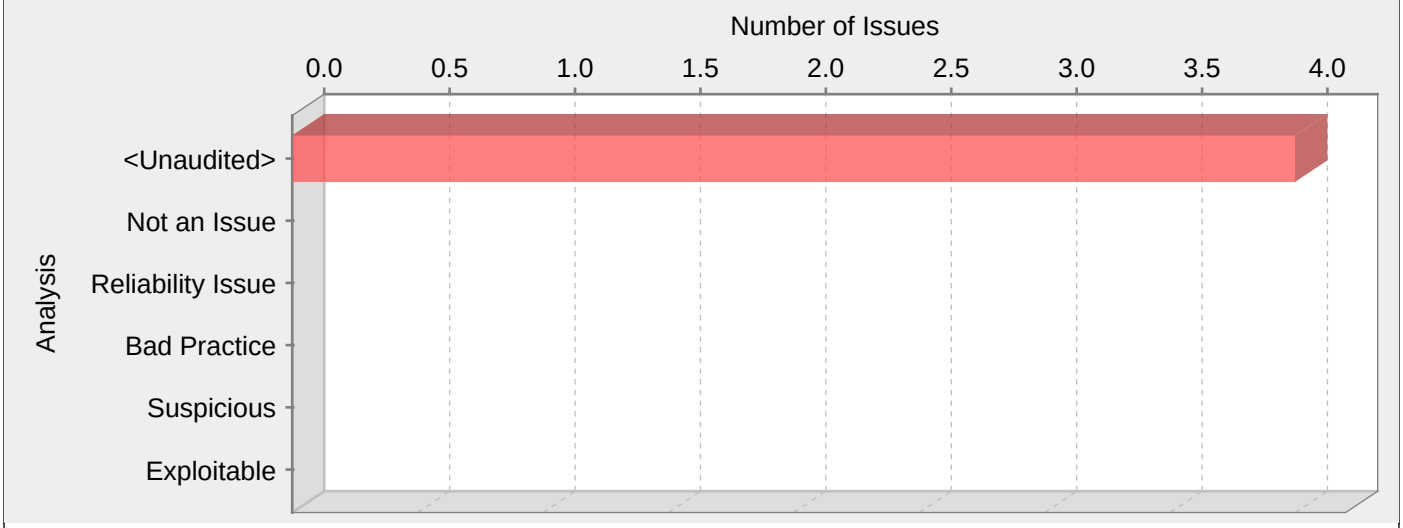
Source: SourceMySqldiffFile.java:112 Read password()

```
110     commands.add("mysql");
111     commands.add("-u" + username);
112     commands.add("-p" + password);
113     String path = tmpOutputFile.getAbsolutePath();
114     if (!OpenmrsConstants.UNIX_BASED_OPERATING_SYSTEM) {
```

Sink: Result.java:631 java.lang.String.valueOf()

```
629         return (valueDatetime == null ? "" : Context.getDateFormat().format(valueDatetime));
630       case NUMERIC:
631         return (valueNumeric == null ? "" : String.valueOf(valueNumeric));
632       case TEXT:
633         return (valueText == null ? "" : valueText);
```

Category: Often Misused: Authentication (4 Issues)



Abstract:

The information returned by the call to getLocalHost() is not trustworthy. Attackers may spoof DNS entries. Do not rely on DNS for security.

Explanation:

Many DNS servers are susceptible to spoofing attacks, so you should assume that your software will someday run in an environment with a compromised DNS server. If attackers are allowed to make DNS updates (sometimes called DNS cache poisoning), they can route your network traffic through their machines or make it appear as if their IP addresses are part of your domain. Do not base the security of your system on DNS names.

Example: The following code uses a DNS lookup to determine whether an inbound request is from a trusted host. If an attacker can poison the DNS cache, they can gain trusted status.

```
String ip = request.getRemoteAddr();
InetAddress addr = InetAddress.getByName(ip);
if (addr.getCanonicalHostName().endsWith("trustme.com")) {
trusted = true;
}
```

IP addresses are more reliable than DNS names, but they can also be spoofed. Attackers may easily forge the source IP address of the packets they send, but response packets will return to the forged IP address. To see the response packets, the attacker has to sniff the traffic between the victim machine and the forged IP address. In order to accomplish the required sniffing, attackers typically attempt to locate themselves on the same subnet as the victim machine. Attackers may be able to circumvent this requirement by using source routing, but source routing is disabled across much of the Internet today. In summary, IP address verification can be a useful part of an authentication scheme, but it should not be the single factor required for authentication.

Recommendations:

You can increase confidence in a domain name lookup if you check to make sure that the host's forward and backward DNS entries match. Attackers will not be able to spoof both the forward and the reverse DNS entries without controlling the nameservers for the target domain. This is not a foolproof approach however: attackers may be able to convince the domain registrar to turn over the domain to a malicious nameserver. Basing authentication on DNS entries is simply a risky proposition.

While no authentication mechanism is foolproof, there are better alternatives than host-based authentication. Password systems offer decent security, but are susceptible to bad password choices, insecure password transmission, and bad password management. A cryptographic scheme like SSL is worth considering, but such schemes are often so complex that they bring with them the risk of significant implementation errors, and key material can always be stolen. In many situations, multi-factor authentication including a physical token offers the most security available at a reasonable price.

Tips:

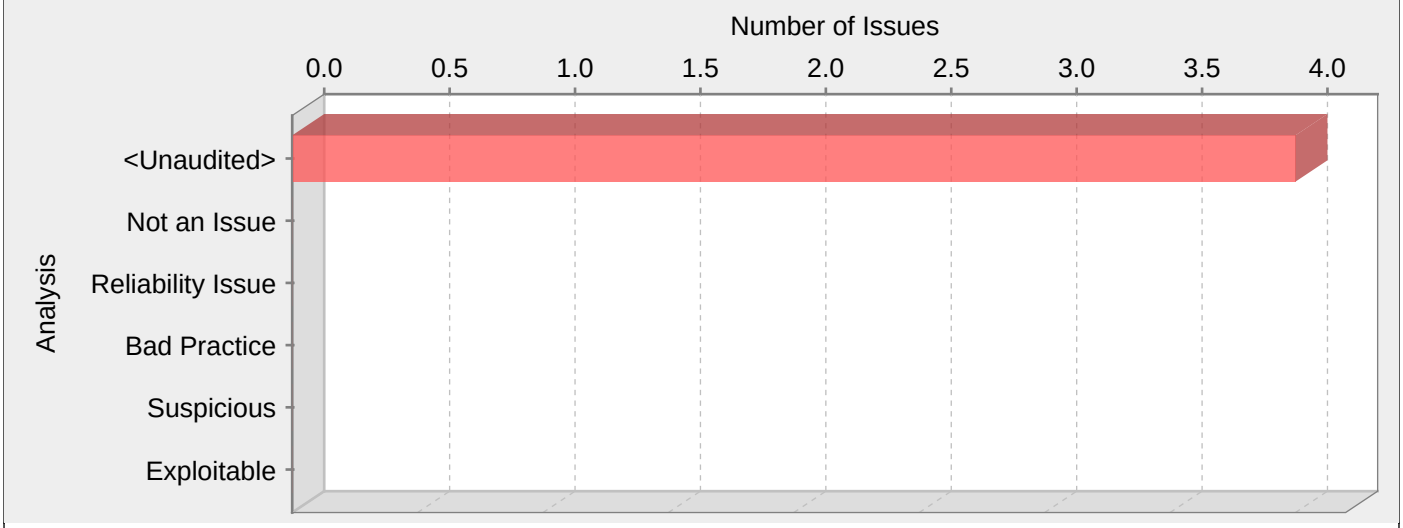
1. Check how the DNS information is being used. In addition to considering whether or not the program's authentication mechanisms can be defeated, consider how DNS spoofing can be used in a social engineering attack. For example, if attackers can make it appear that a posting came from an internal machine, can they gain credibility?

AdministrationServiceImpl.java, line 122 (Often Misused: Authentication)

Fortify Priority:	High	**Folder**	High
Kingdom:	API Abuse		
Abstract:	The information returned by the call to getLocalHost() is not trustworthy. Attackers may spoof DNS entries. Do not rely on DNS for security.		
Sink:	AdministrationServiceImpl.java:122 getLocalHost()		

```
120                     // Added the server's fully qualified domain name
121                     try {
122                      systemVariables.put("OPENMRS_HOSTNAME",
                    InetAddress.getLocalHost().getCanonicalHostName());
123                     }
124                     catch (UnknownHostException e) {
```

Category: Portability Flaw: Locale Dependent Comparison (4 Issues)



Abstract:

The call to equals() on line 987 causes portability problems because it has different locales which may lead to unexpected output. This may also circumvent custom validation routines.

Explanation:

When comparing data that may be locale-dependent, an appropriate locale should be specified.

Example 1: The following example tries to perform validation to determine if user input includes a <script> tag.

```
...
public String tagProcessor(String tag){
if (tag.toUpperCase().equals("SCRIPT")){
return null;
}
//does not contain SCRIPT tag, keep processing input
...
}
...
```

The problem with the above code is that java.lang.String.toUpperCase() when used without a locale uses the rules of the default locale. Using the Turkish locale "title".toUpperCase() returns "T\u0130TLE", where "\u0130" is the "LATIN CAPITAL LETTER I WITH DOT ABOVE" character. This can lead to unexpected results, such as in Example 1 where this will prevent the word "script" from being caught by this validation, potentially leading to a Cross-Site Scripting vulnerability.

Recommendations:

To prevent this from occurring, always make sure to either specify the default locale, or specify the locale with APIs that accept them such as toUpperCase().

Example 2: The following specifies the locale manually as an argument to toUpperCase().

```
import java.util.Locale;
...
public String tagProcessor(String tag){
if (tag.toUpperCase(Locale.ENGLISH).equals("SCRIPT")){
return null;
}
//does not contain SCRIPT tag, keep processing input
...
}
...
```

Example 3: The following uses the function java.lang.String.equalsIgnoreCase() API to prevent this issue.

```
...
public String tagProcessor(String tag){
if (tag.equalsIgnoreCase("SCRIPT")){
```

```
return null;
}
//does not contain SCRIPT tag, keep processing input
...
}
...
```

This prevents the problem because equalsIgnoreCase() changes case similar to Character.toLowerCase() and Character.toUpperCase(). This involves creating temporary canonical forms of both strings using information from the UnicodeData file that is part of the Unicode Character Database maintained by the Unicode Consortium, and even though this may render them unreadable if they were to be read out, it makes comparison possible without being dependent upon locale.

Tips:

1. If SCA sees that java.util.Locale.setDefault() is called anywhere in the application, it will assume that the locale has been set accordingly and these issues will also not appear.

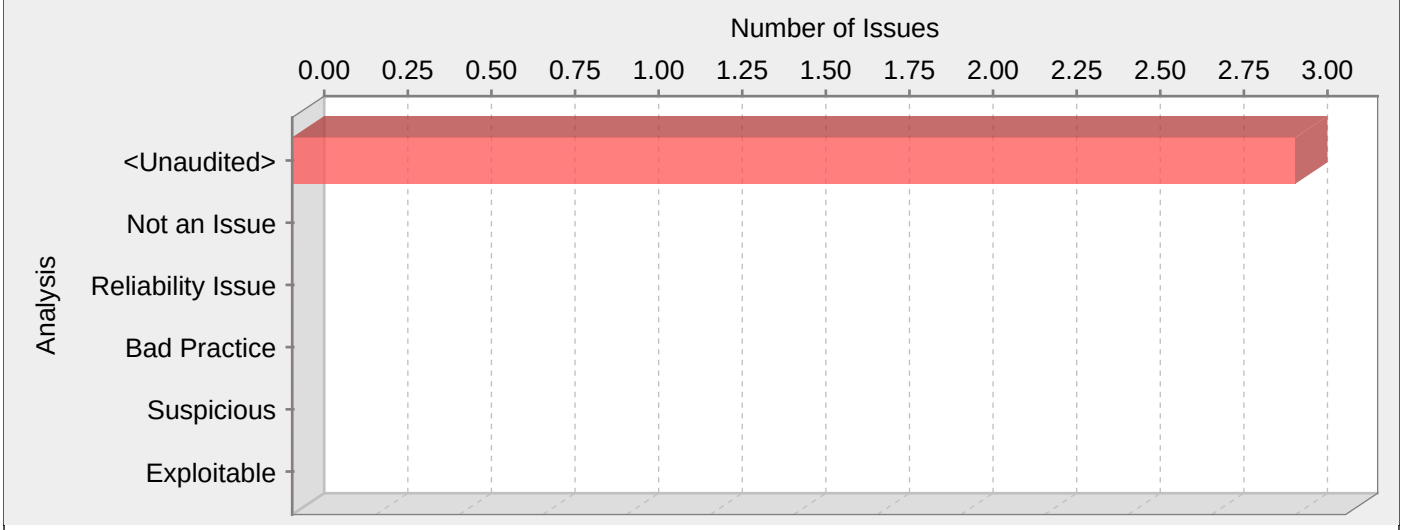
HL7ServiceImpl.java, line 987 (Portability Flaw: Locale Dependent Comparison)

Fortify Priority:	High	**Folder**	High
Kingdom:	Code Quality		
Abstract:	The call to equals() on line 987 causes portability problems because it has different locales which may lead to unexpected output. This may also circumvent custom validation routines.		

Sink: HL7ServiceImpl.java:987 equals(precision) : Comparison without checking locale()

```
985    log.debug("The birthdate is estimated: " + precision);
986
987    if ("Y".equals(precision) || "L".equals(precision)) {
988     person.setBirthdateEstimated(true);
989    }
```

Category: Key Management: Hardcoded Encryption Key (3 Issues)



Abstract:

Hardcoded encryption keys may compromise system security in a way that cannot be easily remedied.

Explanation:

It is never a good idea to hardcode an encryption key because it allows all of the project's developers to view the encryption key, and makes fixing the problem extremely difficult. Once the code is in production, the encryption key cannot be changed without patching the software. If the account that is protected by the encryption key is compromised, the owners of the system will be forced to choose between security and availability.

Example 1: The following code uses a hardcoded encryption key:

```
...
private static final String encryptionKey = "lakdsljkalkjlksdfkl";
byte[] keyBytes = encryptionKey.getBytes();
SecretKeySpec key = new SecretKeySpec(keyBytes, "AES");
Cipher encryptCipher = Cipher.getInstance("AES");
encryptCipher.init(Cipher.ENCRYPT_MODE, key);
...
```

Anyone who has access to the code will have access to the encryption key. Once the application has shipped, there is no way to change the encryption key unless the program is patched. An employee with access to this information could use it to break into the system. Even worse, if attackers had access to the executable for the application, they could extract the encryption key value.

Recommendations:

Encryption keys should never be hardcoded and should be obfuscated and managed in an external source. Storing encryption keys in plain text anywhere on the system allows anyone with sufficient permissions to read and potentially misuse the encryption key.

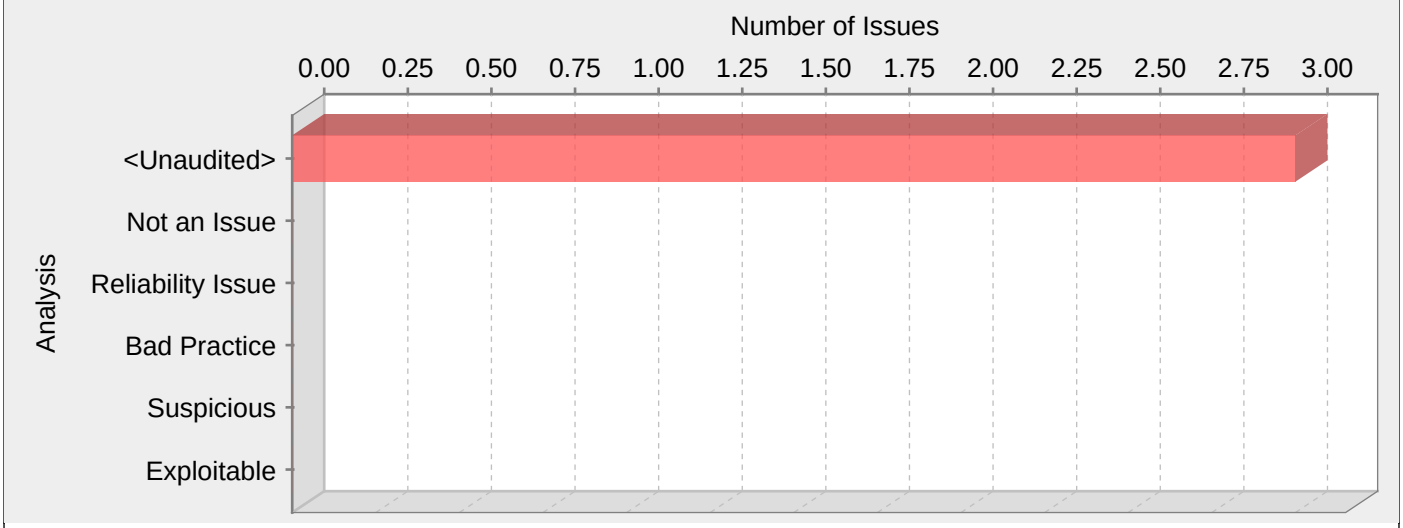
OpenmrsConstants.java, line 528 (Key Management: Hardcoded Encryption Key)

Fortify Priority:	High	**Folder**	High
Kingdom:	Security Features		
Abstract:	Hardcoded encryption keys may compromise system security in a way that cannot be easily remedied.		

Sink: OpenmrsConstants.java:528 FieldAccess: ENCRYPTION_KEY_SPEC()

```
526  public static final String ENCRYPTION_CIPHER_CONFIGURATION = "AES/CBC/PKCS5Padding";
527
528  public static final String ENCRYPTION_KEY_SPEC = "AES";
529
530  public static final String ENCRYPTION_VECTOR_RUNTIME_PROPERTY = "encryption.vector";
```

Category: Unreleased Resource: Files (3 Issues)



Abstract:

The function getResourceFromApi_shouldLoadFileFromApiAsInputStream() in ModuleUtilTest.java sometimes fails to release a file handle allocated by loadModuleJarFile() on line 582.

Explanation:

The program can potentially fail to release a file handle.

Resource leaks have at least two common causes:

- Error conditions and other exceptional circumstances.

- Confusion over which part of the program is responsible for releasing the resource.

Most unreleased resource issues result in general software reliability problems, but if an attacker can intentionally trigger a resource leak, the attacker may be able to launch a denial of service attack by depleting the resource pool.

Example 1: The following method never closes the file handle it opens. The finalize() method for ZipFile eventually calls close(), but there is no guarantee as to how long it will take before the finalize() method will be invoked. In a busy environment, this can result in the JVM using up all of its file handles.

```
public void printZipContents(String fName)
throws ZipException, IOException, SecurityException, IllegalStateException, NoSuchElementException
{
ZipFile zf = new ZipFile(fName);
Enumeration<ZipEntry> e = zf.entries();
while (e.hasMoreElements()) {
printFileInfo(e.nextElement());
}
}
```

Example 2: Under normal conditions, the following fix properly closes the file handle after printing out all the zip file entries. But if an exception occurs while iterating through the entries, the zip file handle will not be closed. If this happens often enough, the JVM can still run out of available file handles.

```
public void printZipContents(String fName)
throws ZipException, IOException, SecurityException, IllegalStateException, NoSuchElementException
{
ZipFile zf = new ZipFile(fName);
Enumeration<ZipEntry> e = zf.entries();
while (e.hasMoreElements()) {
printFileInfo(e.nextElement());
}
}
```

Recommendations:

1. Never rely on finalize() to reclaim resources. In order for an object's finalize() method to be invoked, the garbage collector must determine that the object is eligible for garbage collection. Because the garbage collector is not required to run unless the JVM is low on memory, there is no guarantee that an object's finalize() method will be invoked in an expedient fashion. When the garbage collector finally does run, it may cause a large number of resources to be reclaimed in a short period of time, which can lead to "bursty" performance and lower overall system throughput. This effect becomes more pronounced as the load on the system increases.

Finally, if it is possible for a resource reclamation operation to hang (if it requires communicating over a network, for example), then the thread that is executing the finalize() method will hang.

2. Release resources in a finally block. The code for Example 2 should be rewritten as follows:

```
public void printZipContents(String fName)
throws ZipException, IOException, SecurityException, IllegalStateException, NoSuchElementException
{
ZipFile zf;
try {
zf = new ZipFile(fName);
Enumeration<ZipEntry> e = zf.entries();
...
}
finally {
if (zf != null) {
safeClose(zf);
}
}
}

public static void safeClose(ZipFile zf) {
if (zf != null) {
try {
zf.close();
} catch (IOException e) {
log(e);
}
}
}
```

This solution uses a helper function to log the exceptions that might occur when trying to close the file. Presumably this helper function will be reused whenever a file needs to be closed.

Also, the printZipContents method does not initialize the zf object to null. Instead, it checks to ensure that zf is not null before calling safeClose(). Without the null check, the Java compiler reports that zf might not be initialized. This choice takes advantage of Java's ability to detect uninitialized variables. If zf is initialized to null in a more complex method, cases in which zf is used without being initialized will not be detected by the compiler.

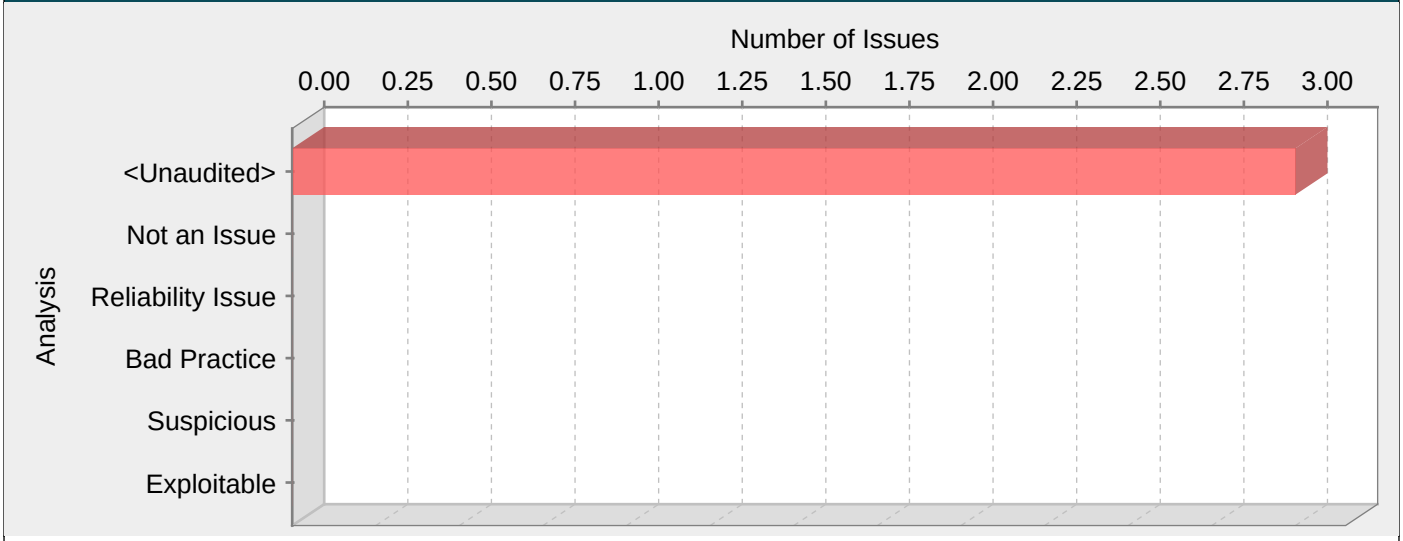
ModuleUtilTest.java, line 582 (Unreleased Resource: Files)

Fortify Priority:	High	**Folder**	High
Kingdom:	Code Quality		
Abstract:	The function getResourceFromApi_shouldLoadFileFromApiAsInputStream() in ModuleUtilTest.java sometimes fails to release a file handle allocated by loadModuleJarFile() on line 582.		

Sink: ModuleUtilTest.java:582 moduleJarFile = loadModuleJarFile(...)

```
580   String version = "1.0-SNAPSHOT";
581   String resource = "messages.properties";
582   JarFile moduleJarFile = loadModuleJarFile(moduleId, version);
583   Assert.assertNotNull(moduleJarFile);
584   InputStream resultStream = ModuleUtil.getResourceFromApi(moduleJarFile, moduleId,
version, resource);
```

Category: Weak SecurityManager Check: Overridable Method (3 Issues)



Abstract:

Non-final methods that perform security checks may be overridden in ways that bypass security checks.

Explanation:

If a method is overridden by a child class, the child class can bypass security checks in the parent class.

Example 1: In the following code, doSecurityCheck() performs a security check and can be overridden by a child class.

```
public class BadSecurityCheck {
private int id;

public BadSecurityCheck() {
doSecurityCheck();
id = 1;
}
protected void doSecurityCheck() {
SecurityManager sm = System.getSecurityManager();
if (sm != null) {
sm.checkPermission(new SomePermission("SomeAction"));
}
}
}
```

In this example, if the SecurityManager permission is not allowed, a SecurityException exception will be thrown, which is a runtime exception and will stop the program from executing any further. Since BadSecurityCheck is not final, and the method doSecurityCheck() is protected and not final, it means that this class can be subclassed to override this function.

Example 2: In the following code, doSecurityCheck() is overridden by a subclass:

```
public class EvilSubclass extends BadSecurityCheck {
private int id;

public EvilSubclass() {
super();
}
protected void doSecurityCheck() {
//do nothing
}
}
```

When EvilSubclass is instantiated, the constructor first calls super(), to invoke the constructor of the superclass. This in turn calls the function doSecurityCheck(), but Java will first look for the function within the subclass prior to looking in the superclass, thus invoking the attacker controlled method that bypasses the security check, so id will still be set to 1.

This category was derived from the Cigital Java Rulepack. http://www.cigital.com/

Recommendations:

Make sure any methods that perform security operations (e.g. methods from SecurityManager or AccessController) are declared in final classes or the methods themselves are declared final.

Example 2: The following code declared the class GoodSecurityCheck as final so none of its methods can be overridden.

```
public final class GoodSecurityCheck {
private int id;

public GoodSecurityCheck() {
doSecurityCheck();
id = 1;
}

void doSecurityCheck() {
SecurityManager sm = System.getSecurityManager();
if (sm != null) {
sm.checkPermission(new SomePermission("SomeAction"));
}
}
}
```

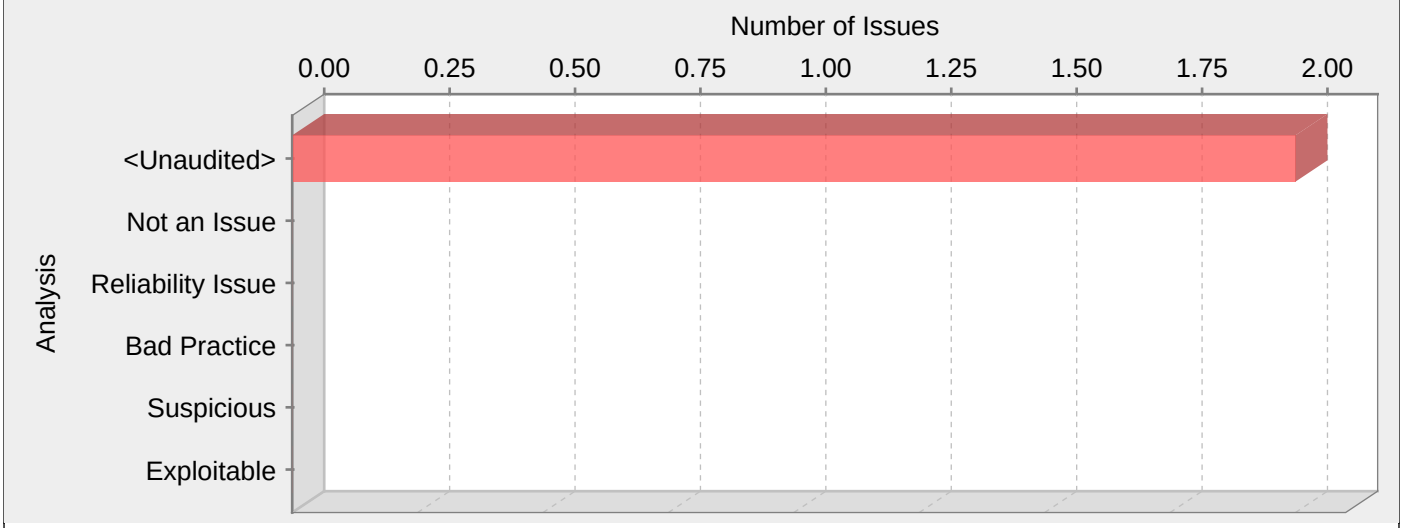
OpenmrsSecurityManager.java, line 32 (Weak SecurityManager Check: Overridable Method)

Fortify Priority:	High	**Folder**	High
Kingdom:	Security Features		
Abstract:	Non-final methods that perform security checks may be overridden in ways that bypass security checks.		

Sink: OpenmrsSecurityManager.java:32 Function: getCallerClass()

```
30    * @should throw an error if given a subzero call stack level
31    */
32   public Class<?> getCallerClass(int callStackDepth) {
33    if (callStackDepth < 0) {
34     throw new APIException("call.stack.depth.error", (Object[]) null);
```

Category: Code Correctness: Double-Checked Locking (2 Issues)



Abstract:

The method getServiceContext() in Context.java relies on double-checked locking, an incorrect idiom that does not achieve the intended effect.

Explanation:

Many talented individuals have spent a great deal of time pondering ways to make double-checked locking work in order to improve performance. None have succeeded.

Example 1: At first blush it may seem that the following bit of code achieves thread safety while avoiding unnecessary synchronization.

```
if (fitz == null) {
synchronized (this) {
if (fitz == null) {
fitz = new Fitzer();
}
}
}
return fitz;
```

The programmer wants to guarantee that only one Fitzer() object is ever allocated, but does not want to pay the cost of synchronization every time this code is called. This idiom is known as double-checked locking.

Unfortunately, it does not work, and multiple Fitzer() objects can be allocated. See The "Double-Checked Locking is Broken" Declaration for more details [1].

Recommendations:

Synchronization is probably less expensive than you believe. In many cases, the best thing to do is to use the most straightforward solution.

Example 2: The code in Example 1 could be rewritten in the following way:

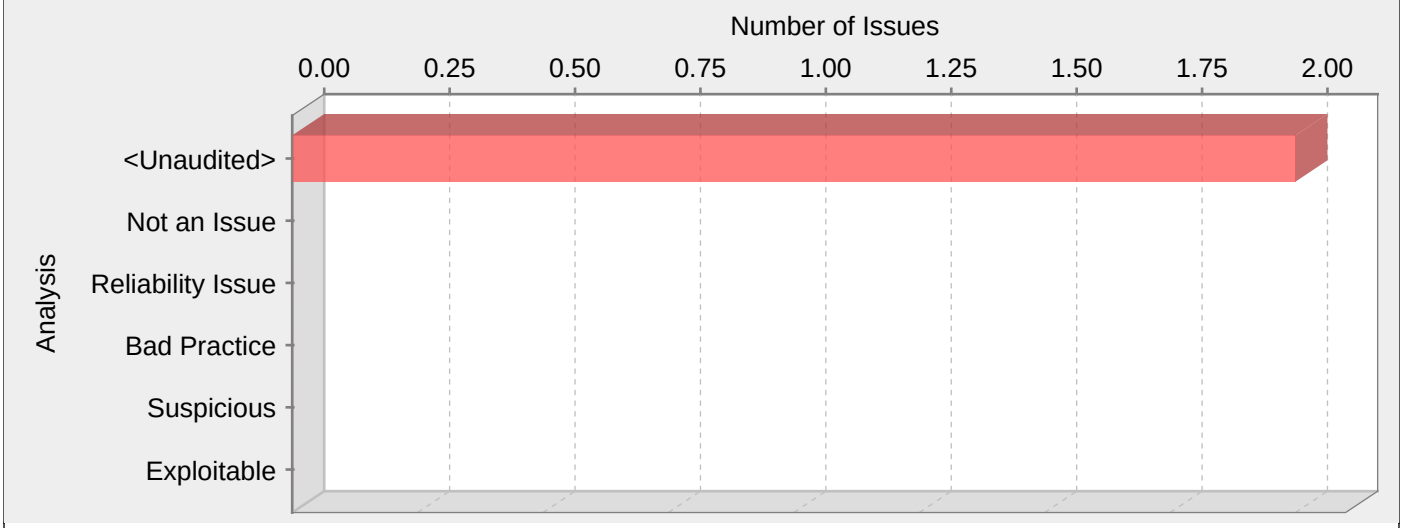
```
synchronized (this) {
if (fitz == null) {
fitz = new Fitzer();
}
return fitz;
}
```

Context.java, line 252 (Code Correctness: Double-Checked Locking)

Fortify Priority:	High	**Folder**	High
Kingdom:	Time and State		
Abstract:	The method getServiceContext() in Context.java relies on double-checked locking, an incorrect idiom that does not achieve the intended effect.		
Sink:	Context.java:252 IfStatement()		
250	`if (serviceContext == null) {`		

```
251                     synchronized (Context.class) {
252                      if (serviceContext == null) {
253                       log.error("serviceContext is null.  Creating new ServiceContext()");
254                       serviceContext = ServiceContext.getInstance();
```

Category: Dynamic Code Evaluation: Unsafe Deserialization (2 Issues)



Abstract:

Deserializing user-controlled object streams at runtime can allow attackers to execute arbitrary code on the server, abuse application logic, and/or lead to denial of service.

Explanation:

Java serialization turns object graphs into byte streams that contain the objects themselves and the necessary metadata to reconstruct them from the byte stream. Developers can create custom code to aid in the process of deserializing Java objects, where they can replace the deserialized objects with different objects, or proxies. The customized deserialization process takes place during objects reconstruction, before the objects are returned to the application and cast into expected types. By the time developers try to enforce an expected type, code may have already been executed.

Custom deserialization routines are defined in the serializable classes which need to be present in the runtime classpath and cannot be injected by the attacker so the exploitability of these attacks depends on the classes available in the application environment. Unfortunately, common third party classes or even JDK classes can be abused to exhaust JVM resources, deploy malicious files, or run arbitrary code.

Example 1: An application deserializing untrusted object streams can lead to application compromise.

```
InputStream is = request.getInputStream();
ObjectInputStream ois = new ObjectInputStream(is);
MyObject obj = (MyObject) ois.readObject();
```

Recommendations:

If possible, do not deserialize untrusted data without validating the contents of the object stream. In order to validate classes being deserialized, the look-ahead deserialization pattern should be used.

The object stream will first contain the class description metadata and then the serialized bytes of their member fields. The Java serialization process allows developers to read the class description and decide whether to proceed with the deserialization of the object or abort it. In order to do so, it is necessary to subclass java.io.ObjectInputStream and provide a custom implementation of the resolveClass(ObjectStreamClass desc) method where class validation and verification should take place.

There are existing implementations of the look-ahead pattern that can be easily used, such as the Apache Commons IO (org.apache.commons.io.serialization.ValidatingObjectInputStream). Always use a strict whitelist approach to only deserialize expected types. A blacklist approach is not recommended since attackers may use many available gadgets to bypass the blacklist. Also, keep in mind that although some classes to achieve code execution are publicly known, there may be others that are unknown or undisclosed, so a whitelist approach will always be preferred. Any class allowed in the whitelist should be audited to make sure it is safe to deserialize.

When deserialization takes place in library, or framework (e.g. when using JMX, RMI, JMS, HTTP Invokers) the above recommendation is not useful since it is beyond the developer's control. In those cases, you may want to make sure that these protocols meet the following requirements:

- Not exposed publicly.
- Use authentication.
- Use integrity checks.
- Use encryption.

In addition, Fortify Runtime provides security controls to be enforced every time the application performs a deserialization from an ObjectInputStream, protecting both application code but also library and framework code from this type of attack.

Tips:

1. Due to existing flaw in ObjectInputStream implementation and the difficulties of blacklisting basic classes that may be used to perform Denial Of Service (DoS) attacks, this issue will be reported even if a look-ahead ObjectInputStream is implemented but its severity will be lowered to Medium.

JavaSerializationTest.java, line 48 (Dynamic Code Evaluation: Unsafe Deserialization)			
Fortify Priority:	High	**Folder**	High
Kingdom:	Input Validation and Representation		
Abstract:	Deserializing user-controlled object streams at runtime can allow attackers to execute arbitrary code on the server, abuse application logic, and/or lead to denial of service.		
Sink:	JavaSerializationTest.java:48 FunctionCall: deserialize()		

```
46
47                  byte[] serialized = SerializationUtils.serialize(originalPerson);
48                  Person copyPerson = (Person) SerializationUtils.deserialize(serialized);
49
50                  assertThat(copyPerson.getGender(), is(originalPerson.getGender()));
```

Category: Insecure Randomness: Hardcoded Seed (1 Issues)

Abstract:

The function getPatients_shouldFindPatientsEfficiently() in PatientDAOTest.java is passed a constant value for the seed. Functions that generate random or pseudorandom values, which are passed a seed, should not be called with a constant argument.

Explanation:

Functions that generate random or pseudorandom values, which are passed a seed, should not be called with a constant argument. If a pseudorandom number generator (such as Random) is seeded with a specific value (using a function such as Random.setSeed()), the values returned by Random.nextInt() and similar methods which return or assign values are predictable for an attacker that can collect a number of PRNG outputs.

Example 1: Below, the values produced by the Random object s are predictable from the Random object r.

```
Random r = new Random();
r.setSeed(12345);
int i = r.nextInt();
byte[] b = new byte[4];
r.nextBytes(b);

Random s = new Random();
s.setSeed(12345);
int j = s.nextInt();
byte[] c = new byte[4];
s.nextBytes(c);
```

In this example, pseudorandom number generators: r and s were identically seeded, so i == j, and corresponding values of arrays b[] and c[] are equal.

This finding is from research found in "An Empirical Study of Cryptographic Misuse in Android Applications". http://www.cs.ucsb.edu/~chris/research/doc/ccs13_cryptolint.pdf

Recommendations:

Use a cryptographic PRNG seeded with hardware-based sources of randomness, such as ring oscillators, disk drive timing, thermal noise, or radioactive decay. Doing so makes the sequence of data produced by Random.nextInt() and similar methods much harder to predict than setting the seed to a constant.

PatientDAOTest.java, line 2336 (Insecure Randomness: Hardcoded Seed)

Fortify Priority:	High	**Folder**	High
Kingdom:	Security Features		
Abstract:	The function getPatients_shouldFindPatientsEfficiently() in PatientDAOTest.java is passed a constant value for the seed. Functions that generate random or pseudorandom values, which are passed a seed, should not be called with a constant argument.		
Sink:	PatientDAOTest.java:2336 Random()		

```
2334
2335          Location location = locationService.getLocation(1);
2336          Random random = new Random(100); //set the seed to have repeatable results
```

```
2337                    List<String> generatedPatients = new ArrayList<>();
2338                    for (int i = 0; i < 20000; i++) {
```

Category: Path Manipulation: Zip Entry Overwrite (1 Issues)

Abstract:

The call to FileOutputStream() at ModuleUtil.java line 634, enables an attacker to arbitrarily write to a file anywhere on the system.

Explanation:

Path Manipulation: ZIP Entry Overwrite errors occur when a ZIP file is opened and expanded without checking the file path of the ZIP entry.

Example 1: The following example extracts files from a ZIP file and insecurely writes them to disk.

```
private static final int BUFSIZE = 512;
private static final int TOOBIG = 0x640000;
...
public final void unzip(String filename) throws IOException {
FileInputStream fis = new FileInputStream(filename);
ZipInputStream zis = new ZipInputStream(new BufferedInputStream(fis));
ZipEntry zipEntry = null;

int numOfEntries = 0;
long total = 0;

try {
while ((zipEntry = zis.getNextEntry()) != null) {
byte data[] = new byte[BUFSIZE];
int count = 0;
String outFileName = zipEntry.getName();
if (zipEntry.isDirectory()){
new File(outFileName).mkdir(); //create the new directory
continue;
}
FileOutputStream outFile = new FileOutputStream(outFileName);
BufferedOutputStream dest = new BufferedOutputStream(outFile, BUFSIZE);
//read data from ZIP, but do not read huge entries
while (total + BUFSIZE <= TOOBIG && (count = zis.read(data, 0, BUFSIZE)) != -1) {
dest.write(data, 0, count);
total += count;
}
...
}
} finally{
zis.close();
}
}
```

```
...
```

In the above example, there is no validation of zipEntry.getName() prior to performing read/write functions on the data within this entry. If the ZIP file was originally placed in the directory "/tmp/" of a Unix-based machine, a ZIP entry was "../etc/hosts", and the application was run under the necessary permissions, it would overwrite the system hosts file. This in turn would allow traffic from the machine to go anywhere the attacker wants, such as back to the attacker's machine.

Recommendations:

The best way to prevent path manipulation via a ZIP file is with a level of indirection. Create a list of legitimate path names to which a ZIP entry can write, and write to the file that matches the ZIP entry location. With this approach, the user input in the ZIP file is never used directly to specify the file location.

This may be impractical in this example. Programmers often resort to blacklisting in these situations. Blacklisting selectively rejects or escapes potentially dangerous characters before using the input. However, any such list of unsafe characters is likely to be incomplete and will almost certainly become out-of-date. A better approach is to create a whitelist of characters that are allowed to appear in the resource name and accept input composed exclusively of characters in the approved set.

In this case, APIs such as java.io.File.getCanonicalPath() can be used to retrieve the canonicalized form of the file path, which can be used for checking the directory in which the file will be written.

Example 2: The following is a utility function used to check that a file name to be created is within a programmer-specified directory.

```
public class MyFileUtils{
...
public static validateFilenameInDir(String filename, String intendedDirectory) throws IOException{
File checkFile = new File(filename);
String canonicalPathToCheck = checkFile.getCanonicalPath();

File intendedDir = new File(intendedDirectory);
String canonicalPathToVerify = intendedDir.getCanonicalPath();

if (canonicalPathToCheck.startsWith(canonicalPathToVerify)){
return canonicalPathToCheck;
} else{
throw new IllegalStateException("This file is outside the intended extraction directory.");
}
}
...
}
```

Example 3: The following uses Example 2 above to fix Example 1.

```
private static final int BUFSIZE = 512;
private static final int TOOBIG = 0x640000;
...
public final void unzip(String filename) throws IOException {
FileInputStream fis = new FileInputStream(filename);
ZipInputStream zis = new ZipInputStream(new BufferedInputStream(fis));
ZipEntry zipEntry = null;

int numOfEntries = 0;
long total = 0;

try {
while ((zipEntry = zis.getNextEntry()) != null) {
byte data[] = new byte[BUFSIZE];
int count = 0;

// verify that the file to be written to is located in the current directory
String outFileName = MyFileUtils.validateFilenameInDir(zipEntry.getName(), ".");

if (zipEntry.isDirectory()) {
new File(outFileName).mkdir(); //create the new directory
continue;
}
```

```
FileOutputStream outFile = new FileOutputStream(outFileName);
BufferedOutputStream dest = new BufferedOutputStream(outFile, BUFSIZE);
//read data from ZIP, but do not read huge entries
while (total + BUFSIZE <= TOOBIG && (count = zis.read(data, 0, BUFSIZE)) != -1) {
dest.write(data, 0, count);
total += count;
}
...
}
} finally {
zis.close();
}
}
...
```

ModuleUtil.java, line 634 (Path Manipulation: Zip Entry Overwrite)

Fortify Priority:	High	**Folder**	High
Kingdom:	Input Validation and Representation		
Abstract:	The call to FileOutputStream() at ModuleUtil.java line 634, enables an attacker to arbitrarily write to a file anywhere on the system.		

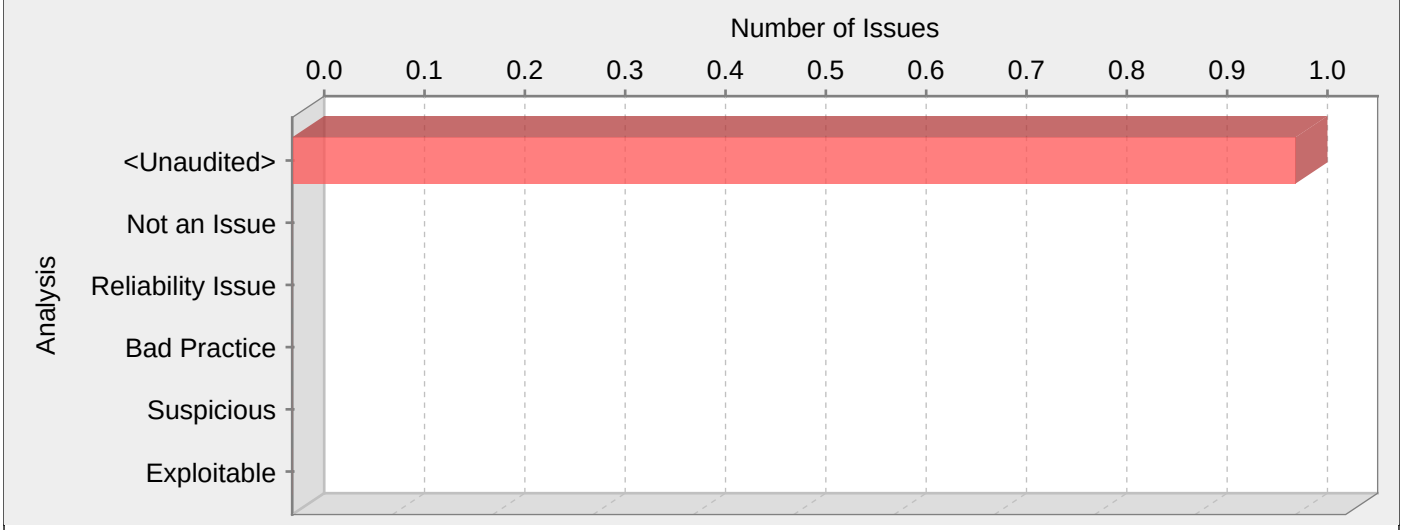
Source: ModuleUtil.java:570 java.util.zip.ZipEntry.getName()

```
568     JarEntry jarEntry = jarEntries.nextElement();
569     if (name == null || jarEntry.getName().startsWith(name)) {
570      String entryName = jarEntry.getName();
571      // trim out the name path from the name of the new file
572      if (!keepFullPath && name != null) {
```

Sink: ModuleUtil.java:634 java.io.FileOutputStream.FileOutputStream()

```
632   FileOutputStream outStream = null;
633   try {
634    outStream = new FileOutputStream(file);
635    OpenmrsUtil.copyFile(input, outStream);
636   }
```

Category: Server-Side Request Forgery (1 Issues)



Abstract:

The function openConnection() on line 714 initiates a network connection to a third-party system using user-controlled data for resource URI. An attacker may leverage this vulnerability to send a request on behalf of the application server since the request will originate from the application server's internal IP address.

Explanation:

A Server-Side Request Forgery occurs when an attacker may influence a network connection made by the application server. The network connection will originate from the application server's internal IP and an attacker will be able to use this connection to bypass network controls and scan or attack internal resources that are not otherwise exposed.

Example: In the following example, an attacker will be able to control the URL the server is connecting to.

```
String url = request.getParameter("url");
CloseableHttpClient httpclient = HttpClients.createDefault();
HttpGet httpGet = new HttpGet(url);
CloseableHttpResponse response1 = httpclient.execute(httpGet);
```

The attacker's ability to hijack the network connection will depend upon the specific part of the URI that can be controlled, and upon libraries used to establish the connection. For example, controlling the URI scheme will let the attacker use protocols different from http or https like:

- up://
- ldap://
- jar://
- gopher://
- mailto://
- ssh2://
- telnet://
- expect://

An attacker will be able to leverage this hijacked network connection to perform the following attacks:

- Port Scanning of intranet resources.
- Bypass firewalls.
- Attack vulnerable programs running on the application server or on the intranet.
- Attack internal/external web applications using Injection attacks or CSRF.
- Access local files using file:// scheme.
- On Windows systems, file:// scheme and UNC paths can allow an attacker to scan and access internal shares.
- Perform a DNS cache poisoning attack.

Recommendations:

Do not establish network connections based on user-controlled data and ensure that the request is being sent to the expected destination. If user data is necessary to build the destination URI, use a level of indirection: create a list of legitimate resource names that a user is allowed to specify, and only allow the user to select from the list. With this approach the input provided by the user is never used directly to specify the resource name.

In some situations this approach is impractical because the set of legitimate resource names is too large or too hard to keep track of. Programmers often resort to blacklisting in these situations. Blacklisting selectively rejects or escapes potentially dangerous characters before using the input. However, any such list of unsafe characters is likely to be incomplete and will almost certainly become out of date. A better approach is to create a whitelist of characters that are allowed to appear in the resource name and accept input composed exclusively of characters in the approved set.

Also, if required, make sure that the user input is only used to specify a resource on the target system but that the URI scheme, host, and port is controlled by the application. This way the damage that an attacker is able to do will be significantly reduced.

ModuleUtil.java, line 714 (Server-Side Request Forgery)

Fortify Priority:	High	**Folder**	High
Kingdom:	Input Validation and Representation		
Abstract:	The function openConnection() on line 714 initiates a network connection to a third-party system using user-controlled data for resource URI. An attacker may leverage this vulnerability to send a request on behalf of the application server since the request will originate from the application server's internal IP address.		

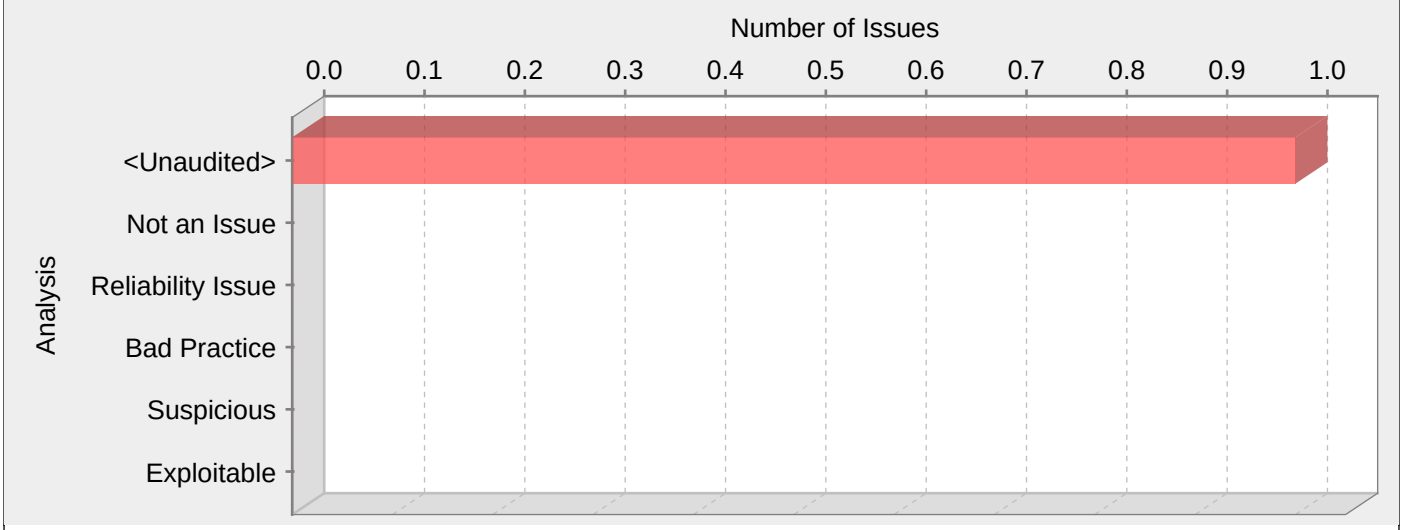
Source: ModuleUtil.java:701 java.net.URLConnection.getHeaderField()

```
699     if (stat == 300 || stat == 301 || stat == 302 || stat == 303 || stat == 305 || stat == 307) {
700       URL base = http.getURL();
701       String loc = http.getHeaderField("Location");
702       URL target = null;
703       if (loc != null) {
```

Sink: ModuleUtil.java:714 java.net.URL.openConnection()

```
712       }
713       redir = true;
714       c = target.openConnection();
715       redirects++;
716     }
```

Category: Server-Side Template Injection (1 Issues)



Abstract:

The call to evaluate() in VelocityMessagePreparator.java on line 60 evaluates user-controlled data as a template engine's template, allowing attackers to access the template context and in some cases inject and run arbitrary code on the application server.

Explanation:

Template engines are used to render content using dynamic data. This context data is normally controlled by the user and formatted by the template to generate web pages, emails and the like. Template engines allow powerful language expressions to be used in templates in order to render dynamic content, by processing the context data with code constructs such as conditionals, loops, etc. If an attacker is able to control the template to be rendered, they will be able to inject expressions that will expose context data or even run arbitrary commands on the server.

Example 1: The example below shows how a template is retrieved from an HTTP request and rendered.

```
// Set up the context data
VelocityContext context = new VelocityContext();
context.put( "name", user.name );

// Load the template
String template = getUserTemplateFromRequestBody(request);
RuntimeServices runtimeServices = RuntimeSingleton.getRuntimeServices();
StringReader reader = new StringReader(template);
SimpleNode node = runtimeServices.parse(reader, "myTemplate");
template = new Template();
template.setRuntimeServices(runtimeServices);
template.setData(node);
template.initDocument();

// Render the template with the context data
StringWriter sw = new StringWriter();
template.merge( context, sw );
```

The example above uses Velocity as the template engine. For that engine, an attacker could submit the following template to run arbitrary commands on the server:

```
$name.getClass().forName("java.lang.Runtime").getRuntime().exec(<COMMAND>)
```

Recommendations:

Whenever possible do not allow users to provide templates. If user-provided templates are necessary, perform careful input validation to prevent malicious code from being injected in the template.

VelocityMessagePreparator.java, line 60 (Server-Side Template Injection)

Fortify Priority:	Critical	**Folder**	Critical
Kingdom:	Input Validation and Representation		

Abstract:	The call to evaluate() in VelocityMessagePreparator.java on line 60 evaluates user-controlled data as a template engine's template, allowing attackers to access the template context and in some cases inject and run arbitrary code on the application server.

Source: HibernateTemplateDAO.java:60 org.hibernate.Query.list()

```
58                log.info("Get template " + name);
59                return sessionFactory.getCurrentSession().createQuery("from Template as template where
template.name = ?")
60                        .setString(0, name).list();
61             }
62
```

Sink: VelocityMessagePreparator.java:60 org.apache.velocity.app.VelocityEngine.evaluate()

```
58                try {
59                 engine.evaluate(context, writer, "template", // I have no idea what this is used for
60                    template.getTemplate());
61                }
62                catch (Exception e) {
```

Category: SQL Injection (1 Issues)

Abstract:

On line 165 of MigrateAllergiesChangeSet.java, the method getConceptByGlobalProperty() invokes a SQL query built using input coming from an untrusted source. This call could allow an attacker to modify the statement's meaning or to execute arbitrary SQL commands.

Explanation:

SQL injection errors occur when:

1. Data enters a program from an untrusted source.

2. The data is used to dynamically construct a SQL query.

Example 1: The following code dynamically constructs and executes a SQL query that searches for items matching a specified name. The query restricts the items displayed to those where the owner matches the user name of the currently-authenticated user.

```
...
String userName = ctx.getAuthenticatedUserName();
String itemName = request.getParameter("itemName");
String query = "SELECT * FROM items WHERE owner = '"
+ userName + "' AND itemname = '"
+ itemName + "'";
ResultSet rs = stmt.execute(query);
...
```

The query that this code intends to execute follows:

```
SELECT * FROM items
WHERE owner = <userName>
AND itemname = <itemName>;
```

However, because the query is constructed dynamically by concatenating a constant base query string and a user input string, the query only behaves correctly if itemName does not contain a single-quote character. If an attacker with the user name wiley enters the string "name' OR 'a'='a" for itemName, then the query becomes the following:

```
SELECT * FROM items
WHERE owner = 'wiley'
AND itemname = 'name' OR 'a'='a';
```

The addition of the OR 'a'='a' condition causes the where clause to always evaluate to true, so the query becomes logically equivalent to the much simpler query:

```
SELECT * FROM items;
```

This simplification of the query allows the attacker to bypass the requirement that the query only return items owned by the authenticated user; the query now returns all entries stored in the items table, regardless of their specified owner.

Example 2: This example examines the effects of a different malicious value passed to the query constructed and executed in Example 1. If an attacker with the user name wiley enters the string "name'; DELETE FROM items; --" for itemName, then the query becomes the following two queries:

```
SELECT * FROM items
WHERE owner = 'wiley'
AND itemname = 'name';

DELETE FROM items;

--'
```

Many database servers, including Microsoft(R) SQL Server 2000, allow multiple SQL statements separated by semicolons to be executed at once. While this attack string results in an error on Oracle and other database servers that do not allow the batch-execution of statements separated by semicolons, on databases that do allow batch execution, this type of attack allows the attacker to execute arbitrary commands against the database.

Notice the trailing pair of hyphens (--), which specifies to most database servers that the remainder of the statement is to be treated as a comment and not executed [4]. In this case the comment character serves to remove the trailing single-quote left over from the modified query. On a database where comments are not allowed to be used in this way, the general attack could still be made effective using a trick similar to the one shown in Example 1. If an attacker enters the string "name'); DELETE FROM items; SELECT * FROM items WHERE 'a'='a", the following three valid statements will be created:

```
SELECT * FROM items
WHERE owner = 'wiley'
AND itemname = 'name';

DELETE FROM items;

SELECT * FROM items WHERE 'a'='a';
```

Some think that in the mobile world, classic web application vulnerabilities, such as SQL injection, do not make sense -- why would the user attack themself? However, keep in mind that the essence of mobile platforms is applications that are downloaded from various sources and run alongside each other on the same device. The likelihood of running a piece of malware next to a banking application is high, which necessitates expanding the attack surface of mobile applications to include inter-process communication.

Example 3: The following code adapts Example 1 to the Android platform.

```
...
PasswordAuthentication pa = authenticator.getPasswordAuthentication();
String userName = pa.getUserName();
String itemName = this.getIntent().getExtras().getString("itemName");
String query = "SELECT * FROM items WHERE owner = '"
+ userName + "' AND itemname = '"
+ itemName + "'";
SQLiteDatabase db = this.openOrCreateDatabase("DB", MODE_PRIVATE, null);
Cursor c = db.rawQuery(query, null);
...
```

One traditional approach to preventing SQL injection attacks is to handle them as an input validation problem and either accept only characters from a whitelist of safe values or identify and escape a blacklist of potentially malicious values. Whitelisting can be a very effective means of enforcing strict input validation rules, but parameterized SQL statements require less maintenance and can offer more guarantees with respect to security. As is almost always the case, blacklisting is riddled with loopholes that make it ineffective at preventing SQL injection attacks. For example, attackers may:

- Target fields that are not quoted
- Find ways to bypass the need for certain escaped meta-characters
- Use stored procedures to hide the injected meta-characters

Manually escaping characters in input to SQL queries can help, but it will not make your application secure from SQL injection attacks.

Another solution commonly proposed for dealing with SQL injection attacks is to use stored procedures. Although stored procedures prevent some types of SQL injection attacks, they fail to protect against many others. Stored procedures typically help prevent SQL injection attacks by limiting the types of statements that can be passed to their parameters. However, there are many ways around the limitations and many interesting statements that can still be passed to stored procedures. Again, stored procedures can prevent some exploits, but they will not make your application secure against SQL injection attacks.

Recommendations:

The root cause of a SQL injection vulnerability is the ability of an attacker to change context in the SQL query, causing a value that the programmer intended to be interpreted as data to be interpreted as a command instead. When a SQL query is constructed, the programmer knows what should be interpreted as part of the command and what should be interpreted as data. Parameterized SQL statements can enforce this behavior by disallowing data-directed context changes and preventing nearly all SQL injection attacks. Parameterized SQL statements are constructed using strings of regular SQL, but where user-supplied data needs to be included, they include bind parameters, which are placeholders for data that is subsequently inserted. In other words, bind parameters allow the programmer to explicitly specify to the database what should be treated as a command and what should be treated as data. When the program is ready to execute a statement, it specifies to the database the runtime values to use for each of the bind parameters without the risk that the data will be interpreted as a modification to the command.

Example 1 can be rewritten to use parameterized SQL statements (instead of concatenating user supplied strings) as follows:

```
...
String userName = ctx.getAuthenticatedUserName();
String itemName = request.getParameter("itemName");
String query = "SELECT * FROM items WHERE itemname=? AND owner=?";
PreparedStatement stmt = conn.prepareStatement(query);
stmt.setString(1, itemName);
stmt.setString(2, userName);
ResultSet results = stmt.execute();
...
```

And here is an Android equivalent:

```
...
PasswordAuthentication pa = authenticator.getPasswordAuthentication();
String userName = pa.getUserName();
String itemName = this.getIntent().getExtras().getString("itemName");
String query = "SELECT * FROM items WHERE itemname=? AND owner=?";
SQLiteDatabase db = this.openOrCreateDatabase("DB", MODE_PRIVATE, null);
Cursor c = db.rawQuery(query, new Object[]{itemName, userName});
...
```

More complicated scenarios, often found in report generation code, require that user input affect the structure of the SQL statement, for instance by adding a dynamic constraint in the WHERE clause. Do not use this requirement to justify concatenating user input to create a query string. Prevent SQL injection attacks where user input must affect command structure with a level of indirection: create a set of legitimate strings that correspond to different elements you might include in a SQL statement. When constructing a statement, use input from the user to select from this set of application-controlled values.

Tips:

1. A common mistake is to use parameterized SQL statements that are constructed by concatenating user-controlled strings. Of course, this defeats the purpose of using parameterized SQL statements. If you are not certain that the strings used to form parameterized statements are constants controlled by the application, do not assume that they are safe because they are not being executed directly as SQL strings. Thoroughly investigate all uses of user-controlled strings in SQL statements and verify that none can be used to modify the meaning of the query.

2. A number of modern web frameworks provide mechanisms for performing validation of user input. Struts and Spring MVC are two examples. To highlight the unvalidated sources of input, the Fortify Secure Coding Rulepacks dynamically re-prioritize the issues reported by Fortify Static Code Analyzer by lowering their probability of exploit and providing pointers to the supporting evidence whenever the framework validation mechanism is in use. We refer to this feature as Context-Sensitive Ranking. To further assist the Fortify user with the auditing process, the Fortify Software Security Research group makes available the Data Validation project template that groups the issues into folders based on the validation mechanism applied to their source of input.

3. Fortify RTA adds protection against this category.

MigrateAllergiesChangeSet.java, line 165 (SQL Injection)

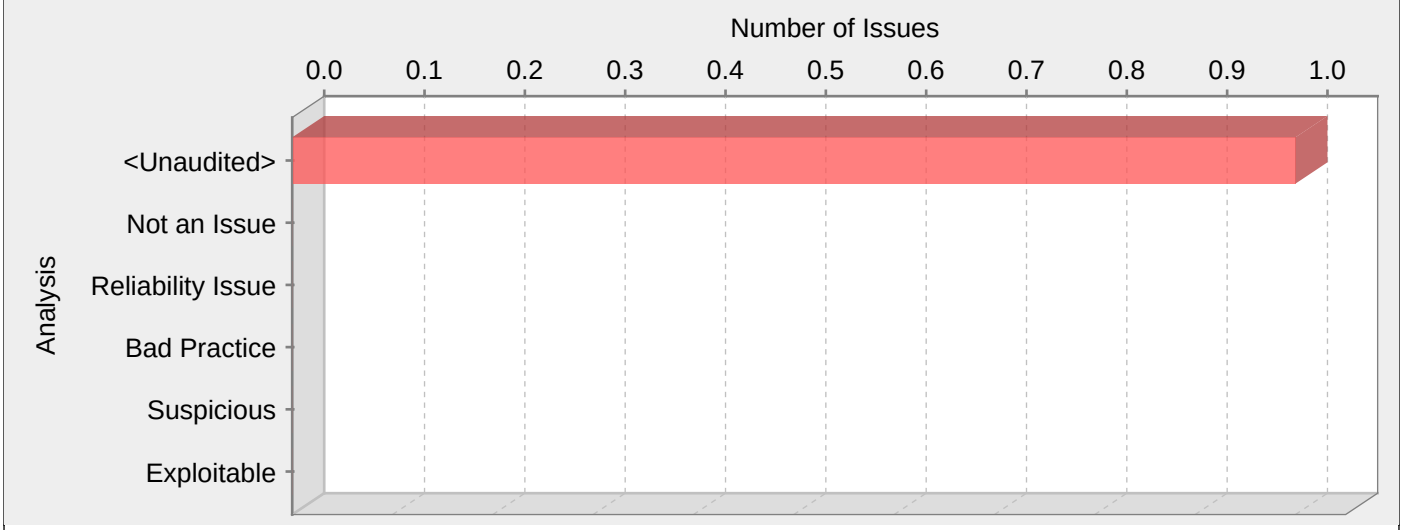
Fortify Priority:	Critical	**Folder**	Critical
Kingdom:	Input Validation and Representation		
Abstract:	On line 165 of MigrateAllergiesChangeSet.java, the method getConceptByGlobalProperty() invokes a SQL query built using input coming from an untrusted source. This call could allow an attacker to modify the statement's meaning or to execute arbitrary SQL commands.		
Source:	MigrateAllergiesChangeSet.java:161 java.sql.PreparedStatement.executeQuery()		

```
159                   PreparedStatement stmt = connection.prepareStatement("SELECT property_value FROM
                    global_property WHERE property = ?");
160                   stmt.setString(1, globalPropertyName);
161                   ResultSet rs = stmt.executeQuery();
162                   if (rs.next()) {
163                    String uuid = rs.getString("property_value");
```

Sink: MigrateAllergiesChangeSet.java:165 java.sql.Statement.executeQuery()

```
163                   String uuid = rs.getString("property_value");
164
165                   rs = stmt.executeQuery("SELECT concept_id FROM concept WHERE uuid = '" + uuid + "'");
166                   if (rs.next()) {
167                    return rs.getInt("concept_id");
```

Category: XML External Entity Injection (1 Issues)



Abstract:

XML parser configured in OpenmrsUtil.java:1177 does not prevent nor limit external entities resolution. This can expose the parser to an XML External Entities attack.

Explanation:

XML External Entities attacks benefit from an XML feature to build documents dynamically at the time of processing. An XML entity allows inclusion of data dynamically from a given resource. External entities allow an XML document to include data from an external URI. Unless configured to do otherwise, external entities force the XML parser to access the resource specified by the URI, e.g., a file on the local machine or on a remote system. This behavior exposes the application to XML External Entity (XXE) attacks, which can be used to perform denial of service of the local system, gain unauthorized access to files on the local machine, scan remote machines, and perform denial of service of remote systems.

The following XML document shows an example of an XXE attack.

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<!DOCTYPE foo [
<!ELEMENT foo ANY >
<!ENTITY xxe SYSTEM "file:///dev/random" >]><foo>&xxe;</foo>
```

This example could crash the server (on a UNIX system), if the XML parser attempts to substitute the entity with the contents of the /dev/random file.

Recommendations:

An XML parser should be configured securely so that it does not allow external entities as part of an incoming XML document.

To avoid XXE injections the following properties should be set for an XML factory, parser or reader:

```
factory.setFeature("http://xml.org/sax/features/external-general-entities", false);
factory.setFeature("http://xml.org/sax/features/external-parameter-entities", false);
```

If inline DOCTYPE declaration is not needed, it can be completely disabled with the following property:

```
factory.setFeature("http://apache.org/xml/features/disallow-doctype-decl", true);
```

To protect a TransformerFactory, the following attribute should be set:

```
TransformerFactory transFact = TransformerFactory.newInstance();
transFact.setAttribute(XMLConstants.ACCESS_EXTERNAL_DTD, "");
Transformer trans = transFact.newTransformer(xsltSource);
trans.transform(xmlSource, result);
```

Alternatively, it is possible to use a securely configured XMLReader to set the transformation sources:

```
XMLReader reader = XMLReaderFactory.createXMLReader();
reader.setFeature("http://xml.org/sax/features/external-general-entities", false);
reader.setFeature("http://xml.org/sax/features/external-parameter-entities", false);
Source xmlSource = new SAXSource(reader, new InputSource(new FileInputStream(xmlFile)));
Source xsltSource = new SAXSource(reader, new InputSource(new FileInputStream(xsltFile)));
Result result = new StreamResult(System.out);
```

TransformerFactory transFact = TransformerFactory.newInstance();
Transformer trans = transFact.newTransformer(xsltSource);
trans.transform(xmlSource, result);

Tips:

1. Fortify RTA adds protection against this category.

OpenmrsUtil.java, line 1177 (XML External Entity Injection)

Fortify Priority:	High	**Folder**	High
Kingdom:	Input Validation and Representation		
Abstract:	XML parser configured in OpenmrsUtil.java:1177 does not prevent nor limit external entities resolution. This can expose the parser to an XML External Entities attack.		
Sink:	OpenmrsUtil.java:1177 tFactory.newTransformer() : XML document parsed allowing external entity resolution()		

```
1175    outStream = new FileOutputStream(outFile);
1176    TransformerFactory tFactory = TransformerFactory.newInstance();
1177    Transformer transformer = tFactory.newTransformer();
1178    transformer.setOutputProperty(OutputKeys.INDENT, "yes");
1179
```

Issue Count by Category

Issues by Category

Poor Error Handling: Overly Broad Throws	633
System Information Leak: Internal	484
Log Forging (debug)	279
Log Forging	258
Access Control: Database	241
Poor Error Handling: Overly Broad Catch	167
Dead Code: Expression is Always false	118
Password Management: Password in Comment	115
Obsolete	111
Poor Error Handling: Empty Catch Block	111
Dead Code: Expression is Always true	95
Path Manipulation	82
Code Correctness: Constructor Invokes Overridable Function	79
Privacy Violation	65
Cross-Site Scripting: Poor Validation	62
System Information Leak	56
Race Condition: Format Flaw	53
Unsafe Reflection	52
Poor Logging Practice: Use of a System Output Stream	50
Unchecked Return Value	47
J2EE Bad Practices: Threads	41
Password Management: Password in Configuration File	38
Poor Style: Value Never Read	37
Null Dereference	35
Missing Check against Null	28
Denial of Service: Regular Expression	24
Password Management: Hardcoded Password	24
Poor Error Handling: Throw Inside Finally	24
Access Specifier Manipulation	22
Unreleased Resource: Streams	22
Redundant Null Check	18
Race Condition: Singleton Member Field	15
Code Correctness: Class Does Not Implement equals	13
Command Injection	13
SQL Injection: Hibernate	13
Code Correctness: Non-Static Inner Class Implements Serializable	11
Insecure Randomness	11
Poor Style: Non-final Public Static Field	11
Dynamic Code Evaluation: Unsafe XStream Deserialization	10
Password Management	10
SQL Injection	9
System Information Leak: External	9
Unreleased Resource: Database	9
Dead Code: Unused Field	8
Code Correctness: Erroneous String Compare	6
Denial of Service: StringBuilder	6
Privacy Violation: Heap Inspection	6
Setting Manipulation	6

Dead Code: Unused Method	5
Denial of Service	5
Often Misused: Authentication	4
Portability Flaw: Locale Dependent Comparison	4
Resource Injection	4
XML Entity Expansion Injection	4
J2EE Bad Practices: getConnection()	3
Key Management: Hardcoded Encryption Key	3
Missing XML Validation	3
Unreleased Resource: Files	3
Weak SecurityManager Check: Overridable Method	3
Build Misconfiguration: External Maven Dependency Repository	2
Code Correctness: Double-Checked Locking	2
Code Correctness: Erroneous Class Compare	2
Code Correctness: null Argument to equals()	2
Dynamic Code Evaluation: Unsafe Deserialization	2
Object Model Violation: Just one of equals() and hashCode() Defined	2
Poor Style: Confusing Naming	2
Weak Cryptographic Hash	2
Code Correctness: Call to Thread.stop()	1
Code Correctness: Comparison of Boxed Primitive Types	1
Insecure Randomness: Hardcoded Seed	1
J2EE Bad Practices: Leftover Debug Code	1
Path Manipulation: Zip Entry Overwrite	1
Poor Error Handling: Program Catches NullPointerException	1
Server-Side Request Forgery	1
Server-Side Template Injection	1
XML External Entity Injection	1

Issue Breakdown by Analysis

Issues by Analysis