Security with AspectJ

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Outline

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   - AspectJ Terminology

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   - Security Requirements
   - Security with AspectJ (with demos)

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   - Discussion
Motivation to AOP

- Modularity in programming languages
  - procedural $\Rightarrow$ object-oriented
- Bad modularity due to crosscutting concerns
  - security, logging, exceptions, database transactions, etc.
- Approach to better modularity (*separation of concerns*)
  - object-oriented $\Rightarrow$ aspect-oriented
Crosscutting Points

Definition

Crosscutting concerns are aspects of a program which affect (crosscut) other concerns and often cannot be cleanly decomposed from the rest of the system in both the design and implementation (from Wikipedia).
Crosscutting Examples

Exceptions

```java
// Create a socket with a timeout
try {
    SocketAddress saddr = new InetSocketAddress("web.de", 80);
    Socket socket = new Socket();
    socket.connect(saddr, 2000); // 2 seconds timeout
} catch (UnknownHostException e) {
} catch (SocketTimeoutException e) {
} catch (IOException e) {
}
```
Crosscutting Examples (cont.)

Authentication

```java
public class Test {
    public void methodOne() {
        if (user.authenticated()) {
            // Log start of the operation
            doBusinessLogic();
            // Log completing of the operation
            // Do exception handling
        }
    }

    public void methodTwo() {
        if (user.authenticated())
            doBusinessLogic();
    }
}
```
Crosscutting Illustration
Aspects

Problem: code tangling and scattering
Solution: separation of concerns
Aspects provide:
- separation of crosscutting concerns
- better reusability
- better code quality
- easy and efficient evolution
After AOP

```java
public class Test {

    public void methodOne() {
        doBusinessLogic();
    }

    public void methodTwo() {
        doBusinessLogic();
    }
}

public aspect TestAspect {
    pointcut p(): call(* Test.method*());

    void around(): p() {
        if (!user.authenticated()) {
            // Authentication check
        } else proceed();
    }
}
```
After AOP (cont.)

Socket Method

```java
public void doSocketConn() {
    SocketAddress saddr = new InetSocketAddress("web.de", 80);
    Socket socket = new Socket();
    socket.connect(saddr, 2000); // 2 seconds timeout
}
```
Exception Handler Aspect for Socket Method

```java
public aspect SocketAspect {

    pointcut pexception(): call(void Socket.connect(..));

    declare soft: java.lang.Exception: pexception();

    void around(): pexception() {
        try {
            proceed();
        } catch (UnknownHostException e) {
        } catch (SocketTimeoutException e) {
        } catch (IOException e) {
        }
    }
}
```
AspectJ

Definition
an aspect-oriented programming extension to Java

History
- **August 1998**: Gregor Kiczales and his team developed this concept at Xerox PARC.
- **December 2002**: Xerox transferred AspectJ to an openly-developed eclipse.org project (www.eclipse.org/aspectj).

Example
"Hello World" AspectJ Example
AspectJ Mechanism

- Java source files (.java)
- Java bytecode (.class)

- Aspect source files (.aj)
- Aspect bytecode (.class)

ajc (weave)

- Modified ByteCode (.class)
AspectJ Terminology

1. Join point
2. Pointcut
3. Advice
4. Aspect
Join Point

Definition

any identifiable execution point in a system

Examples

1. method call/execution
2. constructor call/execution
3. object pre-initialization/initialization
4. read from a variable/write to a variable
5. exception throwing/handler execution
6. advice execution
Join Points in Example

```java
class BankAccount {
    private int account;

    public BankAccount(int account) {
        this.account = account;
    }

    private void increaseAcc(int debit) {
        account += debit;
    }

    public static void main(String[] args) {
        BankAccount bc = new BankAccount(100);
        bc.increaseAcc(50);
    }
}
```
Pointcut

**Definition**
selection of a set of join points

**Pointcut Types**
call, execution, get, set, handler, within, withincode, cflow, cflowbelow, this, target, args, if
Pointcut

Examples

1. `call(void HelloWorld.doTest())`
2. `call(* HelloWorld.doTest*(..))`
3. `execution(* doTest*()) && within(HelloWorld)`
4. `call(HelloWorld.new(..))`
5. `set(int BankAccount.account) || get(int * .account)`
6. `handler(java.io.IOException)`
7. `handler(IOException) && cflow(execution(void doTest()))`
8. `call(void increaseAcc(..)) && target(bc)`
9. `args(String[])`
Advice

Definition

A declaration advising to execute a certain code within a matched pointcut.

Advice Types

1. before
2. around
3. after
   - after
   - after returning
   - after throwing
Aspect

Definition
pointcuts and advices are combined within Aspects

Aspect Features
1. Static structure of a class can be changed
   - add fields, methods, constructors
   - extend parent classes (declare parent)
   - implement an interface
2. Abstract aspects and pointcuts can be defined
3. Introductions are supported (declare soft, declare error, declare warning)
public aspect TracingAspect {

    pointcut ptrace(): call (* *.*(..));

    before(): ptrace() {
        System.out.println(thisJoinPointStaticPart+" Start Time: "+System.currentTimeMillis());
    }

    after(): ptrace() {
        System.out.println(thisJoinPointStaticPart+" End Time: "+System.currentTimeMillis());
    }
}
crosscutting points between classes and aspects are displayed visually in an Eclipse perspective.
Security Requirements

- security belongs to non-functional logic
- separation of security logic from business logic can help better management of security

Requirements

1. Integrity
2. Confidentiality
3. Authentication
Integrity

Definition

the condition in which data are identically maintained during any operation, such as transfer, storage, and retrieval (from Wikipedia)

Problem

- Sensitive data (i.e. messages, files, etc.) can be altered by unauthorized

Solution

- Hash functions (e.g. MD5, SHA1, RIPEMD, etc.)
Integrity and AspectJ

Demo

- Servers should store hash value of passwords, not the clear text.
- For authentication, servers should hash user’s password and compare with the hashed password in the database.
Confidentiality

**Definition**
ensuring that information is accessible only to those authorized to have access \((\text{from IS0})\)

**Problem**
- Confidential data can be sniffed on the wire or accessed on the memory, disk, etc. illegally by unauthorized

**Solution**
- Encryption
  1. Symmetric (e.g. DES, AES, RC4)
  2. Asymmetric (e.g. RSA)
Confidentiality and AspectJ

**Demo**

- Communication over the untrusted networks (e.g. Internet) should be encrypted.
- Use SSL sockets rather than plain sockets for confidential communication.
Authentication with AspectJ

Definition

Verification of the credentials (identity) of a principal/user

Demo

- check credentials before sensitive methods are executed.
Other Aspect Languages

AOP Languages

refer to Wikipedia:
Discussion

- Aspects are great, but ...
- Problems also do exist
  - Unintended weaving can be dangerous.
  - Aspect languages, as *(complicated)* languages, are expected to learn.
  - Aspects should be considered at design time.
Conclusion

- Bad modularity due to crosscutting concerns
- Aspects can separate business and other non-functional logics
- Better security management is possible with AOP
- But aspects should be designed and implemented carefully
Communities


Mailing lists

- AspectJ user mailing list: https://dev.eclipse.org/mailman/listinfo/aspectj-users
- AOSD user mailing list: http://aosd.net/mailman/listinfo/discuss
References and Further Reading II

Tools

- Emacs/AspectJ: http://aspectj4emacs.sourceforge.net
- Other AOP tools:

Books