Introduction to Aspect-Oriented Software Development

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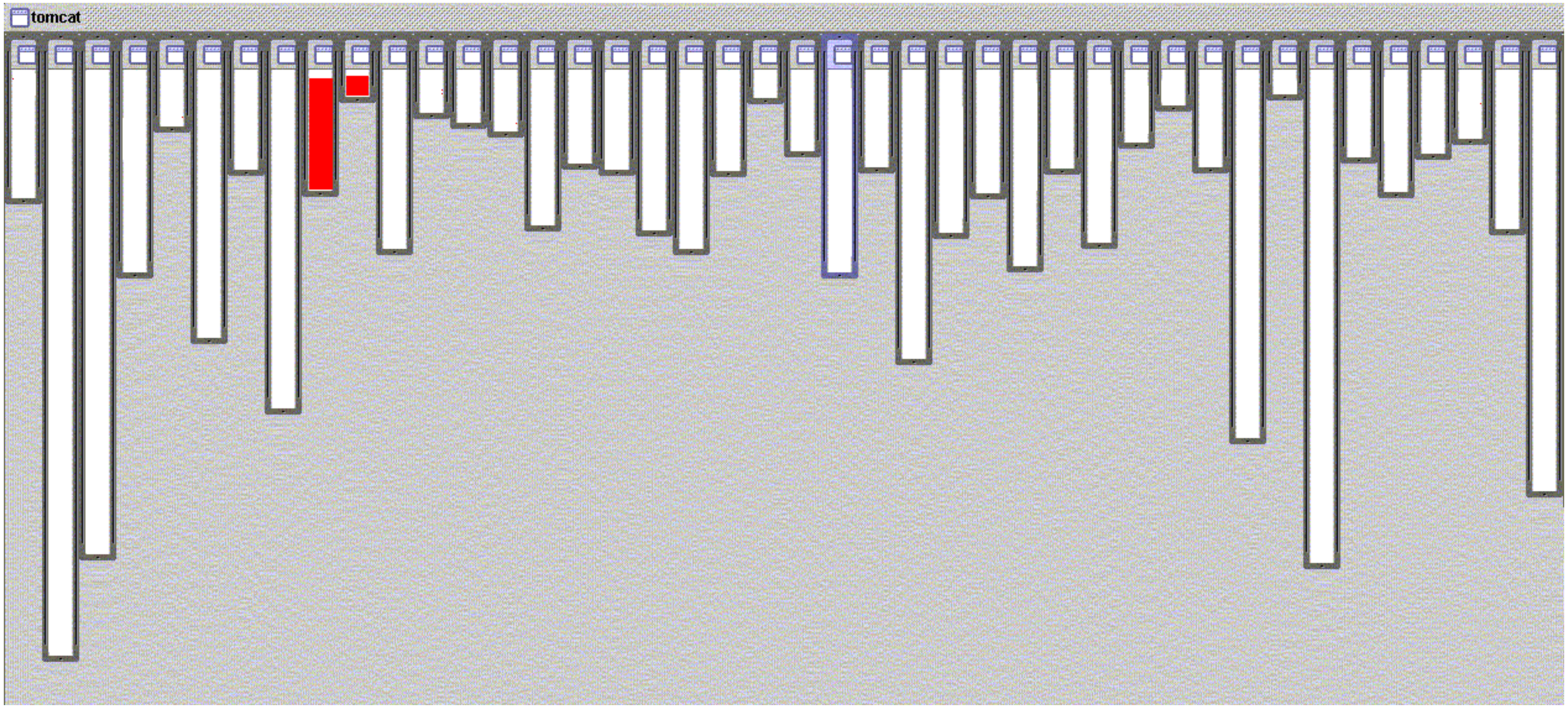
Presentation outline

- Problem: code-tangling
- Concepts of Aspect-Oriented Programming
- AOP Tools
  - AspectJ
- Applications: Design pattern example
- Conclusions

Problem presentation

good modularity

URL pattern matching



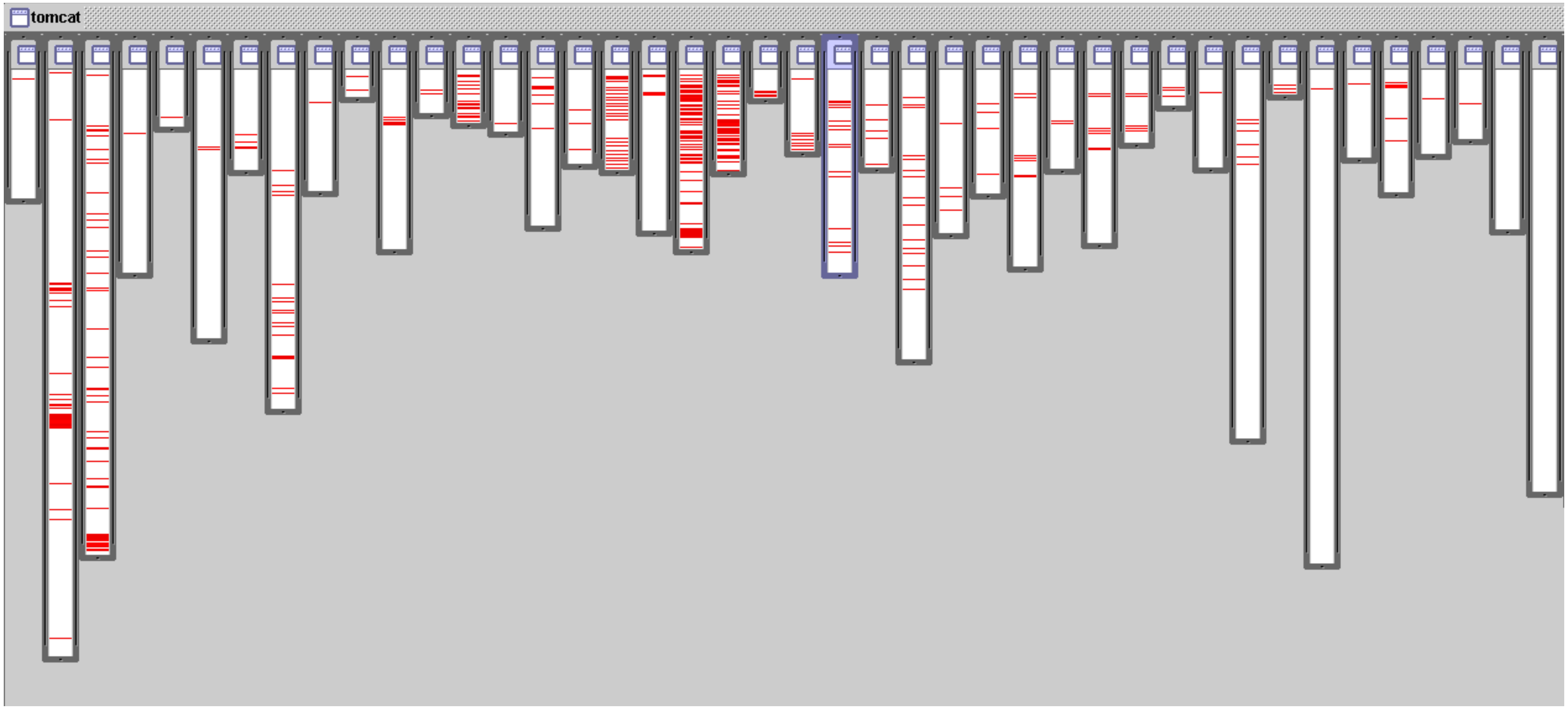
- URL pattern matching in org.apache.tomcat
  - red shows relevant lines of code
  - nicely fits in two boxes (using inheritance)

Source: http://www.eclipse.org/aspectj/teaching.php

aspectj.org

problems like...

logging is not modularized



- logging in org.apache.tomcat
  - red shows lines of code that handle logging
  - not in just one place
  - not even in a small number of places

aspectj.org

Source: http://www.eclipse.org/aspectj/teaching.php

Concepts of Aspect-Oriented Programming

Crosscutting concerns

- **Concern**: *“specific requirement or consideration that must be addressed in order to satisfy the overall system goal”* [Lad03]
- Designing software: separating concerns into units such as procedures, classes, methods, libraries, etc.
- Two concerns **crosscut** each other when their relation implies tangled code.
- **Crosscutting concern**: concern that crosscuts the main purpose of a unit, or that is spanned across multiple units.

Motivation for Aspect-Oriented Programming

- Programming paradigm for encapsulating crosscutting concerns.
- AOP builds on top of other programming paradigms: object-oriented, procedural or functional. It does not supplant them.
- Encapsulate crosscutting concerns into **aspects**.

Concepts of AOP (I)

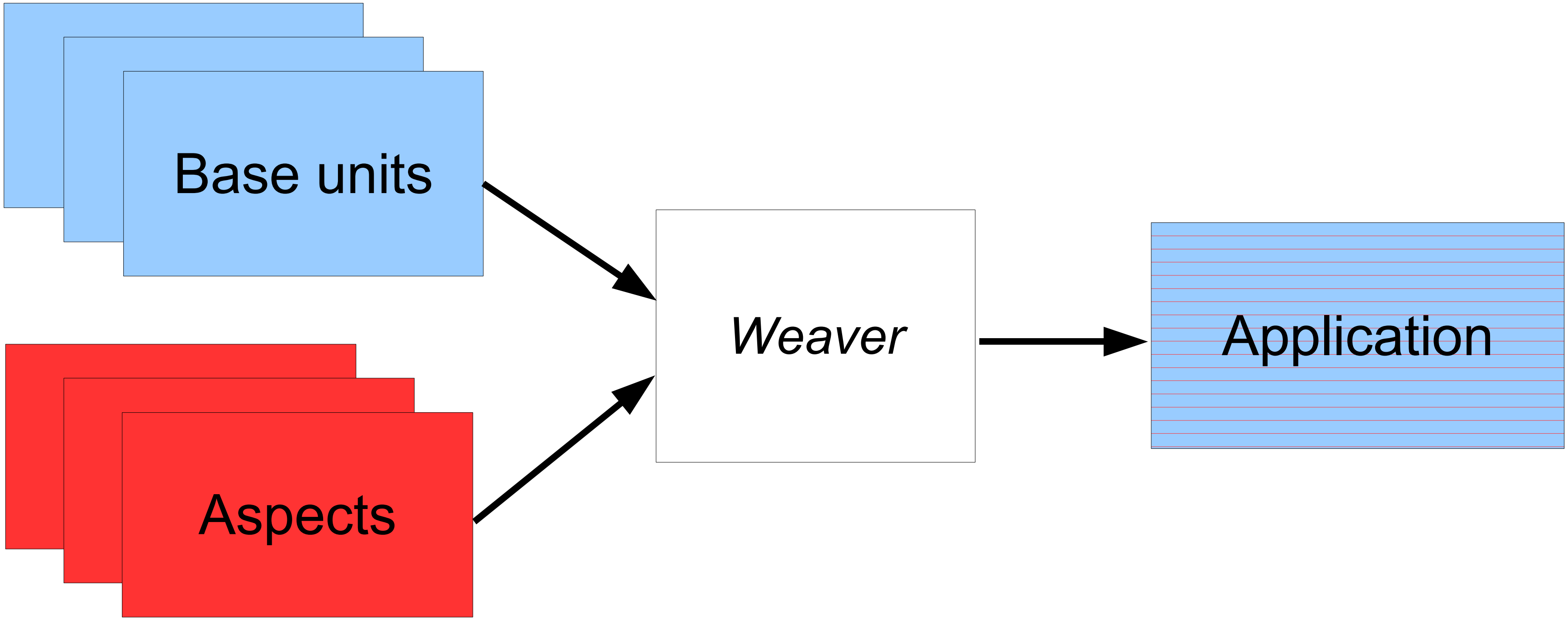
- **Aspect:** unit encapsulating a crosscutting concern.
- **Join point**: point in the execution of a program where an aspect might intervene.
- "*[...] whenever condition C arises, perform action A*" [Fil05]
  - **Pointcut**: expression of a subset of join points (*condition C*)
  - **Advice**: piece of code for *action A*.
  - Pointcuts and advice encapsulated into aspects.

Concepts of AOP (II)

- AOP is not about “patching” pieces of code.
- AOP is about performing an action systematically upon recognition of a behaviour in the code.

Concepts of AOP (III)

- Weaving



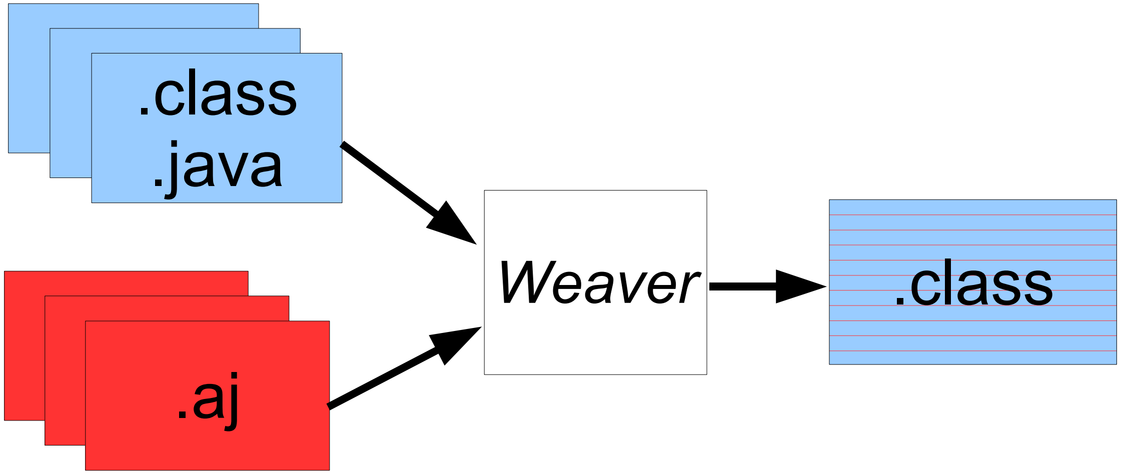
Aspect-Oriented Programming Tools

AOP Tools

- (Java-based tools)
- Languages:
  - AspectJ (now merged with AspectWerkz)
- Frameworks (mainly for J2EE applications):
  - JAC
  - Jboss AOP

AspectJ

- Aspect-Oriented extension to Java.
- Aspect language (new constructs for aspects).
- Produces standard Java bytecode.
- Weaves into class files.



AspectJ example: pre-condition

```
/* Java code */
class Test {
   public int val ;

   /* ... */
}
```

Piece of advice

Pointcut

```
/* AspectJ code */
aspect Precondition {
   public static final int MAX_VALUE = 2000 ;
   before(int newval): set (int Test.val) && args (newval) {
      if (newval > MAX_VALUE)
         throw new RuntimeException(“Invalid value”);
   }
}
```

AspectJ example: persistence

```
aspect DatabaseAspect {
  pointcut transactionalMethods ():
    execution (/* pattern for transactional methods */) ;

  before(): transactionalMethods () {
    initialiseDatabase() ;
  }

  after() returning: transactionalMethods() {
    commitTransaction() ;
  }

  after() throwing: transactionalMethods() {
    rollbackTransaction() ;
  }
}
```

(Soares *et. al. Implementing distribution and persistence aspects with AspectJ.*)

AspectJ – Pointcuts

- Pointcuts define where to intervene
- Expressed from primitive pointcuts:
  - call/execution(<Method signature>)
  - set/get(<Field signature>)
  - cflow(<Pointcut>)
  - args, target, this

-
  ```
  pointcut setvalue(int val):
  call(public void set*(int)) && args(val);
  ```

Application:
Design patterns

Observer pattern (I)

- In Java, explicit “addObserver” and “notify” embedded the observed class.
- “Observable” feature tangled with the main purpose of the class.
-
```
public void process() {
     /* Do something */
     notifyObservers();
}
```

Observer pattern (II)

- In AspectJ, possible to decouple the “observable” from the main purpose of the class.

-
  ```
  after(): execution(* *.process(..)) {
      /* notify or perform an action */
  }
  ```
- The “observer” and “observable” can be encapsulated into a single aspect.

Conclusions

Benefits and pitfalls

- Benefits: clearer decomposition of the roles (more reusability)
- Pitfalls:
  - Learning curve to comprehend the concepts (eased by Java environment)
  - Need for tools to understand the overall behaviour of the application (Eclipse AJDT) http://www.eclipse.org/ajdt/ (available for other IDEs as well)

References (I)

- AOSD website: http://www.aosd.net/
- AspectJ: http://www.eclipse.org/aspectj/
- “*Foundations of AOP for J2EE Development*” by R. Pawlak et al., ISBN: 1590595076
- “*Eclipse AspectJ*” by A. Colyer et al., ISBN: 0321245873
- [Lad03] “AspectJ in Action” by R. Laddad, ISBN: 1930110936
- [Fil05] “Aspect-Oriented Software Development” by R. Filman et al., ISBN: 0321219767

References (II)

- “*Design Pattern Implementation in Java and AspectJ*”, by J. Hannemann and G. Kiczales., OOSPLA 2002.
- “*Deriving Refactorings for AspectJ*”, by L. Cole et al., AOSD 2005.
- “*Towards a Catalog of Aspect-Oriented Refactorings*”, by M. Monteiro et al., AOSD 2005.