Software Engineering

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- Data first, treatments ... second.
- Go back to the treatments structuration.
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- *Don't forget OO design !*

Needs of New Programming Paradigm ?

Model	**Concern**	**Element**
Linear Programming		
Structured Programming	Control flux	instructions
Procedural Programming	Split code in parts	function, procedure
Obj. Orient. Programming	Data as objects	Class
Aspect Orient. Programming	Crossing function	Aspect

Meta-Program and Meta-Programming

- **What is a Meta-Programming ?**
  The creation of procedures and programs that automatically construct the definitions of other procedures and programs.
- **First example the Turing machine**
  With the Universal Turing Machine, named after Alan Turing, it has been proved that it is possible to program a machine to imitate the behavior of any other machine.

Meta-Program and Meta-Programming

- **What is a Meta-Program ?**
  - A program which modifies or generates other programs. A compiler is an example of a metaprogram: it takes a program as input and produces another (compiled) one as output. Genetics programming allows to generate new programs in simulating biological evolution.
  - Meta-programs in general are programs that create, control or make decisions about programs, such as when and how to run them, preferred and unpreferred programs, and strategic choices of fall-back or alternative programs.
  - Well-known examples : compiler, language parser, genetics programs . . .

Why do we need Meta-Programming ?

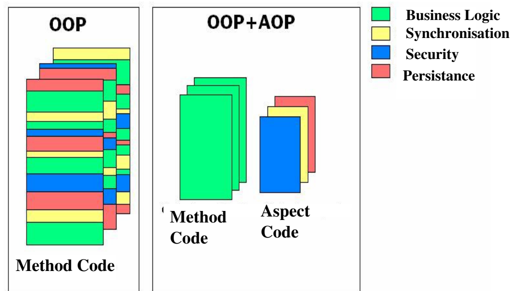
- Object Oriented Design has some interests : capability to capture data semantics, complexity management, abstract level . . .

Why do we need Meta-Programming ?

- Object Oriented Design has some interests : capability to capture data semantics, complexity management, abstract level . . .
- Limitations: the main principle is to tell that all the tasks to accomplish can be assumed by one object and the methods are always into classes.
- **BUT!** it exist several cases where put methods into classes cause code duplication because sometimes we need more *linear* programming than *hierarchical* programming.

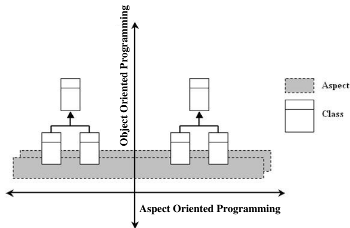
Design example

Some cases of transversal concerns : log management, verification for input parameters, exception treatments . . .



How to write horizontal sharing of behaviors?

- In the Object design we can separate the business objects from the technical objects.
- Object oriented design encapsulatse concerns into single entity.
- But some concerns defy these forms of encapsulation. Software engineers call these crosscutting concerns, because they ”cut” across multiple modules in a program.
- So we need to build a **separation of concerns** and **AOP** give a solution for the **cross-cutting concerns** between several classes.



What is AOP?

- The beginning of the story : Gregor Kiczales and his team at the Palo Alto Xeroc Parc published their works on writing programs in the 90's.
- Aspect Oriented Programming give a new way to share behaviors, or controls without breaking encapsulation.
- They wrote **AspectJ** which implements AOP for Java applications.
- One of the multiple web site with example :

`https://medium.com/@jdvp/aspect-oriented-programming-in-android-159054d52757`

AOP Principles

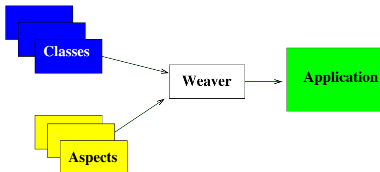
- Calling to a technical module from a business one or another technical modules is not direct. For example calling trace management module. This aspect is specified in a self-working way.
- But if the aspect defined explicitly where it interacts with the business module, this just put the problem in another place.
- The **solution** is a system of rational expressions to precise where are the executing point of the different aspects.

AOP Vocabulary

- **Join point**: points in a running program where additional behavior can be usefully joined. A join point needs to be addressable and understandable by an ordinary programmer to be useful
- **Pointcut**: the place where the join points are put. Determine whether a given join point matches.
- **Advice**: code to run at a join point. It can run **before**, **after** and **around** join points.
- **Weaver**: the tool to link aspect code and code of class methods. It can works before or during the compilation time, befor or during the runtime.
- **Tangled code**:*"spaghetty"* code.
- **Crosscutting concerns**:secondary requirements sharing by several classes.

How to do ?

- The method consists in :
  - Defining functionalities.
  - Implementing functionalities as Aspects.
  - Weaving the aspects with the existing code.



What is a Weaver ?

- Weaving is the operation to link aspects and classes.
- Any programming language which has a weaver can be used with aspects.
- The weaver allows to insert piece of code at some executing points. Weaving can be done at :
  - statically - most often at compilation time. In that case, the executing code mixes classes and aspects, modification needs recompilation. Good performances (Aspectj).
  - dynamically - easy to modify aspects (JBoss-AOP).
- Three ways to do :
  - *Compiling time*, sometimes with a pre-compiler dedicated to aspects. From the source code or bytecode.
  - *Loading time* with a specific class loader.
  - *Running time* by using proxys or interceptions.

Advantages and Limits

- Advantages :
  - Separation between concerns makes maintenance easyest.
  - Good modularity.
  - Solutions to some weakness of object oriented programming.
- Drawbacks :
  - Reading the code does not inform about excuted aspects.
  - No standardisation.
  - Need of programmers training.

Tools for Java

- Generic approach : AspectJ.
- Specific approach : for requirements of some framework as Spring (before version 2,0).

Implementation	URL
AspectJ	http://www.eclipse.org/aspectj
Spring-AOP	http://www.springframework.org
JBoss-AOP	http://jbossaop.jboss.org/
AspectWerkz	http://aspectwerkz.codehaus.org

Example

```
class RealSquareRootExample {
  public static void main(String[] args) {
    System.out.println("sqrt(13.0) is " + Math.sqrt(13.0));
    System.out.println("sqrt(9.0) is " + Math.sqrt(9.0));
    System.out.println("sqrt(-4.0) is " + Math.sqrt(-4.0));
  }
}

aspect EnsureRealSquareRoot {
  before(double d) : call(static double Math.sqrt(double)) && args(d) {
    if(d < 0.0)
      throw new IllegalArgumentException("Positive arguments to sqrt() only, please!");
  }
}
```

AspectJ Language

- **Aspect** to add new method to the `Point` class:

```
aspect VisitAspect {
    void Point.acceptVisitor(Visitor v) {
        v.visit(this);
    }
}
```

- Definition of a **pointcut**:

```
pointcut set() : execution(* set*(..) )
                      && this(Point);
```

- Definition of an **advice**:

```
after () : set() {Display.update();}
```

- Operator like `*` `||` `&&` can be used. Example:
  `call(void Figure.make*(..))`

Editor Example

```
pointcut move():
    call(void FigureElement.setXY(int,int)) ||
    call(void Point.setX(int))              ||
    call(void Point.setY(int))              ||
    call(void Line.setP1(Point))            ||
    call(void Line.setP2(Point));

before(): move() {
    System.out.println("about to move");
}

after() returning: move() {
    System.out.println("just successfully moved");
}


pointcut setXY(FigureElement fe, int x, int y):
    call(void FigureElement.setXY(int, int))
    && target(fe)
    && args(x, y);

after(FigureElement fe, int x, int y) returning: setXY(fe, x, y) {
    System.out.println(fe + " moved to (" + x + ", " + y + ").");
}
```

Another simple example

```
aspect DataLog{
    advise * Worker.performActionA(...), *Worker.performActionB(...){
       static after {
          if (thisResult == true)
             System.out.println("Executed " +thisMethodname+
                                "successfully");
          else
             System.out.println("Error" +thisMethodname);
        }
    }
}
```

The new Observer

```
aspect PointObserving {
    private Vector Point.observers = new Vector();

    public static void addObserver(Point p, Screen s) {
        p.observers.add(s);
    }
    public static void removeObserver(Point p, Screen s) {
        p.observers.remove(s);
    }
        pointcut changes(Point p): target(p) && call(void Point.set*(int));

    after(Point p): changes(p) {
        Iterator iter = p.observers.iterator();
        while ( iter.hasNext() ) {
            updateObserver(p, (Screen)iter.next());
        }
    }
}
```