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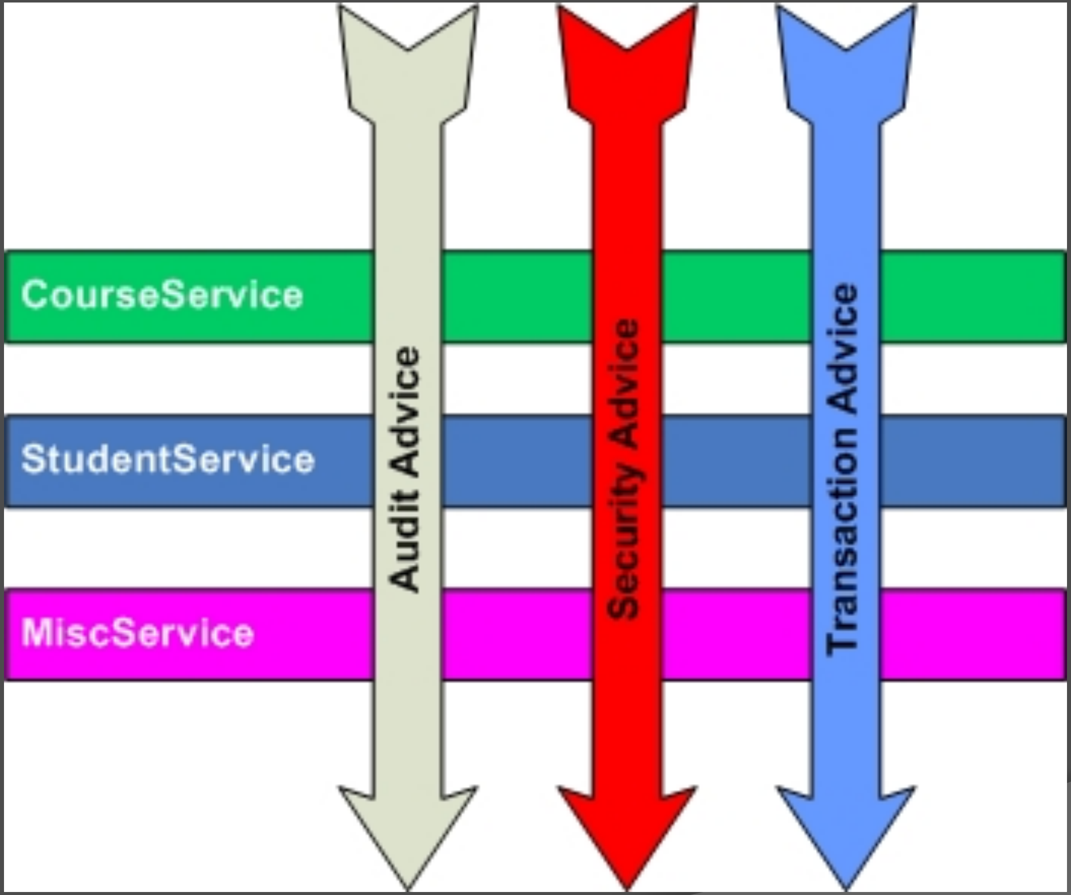
RUNTIME VERIFICATION FROM THEORY TO PRACTICE AND BACK

Separation of Concerns

Some Observations (A Reminder)

- Adding the properties into the system code makes it difficult to separate: where does the property end and the system start.
- Some properties are not simply assertions, and may require additional logic – the code implementing this logic is also mixed with the system.
- Changes to the properties result in direct changes in the project code.
- If we want to change the mode of verification (e.g. produce logs to check offline), it will require reengineering the whole effort.

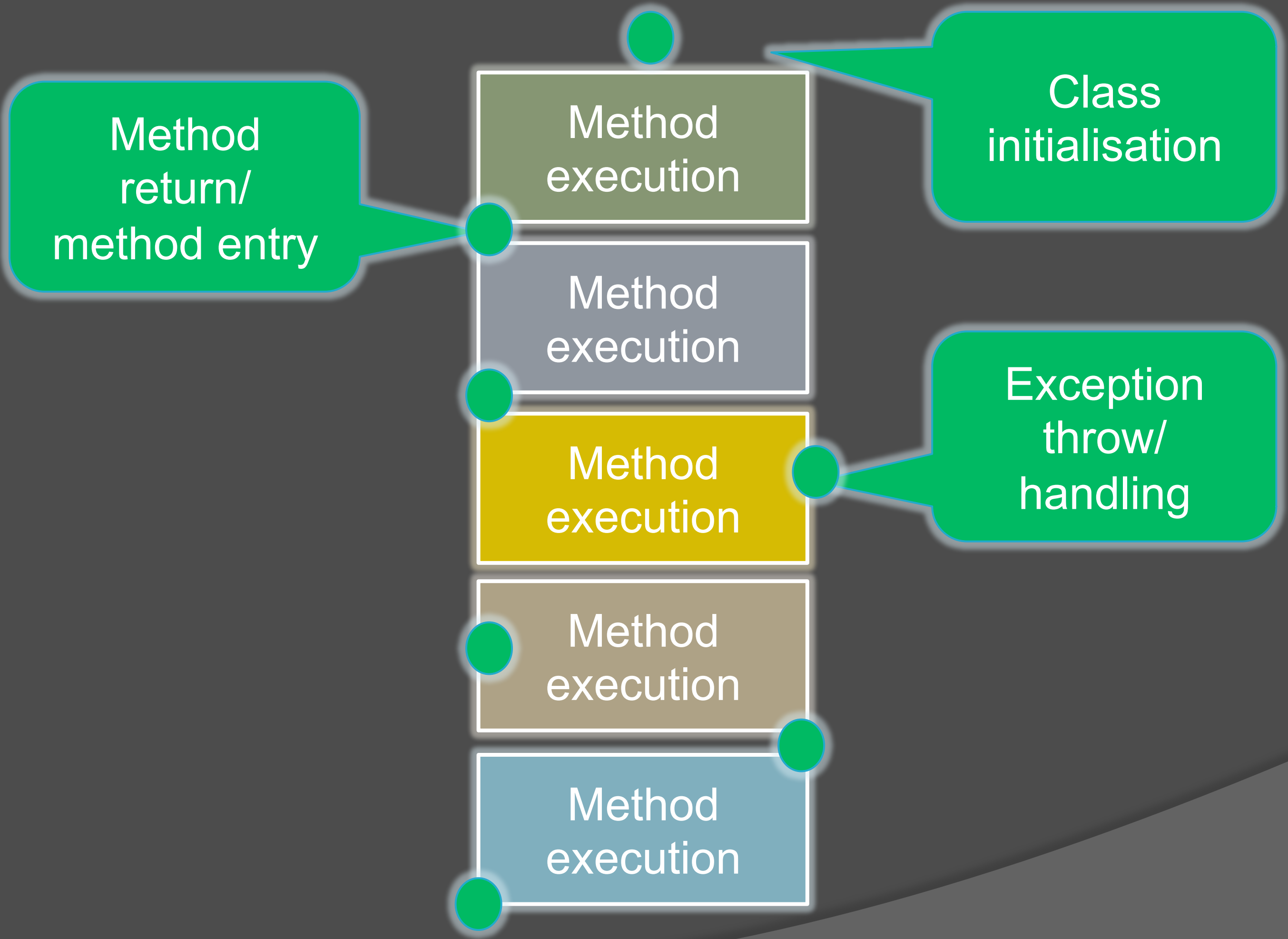
Programming Concerns



Aspect-Oriented Programming

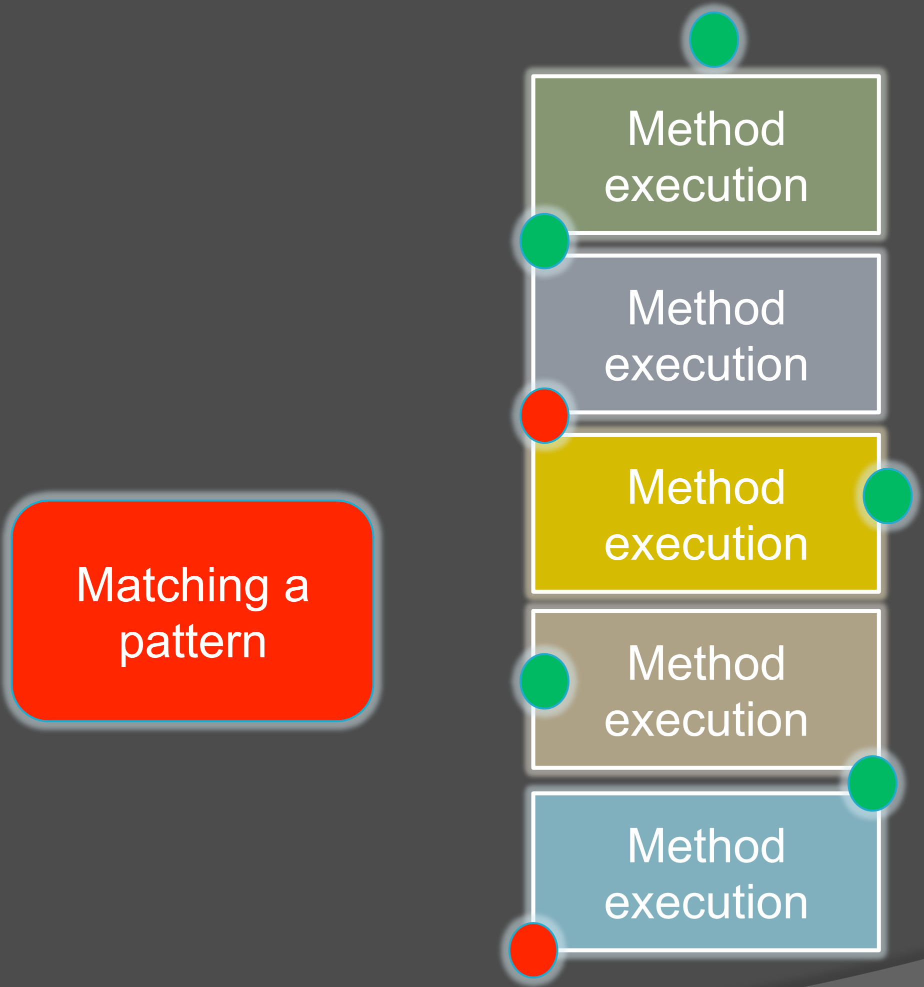
- Aspect-Oriented Programming (AOP) provides a way of addressing cross-cutting concerns in code.
- Provides ways of linking with points in the code.
  - These positions are called *joinpoints*
  - Typical support for joinpoints such as:
    - Method and constructor execution
    - Method and constructor call
    - Field get and set
    - Exception handler execution
    - Static and dynamic initialization

Joinpoints



Method return/ method entry
Method execution
Method execution
Method execution
Method execution
Method execution
Class initialisation
Exception throw/ handling

Pointcuts



Matching a pattern

Method execution

Method execution

Method execution

Method execution

Method execution

Aspect-Oriented Programming

- An AOP script consists of a list of *pointcut* and *advice* pairs.
  - **Pointcut:** A rule (potentially) matching a number of joinpoints e.g. “just before method *login* is called”.
  - **Advice:** Code to be executed when the program reaches the related pointcut.

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- **Examples:**

```
before (): (* *.login(..)) { log.add(“Logging in”); }
after (): (* *.closeSession(..)) { resources.release(); }
```

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AOP for RV

- AOP provides us with a perfect way of separating the writing of verification code from that of the system.

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- AOP provides us with a perfect way of separating the writing of verification code from that of the system.
- **Example:** *Logging out can only occur while logged in.*

A Verification class is defined as before together with the following aspect code:

```
before (): (* *.login(..)) { Verification.setLoggedIn(); }
before (): (* *.logout(..)) {
 Verification.assertion(Verification.isLoggedIn(),“ERR”);
 Verification.setLoggedOut();
}
```

AspectJ

- AspectJ is an AOP tool for Java.
- Built as an extension to Java, allowing for general purpose aspect programming.
- Good support in Eclipse (and other IDEs/ editors) – creating an AspectJ project allows for aspects to be added (in the form of `.aj` files) which are compiled together with the system.
- Here we will show AspectJ bare necessities to be able to use AOP for runtime verification…

Programming in AspectJ

- The anatomy of an AspectJ aspect declaration through a *HelloWorld* example:

```
public aspect Properties {
    before (): call (* *.move (..)) {
          System.out.println(“Hello world”);
    }

    after (): call (* *.move (..)) {
          System.out.println(“Hello world”);
    }
}
```

Programming in AspectJ

- The anatomy of laration through a *HelloWorld* ex

Before a method call…

```
public aspect Properties {
    before (): call (* *.move (..)) {
          System.out.println(“Hello world”);
    }

    after (): call (* *
          System.out.p
    }
}
```

After a method call…

Programming in AspectJ

- The anatomy of laration through a *HelloWorld* ex

Access modifiers and return type (or * for *anything*)

```
public aspect Properties {
    before (): call (* *.move (..)) {
            System.out.println("Hello world");
    }

    after (): call (* *.move (..)) {
            System.out.println("Hello world");
    }
}
```

Programming in AspectJ

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Class name (may use * to indicate *any class*) – may also include packages

```
public aspect Properti  {
    before (): call (* *.move (..)) {
          System.out.println(“Hello world”);
    }

    after (): call (* *.move (..)) {
          System.out.println(“Hello world”);
    }
}
```

Programming in AspectJ

- The anatomy of an As n a *HelloWorld* example

Method name (may use * to indicate *any method*)

```
public aspect Properties {
    before (): call (* *.move (..)) {
          System.out.println(“Hello world”);
    }

    after (): call (* *.move (..)) {
          System.out.println(“Hello world”);
    }
}
```

Programming in AspectJ

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Parameters of the method (use .. to signify *any*)

```
public aspect Properties {
    before (): call (* *.move (..)) {
            System.out.println(“Hello world”);
    }

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    }
}
```

Programming in AspectJ

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The advice to be executed

```
public aspect Properti
    before (): call (* *.move (..)) {
            System.out.println(“Hello world”);
    }

    after (): call (* *.move (..)) {
            System.out.println(“Hello world”);
    }
}
```

Programming in AspectJ

- The *target* is the object on which the method captured is called.
- It can be captured as follows:

```
before (Shape x):
    call (* Shape.move (..)) &&
    target(x)
    {
           System.out.println(“Hello” + x.toString());
    }
```

Programming in AspectJ

- Capturing the return value:

```
after () returning(Position p):
    call (* *.move (..)) {
      System.out.println(“Hello ” + p.toString());
    }
```

Programming in AspectJ

- Capturing the parameters:

```
before (double dx, double dy):
    call (* *.move(..)) &&
    args(dx,dy)
    {
      System.out.println(“Move ” + dx + “,” + dy);
    }
```

Programming in AspectJ

- Accessing target, method parameters and its return value:

```
after
    (Shape s, double dx, double dy)
    returning (Position p):
    call (* *.move(..)) &&
    target(s) &&
    args(dx,dy)
    {
          code
    }
```

Exercises

Add the properties to FiTS using AspectJ.

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Add the properties to FiTS using

Run the scenarios you were given with the code to check that they run as expected.