Programmierung 2
Object-Oriented Programming with Java

1. Introduction

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# P2 — Object-Oriented Programming

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Roadmap

> Goals, Schedule
> What is programming all about?
> What is Object-Oriented programming?
> Foundations of OOP
> Programming tools, subversion
> Why Java?
Roadmap

> **Goals, Schedule**
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Your Learning Targets

Knowledge

- You understand requirements engineering, designing and implementing object-oriented software.
- You are able to understand and create UML Diagrams
- You understand and can apply a range of OO Patterns
- You apply a Test-Driven Development process

Skills

- You use your IDE, Debugger efficiently and effectively
- You easily learn other OO languages (C++, Smalltalk)
- You can communicate and work in Teams
The Big Picture

P1 → P2 → ESE → PSE

DA

DB
Recommended Texts

> **Java in Nutshell: 5th edition**,  
  David Flanagan, O’Reilly, 2005.

> **Object-Oriented Software Construction**,  

> **Object Design - Roles, Responsibilities and Collaborations**,  

> **Design Patterns: Elements of Reusable Object-Oriented Software**,  
  Erich Gamma, Richard Helm, Ralph Johnson and John Vlissides,  

  James Rumbaugh, Ivar Jacobson, Grady Booch, Addison-Wesley,  
  1999
Schedule

1. Introduction
2. Design by Contract
3. A Testing Framework
4. Debugging and Tools
5. Iterative Development
6. Inheritance and Refactoring
7. GUI Construction
8. Generics and Annotation
9. Guidelines, Idioms and Patterns
10. A bit of C++
11. A bit of Smalltalk
12. TBA
13. Final Exam
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What is the hardest part of programming?
How do we become **good** Object-Oriented Software Engineers?

*What is **good** Chess?*

*There is a difference between knowing how the pieces move and how to win the game.*
What constitutes programming?

- Understanding requirements
- Design
- Testing
- Debugging
- Developing data structures and algorithms
- User interface design
- Profiling and optimization
- Reading code
- Enforcing coding standards
- ...

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How can we simplify programming?
Key insights

Real programs change!

Development is incremental

Design is iterative
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What is Object-Oriented Programming?

- **Encapsulation**: Abstraction & Information Hiding
- **Composition**: Nested Objects
- **Distribution of Responsibility**: Separation of concerns (e.g., HTML, CSS)
- **Message Passing**: Delegating responsibility
- **Inheritance**: Conceptual hierarchy, polymorphism and reuse
Procedural versus OO designs

**Problem:** compute the total area of a set of geometric shapes

```java
public static void main(String[] args) {
    Picture myPicture = new Picture();
    myPicture.add(new Square(3,3,3));   // (x,y,width)
    myPicture.add(new Rectangle(5,9,5,3)); // (x,y,width,height)
    myPicture.add(new Circle(12,3,3));   // (x,y,radius)

    System.out.println("My picture has size " + myPicture.size());
}
```

How to compute the size?
**Procedural approach: **`centralize` computation

```java
double size() {
    double total = 0;
    for (Iterator<Shape>i = shapes.iterator(); i.hasNext();)
    {
        Shape shape = i.next();
        switch (shape.kind()) {
        case SQUARE:
            Square square = (Square) shape;
            total += square.width * square.width;
            break;
        case RECTANGLE:
            Rectangle rectangle = (Rectangle) shape;
            total += rectangle.width * rectangle.height;
            break;
        case CIRCLE:
            Circle circle = (Circle) shape;
            total += java.lang.Math.PI * circle.radius * circle.radius / 2;
            break;
        }
    }
    return total;
}
```
Object-oriented approach: *distribute* computation

```java
double size() {
    double total = 0;
    for (Iterator<Shape>i = shapes.iterator(); i.hasNext();) {
        total += i.next().size();
    }
    return total;
}
```

```java
class Square extends Shape {
    public double size() {
        return width*width;
    }
}
```

What are the *advantages* and *disadvantages* of the two solutions?
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Object-Oriented Design in a Nutshell

> Identify *minimal* requirements
> Make the requirements *testable*
> Identify objects and their *responsibilities*
> Implement and *test* objects
> Refactor to *simplify* design
> Iterate!
Design by Contract

> Formalize client/server contract as obligations
> Class invariant — formalize valid state
> Pre- and post-conditions on all public services
  — clarifies responsibilities
  — simplifies design
  — simplifies debugging
> Objects are responsible to maintain information and provide services

> A good design exhibits:
  — high cohesion of operations and data within classes
  — low coupling between classes and subsystems

> Every method should perform one, well-defined task:
  — High level of abstraction — write to an interface, not an implementation
Some key practices:

> Simple design
  — Never anticipate functionality that you “might need later”

> Test-driven development
  — Only implement what you test!

> Refactoring
  — Aggressively simplify your design as it evolves

> Pair programming
  — Improve productivity by programming in pairs
Testing

- Formalize requirements
- Know when you are done
- Simplify debugging
- Enable changes
- Document usage
Code Smells

> Duplicated code
> Long methods
> Large classes
> Public instance variables
> No comments
> Useless comments
> Unreadable code
> …
Refactoring

“Refactoring is the process of rewriting a computer program or other material to improve its structure or readability, while explicitly keeping its meaning or behavior.”

— wikipedia.org

**Common refactoring operations:**

- Rename methods, variables and classes
- Redistribute responsibilities
- Factor out helper methods
- Push methods up or down the hierarchy
- Extract class
- …
Design Patterns

“a general repeatable solution to a commonly-occurring problem in software design.”

**Example**
> Adapter — “adapts one interface for a class into one that a client expects.”

**Patterns:**
> Document “best practice”
> Introduce standard vocabulary
> Ease transition to OO development

**But …**
> May increase flexibility at the cost of simplicity
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Programming Tools

*Know your tools!*

- IDEs (Integrated Development Environment) — e.g., Eclipse,
- Version control system — e.g., svn, cvs, rcs
- Build tools — e.g., maven, ant, make
- Testing framework — e.g., Junit
- Debuggers — e.g., jdb
- Profilers — e.g., java -prof, jip
- Document generation — e.g., javadoc
A **version control system** keeps track of multiple file revisions:

- *check-in* and *check-out* of files
- *logging changes* (who, where, when)
- *merge* and *comparison* of versions
- *retrieval* of arbitrary versions
- “freezing” of versions as releases
- *reduces storage space* (manages sources files + multiple “deltas”)
Version control enables you to make radical changes to a software system, with the assurance that you can always go back to the last working version.

💡 When should you use a version control system?
 ✓ Use it whenever you have one available, for even the smallest project!

Version control is as important as testing in iterative development!
SVN is a standard versioning system for Mac, Windows and UNIX platforms (see subversion.tigris.org)

> *Shared repository* for teamwork
  — Manages hierarchies of files
  — Manages parallel development branches

> Uses *optimistic version control*
  — no locking
  — merging on conflict

> Offers *network-based* repositories

> **Integrated** in Eclipse! *(You may need to install a svn plugin)*
Using SVN

```bash
svn import ${svnrepo}/MyProject

make a svn directory

cd MyProject

make a svn directory

cd somewhere

checkout a svn project

svn co ${svnrepo}/MyProject

cd MyProject

modify and add files (text or binary)

svn add ArrayStack.java

commit changes (with comments)

svn commit

...  

time passes ...

svn update

update working copy (if necessary)

svn update

svn log

list recent changes
```
SVN and Eclipse

Eclipse offers a simple GUI for interacting with **svn repositories**
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Why Java?

Special characteristics
> Resembles C++ minus the complexity
> Clean integration of many features
> Dynamically loaded classes
> Large, standard class library

Simple Object Model
> “Almost everything is an object”
> No pointers
> Garbage collection
> Single inheritance; multiple subtyping
> Static and dynamic type-checking

Few innovations, but reasonably clean, simple and usable.
What you should know!

- What is meant by “separation of concerns”?
- Why do real programs change?
- How does object-oriented programming support incremental development?
- What is a class invariant?
- What are coupling and cohesion?
- How do tests enable change?
- Why are long methods a bad code smell?
Can you answer these questions?

- Why does up-front design increase risk?
- Why do objects “send messages” instead of “calling methods”?
- What are good and bad uses of inheritance?
- What does it mean to “violate encapsulation”?
- Why is strong coupling bad for system evolution?
- How can you transform requirements into tests?
- How would you eliminate duplicated code?
- When is the right time to refactor your code?
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