UNIVERSITÄT
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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
- Why Java?
- Programming tools, version control

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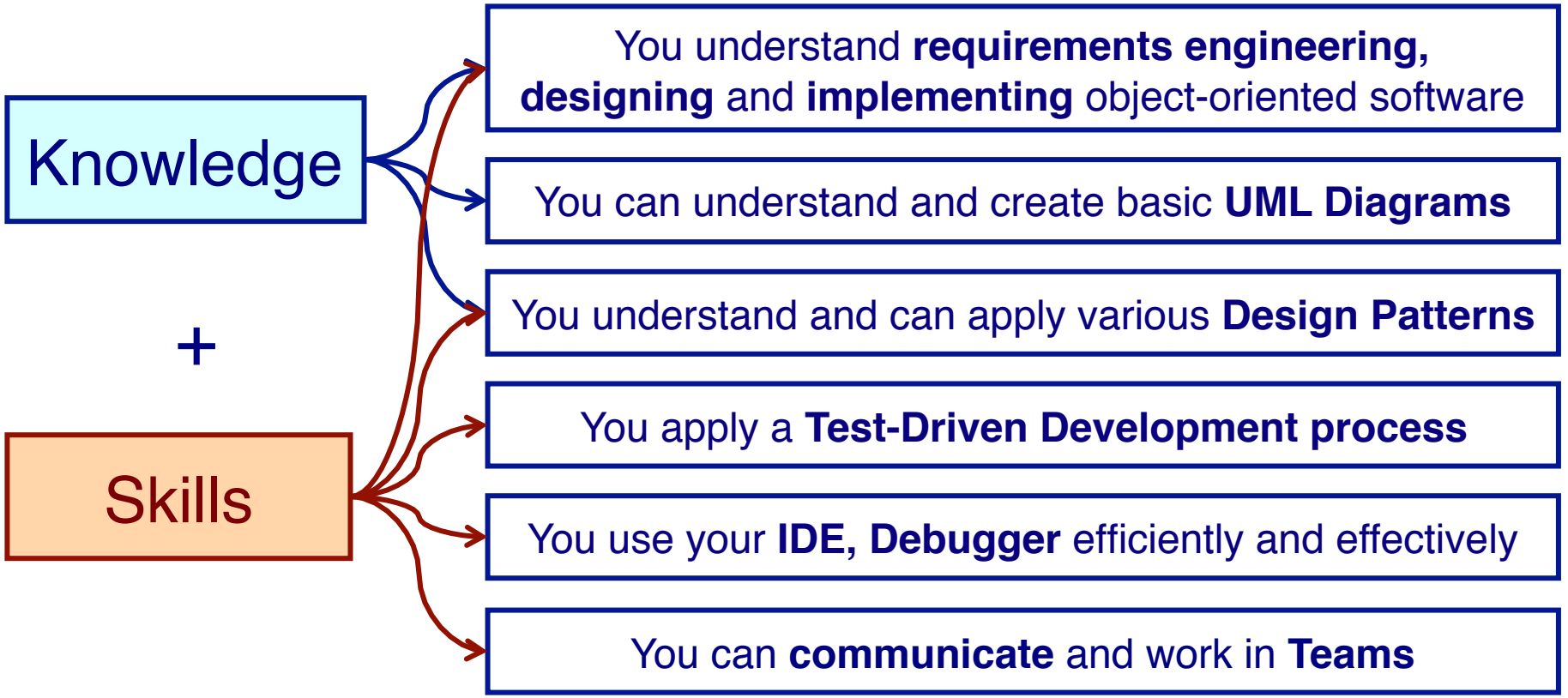
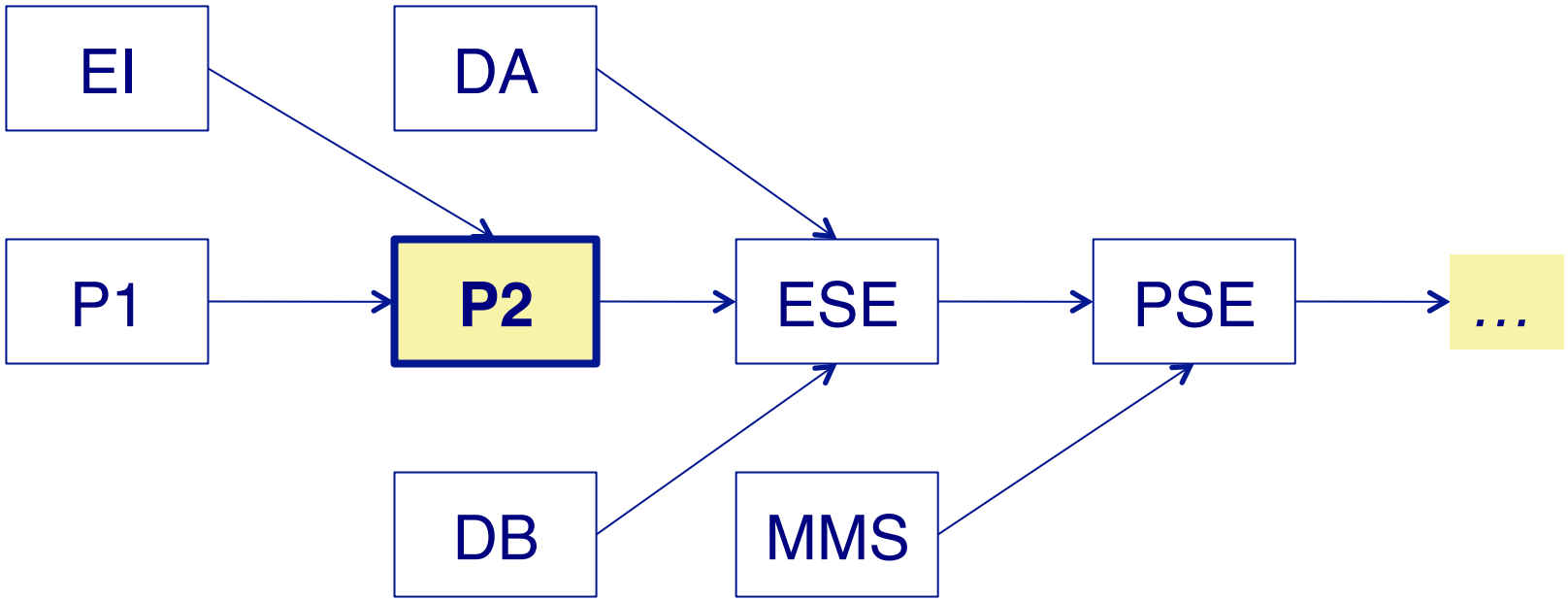
Your Learning Targets

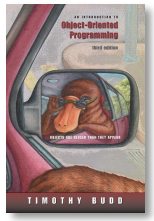


The Big Picture



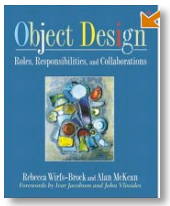
Recommended Texts

- ***Java in Nutshell: 5th edition***, David Flanagan, O'Reilly, 2005.

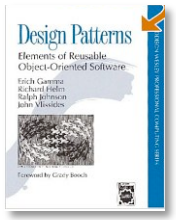


- ***An Introduction to Object-Oriented Programming***, Timothy Budd, Addison-Wesley, 2004.

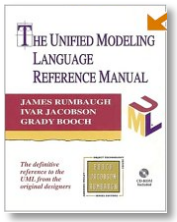
- ***Object-Oriented Software Construction***, Bertrand Meyer,Prentice Hall, 1997.



- ***Object Design - Roles, Responsibilities and Collaborations***, Rebecca Wirfs-Brock, Alan McKean, Addison-Wesley, 2003.



- ***Design Patterns: Elements of Reusable Object-Oriented Software***, Erich Gamma, Richard Helm, Ralph Johnson and John Vlissides, Addison Wesley, Reading, Mass., 1995.



- ***The Unified Modeling Language Reference Manual***, James Rumbaugh, Ivar Jacobson, Grady Booch, Addison-Wesley, 1999

Schedule

1. Introduction
2. Object-Oriented Design Principles
3. Design by Contract
4. A Testing Framework
5. Iterative Development
6. Debugging and Tools
7. Inheritance and Refactoring
8. Advanced OO Design (lab)
9. GUI Construction
10. Guidelines, Idioms and Patterns
11. A bit of C++
12. A bit of Smalltalk
13. Guest Lecture — *Einblicke in die Praxis*
14. *Final Exam*

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What is the hardest part of programming?

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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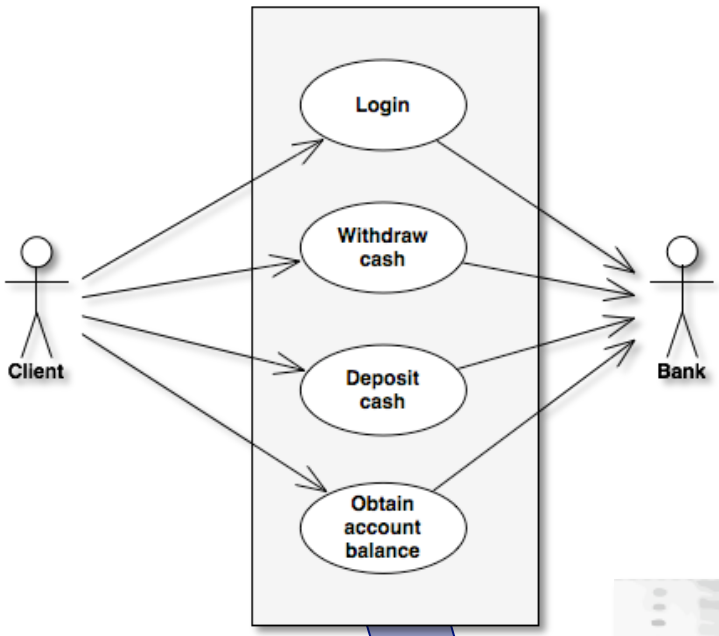
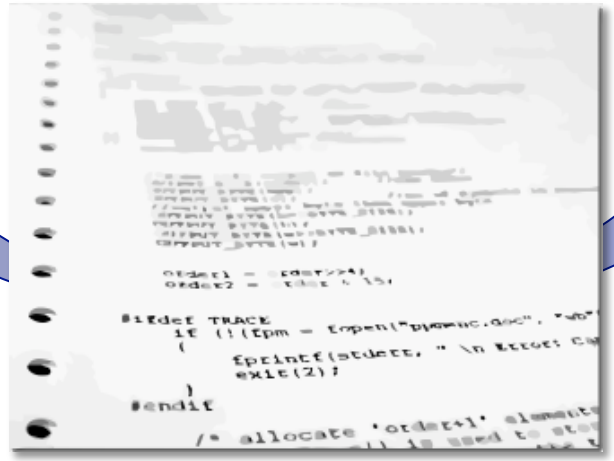
Programming is modeling

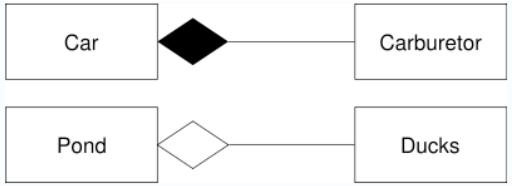




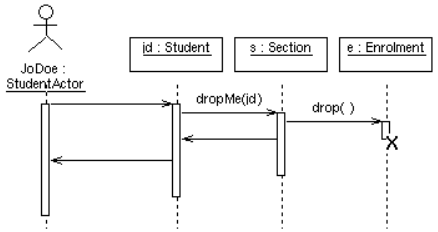
What is Object-Oriented Programming?

Encapsulation — Abstraction & Information Hiding

Composition — Nested Objects

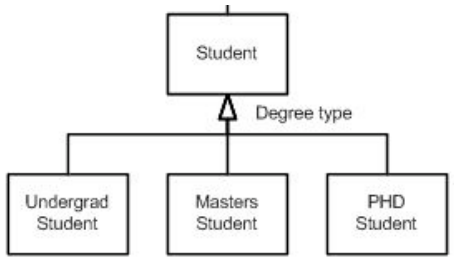


Distribution of Responsibility — *Separation of concerns (e.g., HTML, CSS)*



Message Passing — *Delegating responsibility*

Inheritance — *Conceptual hierarchy, polymorphism and reuse*

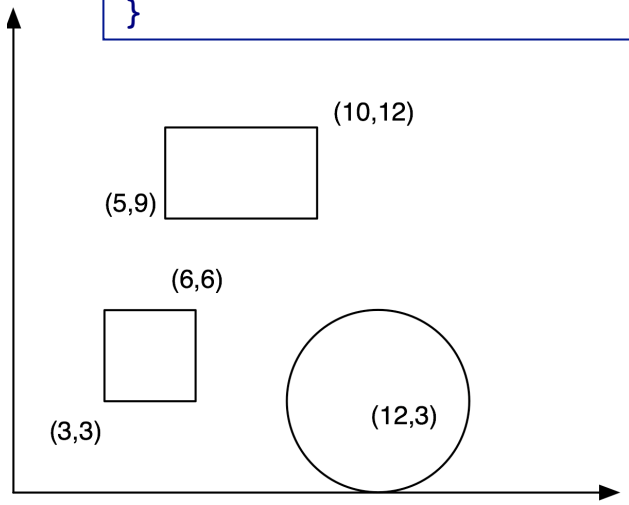


Procedural versus OO designs

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

```
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

```
double size() {
    double total = 0;
    for (Shape shape : shapes) {
        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

```
double size() {
   double total = 0;
   for (Shape shape : shapes) {
      total += shape.size();
   }
   return total;
}
```

```
public 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!

Responsibility-Driven Design

- 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

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*

Extreme Programming

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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Why Java?

Special characteristics

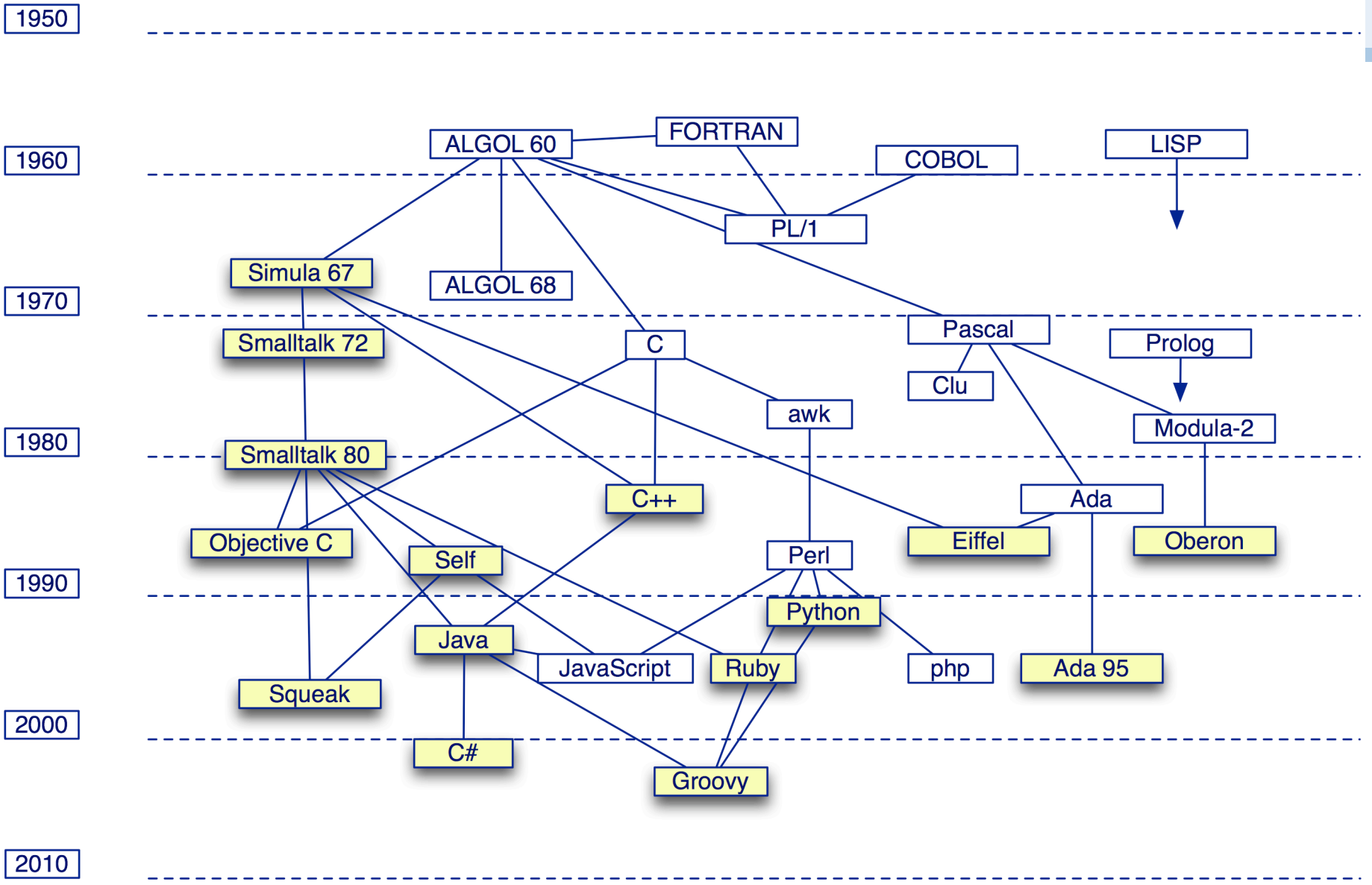
- Resembles C++ minus the complexity
- Clean integration of many features
- Dynamically loaded classes
- Large, standard class library

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.

History


1950
1960
1970
1980
1990
2000
2010
ALGOL 60
FORTRAN
COBOL
LISP
PL/1
Simula 67
ALGOL 68
Smalltalk 72
C
Pascal
Prolog
Clu
awk
Modula-2
Smalltalk 80
C++
Ada
Objective C
Self
Perl
Eiffel
Oberon
Python
Java
JavaScript
Ruby
php
Ada 95
Squeak
C#
Groovy

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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

Version Control Systems

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

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!*

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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