IPP
Principles of Programming Languages and OOP

Dušan Kolář

kolar@fit.vutbr.cz

+420-54-114-1238

Points

Mid-term exam	20
Project	20
Inclusion	*20*
Final exam	60 (25)
SUM	100 (**45**)

Important Dates

- Mid-term exam: 31st March & 1st April (8th week)
- Project: *two periods*
  - *Will be explained in detail during the next lecture*
- Final Exam
  - Regular: ??.??. 2025
  - 1st retake: ??.??. 2025
  - 2nd retake: ??.??. 2025
  - *Too many students => global decision*

Time Schedule

- Lectures:
  - Day: Monday, **Wednesday**
  - Room: E112 (& others) – Mo, We
  - Time: 08:00 – 10:50 (Mo)
    10:00 – 12:50 (We)

Lecturers

- Dušan Kolář
- Zbyněk Křivka
- Guest (Dominika Regéciová)
- Structuring (supposed)
  - see Moodle pages (IS VUT)
  - may be changed (hopefully not)

Project

- Specification will be released during the 1st week of summer term
  - Unclear formulation and error/typos reports are expected and welcome
  - 2nd week – fix and freeze of the spec.
- 1st task: 18th March 2025 (11th March)
- 2nd task: 23rd April 2025 (16th April)

Students Involvement in Study

- University study
  - Full time job
    - 8h (optimistic, usually 10h ☹) => 40h a week
- 30 credits per term
  - 6 courses, each 5 credits
  - 6x4 hours (50 minutes) = 24x50 = 1200m
  - Which is 20h, that means a half

Study Model

- Official model expectation
  - 20h at home
- Recommended
  - Active participation on lectures
  - Repeat the new stuff at home

Practice

- Probably not the one expected ☺
- Missing prerequisite/s

- Effect
  - Mid-term exam
    - Force studying at least something during term
  - Projects
    - Get the things working

Lecture Streaming

- Original intention:
  - Additional studying resource
- Reality:
  - The only (if any) resource ☹
- Lectures will be online as processed
  - We cannot influence processing
    - Must be both voice and video, otherwise empty
- !! Use additional resources !!

Recommendations

- Solve the project as soon as possible – except this lecture, on organizational topics next, and the guest (Python) there is no other devoted to it
  - **Try to beat the deadline about one week**!
- A feeling you understand a lecture does not imply you can reproduce the content later
  - **We do require full, deep and clear answers**!

Literature/References

- **Reynolds, J.C.: Theories of Programming Languages**
- Sethi, R.: Programming Languages, Concepts and Constructs
- Friedman, D.P., Wand, M., Haynes, C.T.: Essentials of Programming Languages

Literature/References

- Horowitz, E.: Fundamentals of Programming Languages, 2nd edition
- Henderson, P.: Functional Programming, Application and Implementation
- Schmidt, D.A.: The Structure of Typed Programming Languages
- Hruška, T., Beneš, M., Češka, M.: Překladače
- Češka, M., Motyčková, L., Hruška, T.: Vyčíslitelnost a složitost

WWW Resources

- http://www.uml.org
- Manuals and standards (ANSI) of programming languages
- Implementations of programming languages compilers/interpreter
- Lecture notes and supplementary texts for programming languages coming from universities worldwide

Lectures Overview – I

1. Introduction – Terms, PHP
2.-4. Object Oriented P.L. – features, insight, terms
5. Language classification, Non-structured languages
6. Structured languages
7. Modular languages

Lectures Overview – II

8. Design patterns
9. Introduction to Declarative P.L. – Lambda Calculus
10. Functional P.L.
11. Logic P.L.

Lectures Overview – III

12. Other declarative P.L., Main Differences in Use and Implementation Among Imperative and Declarative P.L.
13. Summary, Discussion about Following Courses, etc.

1. Introduction – Terms

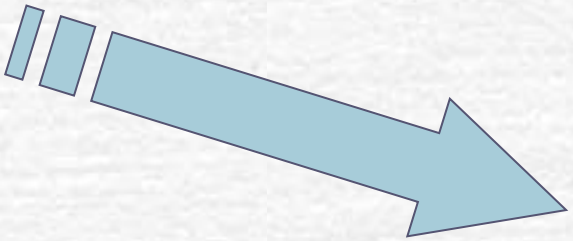
Aims of the Lecture

- Definition of Terms Known and Used in the Area of Programming Languages
  - Language Categories
  - Terms for Characterization
  - Etc.

Why IPP?

- Programming is really hard stuff!
  - Warning!!
    - Schematic work with programming languages is not programming!
    - “Google programming”, “COPILOT programming” is not programming!
- And, moreover: https://x.com/Rainmaker1973/status/1752426357747818695?s=20

Programming Process



Programming Process

- Difficult time & resources consuming task
- Knowledge of P.L. not sufficient
- Requirements specification usually not complete (vague determination, etc.)
- Under/Over-estimation
- Tight time schedules

and many others…

What a Programming Language Is?

- Programming language is an *intermediary mean* between common speech and sequence of usually binary digits

What a Programming Language Is? – II

- A *finite set of commands* of a specific syntactic form with strictly defined semantics

Why Programming Languages

- Natural languages are not suitable
  - Too complex analysis (none, so far)
  - Ambiguous, exact description too difficult
  - Etc.
- Binary code of target architecture is
  - Too complex to remember
  - Not suitable for more complex problems
  - Not usable for *fast* programming

What a Computer Program Is?

- Computer program is an abstraction of reality
  - It implements abstract models
  - CPU abstraction – model is implemented over it

Why We Need to Understand

- Make our programs better!
- Not sufficient to guess and test a programs does what we want..
- We must know why!
  Why not another way!

A Bit of History

- Early Fifties of 20th century
  - Symbolic names only (memory cell, operation)
  - Subroutines (macros)
    - Names for groups of actions, separation of views
    - Subroutine **implementation**
      - What is the realization
    - Subroutine **invocation**
      - What it does (call/interface)

History – cont.

- Early Sixties of 20th century
  - Level of abstraction increases
  - Programming comfort increases
    - Data abstraction
      - Data model used within a program
    - Control abstraction
      - Computational model, combination of elementary actions

History – cont.

- Seventies of 20th century
  - Simplicity, abstraction on higher level, research, broader application
    - Algol-W
    - Pascal
    - C
    - CLU
    - Euclid
    - Mesa

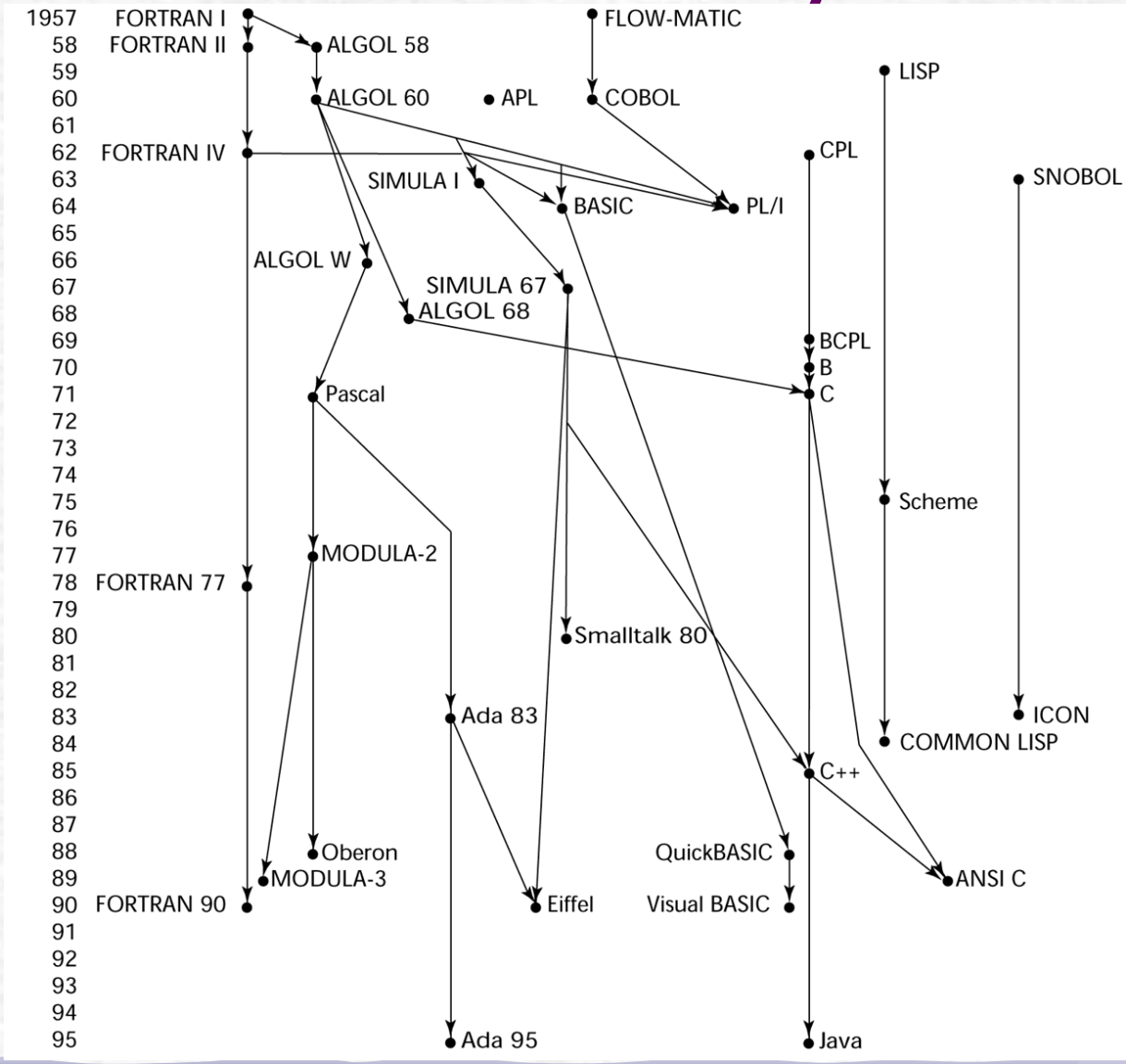
History – cont.

- Eighties of 20th century
  - New directions, modularity, object orientation
    - Ada
    - Modula-2
    - Smalltalk
    - C++
    - Scheme
    - ML
    - Miranda
    - FP
    - Prolog

History – cont.

- Nineties of 20th century
  - Internet, libraries, scripting languages, etc.
    - Java
    - Haskell
    - AWK
    - Perl
    - Tcl
    - Javascript
    - Python
    - Visual Basic

Summary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FORTRAN I
FORTRAN II
ALGOL 58
ALGOL 60
APL
FLOW-MATIC
COBOL
LISP
FORTRAN IV
CPL
SNOBOL
SIMULA I
BASIC
PL/I
ALGOL W
SIMULA 67
ALGOL 68
BCPL
B
C
Pascal
Scheme
MODULA-2
FORTRAN 77
Smalltalk 80
Ada 83
ICON
COMMON LISP
C++
Oberon
QuickBASIC
MODULA-3
ANSI C
FORTRAN 90
Eiffel
Visual BASIC
Ada 95
Java

Future ?

- Another new technologies
- Area of computer science is extremely dynamic, thus, it is hard to predict
- Nevertheless, there is enough space for new ideas

Term Simplification

- Program = computer program
- Language, P.L. = programming, or another computer-processed language for description of input data transformation to output data

Programming languages specification

- Syntax
  - Defines program structure
    - Grammars, formal languages (IFJ)
- Semantics
  - Description/definition of meaning of individual constructs, way of evaluation, etc.

Syntax (summary)

- 3 levels of description
  - Lexical
  - Context-free
  - Context bindings and limitations
- Methods of description
  - *Natural languages*
  - Syntactic graphs
  - BNF, EBNF
  - Grammars

Semantics

- Static
  - Describes features, that can be studied during translation/compilation
    - Type compatibility, etc.
- Dynamic
  - Describes features, that can be detected and investigated during program evaluation (run)
    - Index size, etc.

Formal Semantics Definition

- Axiomatic semantics
  - Defines axioms, that hold for individual constructs
- Operational semantics
  - Defines program behavior as a sequence of state transitions
- Denotational semantics
  - Defines program as a function mapping input values to output ones

Declaration X Definition

- Declaration
  - Just attributes
  - Explicit X implicit
- Definition
  - Variables
    - Attributes, a way of allocation
  - Function
    - Attributes, function body

Binding

- Connects entity with its feature/attribute
- Time of binding
  - During language design
  - During program implementation
  - During program translation/compilation
  - During program linkage
  - During program load
  - During program runtime/evaluation

A Kind of Binding

- Static
- Dynamic
  - It is created and/or it can be changed during program run/evaluation

Example – variable

- `int count; ... ; count = count + 5;`
  - Set of types of variable count
  - Type of variable count
  - Set of values of variable count
  - Value of variable count
  - Set of meanings of symbol +
  - Meaning of symbol + in this case
  - Internal representation of literal 5

Variable Features

- Name
- Address and location in memory space
- Values
- Type
- Life time
- Scope (rozsah platnosti)

Variable Name

- Name length
  - Maximal X effective
- Character set
  - Letters of (US) alphabet
  - Special characters
- Case sensitivity
- Key words X reserved words

Location, Address, and Value of Variable

- L = R
  - Variable on the left-hand side is *location+address*
    - L-value
  - Variable on the right-hand side is a value
    - R-value
- Name can be connected with various locations and addresses
  - Local variables in different subroutines
  - Local variables in recursive subroutines
  - Global constant variables
- Address can be connected with various names
  - Pointers, parameter passing by reference
  - Advanced optimization

Location, Address, and Value of Variable

- Static binding
  - Location, Address – static variables
  - Value – constants
- Dynamic binding
  - Variables located on the stack
  - Variables located on the heap
    - Allocation
    - De-allocation – implicit X explicit

Type of a Variable

- Denotes
  - Set of possible values
  - Set of possible operations
- Static binding
  - Majority of *classic* languages (declaration)
  - Implicit declaration (Fortran, Basic)
- Dynamic binding
  - Scripting and interpretative languages
  - Dynamic type checking – time consuming

Type of a Variable

- Example of dynamic binding
  - `if ( $p ) $x = 10; else $x = „abc“;`
    `echo $x+1;  // 11 or „abc1“`
- Languages
  - Type-less
  - Non-typed
  - Typed
    - Explicit typing X type inference (odvození)

Scope of a Variable

- Part of a program, in which it is possible to work with the entity
- Variable visibility
  - Variable hiding
- Static binding
  - Denoted by program structure, majority of languages
- Dynamic binding
  - Till next declaration (APL, SNOBOL4, *LISP*)
  - Simple in interpreted languages, not suitable from SE viewpoint

Lifetime of a Variable

- Interval, when there is a memory allocated for the variable
- Static allocation
  - Before program run/evaluation
- Dynamic allocation
  - Automatic
  - Command for creation/allocation

Another Terms

- Dynamic programming languages
  - usually non-typed – dynamic typing
  - features through whole spectrum of paradigms, but not necessarily
    - Non-structured
    - Structured
    - Modular
    - OO

Terms to Remember

- Syntax, semantics
- Binding
  - Static, dynamic
- Abstraction
- Declaration X definition

Exercises/Motivation

- Examine taught terms within your favorite languages:
  - C, C++, C#, Java, JavaScript, Perl, Python, ML, Haskell, Hope, LISP, PHP, Pascal, Object-Pascal, Objective C, SmallTalk, Prolog