Programming Languages: Introduction and Overview

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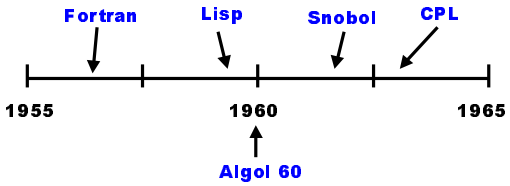
History of Programming Languages



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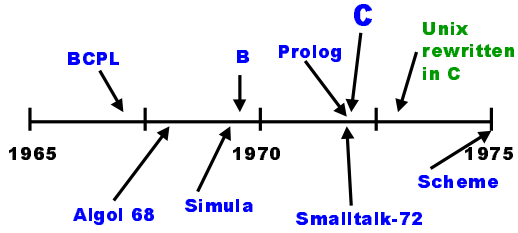

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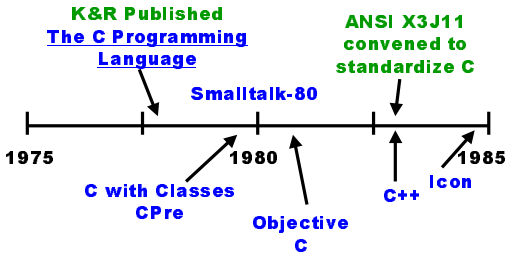

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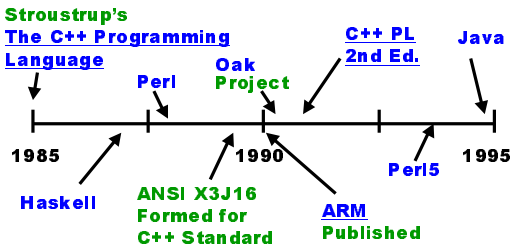


What is a programming language for?

- Instructing machines?
- Communicating among programmers?
- Expressing high level designs?
- Notation for algorithms?
- Tool for experimentation?

Languages are for both humans and computers!

Effective Use of Programming Languages

"Learning the fundamentals of a programming language is one thing: learning how to design and write effective programs in that language is something else entirely."

—Scott Meyers

Why do we care?

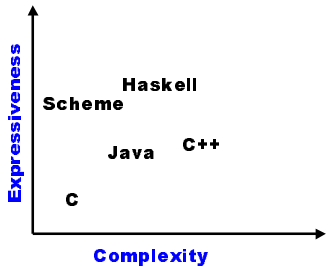
- Whorf-Sapir hypothesis for natural languages
- Tradeoffs among languages
  - reusability, maintainability
  - performance, robustness
  - flexibility, dynamicism
  - libraries
  - aesthetics (i.e., "fun-ness")

Language classification

- Imperative (Fortran, Algol, C)
- Functional ("Pure" Scheme/Lisp, Haskell)
- Logic/Relational (Prolog)
- Object-oriented (Smalltalk, Java, C++)

⇨Languages may encourage a certain style even if they do not force it on you!

Complexity vs. Expressiveness



What's wrong with imperative?

```
int i = 7;
   ⋮
printf("%d\n",i*2);
```

- What gets printed?

Assignments make reasoning difficult!

```
int i = 7;
   ⋮
i = 3;
   ⋮
printf("%d\n",i*2);
```

Are we safe yet?

```
const int i = 7;
   ⋮
/* no assignments in here */
   ⋮
printf("%d\n",i*2); /* 14? */
```


Imperative programming

- Nice for execution, translation... BUT:
- Harder for humans to understand and reason about
- Harder for sophisticated software tools
  - Proving correctness is harder
  - Restricts code motion, limits optimizer (especially important for parallel machines)

The Functional Approach

- Eliminates assignments (side effects), focus on expressions
- Tell **what** to compute, not **how** (leave order of computation unspecified)
- Higher level programming model— leave more details to machine

Scheme

- Very simple syntactically
- Still an imperative language, though
- But encourages a functional style
- Can write in a purely functional subset
  - we will do this in the beginning
  - still has assignments
- Dynamically typed

Haskell

- Pure functional language
- Statically-typed
- "Lazy" evaluation