# Chapter 2 – Evolution of the Major Programming Languages

## *Chapter 2 Topics*

Zuse's Plankalkül

Minimal Hardware Programming: Pseudocodes

The IBM 704 and Fortran

Functional Programming: LISP

The First Step Toward Sophistication: ALGOL 60

Computerizing Business Records: COBOL

The Beginnings of Timesharing: BASIC

Everything for Everybody: PL/I

Two Early Dynamic Languages: APL and SNOBOL

The Beginnings of Data Abstraction: SIMULA 67

Orthogonal Design: ALGOL 68

Some Early Descendants of the ALGOLs

Programming Based on Logic: Prolog

History's Largest Design Effort: Ada

Object-Oriented Programming: Smalltalk

Combining Imperative ad Object-Oriented Features: C++

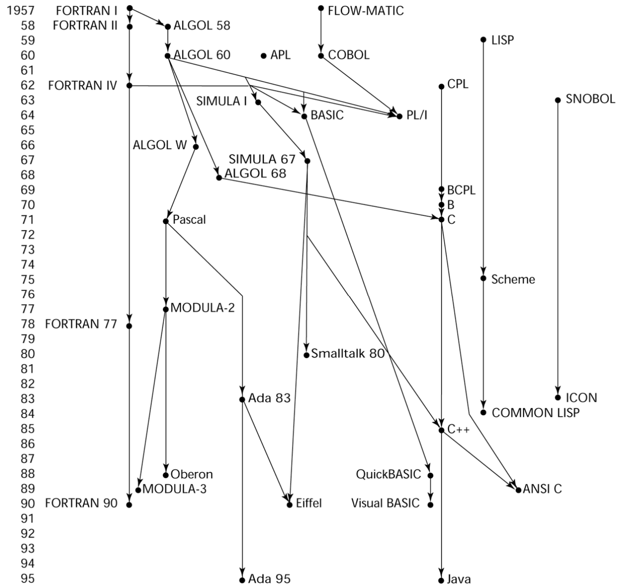
An Imperative-Based Object-Oriented Language: Java

Scripting Languages

A C-Based Language for the New Millennium: C#

Markup/Programming Hybrid Languages

## *Genealogy of Common Languages*



## *Zuse's Plankalkül*

Designed in 1945, but not published until 1972

Never implemented

Advanced data structures

- floating point, arrays, records

Invariants

## *Plankalkül Syntax*

An assignment statement to assign the expression A[4] + 1 to A[5]

| | A + 1 | ⇒ | A | |
|---|---|---|---|---|
| V | 4 | | 5 | (subscripts) |
| S | 1.n | | 1.n | (data types) |

## *Minimal Hardware Programming: Pseudocodes*

What was wrong with using machine code?

- Poor readability
- Poor modifiability
- Expression coding was tedious
- Machine deficiencies--no indexing or floating point

## *Pseudocodes: Short Code*

Short Code developed by Mauchly in 1949 for BINAC computers

Expressions were coded, left to right

Example of operations:

| | | | | | |
|---|---|---|---|---|---|
| *01* | *–* | *06* | *abs value* | *1n* | *$(n+2)^{nd}$ power* |
| *02* | *)* | *07* | *+* | *2n* | *$(n+2)^{nd}$ root* |
| *03* | *=* | *08* | *pause* | *4n* | *if ≤ n* |
| *04* | */* | *09* | *(* | *58* | *print and tab* |

## *Pseudocodes: Speedcoding*

**Speedcoding developed by Backus in 1954 for IBM 701**

Pseudo ops for arithmetic and math functions

Conditional and unconditional branching

Auto-increment registers for array access

Slow!

Only 700 words left for user program

## *Pseudocodes: Related Systems*

**The UNIVAC Compiling System**

Developed by a team led by Grace Hopper

Pseudocode expanded into machine code

**David J. Wheeler (Cambridge University)**

developed a method of using blocks of re-locatable addresses to solve the problem of absolute addressing

## *IBM 704 and Fortran*

**Fortran 0: 1954 - not implemented**

**Fortran I:1957**

Designed for the new IBM 704, which had index registers and floating point hardware

- This led to the idea of compiled programming languages, because there was no place to hide the cost of interpretation (no floating-point software)

Environment of development

Computers were small and unreliable

Applications were scientific

No programming methodology or tools

Machine efficiency was the most important concern

## *Design Process of Fortran*

**Impact of environment on design of Fortran I**

No need for dynamic storage

Need good array handling and counting loops

No string handling, decimal arithmetic, or powerful input/output (for business software)

## *Fortran I Overview*

**First implemented version of Fortran**

Names could have up to six characters

Post-test counting loop (`DO`)

Formatted I/O

User-defined subprograms

Three-way selection statement (arithmetic **`IF`**)

No data typing statements

**First implemented version of FORTRAN**

No separate compilation

Compiler released in April 1957, after 18 worker-years of effort

Programs larger than 400 lines rarely compiled correctly, mainly due to poor reliability of 704

Code was very fast

Quickly became widely used

## *Fortran II*

**Distributed in 1958**

Independent compilation

Fixed the bugs

## *Fortran IV*

**Evolved during 1960-62**

Explicit type declarations

Logical selection statement

Subprogram names could be parameters

ANSI standard in 1966

## *Fortran 77*

**Became the new standard in 1978**

Character string handling

Logical loop control statement

`IF-THEN-ELSE` statement

## *Fortran 90*

**Most significant changes from Fortran 77**

Modules

Dynamic arrays

Pointers

Recursion

**`CASE`** statement

Parameter type checking

## *Latest versions of Fortran*

**Fortran 95**

relatively minor additions, plus some deletions

**Fortran 2003**

ditto

## *Fortran Evaluation*

Highly optimizing compilers (all versions before 90)

Types and storage of all variables are fixed before run time

Dramatically changed forever the way computers are used

Characterized as the *lingua franca* of the computing world

## *Functional Programming: LISP*

LISt Processing language

Designed at MIT by McCarthy

AI research needed a language to

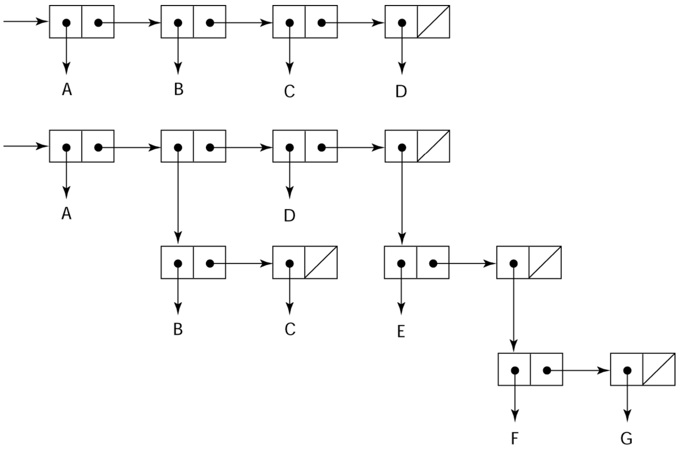
Process data in lists (rather than arrays)

Symbolic computation (rather than numeric)

Only two data types: atoms and lists

Syntax is based on *lambda calculus*

## *Representation of Two LISP Lists*



Representing the lists `(A B C D)`

and `(A (B C) D (E (F G)))`

## *LISP Evaluation*

Pioneered functional programming

No need for variables or assignment

Control via recursion and conditional expressions

Still the dominant language for AI

COMMON LISP and Scheme are contemporary dialects of LISP

ML, Miranda, and Haskell are related languages

## *Scheme*

Developed at MIT in mid 1970s

Small

Extensive use of static scoping

Functions as first-class entities

Simple syntax (and small size) make it ideal for educational applications

## *COMMON LISP*

An effort to combine features of several dialects of LISP into a single language

Large, complex

## *The First Step Toward Sophistication: ALGOL 60*

**Environment of development**

FORTRAN had (barely) arrived for IBM 70x

Many other languages were being developed, all for specific machines

No portable language; all were machine- dependent

No universal language for communicating algorithms

**ALGOL 60 was the result of efforts to design a universal language**

## *Early Design Process*

ACM and GAMM met for four days for design (May 27 to June 1, 1958)

Goals of the language

- Close to mathematical notation
- Good for describing algorithms
- Must be translatable to machine code

## *ALGOL 58*

Concept of type was formalized

Names could be any length

Arrays could have any number of subscripts

Parameters were separated by mode (in & out)

Subscripts were placed in brackets

Compound statements (**`begin ... end`**)

Semicolon as a statement separator

Assignment operator was :=

**`if`** had an **`else-if`** clause

No I/O - “would make it machine dependent”

## *ALGOL 58 Implementation*

Not meant to be implemented, but variations of it were (MAD, JOVIAL)

Although IBM was initially enthusiastic, all support was dropped by mid 1959

## *ALGOL 60 Overview*

Modified ALGOL 58 at 6-day meeting in Paris

New features

- Block structure (local scope)
- Two parameter passing methods
- Subprogram recursion
- Stack-dynamic arrays
- Still no I/O and no string handling

## *ALGOL 60 Evaluation*

**Successes**

It was the standard way to publish algorithms for over 20 years

All subsequent imperative languages are based on it

First machine-independent language

First language whose syntax was formally defined (BNF)

**Failure**

Never widely used, especially in U.S.

Reasons

- Lack of I/O and the character set made programs non-portable
- Too flexible--hard to implement
- Entrenchment of Fortran
- Formal syntax description
- Lack of support from IBM

## *Computerizing Business Records: COBOL*

**Environment of development**

UNIVAC was beginning to use FLOW-MATIC

USAF was beginning to use AIMACO

IBM was developing COMTRAN

## *COBOL Historical Background*

**Based on FLOW-MATIC**

**FLOW-MATIC features**

Names up to 12 characters, with embedded hyphens

English names for arithmetic operators (no arithmetic expressions)

Data and code were completely separate

The first word in every statement was a verb

## *COBOL Design Process*

First Design Meeting (Pentagon) - May 1959

Design goals

Must look like simple English

Must be easy to use, even if that means it will be less powerful

Must broaden the base of computer users

Must not be biased by current compiler problems

Design committee members were all from computer manufacturers and DoD branches

Design Problems: arithmetic expressions? subscripts? Fights among manufacturers

## *COBOL Evaluation*

**Contributions**

First macro facility in a high-level language

Hierarchical data structures (records)

Nested selection statements

Long names (up to 30 characters), with hyphens

Separate data division

## *COBOL: DoD Influence*

First language required by DoD

would have failed without DoD

Still the most widely used business applications language

## *The Beginning of Timesharing: BASIC*

Designed by Kemeny & Kurtz at Dartmouth

Design Goals:

Easy to learn and use for non-science students

Must be “pleasant and friendly”

Fast turnaround for homework

Free and private access

User time is more important than computer time

Current popular dialect: Visual BASIC

First widely used language with time sharing

## *2.8 Everything for Everybody: PL/I*

Designed by IBM and SHARE

Computing situation in 1964 (IBM's point of view)

- Scientific computing
  - *IBM 1620 and 7090 computers*
  - *FORTRAN*
  - *SHARE user group*
- Business computing
  - *IBM 1401, 7080 computers*
  - *COBOL*
  - *GUIDE user group*

## *PL/I: Background*

**By 1963**

Scientific users began to need more elaborate I/O, like COBOL had; business users began to need floating point and arrays for MIS

It looked like many shops would begin to need two kinds of computers, languages, and support staff--too costly

**The obvious solution**

Build a new computer to do both kinds of applications

Design a new language to do both kinds of applications

## *PL/I: Design Process*

Designed in five months by the 3 X 3 Committee

- Three members from IBM, three members from SHARE

Initial concept

- An extension of Fortran IV

Initially called NPL (New Programming Language)

Name changed to PL/I in 1965

## PL/I: Evaluation

**PL/I contributions**

First unit-level concurrency

First exception handling

Switch-selectable recursion

First pointer data type

First array cross sections

**Concerns**

Many new features were poorly designed

Too large and too complex

## Two Early Dynamic Languages: APL and SNOBOL

Characterized by dynamic typing and dynamic storage allocation

Variables are untyped

A variable acquires a type when it is assigned a value

Storage is allocated to a variable when it is assigned a value

## APL: A Programming Language

Designed as a hardware description language at IBM by Ken Iverson around 1960

Highly expressive (many operators, for both scalars and arrays of various dimensions)

Programs are very difficult to read

Still in use; minimal changes

## SNOBOL

Designed as a string manipulation language at Bell Labs by Farber, Griswold, and Polensky in 1964

Powerful operators for string pattern matching

Slower than alternative languages (and thus no longer used for writing editors)

Still used for certain text processing tasks

## The Beginning of Data Abstraction: SIMULA 67

Designed primarily for system simulation in Norway by Nygaard and Dahl

Based on ALGOL 60 and SIMULA I

Primary Contributions

Coroutines - a kind of subprogram

Classes, objects, and inheritance

## *Orthogonal Design: ALGOL 68*

From the continued development of ALGOL 60 but not a superset of that language

Source of several new ideas (even though the language itself never achieved widespread use)

Design is based on the concept of orthogonality

A few basic concepts, plus a few combining mechanisms

## *ALGOL 68 Evaluation*

**Contributions**

User-defined data structures

Reference types

Dynamic arrays (called flex arrays)

**Comments**

Less usage than ALGOL 60

Had strong influence on subsequent languages, especially Pascal, C, and Ada

## *Pascal - 1971*

Developed by Wirth (a former member of the ALGOL 68 committee)

Designed for teaching structured programming

Small, simple, nothing really new

Largest impact was on teaching programming

From mid-1970s until the late 1990s, it was the most widely used language for teaching programming

## *C - 1972*

Designed for systems programming (at Bell Labs by Dennis Richie)

Evolved primarily from BCLP, B, but also ALGOL 68

Powerful set of operators, but poor type checking

Initially spread through UNIX

Many areas of application

## *Programming Based on Logic: Prolog*

Developed, by Comerauer and Roussel (University of Aix-Marseille), with help from Kowalski ( University of Edinburgh)

Based on formal logic

Non-procedural

Can be summarized as being an intelligent database system that uses an inferencing process to infer the truth of given queries

Highly inefficient, small application areas

## *History's Largest Design Effort: Ada*

Huge design effort, involving hundreds of people, much money, and about eight years

Strawman requirements (April 1975)

Woodman requirements (August 1975)

Tinman requirements (1976)

Ironman equipments (1977)

Steelman requirements (1978)

Named Ada after Augusta Ada Byron, the first programmer

## *Ada Evaluation*

**Contributions**

Packages - support for data abstraction

Exception handling - elaborate

Generic program units

Concurrency - through the tasking model

**Comments**

Competitive design

Included all that was then known about software engineering and language design

First compilers were very difficult; the first really usable compiler came nearly five years after the language design was completed

## *Ada 95*

Ada 95 (began in 1988)

Support for OOP through type derivation

Better control mechanisms for shared data

New concurrency features

More flexible libraries

Popularity suffered because the DoD no longer requires its use but also because of popularity of C++

## *Object-Oriented Programming: Smalltalk*

Developed at Xerox PARC, initially by Alan Kay, later by Adele Goldberg

First full implementation of an object-oriented language (data abstraction, inheritance, and dynamic binding)

Pioneered the graphical user interface design

Promoted OOP

## *Combining Imperative and Object-Oriented Programming: C++*

Developed at Bell Labs by Stroustrup in 1980

Evolved from C and SIMULA 67

Facilities for object-oriented programming, taken partially from SIMULA 67

Provides exception handling

A large and complex language, in part because it supports both procedural and OO programming

Rapidly grew in popularity, along with OOP

ANSI standard approved in November 1997

Microsoft's version (released with .NET in 2002): Managed C++

delegates, interfaces, no multiple inheritance

## *Related OOP Languages*

**Eiffel (designed by Bertrand Meyer - 1992)**

Not directly derived from any other language

Smaller and simpler than C++, but still has most of the power

Lacked popularity of C++ because many C++ enthusiasts were already C programmers

**Delphi (Borland)**

Pascal plus features to support OOP

More elegant and safer than C++

## *An Imperative-Based Object-Oriented Language: Java*

**Developed at Sun in the early 1990s**

C and C++ were not satisfactory for embedded electronic devices

**Based on C++**

Significantly simplified (does not include **`struct, union, enum`**, pointer arithmetic, and half of the assignment coercions of C++)

Supports *only* OOP

Has references, but not pointers

Includes support for applets and a form of  concurrency

## *Java Evaluation*

Eliminated many unsafe features of C++

Supports concurrency

Libraries for applets, GUIs, database access

Portable: Java Virtual Machine concept, JIT compilers

Widely used for Web programming

Use increased faster than any previous language

Most recent version, 5.0, released in 2004

## *Scripting Languages for the Web*

**Perl**

Designed by Larry Wall—first released in 1987

Variables are statically typed but implicitly declared

Three distinctive namespaces, denoted by the first character of a variable's name

Powerful, but somewhat dangerous

Gained widespread use for CGI programming on the Web

Also used for a replacement for UNIX system administration language

**JavaScript**

Began at Netscape, but later became a joint venture of Netscape and Sun Microsystems

A client-side HTML-embedded scripting language, often used to create dynamic HTML documents

Purely interpreted

Related to Java only through similar syntax

**PHP**

PHP: Hypertext Preprocessor, designed by Rasmus Lerdorf

A server-side HTML-embedded scripting language, often used for form processing and database access through the Web

Purely interpreted

## *Scripting Languages for the Web*

## *Scripting Languages for the Web*

**Ruby**

Designed in Japan by Yukihiro Matsumoto (a.k.a, “Matz”)

Began as a replacement for Perl and Python

A pure object-oriented scripting language

- All data are objects

Most operators are implemented as methods, which can be redefined by user code

Purely interpreted

## *A C-Based Language for the New Millennium: C#*

Part of the .NET development platform (2000)

Based on C++ , Java, and Delphi

Provides a language for component-based software development

All .NET languages use Common Type System (CTS), which provides a common class library

## *Markup/Programming Hybrid Languages*

**XSLT**

eXtensible Markup Language (XML): a metamarkup language

eXtensible Stylesheet Language Transformation (XSTL) transforms XML documents for display

Programming constructs (e.g., looping)

**JSP**

Java Server Pages: a collection of technologies to support dynamic Web documents

servlet: a Java program that resides on a Web server and is enacted when called by a requested HTML document; a servlet's output is displayed by the browser

JSTL includes programming constructs in the form of HTML elements

## *Summary*

Development, development environment, and evaluation of a number of important programming languages

Perspective into current issues in language design