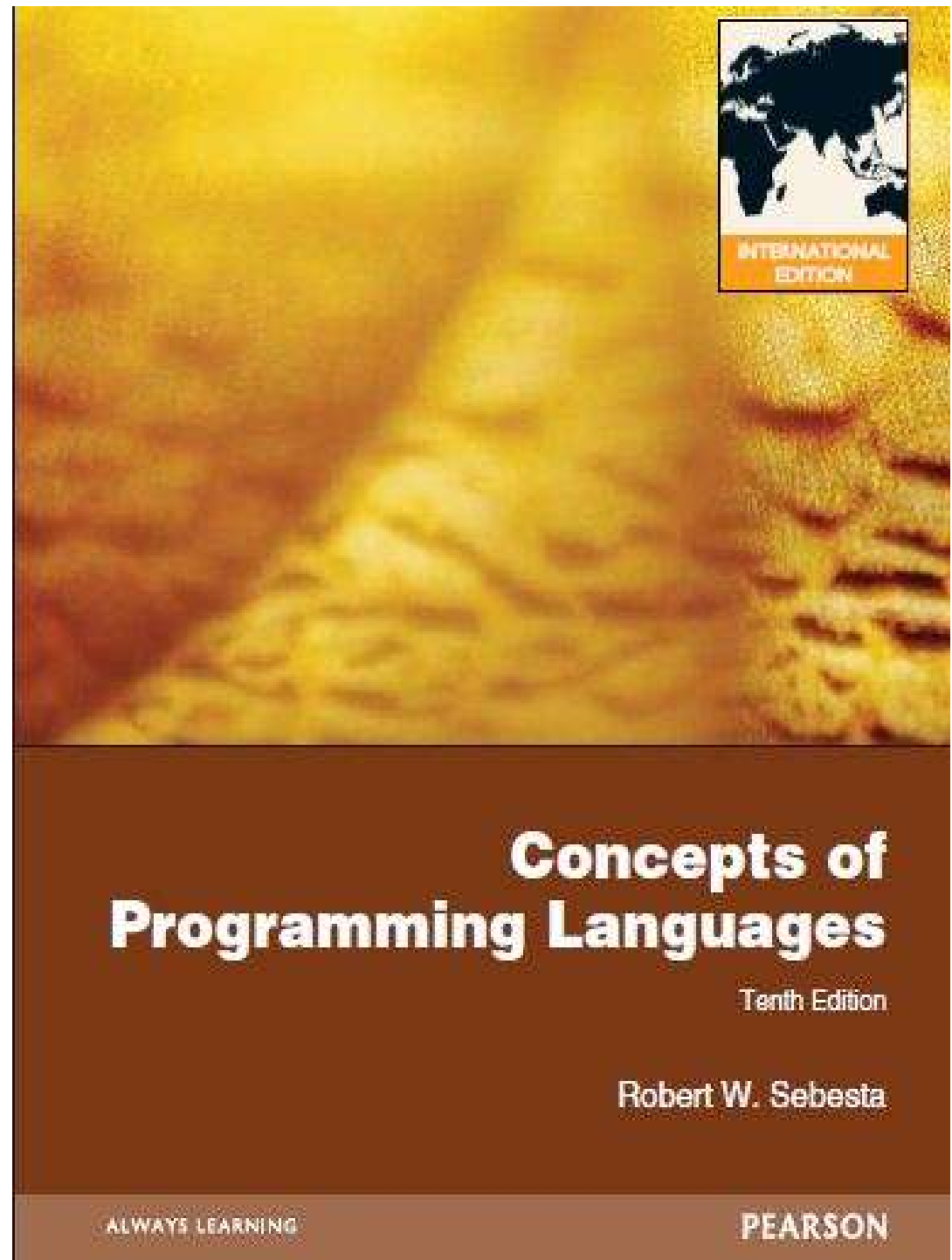


Programming Language

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Lecture 1

Introduction

- ▣ Evolution of the Major Programming Languages

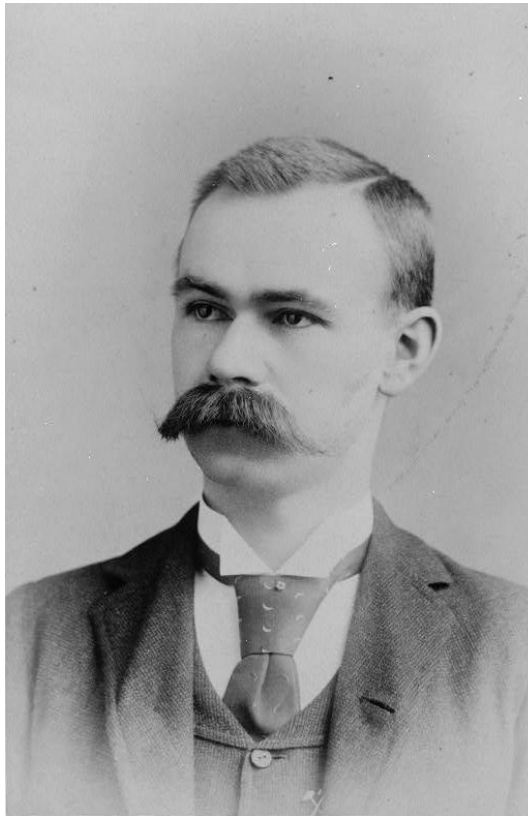
Four Paradigms of High-Level Programming Languages

- Imperative Language
- Functional Language
- Logical Language
- Object-Oriented Language

Evolution of Programming Language

- Machine Language
- Assembly Language
- High Level Language
 - ▣ BASIC, FORTRAN, COBOL, PASCAL, C, ...
- Query Language
 - ▣ Oracle, Informix,...
- Object–Oriented Programming (OOP)
 - ▣ Visual BASIC, Visual C++, Delphi, ...

The 1st Program



Herman Hollerith



Ada Lovelace



Evolution of the Major Programming Languages

- 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

Evolution of the Major Programming Languages

- Programming Based on Logic: Prolog
- History's Largest Design Effort: Ada
- Object–Oriented Programming: Smalltalk
- Combining Imperative and Object–Oriented Features: C++
- An Imperative–Based Object–Oriented Language: Java
- Scripting Languages
- The Flagship .NET Language: C#
- Markup/Programming Hybrid Languages

Zuse's Plankalkül

- The world's **first complete high-level language**
- Designed in 1945, but not published until 1972
- Never implemented
- With **advanced data structures**
 - ▢ Integer, floating point, arrays, records
- Includes a **iterative statement** similar to Ada **for**
- Includes a **selection statement**, but does not allow **else** clause
- Includes **mathematical expressions** showing the current relationships between variables
- Syntax: e.x. assign the expression $A[4] + 1$ to $A[5]$



		$A + 1 \Rightarrow A$		
V		4	5	(subscripts)
S		1.n	1.n	(data types)

Pseudocodes

- Drawbacks of using machine code:
 - Expression coding is tedious
 - Poor readability
 - Use numerical codes for specifying instructions
 - Poor modifiability and error prone
 - Machine deficiencies--no indexing or floating point



Pseudocodes: Short Code


- Short Code was developed by John Mauchly in 1949 for BINAC computers, and was later transferred to UNIVAC I computer.
- Expressions were coded, left to right
- Example of operation codes:

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

- Example: the statement **X0=SQRT(ABS(Y0))** would be coded in a word as **00 X0 03 20 06 Y0**



Pseudocodes: Speedcoding

- Speedcoding was developed by John Backus in 1954 for IBM 701
- Includes pseudoinstructions for **arithmetic operations** (+ - x /) and **math functions** (root, sine, arc tangent, exponent, logarithm)
- Includes conditional/unconditional **branching**
- Includes input/output **conversions**
- Includes **auto-increment registers for array access** (**matrix multiplication** could be done in 12 Speedcoding instructions)
- Slow!
- Only 700 words were left for user program after loading the interpreter 

Pseudocodes: Related Systems

- The UNIVAC Compiling Systems
 - ▣ Developed by a team led by Grace Hopper between 1951 and 1953
 - ▣ Expands Pseudocode 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
 - 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 developing Fortran
 - Computers had small memories and unreliable
 - Applications were scientific computation
 - No efficient/effective programming methodology or tools
 - Computers are much more expensive than programmers

Fortran I Overview

- First implemented version of Fortran
 - Formatted I/O
 - Variable names could have up to six characters
 - User-defined subprograms, but no separate compilation
 - Post-test counting loop (**DO**)
 - Three-way selection statement (arithmetic **IF**)
 - No data typing statements
 - Variable name begins with I, J, K, L, M, and N are integer type, and all others are floating-point



Fortran I Overview (continued)

- First implemented version of FORTRAN
 - 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 & IV

- Fortran II was distributed in 1958
 - Independent compilation
 - Fixed the bugs
- Fortran IV was evolved during 1960–62
 - Explicit type declarations
 - Logical selection statement
 - Subprogram names could be parameters
 - ANSI (American National Standards Institute) standard in 1966

Fortran 77 & 90

- Fortran 77 became the new standard in 1978
 - Character string handling
 - Logical loop control statement
 - **IF-THEN-ELSE** statement
- Fortran 90 had 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 – support for OOP, procedure pointers, interoperability with C
- Fortran 2008 – blocks for local scopes, co-arrays, `Do Concurrent`

Functional Programming: LISP

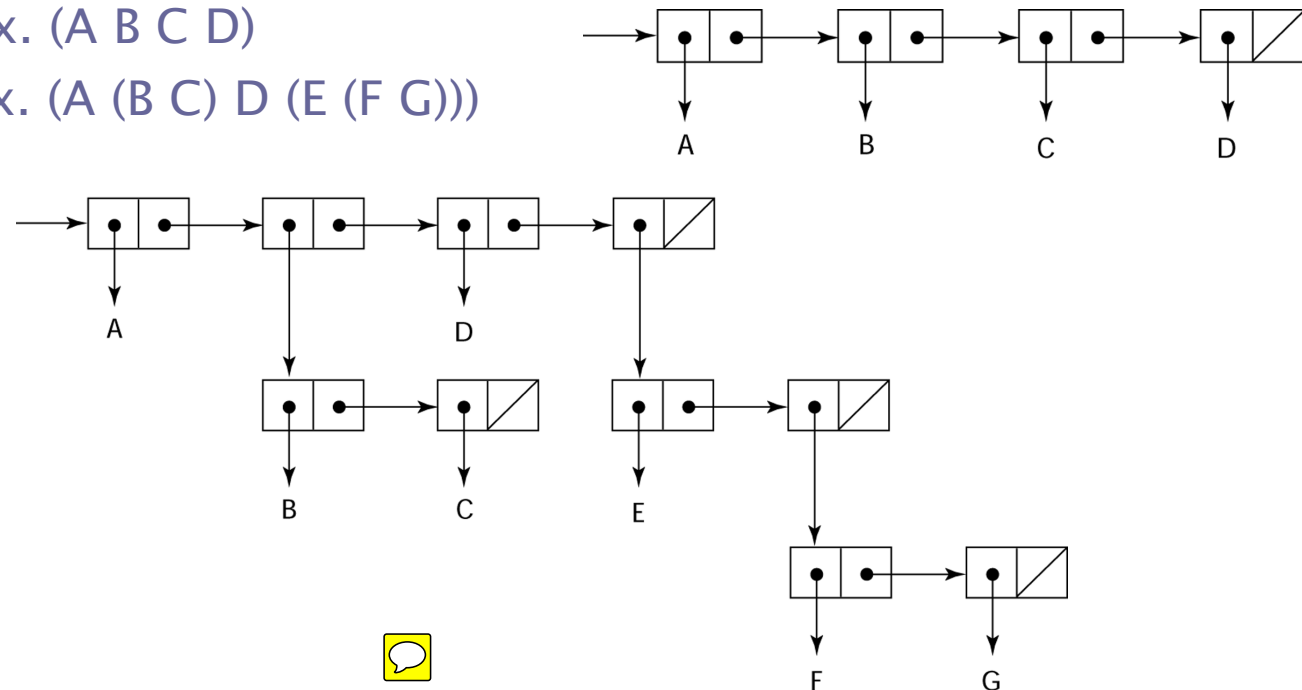
- The first functional programming language
- Designed by McCarthy, MIT, 1958
- List processing language:
 - ❑ Process symbolic data in linked lists rather than numeric data in arrays
 - ❑ LISP includes recursion, conditional expression, dynamic storage allocation
 - ❑ Applied in the area of Artificial Intelligence
 - Linguists: Natural language processing
 - Psychologists: Modeling human information storage and retrieval
 - Mathematicians: mechanizing certain intelligent process, e.g. theorem proving

Data Structure and Syntax of LISP

- Pure LISP only two data types
 - atoms : symbols or numerical literals
 - lists : specified by delimiting elements with parentheses

➤ ex. (A B C D)

➤ ex. (A (B C) D (E (F G)))



- LISP Syntax is based on *lambda calculus*

An Example of LISP program

```
( DEFUN equal_lists (lis1 lis2)
  ( COND
    ( (ATOM lis1) ( EQ lis1 lis2) )
    ( (ATOM lis2) NIL )
    ( (equal_lists (CAR lis1) (CAR lis2) )
      (equal_lists (CDR lis1) (CDR lis2) ) )
    ( T NIL )
  )
)
```

Two Descendants of LISP

- Scheme

- Developed at MIT in mid 1970s
- Small
- Extensive use of static scoping
- Treat 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, used in industry for some large applications

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 International **Algorithmic** Language (May 27 to June 1, 1958)
- Goals of the language
 - Close to mathematical notation and readable with little further explanation
 - Good for describing algorithms in printed publications
 - Must be translatable to machine code

ALGOL 58

- Concept of data type was formalized
- Variable names could be any length
- Allow any number of arrays dimensions
- 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, 1960
- New features
 - Block structure (local scope)
 - Two parameter passing methods
 - Pass by value and Pass by name
 - Subprogram recursion
 - Stack-dynamic arrays
 - Still no I/O and no string handling

ALGOL 60 Evaluation

- Successes

- ▣ 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, Backus–Naur form)

- Failure

- ▣ Never widely used, especially in U.S.
 - 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
 - ▣ U.S. Air Force was beginning to use AIMACO
 - ▣ IBM was developing COMTRAN
- Based on FLOW-MATIC
 - ▣ 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
- 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 College
- 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

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 one that allows to create concurrently executing subprograms
 - Detect and handle 23 different types of exceptions or run-time errors
 - Switch-selectable recursion
 - First pointer data type
 - First one that allows cross-sections of array to be referenced.
- Concerns
 - Many new features were poorly designed
 - Too large and too complex

Two Early Dynamic Languages: APL and SNOBOL

- Characteristics shared by APL and SNOBOL:
 - Dynamic typing
 - Variables are untyped: A variable acquires a type when it is assigned a value
 - Dynamic storage allocation
 - 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
- Includes many operators, for both scalars and arrays of various dimensions
 - Highly expressive
 - Programs are very difficult to read
- Still in use, but not widely

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
 - 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 relative small set of primitive constructs can be combined in a relative small number of ways to build a large number of control and data structures of the language

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

Portable System Language : C

- Designed for **systems programming** (at Bell Labs by Dennis Richie, 1972)
- Evolved primarily from BCLP and B, but also ALGOL 68
- Powerful set of operators, but poor type checking
- Initially spread through UNIX
- Though designed as a systems language, it has been used in many application areas

Programming Based on Logic: Prolog

- Developed, by Comerauer and Roussel (University of Aix-Marseille), with help from Kowalski (University of Edinburgh)
- Name Prolog based on *Programming Logic*
- Designed 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
- Comparatively inefficient
- Few application areas

Two kinds of Statements

- Facts

- mother(mary, jake)
- father(vern, mary)

- Rules

- grandparent(X,Z) :- parent(X, Y), parent(Y,Z)

History's Largest Design Effort: Ada

- Huge design effort, involving hundreds of people, much money, and about eight years
- Sequence of requirements (1975–1978)
 - ▣ Strawman, Woodman, Tinman, Ironman, Steelman
- High-level language for **embedded systems**
- 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
- Ada 2005
 - ▣ Interfaces and synchronizing interfaces
- 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 (GUI) 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
- 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 release .NET computing platform in 2002
 - ▣ Including a new version of C++: Managed C++ (MC++)
 - ▣ Properties, delegates, interfaces, a reference type for garbage-collected objects
 - ▣ Does not support multiple inheritance

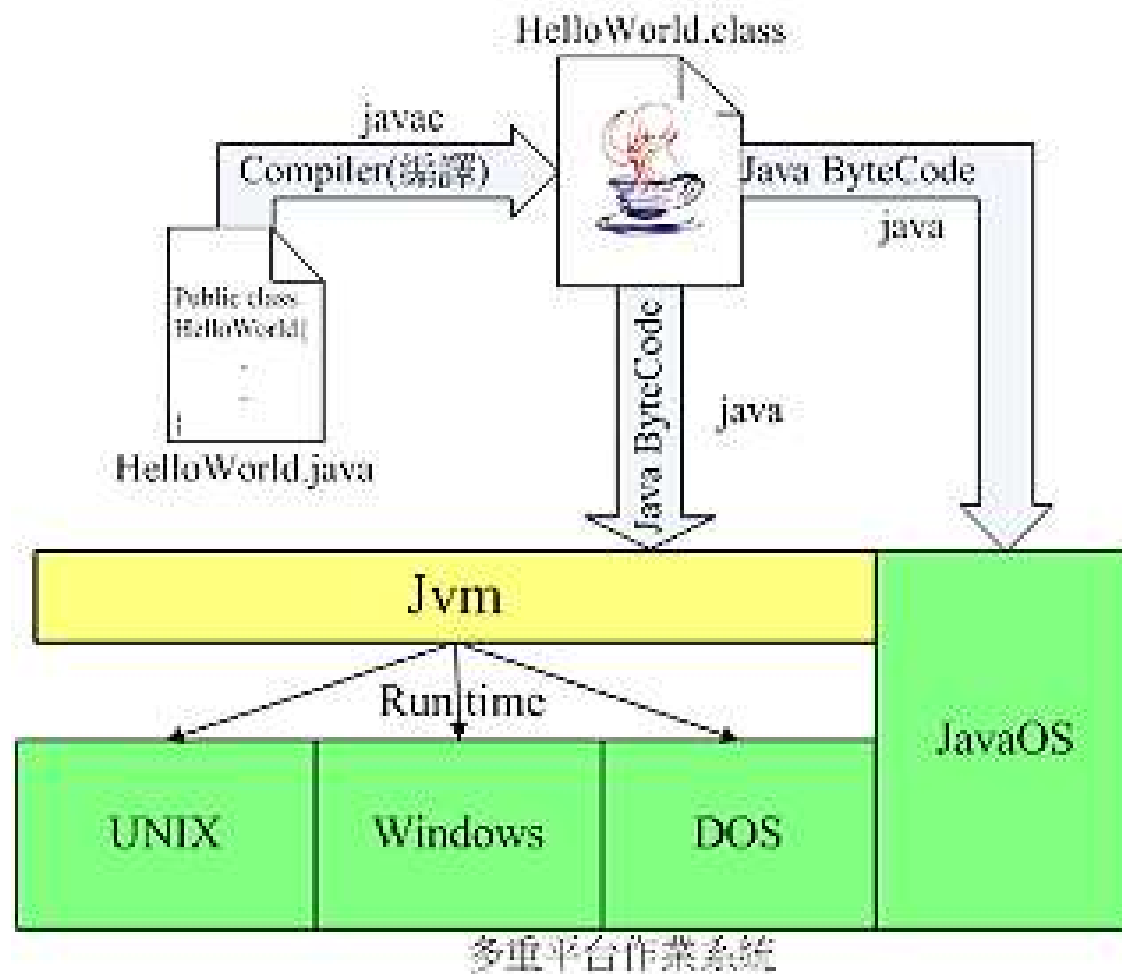
Related OOP Languages

- Objective-C (designed by Brad Cox – early 1980s)
 - ▣ C plus support for OOP based on Smalltalk
 - ▣ Uses Smalltalk's method calling syntax
 - ▣ Used by Apple for systems programs
- Delphi (Borland)
 - ▣ Pascal plus features to support OOP
 - ▣ More elegant and safer than C++
- Go (designed at Google – 2009)
 - ▣ Loosely based on C, but also quite different
 - ▣ Does not support traditional OOP

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

How a JAVA Program Works?



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, 7, released in 2011

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

- Python
 - ❑ An OO interpreted scripting language
 - ❑ Type checked but dynamically typed
 - ❑ Used for CGI programming and form processing
 - ❑ Dynamically typed, but type checked
 - ❑ Supports lists, tuples, and hashes
- 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

Scripting Languages for the Web

- Lua
 - ❑ An OO interpreted scripting language
 - ❑ Type checked but dynamically typed
 - ❑ Used for CGI programming and form processing
 - ❑ Dynamically typed, but type checked
 - ❑ Supports lists, tuples, and hashes, all with its single data structure, the table
 - ❑ Easily extendable

The Flagship .NET Language: C#

- Part of the .NET development platform (2000)
- Based on C++ , Java, and Delphi
- Includes pointers, delegates, properties, enumeration types, a limited kind of dynamic typing, and anonymous types
- Is evolving rapidly

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
 - JSTL, a JSP library, 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