

Programming Languages and Program Development

What You Will Learn About

- What a programming language is
- Machine language and assembly language
- High-level programming languages
- The shortcomings of early languages
- Popular programming languages

What You Will Learn About

- The six phases of the program development life cycle (PDLC)
- Why top-down programming makes programs easier to debug and maintain
- The three basic types of control structures
- Syntax errors and logic errors in programs

Programming Languages

Machine Language

COBOL

Visual Basic

Smalltalk

Fortran

BASIC

C and C++

Assembly Language

Pascal

Ada

Java

- **Programming languages** are artificial languages created to tell the computer what to do
- They consist of vocabulary and a set of rules to write programs
- The **program development life cycle (PDLC)** is an organized method of software development

Development of Programming Languages

- Programming languages are classified by levels or generations
- Lower-level languages are the oldest
- The five generations of programming languages are:
 - Machine languages
 - Assembly languages
 - Procedural languages
 - Problem-oriented languages
 - Natural languages

First-Generation Languages

- **Machine language:**
 - Consists of binary numbers (0s and 1s)
 - Is the earliest programming language
 - Is the only language the computer understands without translation
 - Is machine dependent
 - Each family of processors has its own machine language

```
Program Fragment:      Y = Y + X
Machine Language Code
(Binary Code)

Opcode      Address
1100 0000   0010 0000 0000 0000
1011 0000   0001 0000 0000 0000
1001 0000   0010 0000 0000 0000

Memory Cell Definitions:

  Addr.      Name      Cell Contents
  1000      X          32
  2000      Y          16
```

Second-Generation Languages

- **Assembly language:**
 - Resembles machine language
 - Is a low-level language
 - Uses brief abbreviations for program instructions.
 - Abbreviations are called **mnemonics**
 - A program is written in **source code** (text file) and translated into machine language by an **assembler**

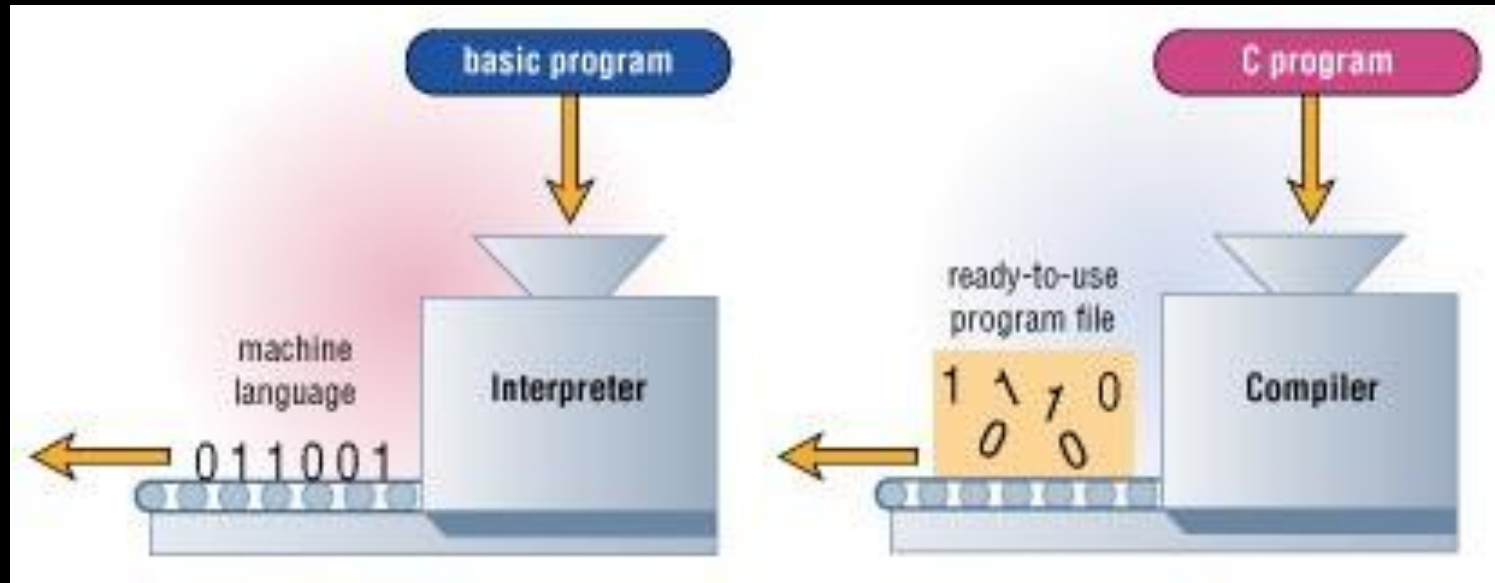
Assembly Language Code

```
LOAD Y  
ADD X  
STORE Y
```

Third-Generation Languages

- **Procedural languages:**
 - Are high-level languages that tell the computer what to do and how to do it
 - Create programs at a high level of abstraction
 - Are easier to read, write, and maintain than machine and assembly languages
 - Use a compiler or interpreter to translate code
- Fortran and COBOL are third-generation languages

Compilers and Interpreters



- A compiler is a program that changes source code to object code
- An interpreter translates source code one line at a time and executes the instruction



Third-Generation Languages (continued)

- Spaghetti Code and the Great Software Crisis:
 - GOTO statements resulted in programs that were difficult to follow
 - This problem led to the software crisis of the 1960s
 - Programs were not ready on time
 - Programs exceeded their budgets
 - Programs contained too many errors
 - Customers were not satisfied

Third-Generation Languages (continued)

- **Structured programming languages:**
 - Were developed to improve software development
 - Include Algol and Pascal
 - Forbid the use of GOTO statements
 - Use control structures
 - IF-THEN-ELSE

Third-Generation Languages (continued)

- **Modular programming languages:**
 - Were developed because of problems in structured programming languages
 - Are used to create programs that are divided into separate modules
 - Each module carries out a special function
 - Require specified input to produce specified output

Fourth-Generation Languages

- Types of fourth-generation languages include:
 - Report generators
 - Languages for printing database reports
 - Query languages
 - Languages for getting information out of databases
- Fourth-generation languages are **nonprocedural**
 - They do not force programmers to follow procedures to produce results

Object-Oriented Programming

- **Object-oriented programming (OOP):**
 - Relies on **component reusability**
 - The ability to produce program modules that perform a specific task
 - Eliminates the distinction between programs and data
 - Uses **objects** that contain data and procedures

Objects

- **Objects** are units of information that contain data as well as methods that process and manipulate the data
- **Classes of objects:**
 - Hierarchy or category of objects
 - Objects at the top of the category are broader in scope than the subclass objects
- **Inheritance** refers to an object's capacity to "pass on" its characteristics to its subclasses



Common Business-Oriented Language (COBOL)

COBOL:

- The earliest (1959) high-level language
- The most widely used business language
- A proven way to do accounting, inventory, billing, and payroll
- Requires programmers to explain what the program is doing at each step

Sample Cobol program

```
      $ SET SOURCEFORMAT"FREE"
IDENTIFICATION DIVISION.
PROGRAM-ID.  Multiplier.
AUTHOR.    Michael Coughlan.
* Example program using ACCEPT, DISPLAY and MULTIPLY to
* get two single digit numbers from the user and multiply them together

DATA DIVISION.

WORKING-STORAGE SECTION.
01  Num1                                PIC 9  VALUE ZEROS.
01  Num2                                PIC 9  VALUE ZEROS.
01  Result                              PIC 99 VALUE ZEROS.

PROCEDURE DIVISION.
      DISPLAY "Enter first number (1 digit) : " WITH NO ADVANCING.
      ACCEPT Num1.
      DISPLAY "Enter second number (1 digit) : " WITH NO ADVANCING.
      ACCEPT Num2.
      MULTIPLY Num1 BY Num2 GIVING Result.
      DISPLAY "Result is = ", Result.
      STOP RUN.
```


Formula Translator (Fortran)

Fortran:

- Began in the 1950s
- Is suited to scientific, mathematical, and engineering applications
- Is used to solve complex equations
- Features simplicity, economy, and ease of use

Sample Fortran program

A code excerpt implementing an "open loop" for processing several consecutive "input blocks" like the one showed above:

```
100  continue
      read(unit=10, fmt='(/)', err=998, end=999)
      read(unit=10, fmt=*,      err=998, end=999) nstep

      read(unit=10, fmt='(/)', err=998, end=999)
      read(unit=10, fmt=*,      err=998, end=999) x1, x2

      read(unit=10, fmt='(/)', err=998, end=999)
      read(unit=10, fmt=*,      err=998, end=999) k

      read(unit=10, fmt='(/)', err=998, end=999)
      read(unit=10, fmt=*,      err=998, end=999) eps

      call compute(nstep, x1, x2, k, eps)
      goto 100

998  stop ' error reading input file '
999  stop ' end of input file '
```

Ada

- **Ada:**
 - Named after Augusta Ada Byron
 - Incorporates modular programming
 - The required language for the U.S. Defense Department
 - Suitable for control of real-time systems (missiles)

Sample Ada program

Examples involving scalar subtype conversions:

```
(22)
I, J : Integer range 1 .. 10 := 5;
K    : Integer range 1 .. 20 := 15;
...

(23)
I := J; -- identical ranges
K := J; -- compatible ranges
J := K; -- will raise Constraint_Error if K > 10
```

(24)

Examples involving array subtype conversions:

```
(25)
A : String(1 .. 31);
B : String(3 .. 33);
...

(26)
A := B; -- same number of components

(27)
A(1 .. 9) := "tar sauce";
A(4 .. 12) := A(1 .. 9); -- A(1 .. 12) = "tartar sauce"
```

Beginner's All-Purpose Symbolic Instruction Code (BASIC)

Sample BASIC program ~~Multiple Choice Structures~~

The old BASIC ON statement allowed multiple branching.

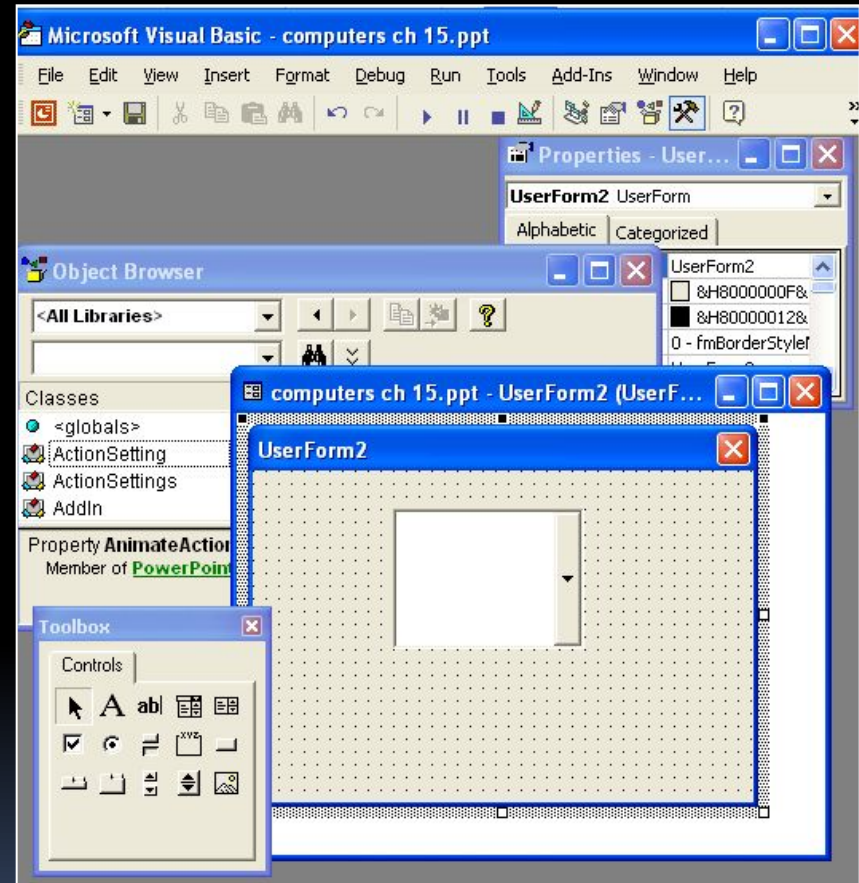
```
100 ON case GOTO 200, 300, 400
200 REM Here for the first case
210 GOTO 500
300 REM Here for the second case
310 GOTO 500
400 REM Here for the third case
410 GOTO 500
500 ...
```

- **BASIC:**
 - An easy-to-use language available on personal computers
 - Widely taught in schools as a beginner's programming language
 - Designed as an interpreted language

Visual Basic (VB)

Sample Visual Basic

- **Visual Basic:**
 - Is widely used in program development packages
 - Uses event-driven programming
 - Enables the programmer to develop an application by using on-screen graphical user interfaces



Pascal

Sample Pascal program

```
var                                {outer-block variables}
    {small variables...}
    ktr          : integer;

    {big variables...}
    big_array    : array [0..9999] of integer;
...
procedure foo;
  var
    {big variables...}
    big_array_2 : array [0..9999] of integer; {40K bytes}

    {small variables...}
    ktr2        : integer;
```

■ Pascal:

- Is named after Blaise Pascal
- Encourages programmers to write well-structured programs
- Widely accepted as a teaching language
- Has been updated to reflect new approaches to programming

C

Sample C program

- C:
 - Was developed by AT&T's Bell Labs in the 1970s
 - Combines high-level programming language with assembly language
 - Programmers manipulate bits of data within a processing unit

```
#include <stdio.h>

int main()
{
    printf("This is output from my first program!\n");
    return 0;
}
```

- Difficult to learn and programming is time consuming

Smalltalk

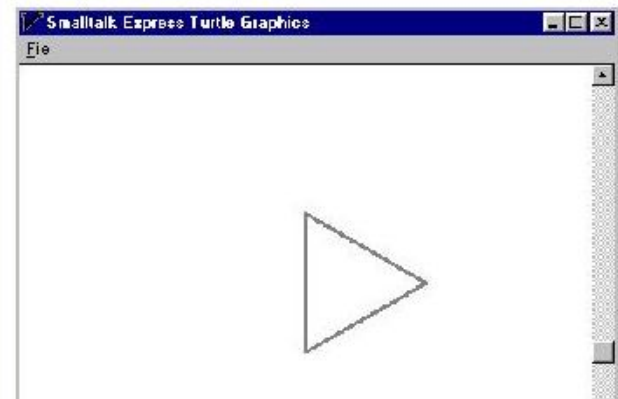
Sample Smalltalk program

- **Smalltalk:**
 - Developed in the 1970s by Xerox Corp
 - “100% pure” object-oriented programming language
 - Not often chosen for software development

Source Code

```
Window turtleWindow: 'Turtle Graphics'.
Turtle
  defaultNib: 2;
  foreColor: ClrDarkgray;
  home;
  go: 100;
  turn: 120;
  go: 100;
  turn: 120;
  go: 100;
  turn: 120
```

Sample Run



C++

Sample C++ program

- C++:
 - Incorporates object-oriented features
 - Is widely used for professional program development

```
#include <iostream.h>

int main()
{
    cout<<"HEY, you, I'm alive! Oh, and Hello World!";

    return 0;
}
```


Java

- **Java:**
 - Developed by Sun Microsystems
 - An object-oriented, high-level programming language with a twist
 - First true cross-platform programming language
 - Gained acceptance faster than any other programming language
 - A simplified version of C++

Java

- **Java, continued :**

- Java is designed to run on any computer platform

- **Java Virtual Machine** enables cross-platform use

- **Java applets** or small programs are downloaded to computers through networks

- Weaknesses include:

- The security risk in downloading applets

- The speed in running the programs

Sample Java Program

```
public void.ejbCreate(String person, String id)
    throws CreateException {

    if (person == null) {
        throw new CreateException("Null person not allowed.");
    }
    else {
        customerName = person;
    }

    IdVerifier idChecker = new IdVerifier();
    if (idChecker.validate(id)) {
        customerId = id;
    }
    else {
        throw new CreateException("Invalid id: "+ id);
    }

    contents = new Vector();
}
```

Web-Based Languages

- **Markup languages:**
 - **Hypertext markup language (HTML)** sets the attributes of text and objects within a Web page
 - **Extensible markup language (XML)** is used for sharing data and objects in a Web environment
- **Scripting languages:**
 - **VBScript** is used to write short programs (scripts) that are embedded in Web pages
 - **JavaScript** is used to write scripts on Web pages
- **Visual Studio .NET:**
 - Used for the development of scripts and programs that are accessible from the Web

The Program Development Life Cycle (PDLC)

- The PDLC was introduced in the 1970s to address problems in creating programs
- It provides an organized plan for breaking down the task of program development into manageable parts
- Six phases of the PDLC:
 1. Defining the problem
 2. Designing the program
 3. Coding the program
 4. Testing and debugging the program
 5. Formalizing the solution
 6. Implementing and maintaining the program

Phase 1: Defining the Problem

- The first step in program development
- Systems analysts provide program specifications (specs) to programmers
- Specs define:
 - Input data
 - Processing
 - Output
 - Appearance of user interface

Phase 2: Designing the Program

- Programmers create the program's design
 - **Top-down design** focuses on the program's main goal (main routine), then breaks the program into manageable components (subroutines/modules)
 - Control structures are used to see how each subroutine will do its job
- Developing an algorithm is a step-by-step description of how to arrive at a solution
- Program design tools:
 - Structure charts – show the top-down design
 - Flow charts – show the logic of program
 - Pseudo code – alternative to flow charts

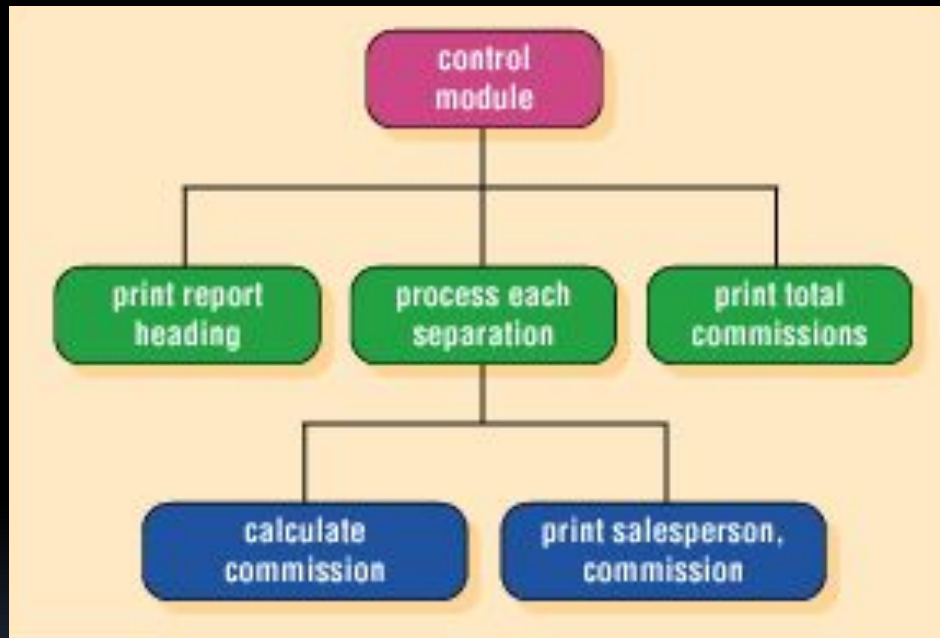
Structured Design

- **Control structures** are logical constructs that specify how the instructions in a program are to be executed
- Three types of control structures:
 - **Sequence control structure** – Instructions are executed in the order in which they appear
 - **Selection control structures** – The program branches to different instructions depending on whether a condition is met; IF...THEN...ELSE
 - **Repetition control structure** – The program repeats the same instructions over and over; DO-WHILE and DO-UNTIL



Structure Chart and Flowchart

Structure Chart



Flowchart



Phase 3: Coding the Program

- Coding requires the translation of the algorithm into specific program instructions
- An appropriate programming language is chosen, and the code is typed according to its syntax rules

Phase 4: Testing and Debugging the Program

- Testing and debugging eliminate all errors
- Syntax and logic errors are corrected
- Debugging is the process of eliminating errors

Phase 5: Formalizing the Solution

- Documentation is created for future use
- The variable names and definitions, a description of the files needed, and the layout of the output are produced
- A user manual is developed to explain how the program works

Phase 6: Implementing and Maintaining the Program

- The program is:
 - Tested by users
 - Thoroughly documented
 - Maintained and evaluated regularly

Summary

- A programming language is an artificial language consisting of a vocabulary and a set of rules
- Machine language is the lowest-level programming language
- Assembly language contains symbols for programming instructions
- Third-generation (high-level) languages require programmers to specify the procedures to be followed
- Object-oriented languages combine procedures and data

Summary, continued

- The PDLC's six phases are:
 - Defining the program
 - Designing the program
 - Coding the program
 - Testing and debugging the program
 - Formalizing the solution
 - Implementing and maintaining the program
- Top-down programming makes programs easier to debug and maintain
- Debugging requires finding and correcting syntax errors and logic errors