CS102A: Introduction to Computer Programming

Yida Tao (陶伊达)

taoyd@sustech.edu.cn

Course Instructor

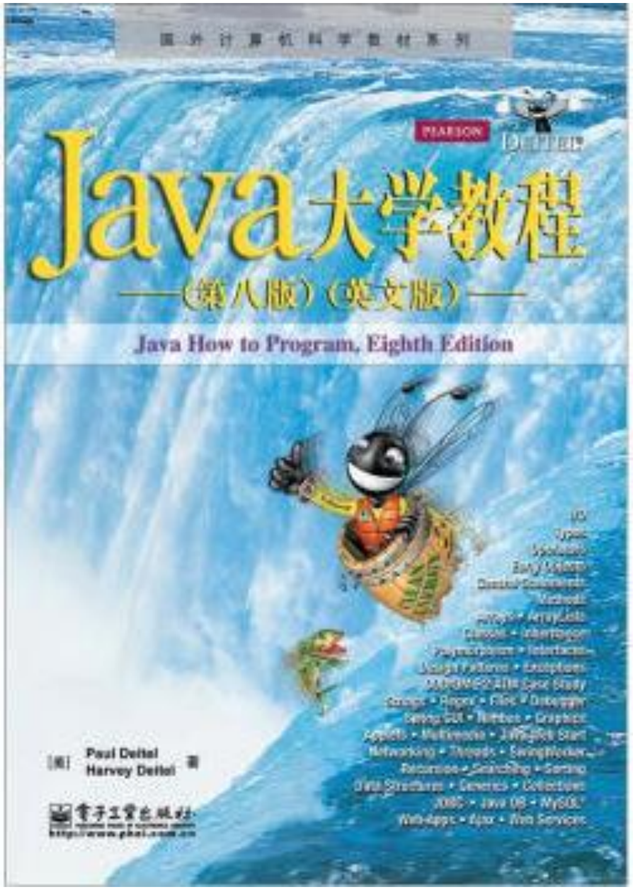
- Dr. Yida TAO (Lecturer in CSE)
- Office: Room 411, CoE Building (工学院)
- Email: taoyd@sustech.edu.cn
- Office hour: Monday 10:30 am – 11:30 am

  (you can drop by my office; no appointment is needed)

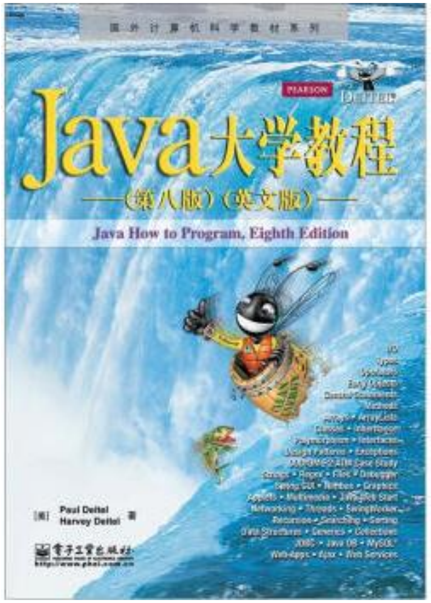
Textbook

- Main textbook:
  - P. Deitel, H. Deitel, **Java: How to Program（Java大学教程，第八版）, 电子工业出版社**

- Reference books:
  - Y. Daniel Liang. **Introduction to Java Programming**, 10e, Pearson, Prentice Hall, 2015.
  - Allen B. Downey and Chris Mayfield. **Think Java, How to Think Like a Computer Scientist**, O'Reilly, 2016.



Course Syllabus



- Introduction to Computers and Java
- Primitive Data Types
- Control Statements and Structured Programming
- Array
- Procedural Programming: Methods and APIs
- Introduction to Classes, Objects, Methods
- Strings and Wrapper Classes
- Classes, Objects and Methods: A Deeper Look
- Object-Oriented Programming: Inheritance
- Object-Oriented Programming: Polymorphism
- Graphical User Interface (GUI)
- Generic Classes and Methods
- Exception Handling: A Deeper Look

Lecture Notes

- Available at the Sakai course site
- Computing technologies advance quickly. Search online to learn more by yourself.
  - Google, Bing, Baidu
  - Stack Overflow: https://stackoverflow.com/
  - GitHub: https://github.com/

Course Objectives

- Learn how to solve problems by writing computer programs
- Learn how to design a computer program
- Learn the basics of the Java programming language
- Learn the basic concepts of object-oriented programming
- Prepare you for future courses and career

Grading Scheme

- Final exam: 40%
- Project: 20%
- Labs: 5% (14 weeks)
- Assignments: 30%
  - 5 assignments, starting from week 3
- Quizzes: 5%

Programming!

You will pass the course if your overall grade >= 60

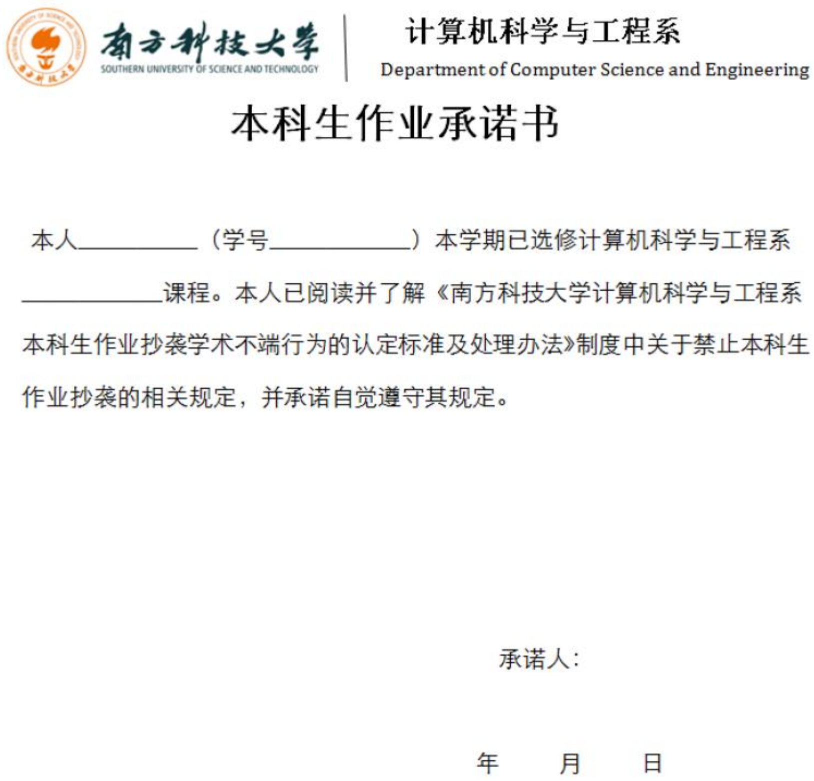
Academic Integrity

- It's OK to work on an assignment with a friend, and think together about the program structure, share ideas and even the global logic. At the time of actually writing the code, you should write it alone.
- It's OK to use in an assignment a piece of code found on the web, as long as you indicate in a comment where it was found and don't claim it as your own work.
- It's OK to help friends debug their programs (you'll probably learn a lot yourself by doing so).
- It's OK to show your code to friends to explain the logic, as long as the friends write their code on their own later.

- It's NOT OK to take the code of a friend, make a few cosmetic changes (comments, some variable names) and pass it as your own work.

Academic Integrity

Please submit the form before the end of the course selection & drop period!



南方科技大学
SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

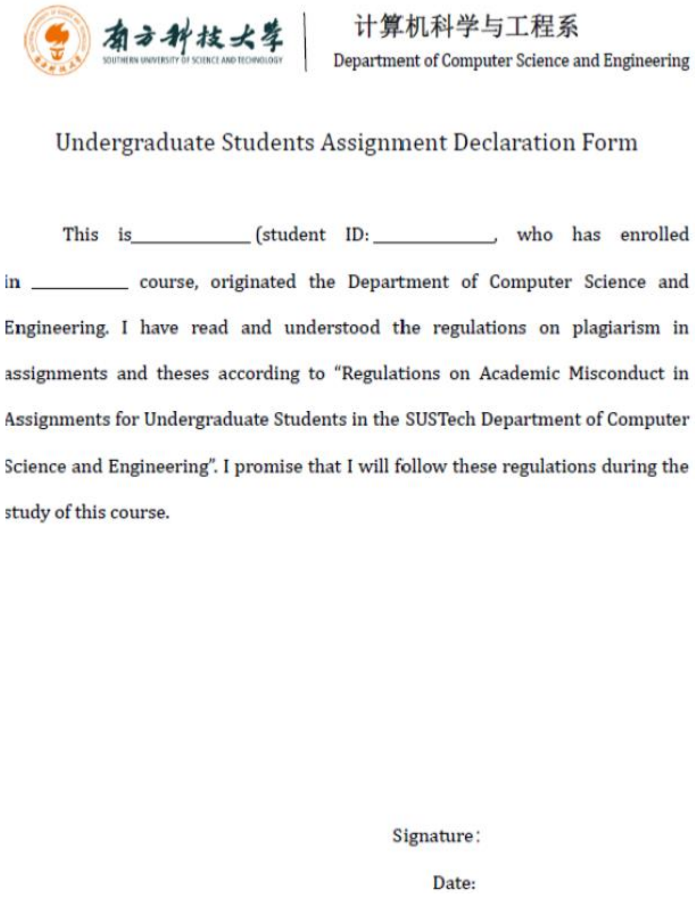
计算机科学与工程系
Department of Computer Science and Engineering

本科生作业承诺书

本人__________（学号__________）本学期已选修计算机科学与工程系__________课程。本人已阅读并了解《南方科技大学计算机科学与工程系本科生作业抄袭学术不端行为的认定标准及处理办法》制度中关于禁止本科生作业抄袭的相关规定，并承诺自觉遵守其规定。

承诺人：

年　　月　　日



南方科技大学
SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

计算机科学与工程系
Department of Computer Science and Engineering

Undergraduate Students Assignment Declaration Form

This is__________(student ID:__________, who has enrolled in ________ course, originated the Department of Computer Science and Engineering. I have read and understood the regulations on plagiarism in assignments and theses according to "Regulations on Academic Misconduct in Assignments for Undergraduate Students in the SUSTech Department of Computer Science and Engineering". I promise that I will follow these regulations during the study of this course.

Signature:

Date:

Let’s Start & Have fun ☺

Practice Makes Perfect!

Chapter 1:
Introduction to Computers, the Internet and the Web

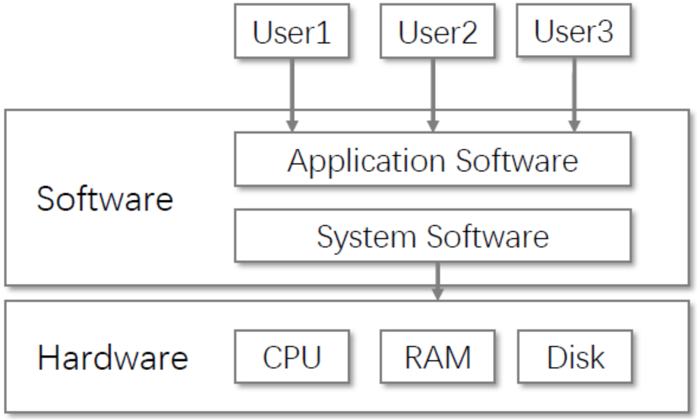
Java™ How to Program, 8/e

Outline

- Computer System Overview
- Introduction to computer programs
- Software, Internet, World Wide Web
- Introduction to Java

Computer System

- Hardware (physical parts, e.g., keyboard, mouse, hard disk, memory, processing units)
- Software (computer programs, libraries, non-executable data, e.g., documentation)



- Software is a set of programs, which could be further viewed as a set of instructions
- Hardware is directed by software to execute commands or instructions. A combination of hardware and software forms a usable computer system.

The von Neumann Architecture

- A design model for a stored-program digital computer

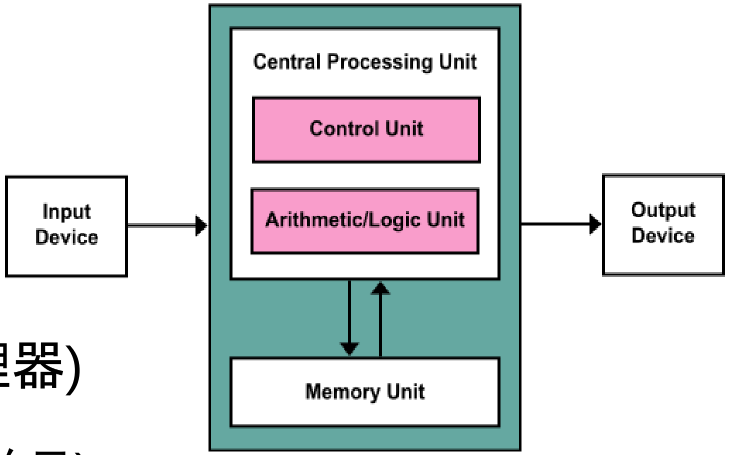
History of computing machines

- **Fixed program**: function is very specific (e.g., calculator) and can hardly be used for other purposes (hence “fixed”)
- **Stored program(存储程序)**: program instructions and data are treated the same way, all stored in memory. Reprogramming is much easier and we could carry out many different tasks on such computers (硬件设计和程序设计可以分开执行)

John von Neumann
(1903-1957)
Hungarian-American
mathematician, physicist

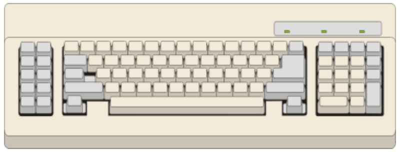
Computer Organization

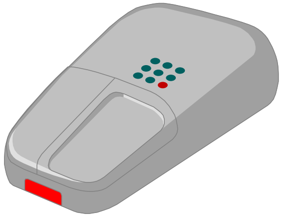
- Modern computers consist of the following logical units:
  - Input unit
  - Output unit
  - Memory unit (内存，主存)
  - Central processing unit (CPU, 中央处理器)
    - Arithmetic and logic unit (ALU, 算术逻辑单元)
    - Control Unit (CU, 控制单元)
  - Secondary storage unit (辅助存储单元，二级存储器)



Input Unit

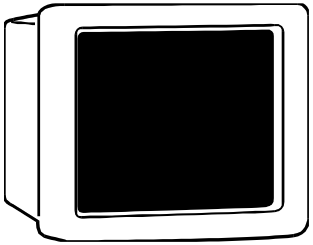
- The “receiving” section of a computer
- Obtains information (data and programs…) for other units to process.

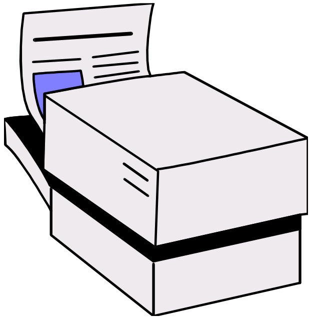




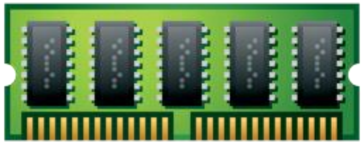
Output Unit

- The “shipping” section of a computer
- Takes the information that the computer has processed and makes it available for use outside the computer.



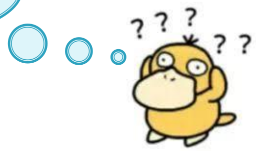


Memory Unit

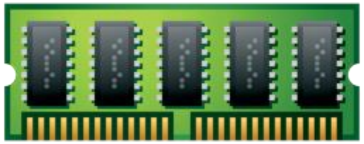


- Rapid-access, relatively low-capacity “warehouse” section
- Retains information entered through the input unit, making it immediately available for processing when needed.
- Retains processed information until it is placed on output devices.
- Information in the memory unit is **volatile** (易失) and will be lost when the computer’s power is turned off.
- Also known as main memory, primary memory, memory, or RAM (Random Access Memory 随机存取存储器)

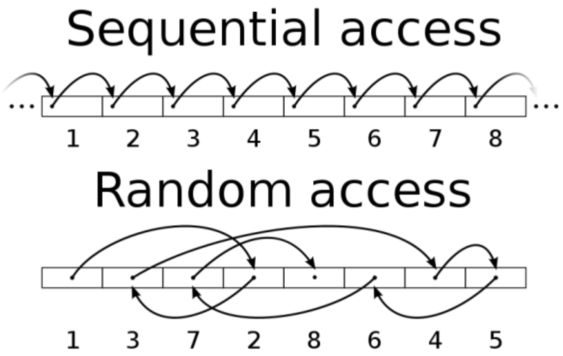
Why “Random Access?”



Memory Unit



- The term is used to distinguish from “Sequential Access”
- Sequential Access: store the data sequentially (e.g., on a magnetic tape in which an item of data could only be accessed by starting from the beginning of the tape and finding an address sequentially)
- Random Access: read and write information to anywhere in the storage (knowing the “location” is the data and directly get it). Good for accessing data that is rapidly modified.

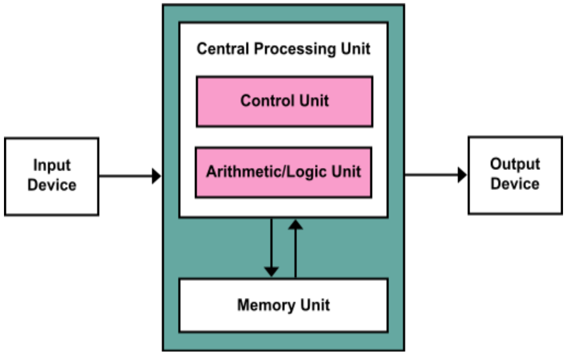


Arithmetic and Logic Unit (ALU)

- “Manufacturing” section that performs arithmetic operations, (e.g., addition, subtraction, multiplication, and division) and logic/bitwise operations (e.g., AND, OR, NOT).

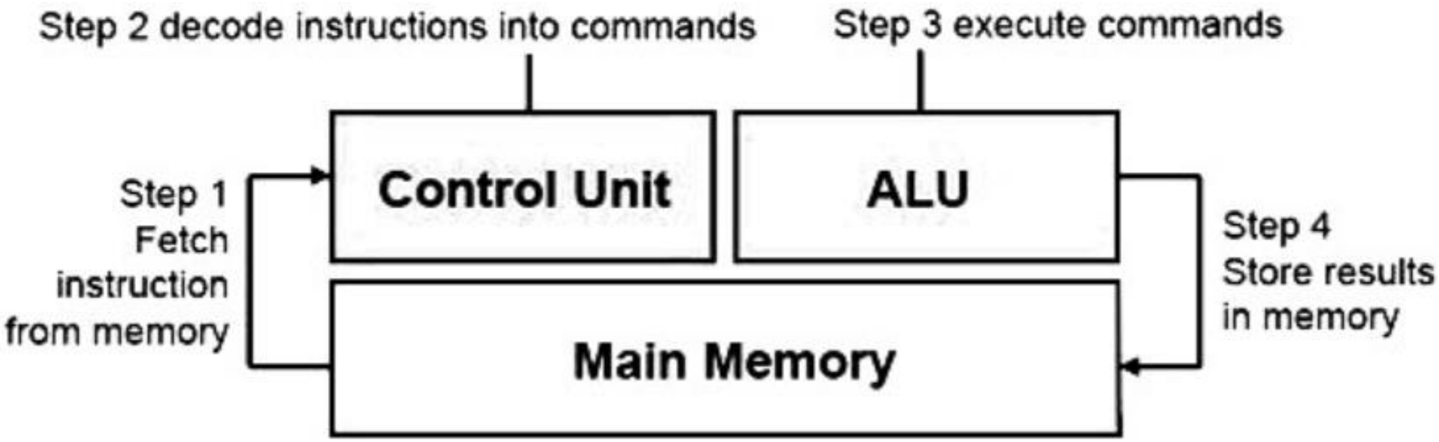
- Contains the mechanisms that allow the computer to make decisions, e.g., comparing two items from the memory to determine whether they are equal.

- In today’s computer systems, the ALU is usually implemented as part of a CPU.



Control Unit (CU)

- It directs operations between ALU, memory, and input/output devices
- CU and ALU are often integrated into a single block, known as Central Processing Unit (CPU).

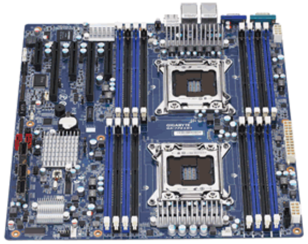

Step 2 decode instructions into commands
Step 3 execute commands
Step 1 Fetch instruction from memory
Control Unit
ALU
Step 4 Store results in memory
Main Memory

Central Processing Unit (CPU)

- "Administrative" section that coordinates the operations of the other units (the brain/heart of a computer).
  - Tells the input unit when information should be read into the memory unit
  - Tells the ALU when information in the memory unit should be used in calculations
  - Tells the output unit when to send information from the memory unit to output devices

Central Processing Unit (CPU)

- Many of today’s computers have multiple CPUs (can perform operations simultaneously). They are called multiprocessors (多处理器).
- A multicore processor (多核处理器) implements multiprocessing on a single integrated circuit chip (e.g., dual-core, quad-core, octa-core)



How many cores in your phone?

Secondary Storage Unit (辅助存储单元)

- Long-term, high-capacity “warehousing” section
- Programs or data not actively being used by the other units normally are placed on the secondary storage units (e.g., hard drive)
- Information on secondary storage devices is persistent and will be preserved even when the computer is turned off
- Storage devices are typically much cheaper than main memory.

Are They Computers?

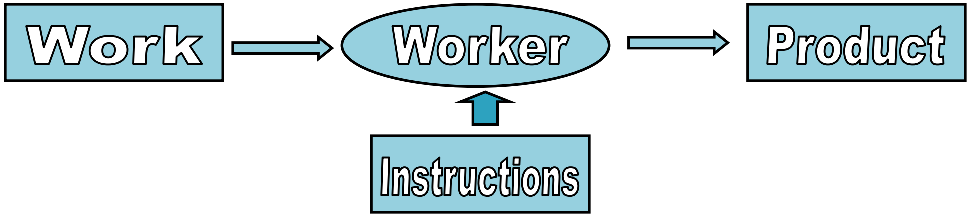
- What is the input unit?
- What is the output unit?
- Do they have CPU, RAM and disk?

Outline

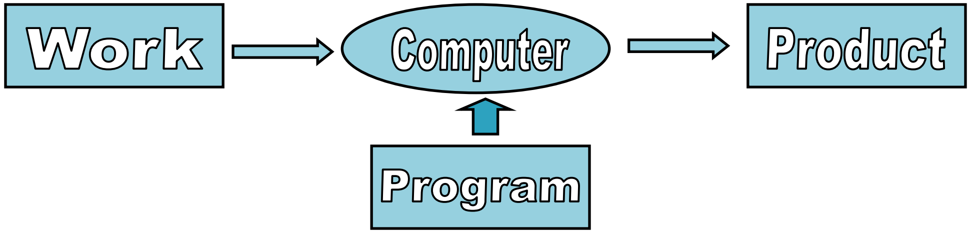
- Computer System Overview
- Introduction to computer programs
- Software, Internet, World Wide Web
- Introduction to Java

What is a computer program?

- Human work model

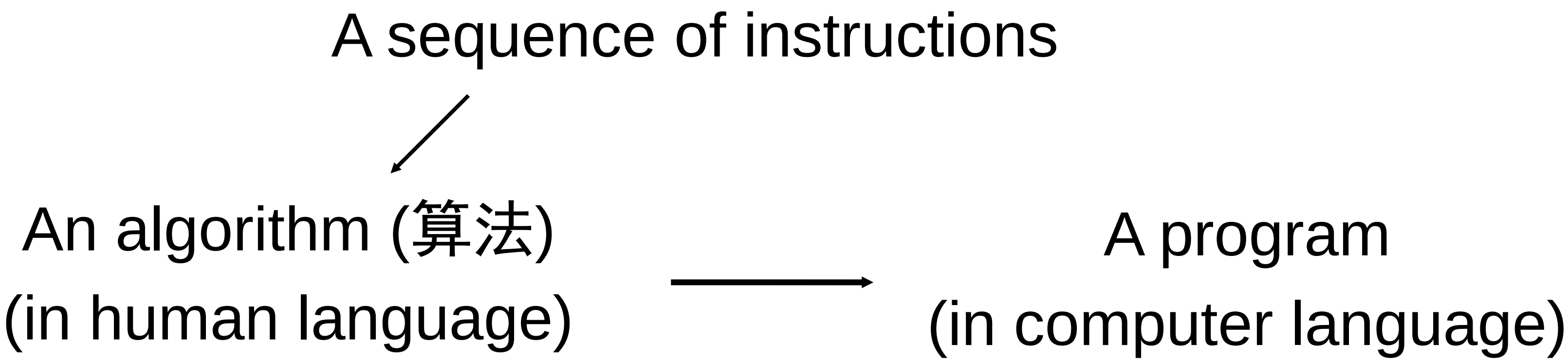


- Computer work model



- A computer program is a set of machine-readable instructions that tells a computer how to preform a specific task.

What is a (programming) language?



A sequence of instructions

An algorithm (算法)
(in human language)

A program
(in computer language)

- Programs are written in programming languages
- There are many programming languages
  - Low-level (低级语言), understandable by a computer
  - High-level (高级语言), understandable by human

Can you understand this?

```
0000100100101110011001100110100101101100011001010000100100100010011011000110
0101011000110111010001110101011100100110010100110001001011100110001100100010
0000101001100111011000110110001100110010010111110110001101101111011011010111 0
0000110100101101100011001010110010000101110001110100000101000101110011100110
1100101011000110111010001101001011011110110111000001001001000100010111001110
1000110010101111000011101000010001000001010000010010010111001100001011011000
1101001011001110110111000100000001101000000101000001001001011100110011101101
1000110111101100010011000010110110000100000011011010110000101101001011011100
0001010000001001001011100111010001111001011100000110010100001001001000000001101
1010110000101101001011011100010110000100011011001100111010101101110011000110
1110100011010010110111101101110000001010000001001001011100111000000111001001101 1
1101100011000010010011000000110100000010100110110101100001011010010110111000
1110100000010100000010010010000100100011010100000101001001001111010011000100 1
1110100011101010101010001010010001100100000001100000000010100000100101110011
01100001011101101 1001
```

How about this?

```
main:
        !#PROLOGUE# 0
        save %sp,-128,%sp
        !#PROLOGUE# 1
        mov 1,%o0
        st %o0,[%fp-20]
        mov 2,%o0
        st %o0,[%fp-24]
        ld [%fp-20],%o0
        ld [%fp-24],%o1
        add %o0,%o1,%o0
        st %o0,[%fp-28]
        mov 0,%i0
        nop
```

Is it better now?

```
int valueofz( )
{
        int x, y, z;
        x = 1;
        y = 2;
        z = x+y;
        return z;
}
```

Levels of programming languages

- Machine (binary) language is unintelligible (bits)

```
0000100100101110011001100110100101101100011001010000100100100010011011000110
0101011000110111010001110101011100100110010100110001001011100110001100100010
0000101001100111011000110110001100110010010111110110001101101111011010101110
0000110100101101100011001010110010000101110001110100000101000101110011100110
1100101011000110111010001101001011011110110111000001001001000100010111001110
1000110010101111000011101000010001000001010000010010010111001100001011011000
1101001011001110110111000100000001101000000101000001001001011100110011101101
1000110111101100010011000010110110000100000011011010110000101101001011011100
0001010000010010010111001110100011110010111000001100101000010010010000001101
1010110000101101001011011100010110000100011011001100111010101101110011000110
11101000110100101101111011011100000101000001001001011100111000001110010011011
```

Levels of programming languages

- Assembly language (汇编语言) is low level
  - Mnemonic names (助记符) for machine operations
  - Explicit manipulation of memory addresses and contents
  - Machine-dependent

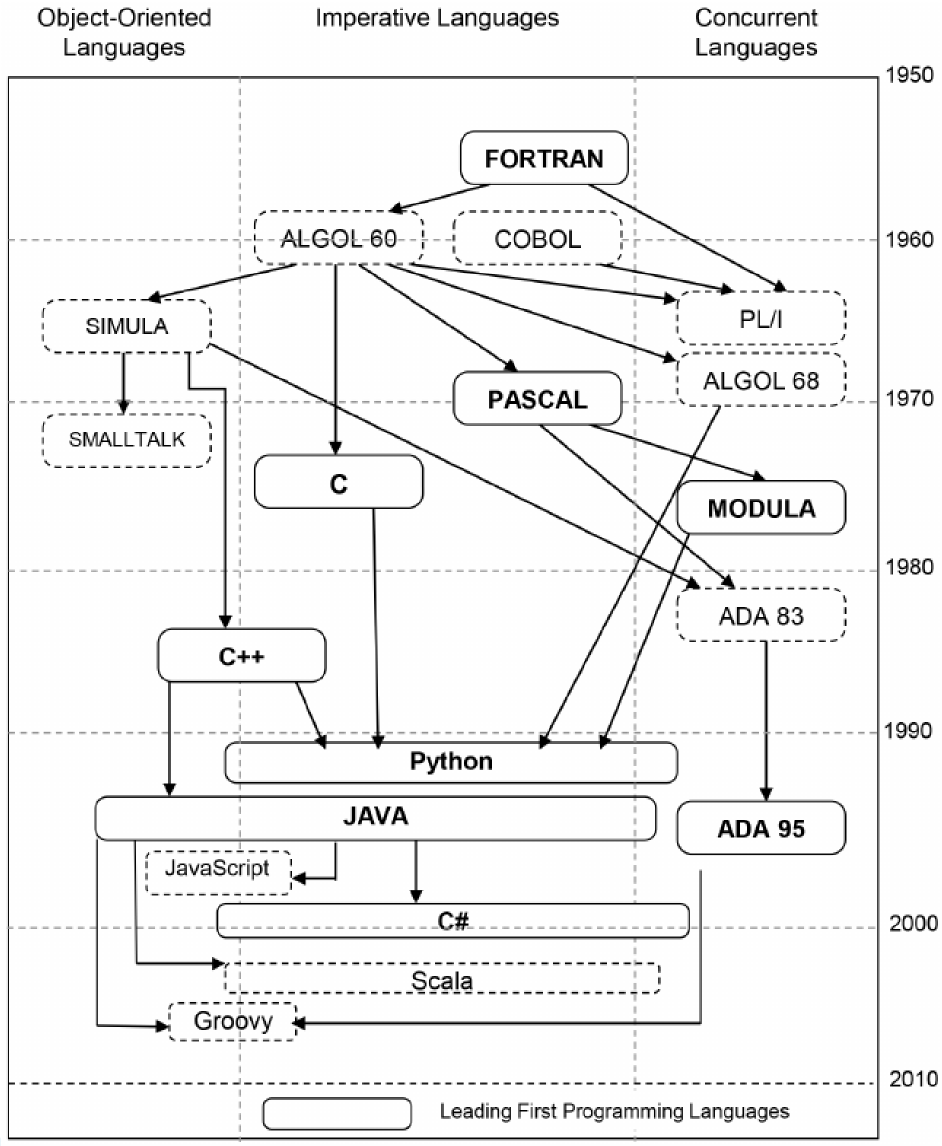
```
main:
        !#PROLOGUE# 0
        save %sp,-128,%sp
        !#PROLOGUE# 1
        mov 1,%o0
        st %o0,[%fp-20]
        mov 2,%o0
        st %o0,[%fp-24]
        ld [%fp-20],%o0
        ld [%fp-24],%o1
        add %o0,%o1,%o0
        st %o0,[%fp-28]
        mov 0,%i0
        nop
```

Levels of programming languages

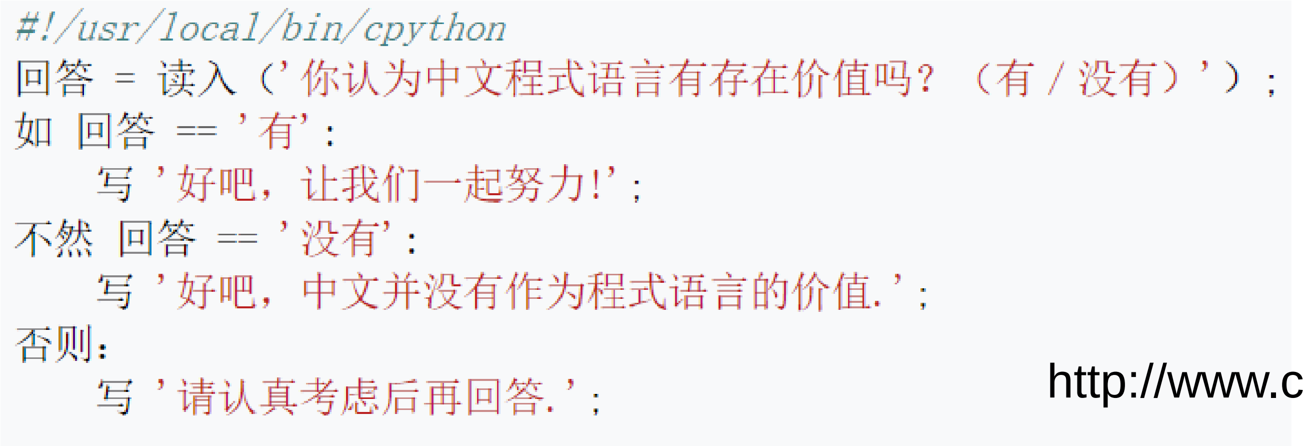
- High-level language
  - Readable: instructions are easy to remember (faster coding)
  - Less error-prone
  - No mention of memory locations
  - Machine-independent = portable

```
int valueofz( )
{
        int x, y, z;
        x = 1;
        y = 2;
        z = x+y;
        return z;
}
```

Genealogy of programming languages

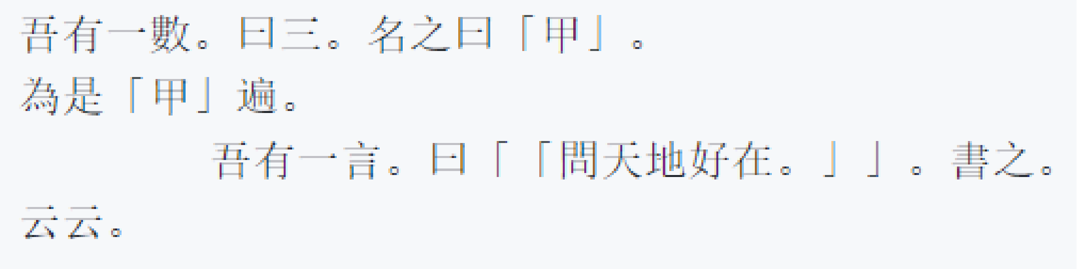


Create Your Own Programming Language ☺



```
#!/usr/local/bin/cpython
回答 = 读入（’你认为中文程式语言有存在价值吗？（有 / 没有）’）；
如 回答 == ’有’：
    写 ’好吧，让我们一起努力!’；
不然 回答 == ’没有’：
    写 ’好吧，中文并没有作为程式语言的价值.’；
否则：
    写 ’请认真考虑后再回答.’；
```

http://www.chinesepython.org/

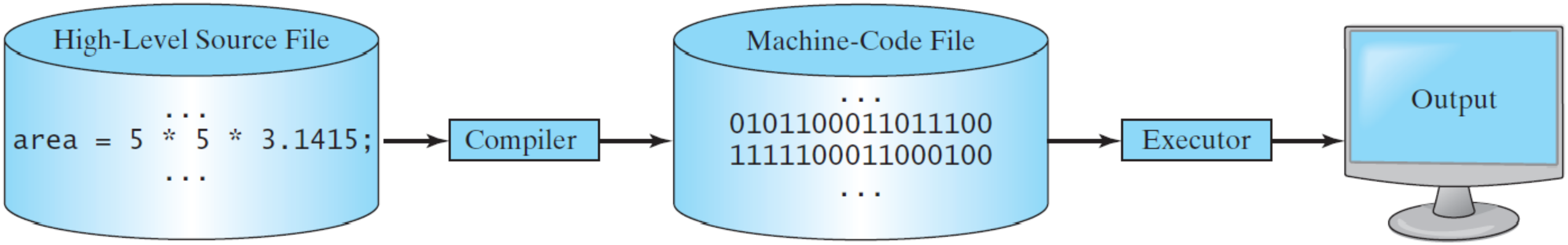


```
吾有一數。曰三。名之曰「甲」。
為是「甲」遍。
    吾有一言。曰「「問天地好在。」」。書之。
云云。
```

https://github.com/wenyan-lang/wenyan

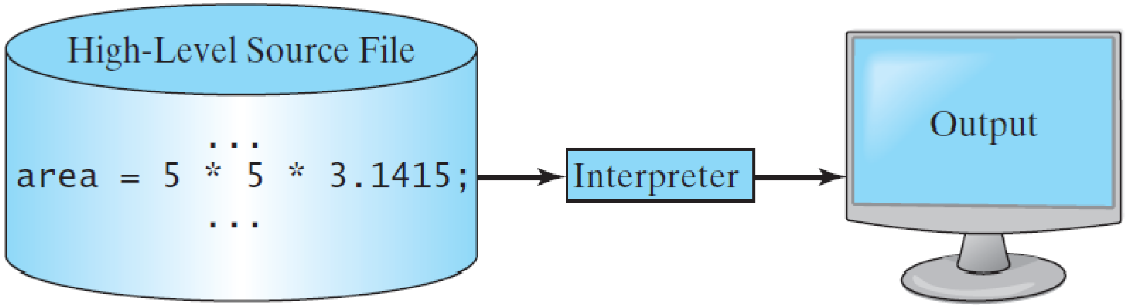
Compilation: from source to executables

- A complier (编译器) translates source programs written in high-level languages into machine codes that can run directly on the target computer.



Interpreter

- An **interpreter** (解释器) directly executes the statements from source code, without requiring the programs to have been compiled into machine codes.



Compiler vs. Interpreter

Interpreter	Compiler
Interprets and executes one statement at a time.	Scans the entire program and translates it as a whole into machine codes.
Continues executing a program until the first error is met, in which case it stops.	Programs are executable only after they are successfully compiled.
Takes less time to analyze the source code but the overall execution is usually slower.	Takes more time to analyze the source code but the overall execution is typically faster.
Programming languages like Python, Ruby use interpreters.	Programming languages like C, C++ use compilers.

How about Java?

Outline

- Computer System Overview
- Introduction to computer programs
- Software, Internet, World Wide Web
- Introduction to Java

What is software?

A set of programs (also including libraries and non-executable data, e.g., documentation)

- Application software (应用软件): Programs designed for end users to perform specific tasks. They are typically easy to use.
  - MS Word, PowerPoint, Chrome, Photoshop, WeChat etc.
- System software (系统软件): Programs that support the execution and development of other programs.
  - Operating systems (e.g., Windows, Mac OSX, Linux for desktops, and iOS & Android for mobile devices)
  - Translation systems (e.g., compilers, assemblers)

What is the Internet (因特网)?

- A global network of computers. It dates back to the research commissioned by the United States Federal Government to build robust, fault-tolerant communication via computer networks (1960s).
- The linking of commercial networks and enterprises in the early 1990s marked the beginning of the transition to the modern Internet, and generated rapid growth as institutional, personal, and mobile computers were connected to the network.
- By the late 2000s, its services and technologies had been incorporated into virtually every aspect of human lives.

https://en.wikipedia.org/wiki/Internet

What is the World Wide Web?

- The World Wide Web (万维网), or simply the Web, is a way of accessing information over the medium of the Internet. It is an **information-sharing model** that is built on top of the Internet.

- The Web uses the HTTP protocol to transmit data.

- Users can use browsers, such as Chrome to access Web documents called web pages that are linked to each other via hyperlinks. Web documents contain graphics, sounds, and video.

Internet vs Web

Internet	World Wide Web
Infrastructure (基础结构)	Service on top of the infrastructure
Connecting computers	Connecting people
Hardware	Software

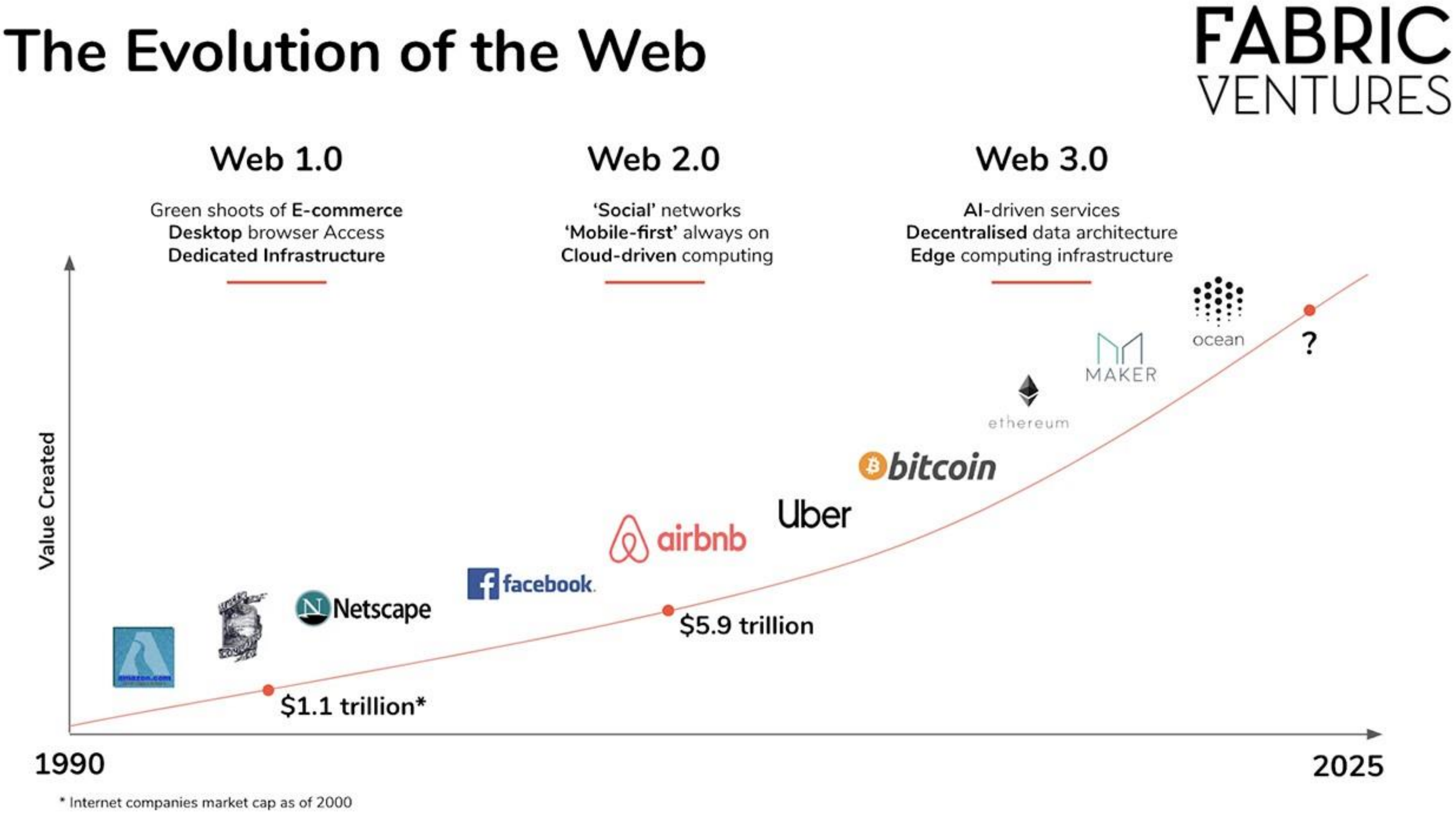
Web 1.0

- Web usage exploded in the mid-to-late 1990s. During this period, many Internet-based companies were founded, many of which failed (doc-com economic crisis).
- On the first-generation websites, people were limited to the passive viewing of content, i.e., limited interactions between sites and users (i.e., the “readable” phase of Web)
- Website often include static pages, users rarely comment or provide feedback

Web 2.0

- Resurgence began in 2004 with Web 2.0, which refers to the websites that emphasize user-generated content and usability for end users (i.e., the “writable” phase of Web)
- A Web 2.0 website may allow users to interact and collaborate with each other in a social media dialogue as content creators in a virtual community (user-centric, sharing, social, interactive, dynamic)
- Signature companies in the Web 2.0 era: Google, Facebook, YouTube, Tencent

Web 3.0?


The Evolution of the Web
FABRIC VENTURES
Web 1.0
Green shoots of E-commerce
Desktop browser Access
Dedicated Infrastructure
Web 2.0
'Social' networks
'Mobile-first' always on
Cloud-driven computing
Web 3.0
AI-driven services
Decentralised data architecture
Edge computing infrastructure
Value Created
amazon.com
Netscape
facebook.
airbnb
Uber
bitcoin
ethereum
MAKER
ocean
?
$1.1 trillion*
$5.9 trillion
1990
2025
* Internet companies market cap as of 2000

Outline

- Computer System Overview
- Introduction to computer programs
- Software, Internet, World Wide Web
- Introduction to Java

We learn Java, why?

- An object-oriented computer programming language – today's key methodology
- The most widely used computer programming language – billions of devices run Java programs
- Preferred for Internet-based applications and devices over a network

A brief history of Java

- In 1991, Sun Microsystems (acquired by Oracle in 2009) funded an internal research project, aiming to achieve the goal of "write once, run anywhere". This resulted in a C++-based language named Java.
- Why called "Java"? Java is an island in Indonesia where the first coffee was produced (Java coffee)

The father of Java:
James Gosling

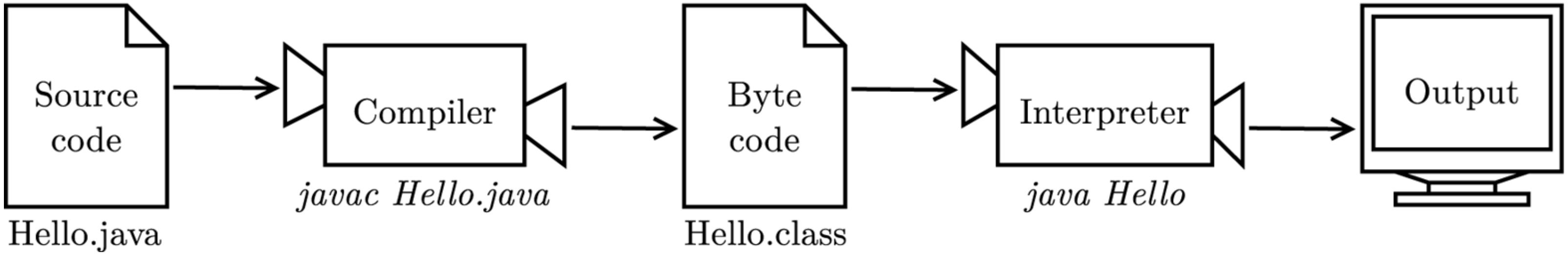
A brief history of Java

- In 1993, Sun saw the potential of using Java to add dynamic content to web pages. Java's connection to the Internet began.

- In 1995, Java was officially released; and the Netscape browser (网景浏览器) started to support Java.

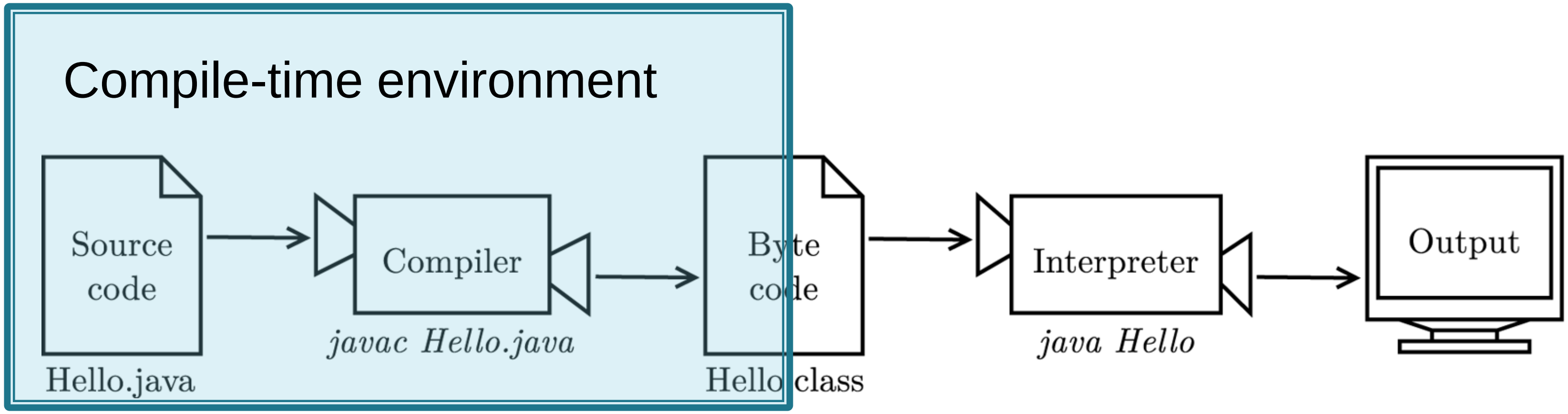
The symbol of the early Web

Java is both compiled and interpreted



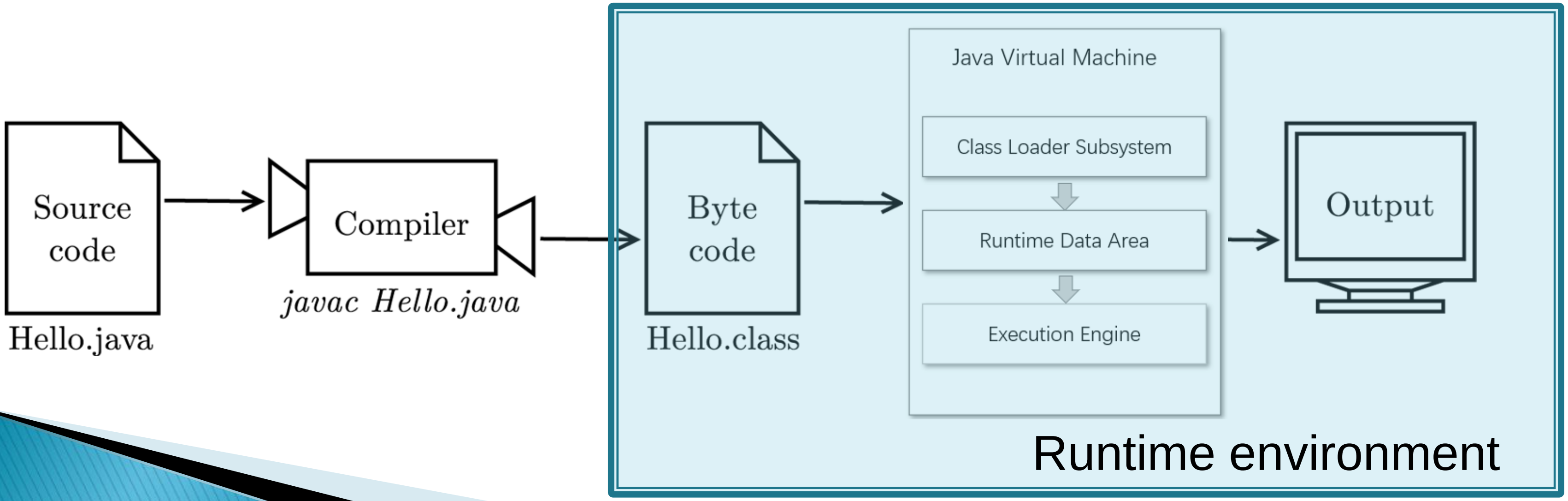
Java programming steps

- Edit (write the program and store it in the disk `.java`)
- Compile (create bytecodes and store them in a file `.class`)



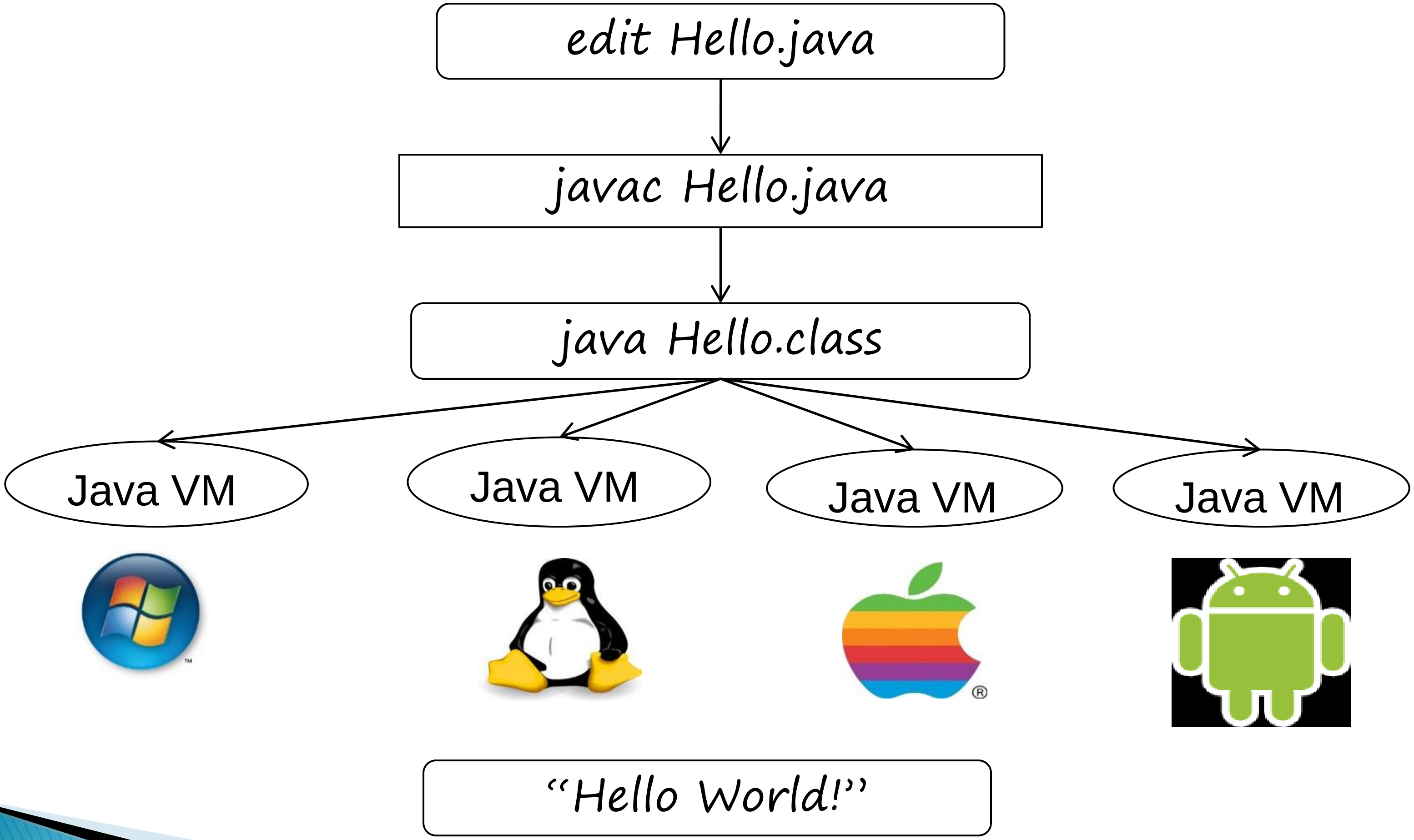
Java programming steps

- Load (read `.class` files and put those bytecodes in memory)
- Verify (confirm the bytecodes are valid and secure)
- Execute (using Java interpreter and/or JIT compiler)



Write Once and Run Anywhere

Java is platform independent



edit Hello.java

javac Hello.java

java Hello.class

Java VM

Java VM

Java VM

Java VM

“Hello World!”

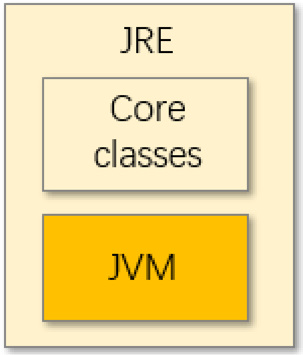
JRE and JVM

"I wrote a piece of Java source code; Can I run it with only JRE installed?"

- A **Java Virtual Machine (JVM)** is an abstract computing machine that enables a computer to run a Java program.

- The **Java Runtime Environment (JRE)** provides the minimum requirements for executing a Java application. It consists of the Java Virtual Machine (JVM), core classes, and supporting files.

- In short, JRE = JVM + Library classes



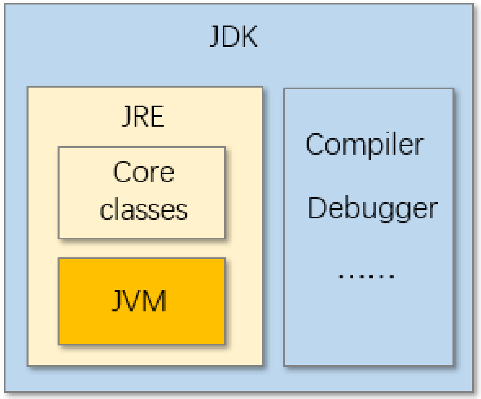
JRE

Core classes

JVM

JDK（开发套件）

- The **Java Development Kit (JDK)** is a software development environment for developing Java programs. It includes:
  - A Java Runtime Environment (JRE, 运行环境)
  - A compiler (javac)
  - An interpreter/loader (java)
  - An archiver (jar)
  - A documentation generator (javadoc)
  - Other tools needed in Java development.



- In short, JDK = JRE + Development tools

Java Editions

- Java Standard Edition (Java SE)
  - Java SE 11 (long term support) was released in Sept. 2018
- Java Enterprise Edition (Java EE)
  - For large-scale, distributed networking and web-based applications
- Java Micro Edition (Java ME)
  - For small, memory-constrained devices, e.g., micro controllers, sensors, TV boxes etc. (适用于移动设备和嵌入式设备)

What is debugging?

- The process of tracking down and correcting bugs (errors) in your programs
  - Syntax Errors（语法错误）: Syntax refers to the structure of your program and the rules about that structure (e.g., missing a semicolon at the end of a statement)
  - Runtime Errors (运行时错误, 异常): Runtime errors or exceptions occur when the interpreter is running the byte code and something goes wrong, e.g., an infinite recursion (无限递归) causes a StackOverflowException
  - Logic Errors (逻辑错误): The semantics or meaning of your program are wrong (e.g., it yields an unexpected result)

Integrated Development Environment (IDE)

- Combine all the capabilities that a programmer would want while developing software (Eclipse, IntelliJ IDEA, BlueJ, etc.)
  - We will use IDEA in this course (https://www.jetbrains.com/idea/)
  - BlueJ is good for beginners (https://www.bluej.org/)

- Before you begin programming, install JDK (Java SE Software Development Kit) and set the PATH Environment Variable properly (attend the first lab to learn this)
  - http://www.oracle.com/java/technologies/downloads

Outline

- Computer System Overview
  - CS202 计算机组成原理
- Introduction to computer programs
  - CS323 编译原理
- Software, Internet, World Wide Web
  - CS305 计算机网络
- Introduction to Java
  - CS209A Java 2