

CS100 Lecture 0

Introduction

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Introduction to programming

What is programming?

Introduction to programming

Computer programming is the process of writing instructions that get executed by computers.

The instructions, also known as **code**, are written in a **programming language** which the computer can *understand* and use to perform a task or solve a problem.

Machine code

The only language that the computer can directly understand is the **machine code**, which is **binary**!

- For convenience, write binary code in hexadecimal form.

```
gkxx@nodiscard-gkxx ~/tmp> objdump -d a.out
```

```
a.out:      file format elf64-x86-64
```

```
Disassembly of section .init:
```

```
00000000000001000 <_init>:
```

```
1000:  f3 0f 1e fa
1004:  48 83 ec 08
1008:  48 8b 05 d9 2f 00 00
100f:  48 85 c0
1012:  74 02
1014:  ff d0
1016:  48 83 c4 08
101a:  c3
```

Machine code (in hexadecimal form)

Equivalent assembly code
(more human-readable)

```
endbr64
sub    $0x8,%rsp
mov    0x2fd9(%rip),%rax      # 3fe8 <__gmon_start__@Base>
test   %rax,%rax
je     1016 <_init+0x16>
call   *%rax
add    $0x8,%rsp
ret
```

Assembly code

The assembly code is just a more human-readable form of the machine code.

- It can be translated into machine code straightforwardly.

```
gkxx@nodiscard-gkxx ~/tmp> objdump -d a.out
```

```
a.out:      file format elf64-x86-64
```

```
Disassembly of section .init:
```

```
0000000000000100 <_init>:
```

```
1000:  f3 0f 1e fa
1004:  48 83 ec 08
1008:  48 8b 05 d9 2f 00 00
100f:  48 85 c0
1012:  74 02
1014:  ff d0
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Machine code (in hexadecimal form)

Equivalent assembly code
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add    $0x8,%rsp
ret
```

High-level languages

Disadvantages of assembly code:

- Not portable: Different machines (architectures) may have different instruction sets.
- Too difficult to write and understand:
 - Instructions are very primitive and low-level, e.g. load, store, add, jump, ...
 - No high-level structures/abstractions: ~~control-flow statements, classes, ...~~

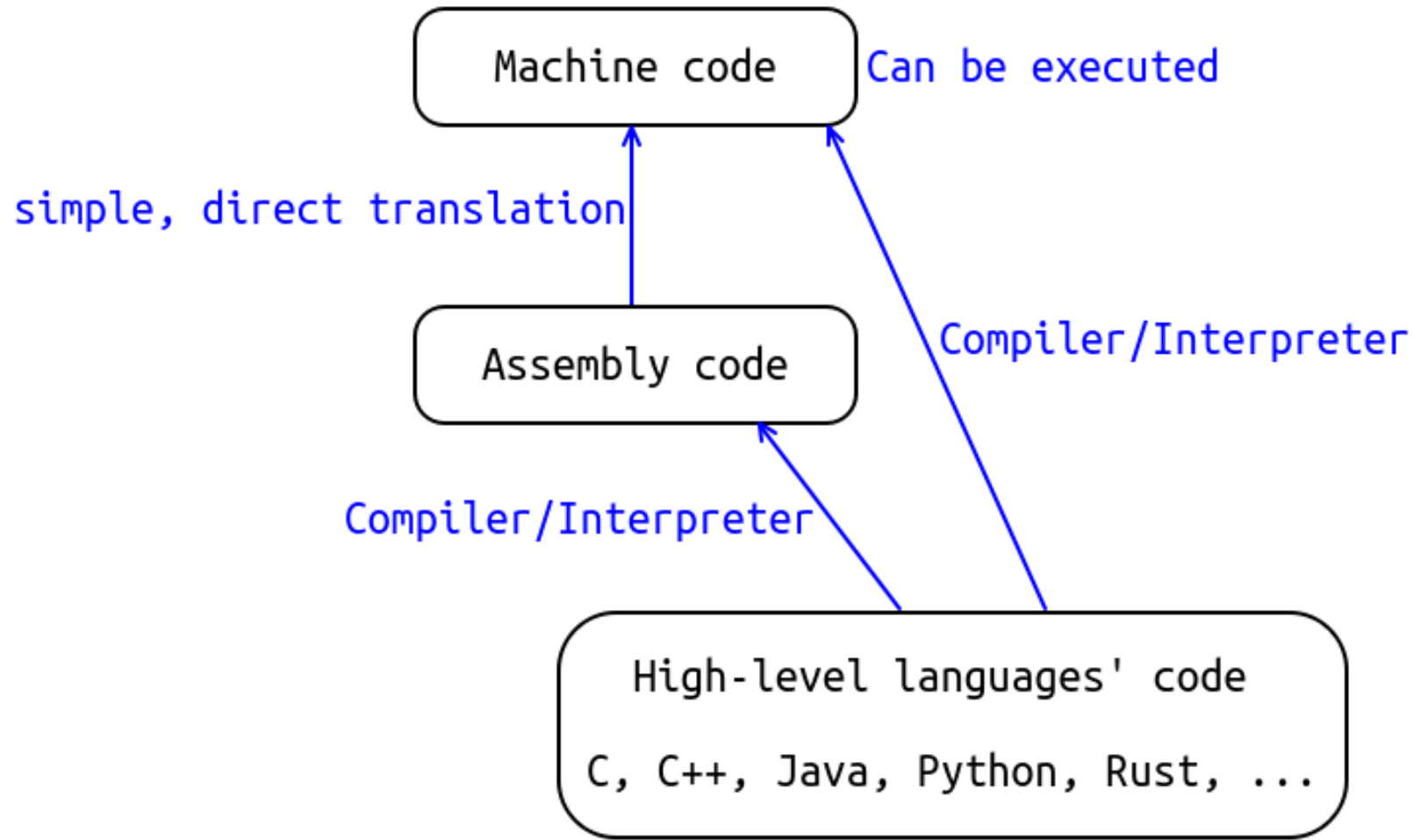
Learn more about them in senior courses (CS110, CS130, etc.)

High-level languages

Examples: C, Java, Python, C++, Rust, JavaScript, ...

- Syntactically rich
- Better abstraction ability
- More structured code
- Easier to code, debug and maintain
- Easier to ensure safety

High-level languages and compilers (including interpreters)



High-level languages and compilers

A **compiler** is a special program that **translates** a programming language's source code into machine code, bytecode or another programming language.

- The high-level code cannot be understood by the computer directly! It needs to be translated by a compiler.
 - The C/C++ compiler will translate the program and generate an executable (`.exe` file).
- Some languages (e.g. Python) use **interpreters**, which may be seen as a special kind of compiler.
 - An interpreter reads and executes the program directly, without earlier compiling it into machine code.
 - When executing a Python program, you don't see a `.exe` file!

High-level languages and compilers

The image shows a side-by-side comparison of C source code and its compiled assembly. The left pane, titled 'C source #1', contains a simple C program in the Vim editor. The right pane, titled 'x86-64 gcc 13.2 (Editor #1)', shows the corresponding assembly code for the same program, with labels like .LC0, .LC1, and main: indicating different sections of the code. The assembly includes instructions for stack frame setup, argument passing, function calls (scanf, printf), and return handling. The status bar at the bottom indicates the assembly was generated by 'x86-64 gcc 13.2' and shows some performance metrics.

```
C source #1
1 #include <stdio.h>
2
3 int main(void) {
4     int a, b;
5     scanf("%d%d", &a, &b);
6     printf("%d\n", a + b);
7     return 0;
8 }
```

```
x86-64 gcc 13.2 (Editor #1)
x86-64 gcc 13.2
1 .LC0:
2     .string "%d%d"
3 .LC1:
4     .string "%d\n"
5 main:
6     push    rbp
7     mov     rbp, rsp
8     sub     rsp, 16
9     lea     rdx, [rbp-8]
10    lea     rax, [rbp-4]
11    mov     rsi, rax
12    mov     edi, OFFSET FLAT:.LC0
13    mov     eax, 0
14    call    __isoc99_scanf
15    mov     edx, DWORD PTR [rbp-4]
16    mov     eax, DWORD PTR [rbp-8]
17    add     eax, edx
18    mov     esi, eax
19    mov     edi, OFFSET FLAT:.LC1
20    mov     eax, 0
21    call    printf
22    mov     eax, 0
23    leave
24    ret
```

(6, 27) Output (0/0) x86-64 gcc 13.2 i - 559ms (5352B) ~345 lines filtered Compiler License

High-level languages and compilers

A **compiler** is a special program that **translates** a programming language's source code into machine code, bytecode or another programming language.

```
#include <stdio.h>
int main(void) {
    puts("hello world");
}
```

`gcc hello.c -o hello.exe` \Rightarrow Generates an **executable** `hello.exe` .

- `gcc` is the C compiler used here.
- `-o xxx` indicates that the name of the generated file is `xxx` .

`.\hello` \Rightarrow Prints `hello world` .

Compilers

Popular C/C++ compilers:

- GCC (**G**NU **C**ompiler **C**ollection)
- MSVC (**M**icrosoft **V**isual **C** compiler)
- Clang
- ICC (**I**ntel **C/C++** **C**ompiler)

Why C and C++?

- C is a high-level language that is closest to assembly.
- C++ "is as close to C as possible, but no closer".
- C++ is a language that
 - is a better C,
 - supports data abstraction,
 - and supports object oriented programming.
- C and C++ are popular, powerful, general-purpose and efficient, and play an essential role in areas like systems programming, game engines development, high frequency trading, ...

Standardization of C and C++

Standardization of C and C++

Both C and C++ have **ISO** standards:

- C: ISO/IEC 9899, since 1990
 - C89/90, C99, C11, C17, C23, ...
 - Since C11 (2011), a new standard every 6 years.
- C++: ISO/IEC 14882, since 1998
 - C++98/03, C++11, C++14, C++17, C++20, C++23, ...
 - Since C++11 (2011), a new standard every 3 years.

CS100 is based on **C17** and **C++17**.

What is the value of a standard?

- Offers a unique, standard definition of the language.
- Every compiler should accept the programs that conform to the standard, with some possible compiler extensions.
- **If we want our code to be compiled and run with different compilers on different platforms, make it standard-conforming.**

How to get the standard?

Possible ways:

- Purchase the standard documentation from ISO (or ANSI) \implies Very expensive
- Download the working drafts (free): Some working drafts are really close to the standards.
 - [Useful resources for C](#) and [for C++](#).
- [cppreference](#) \longleftarrow RECOMMENDED!

About **cppreference**

The standard documentations are not friendly for learning:

- They aim to provide a **precise definition** of the language, instead of teaching the language.
- The chapters are not organized in a way suitable for learning.
- Changes between different standards are not shown in-place.

Cppreference is a complete online reference for the C and C++ languages and standard libraries.

- A more convenient and friendly version of the standards.

Course Information

Course objectives

Upon completion of the course, you should be able to:

- Know how to analyze simple problems and design programs.
- Know how to write them in C and C++.
- Know C/C++ syntax.
- Understand some basic ideas of programming.
- Understand sequential and OO programming.

Course Structure

- 16 weeks teaching
 - C: Week 1 ~ 6
 - C++: Week 7 ~ 16
 - 1 midterm exam, in week 13 ~ 15
- 2 lectures every week
 - Tuesday 13:00-14:40
 - Thursday 13:00-14:40
 - Room: SIST 1D-107
- Weekly recitations

Assessment

Homework 72% + Midterm Exam 22% + Quiz 4% + Recitation attendance checks 2%.

- No final exams
- No projects
- Homework assignments make up a large proportion!

Recitations

- About 15 recitations
- 2 hours every week
- Include review of important contents, some extensions, homework/quiz/exam solutions, and some coding examples.
- **Attendance mandatory!** (2% in total)
- Videos will be available on Bilibili.

Homework assignments

- 8 homework assignments:
 - $7\% + 7\% + 7\% + 11\% + 7\% + 11\% + 11\% + 11\% = \mathbf{72\%}$ (may be adjusted)
- **Submit through Online Judge!!!**
 - Any other forms of submissions are not accepted, unless with special reasons.
 - For every problem, the score of **the last submission** will be taken as the final score.
- **No plagiarism!!!** The penalty will be heavy.
 - The TAs are really experienced. Don't take any chances.

*Academic integrity and AI (GPT, Copilot, etc.)

- Anything obtained from AI tools is treated equivalently as the contents from the Internet.
 - If two students copied the same code from the Internet and submitted them
⇒ **PLAGIARISM!**
 - If two students copied the same answer from AI tools and submitted them
⇒ **PLAGIARISM!**
- Typical excuses we **don't** accept:
 - "We used the same ChatGPT account, and ChatGPT gave me his code."
 - "Copilot generated the same code for us."

Quizzes

- 1 or 2 quizzes, 4% in total.
- During regular classes
- **Time will not be announced in advance!**

Midterm exam

- 22%
- Will be held in the 13th ~ 15th week
- Covers **everything in regular classes and recitations**, unless otherwise stated.
 - Ranging from the beginning to *operator overloading* (C++).
- Will not be too difficult. Don't worry.

PIAZZA!!

- All the notifications will be announced on Piazza.
- All the course materials will be available on Piazza.
- Ask and answer questions on Piazza.
- In case you miss any important notifications, we suggest **checking Piazza once every 12 hours.**

Textbooks and references

Recommended textbooks:

- *C++ Primer* (5th edition) (**NOT C++ *Primer Plus!***) (based on C++11)
- *Effective C++* (based on C++98), *Effective Modern C++* (based on C++14)
- *The C++ Programming Language* (4th edition) (based on C++11), written by **Bjarne Stroustrup**, the inventor of C++

All of the course materials conform to the C17 and C++17 standards, based on cppreference and the standard committee's papers.

Textbooks and references

Note on textbooks:

- You are not required to read the entire books.
- We will recommend (or require) reading some of the chapters/sections when necessary.
- We will upload the materials to Piazza.

Textbooks and references

Note on cppreference/standard documentations:

- You may find them difficult to read at the beginning. Don't worry!
- We will teach you how to read them (maybe during recitations).
- By the time you have learned some major aspects of the language, you should have less difficulty reading them.

C/C++ environment setup

- We recommend VSCode + GCC (MinGW on Windows). Follow [this video](#).
- Advanced tools (Visual Studio, CMake, ...) may be needed in further homework assignments.