课程主页

QQ群

Overview

Introduction to Computer Systems

https://xjtu-ics.github.io/ or http://ics.xjtu-ants.net/

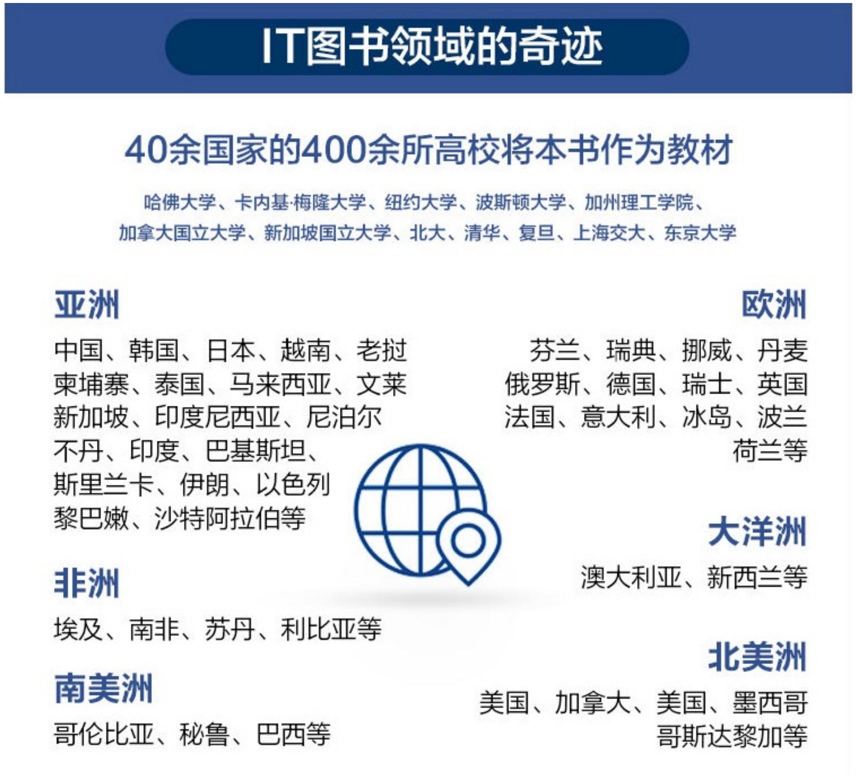
2025. Spring

Xi’an Jiaotong University

Danfeng Shan

教材与参考书

- 深入理解计算机系统（第三版）
- Computer Systems: A Programmer’s Perspective (CSAPP 3e)


IT图书领域的奇迹

40余国家的400余所高校将本书作为教材

哈佛大学、卡内基·梅隆大学、纽约大学、波斯顿大学、加州理工学院、
加拿大国立大学、新加坡国立大学、北大、清华、复旦、上海交大、东京大学

亚洲

中国、韩国、日本、越南、老挝
柬埔寨、泰国、马来西亚、文莱
新加坡、印度尼西亚、尼泊尔
不丹、印度、巴基斯坦、
斯里兰卡、伊朗、以色列
黎巴嫩、沙特阿拉伯等

非洲

埃及、南非、苏丹、利比亚等

南美洲

哥伦比亚、秘鲁、巴西等

欧洲

芬兰、瑞典、挪威、丹麦
俄罗斯、德国、瑞士、英国
法国、意大利、冰岛、波兰
荷兰等

大洋洲

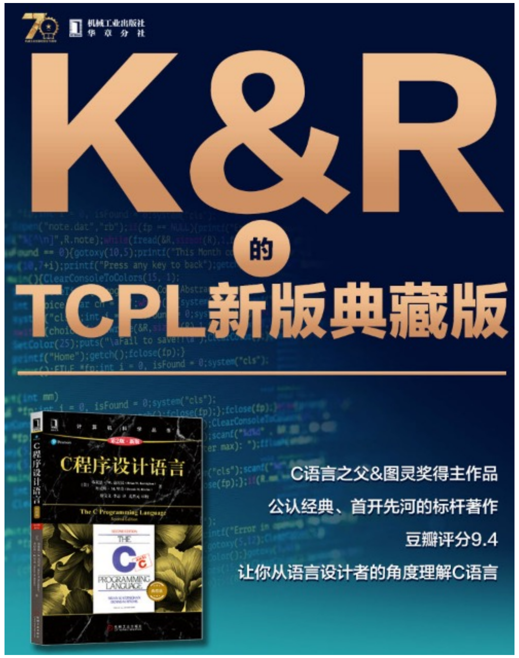
澳大利亚、新西兰等

北美洲

美国、加拿大、美国、墨西哥
哥斯达黎加等

参考书

- C语言程序设计 第二版 （K&R）
- 操作系统导论（OSTEP）



教学规划——授课

内容	参考学时
信息的处理与表示	4
程序的机器级表示	16
存储器体系结构	4
程序优化	4
程序链接	4
异常控制流	6
虚拟存储器	10
网络编程	4
并行编程	4
处理器体系结构	8

教学规划——实践

内容	参考学时
datalab	2
bomblab	2
attacklab	2
cachelab	4
optlab	4
loadderlab	4

考核方法

- ■ 平时成绩 10%
  - □ 考勤、课堂纪律、上课回答问题、课堂测验
- ■ 项目实践 50%
  - □ Auto-Grading系统对代码自动打分
  - □ Anti-Cheating系统自动检测代码抄袭
  - □ 抄袭是高压线，一经核实双方项目实践分数为0
- ■ 期末考试 40%
  - □ 以课堂和Lab内容为主

关于实验的几点补充

- ■ 实验环境：Linux/GCC
  - □ 提供完整环境配置的服务器（ICSServer）
  - □ 提供预先写好的Makefile
  - □ 组织Bootcamp，带新人快速上手
- ■ 实验发布：课程主页
  - □ https://xjtu-ics.github.io/ 或 http://ics.xjtu-ants.net/
  - □ 有详细的实验指导书
- ■ 实验提交和分数公布：在线学习平台
  - □ http://class.xjtu.edu.cn/course/88273
  - □ 允许迟交，但会根据延后时间扣分

关于实验的几点补充

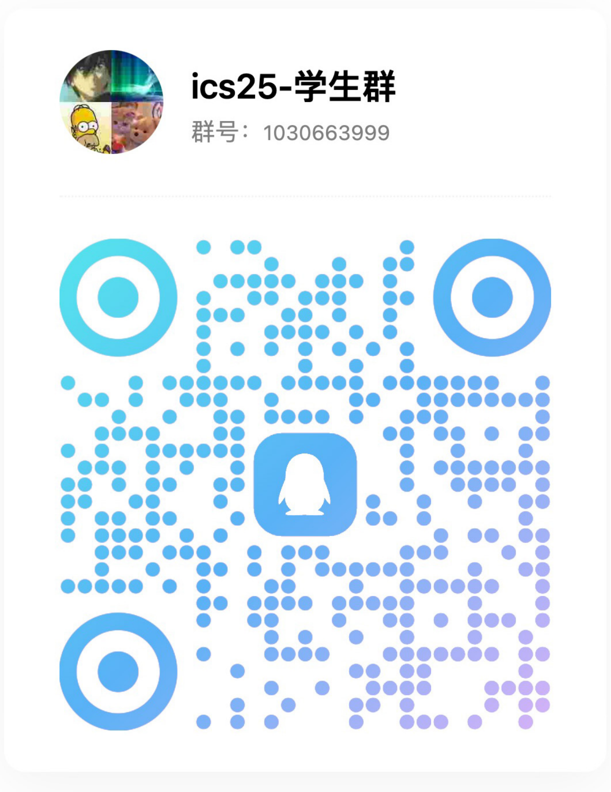
- 独立完成实验
- 做好时间管理
  - ✗ 跟不上节奏、在截止日期前疯狂弥补☹️
  - ✓ 紧跟节奏😁
  - 预期：每个lab需要2周的时间全力以赴完成
- 实验所需预备知识

必要	有益
• C编程 • Linux命令行 • ssh • gcc/gdb	• vim • Make/Cmake • Git • Google

答疑

- Piazza：一款专业的国际性课程答疑论坛
  - 注册链接：https://piazza.com/stu.xjtu.edu.cn/spring2025/xjtuics
- QQ群：不保证每个问题都能被解答
- 一对一：Office Hour
- 《提问的智慧》

- 遇到问题不要不解决！

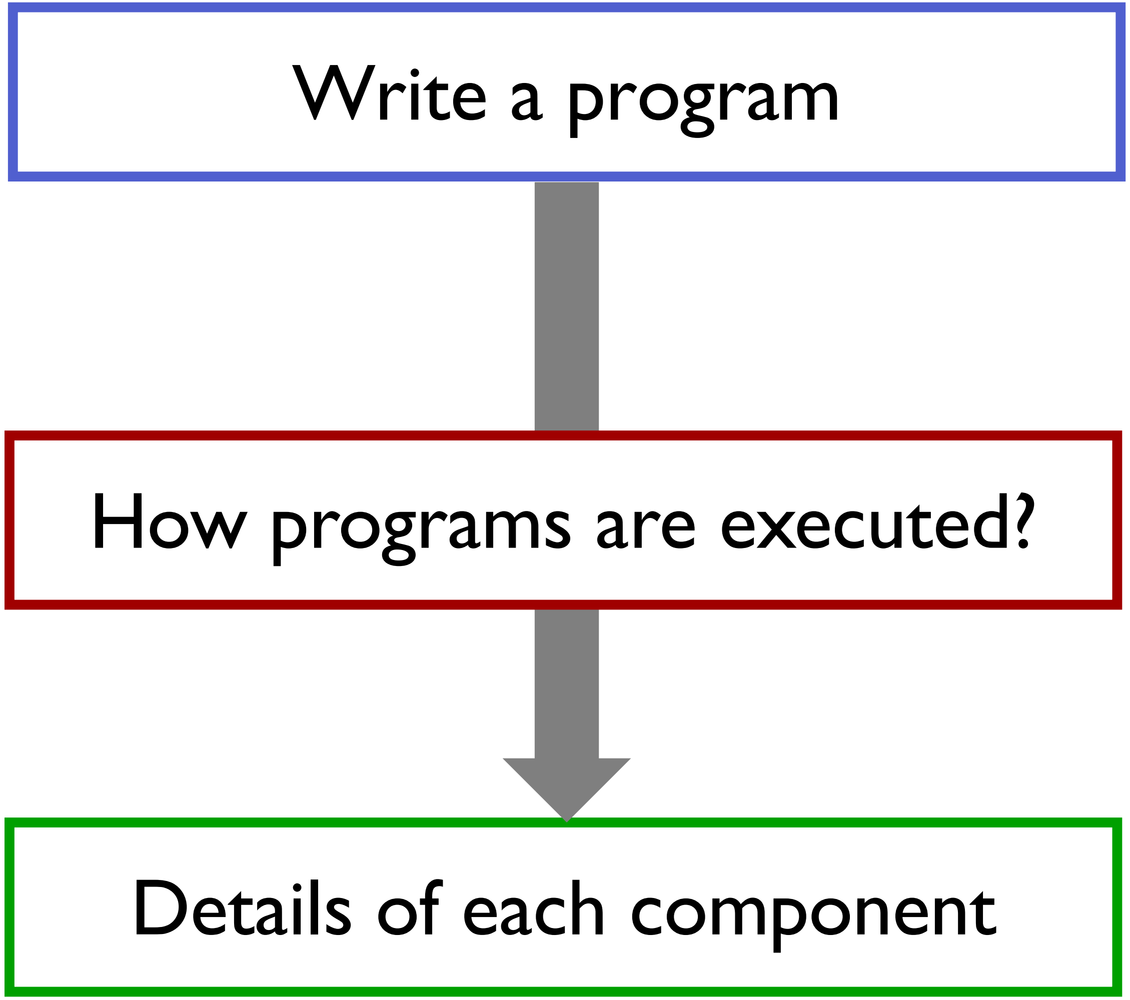


ics25-学生群

群号：1030663999

Course Overview

What you have known



Write a program

How programs are executed?

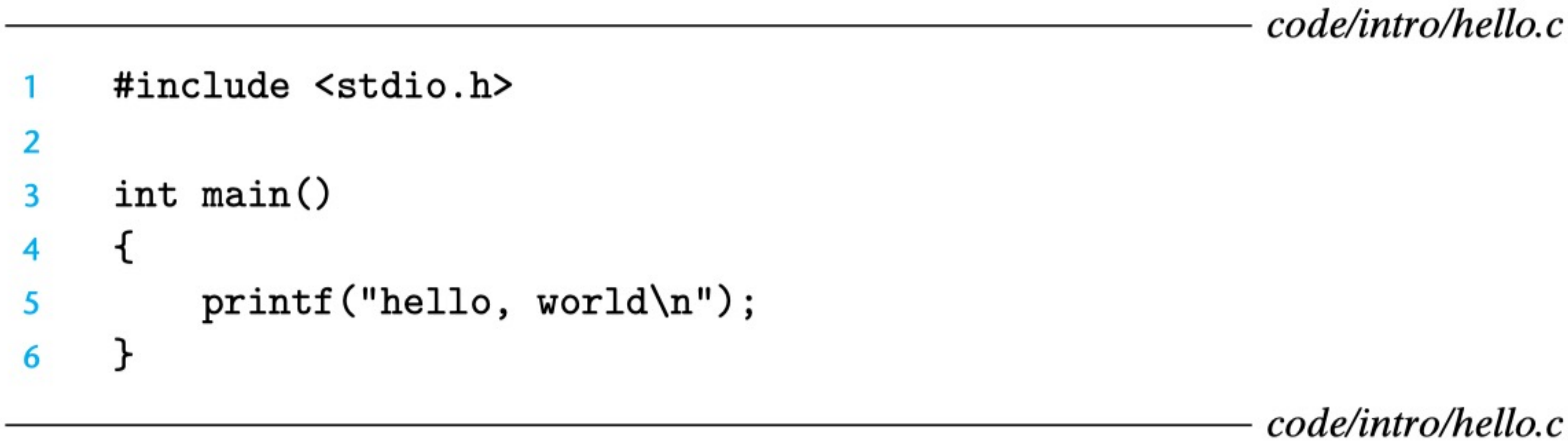
Details of each component

What you are about to learn

Overview

- Representing Program (Chapter 2)
- Translating Program (Chapter 3&4)
- Executing Program (Chapter 7&8&9)
  - □ Hardware Organization
- Memory Architecture (Chapter 6)
- Operating System
- Network

Representing Program



code/intro/hello.c

```
#include <stdio.h>

int main()
{
    printf("hello, world\n");
}
```

code/intro/hello.c

The `hello` program

Representing Program

- Source program from the computer’s perspective
  - □ A sequence of bits (0 or 1)
  - □ 8-bit chunks → bytes
  - □ Each byte represents some text character
  - □ ASCII standard

```
  #     i     n     c     l     u     d     e   <sp>    <     s     t     d     i     o     .
 35   105   110    99   108   117   100   101    32    60   115   116   100   105   111    46

  h     >    \n    \n     i     n     t   <sp>    m     a     i     n     (     )    \n     {
104    62    10    10   105   110   116    32   109    97   105   110    40    41    10   123

 \n   <sp>  <sp>  <sp>  <sp>    p     r     i     n     t     f     (     "     h     e     l
 10    32    32    32    32   112   114   105   110   116   102    40    34   104   101   108

  l     o     ,   <sp>    w     o     r     l     d     \     n     "     )     ;    \n     }
108   111    44    32   119   111   114   108   100    92   110    34    41    59    10   125
```

What about Chinese Character?

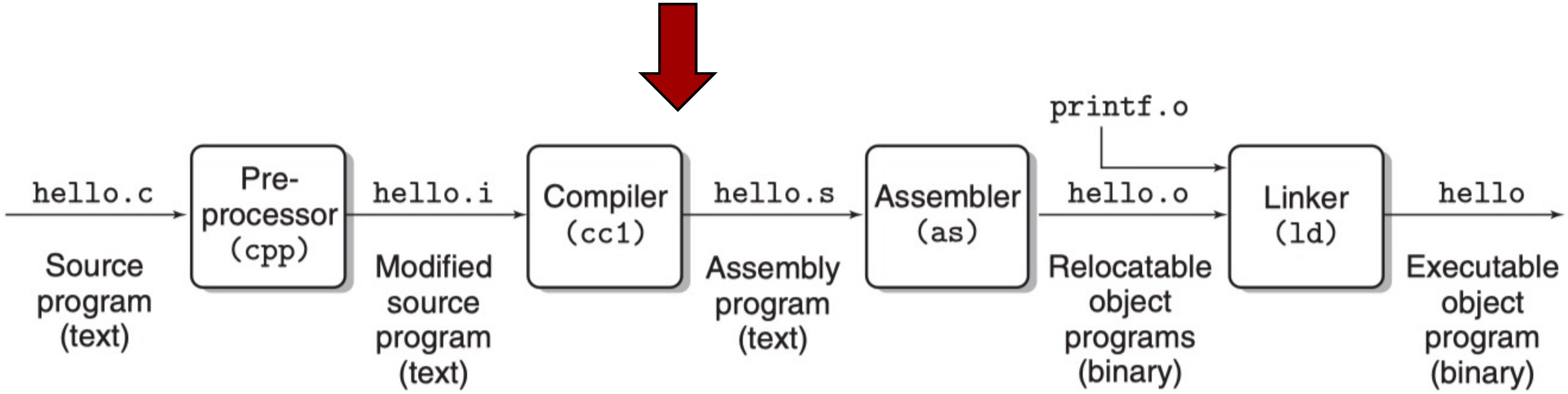
Representing Program

- Source program from the computer's perspective
  - A sequence of bits (0 or 1)
  - 8-bit chunks → bytes
  - Each byte represents some text character
  - ASCII standard
- All information in a system is represented as a bunch of bits
  - Integer, floating number, text character, …
  - How to distinguish?
    - Contexts!
- Lessons Leaned
  - As a programmer, we need understand machine representations of numbers

Translating Program

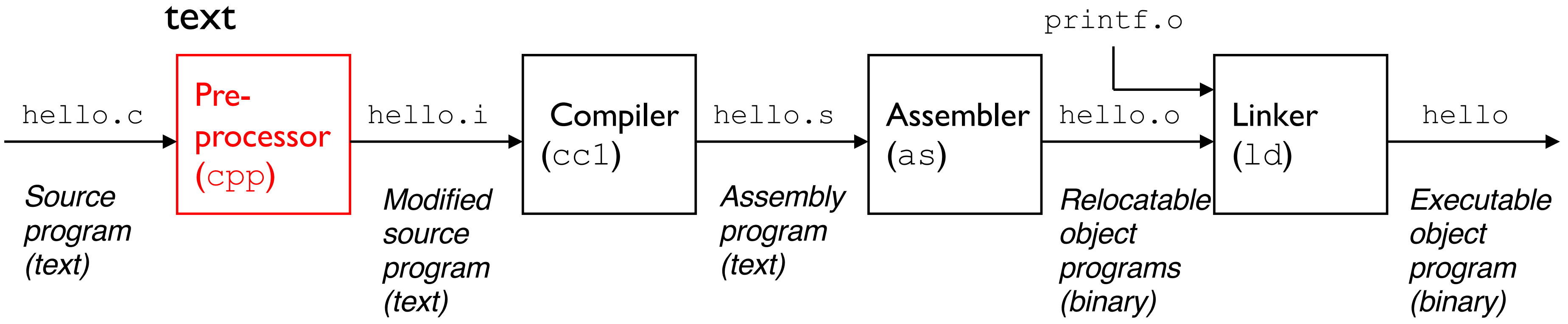
- C program is a high-level language
  - □ Why: Easy to be understood by human
- Machine only execute instructions (i.e., low-level *machine language*)
  - □ A binary disk file (called executable object files)

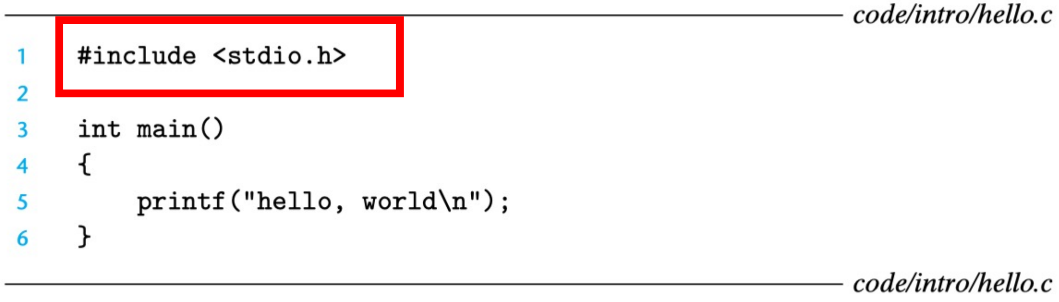
```
unix> gcc -o hello hello.c
```



Translating Program

- Preprocessing phase (cpp)
  - Modifies the original C program according to directives that begin with the # character
  - `hello.c`: Read the contents of `stdio.h` and insert it into the program text




code/intro/hello.c

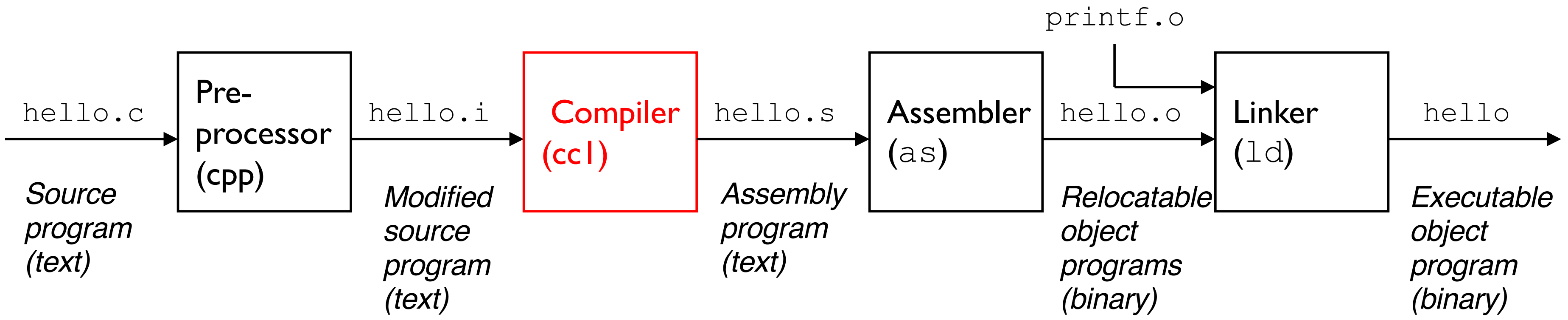
```c
#include <stdio.h>

int main()
{
    printf("hello, world\n");
}
```

code/intro/hello.c

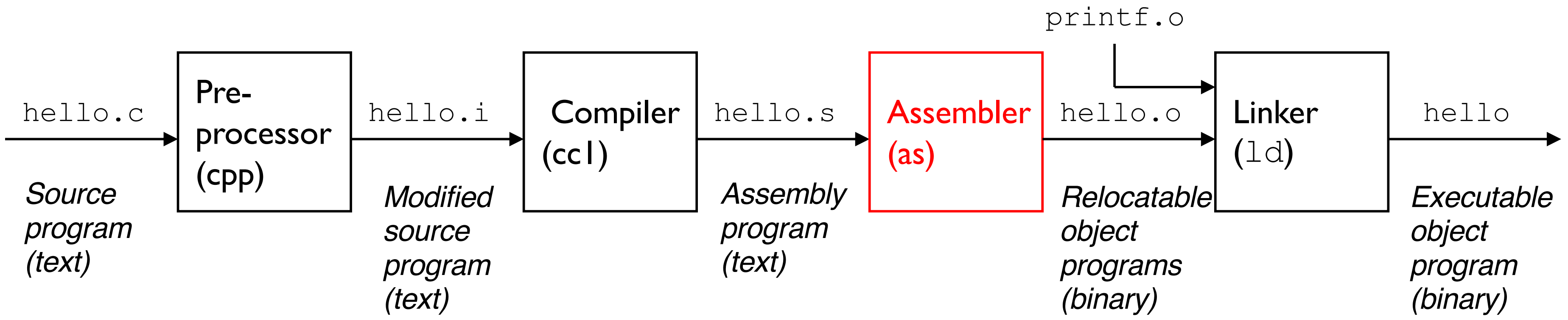
Translating Program

- Compilation phase (cc1)
  - Translates the C to an assembly-language program
  - Assembly-language
    - Also in a standard text form
    - Each statement exactly describes one low-level machine-language instruction



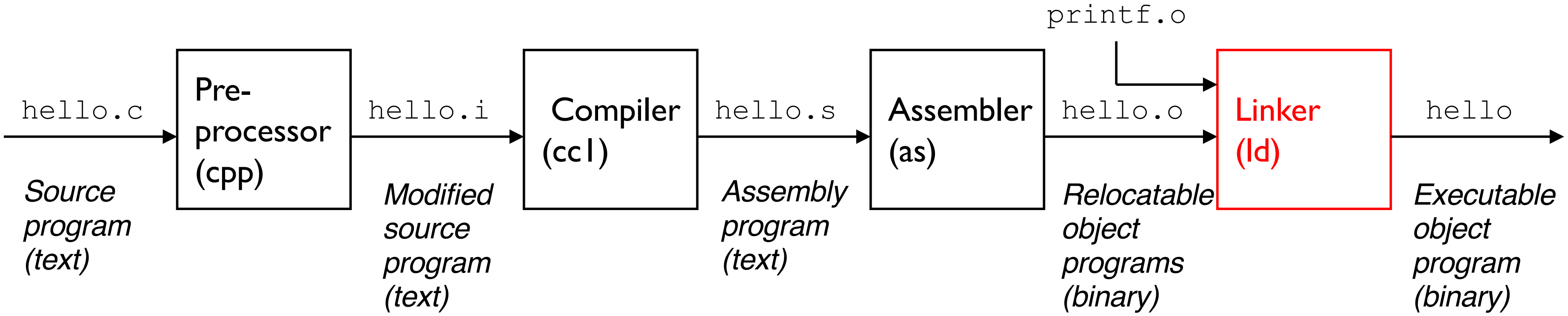
Translating Program

- Assembly phase (as)
  - Translates hello.s into machine-language instructions
  - Package into *relocatable object program*



Translating Program

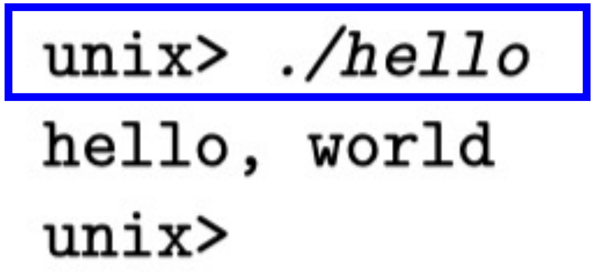
- Linking phase
  - □ Where to find `prinf`?
    - ○ `printf.o`
    - ○ Provided by Standard C library
  - □ Merge `hello.o` and `prinf.o`
  - □ Result: `hello` (i.e., *executable object file*)


printf.o
hello.c
Pre-processor (cpp)
hello.i
Compiler (cc1)
hello.s
Assembler (as)
hello.o
Linker (ld)
hello
Source program (text)
Modified source program (text)
Assembly program (text)
Relocatable object programs (binary)
Executable object program (binary)

Why we need to understand this

- Eliminating bugs
  - □ `#define min(x, y) x < y ? x : y` [example01.c]
- Optimizing program performance
  - □ If-else vs. switch-case
  - □ `foo * 1024` → `foo << 10`
- Understanding link-time errors
  - □ undefined reference to….
- Avoiding security holes
  - □ Buffer overflow

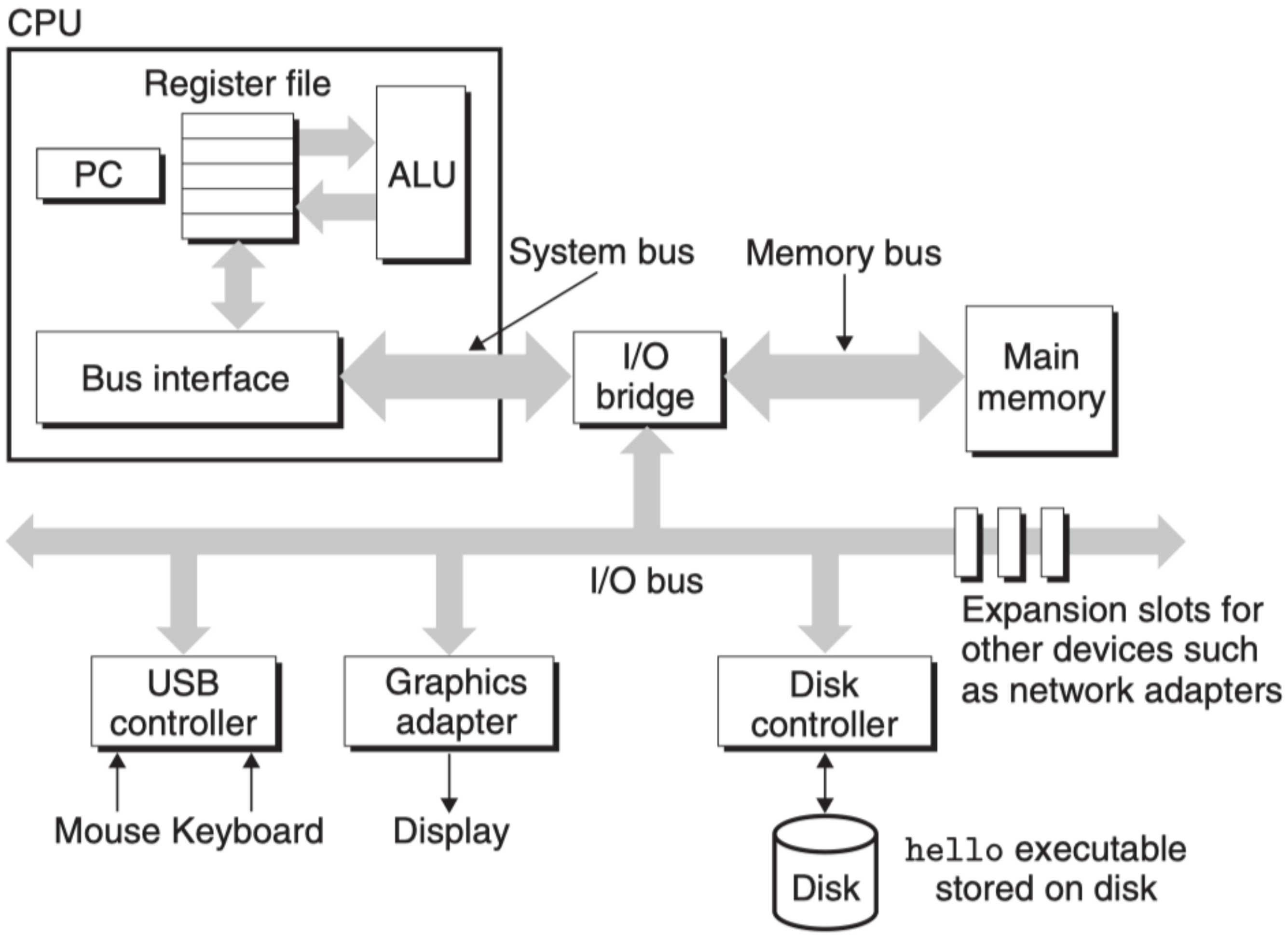
Executing Program



```
unix> ./hello
hello, world
unix>
```

Shell loads and runs the program

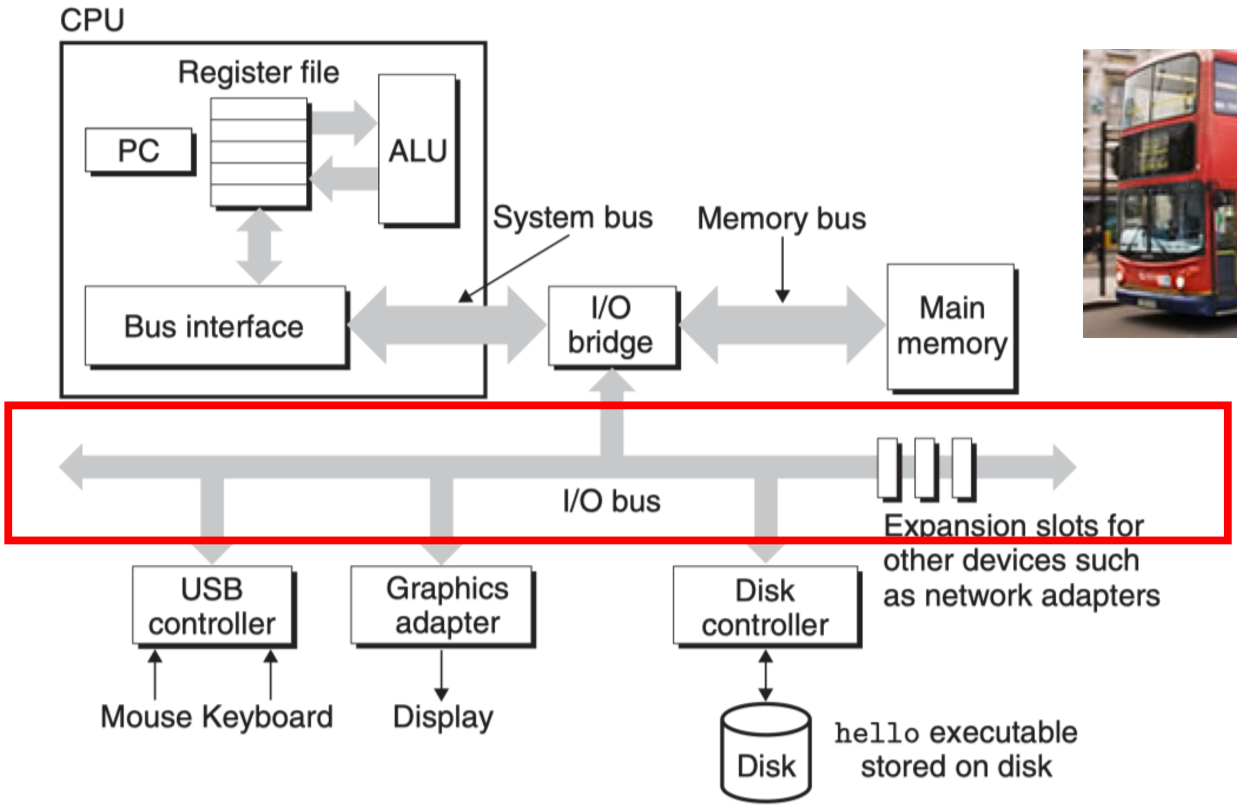
Hardware Organization



Hardware organization of a typical system

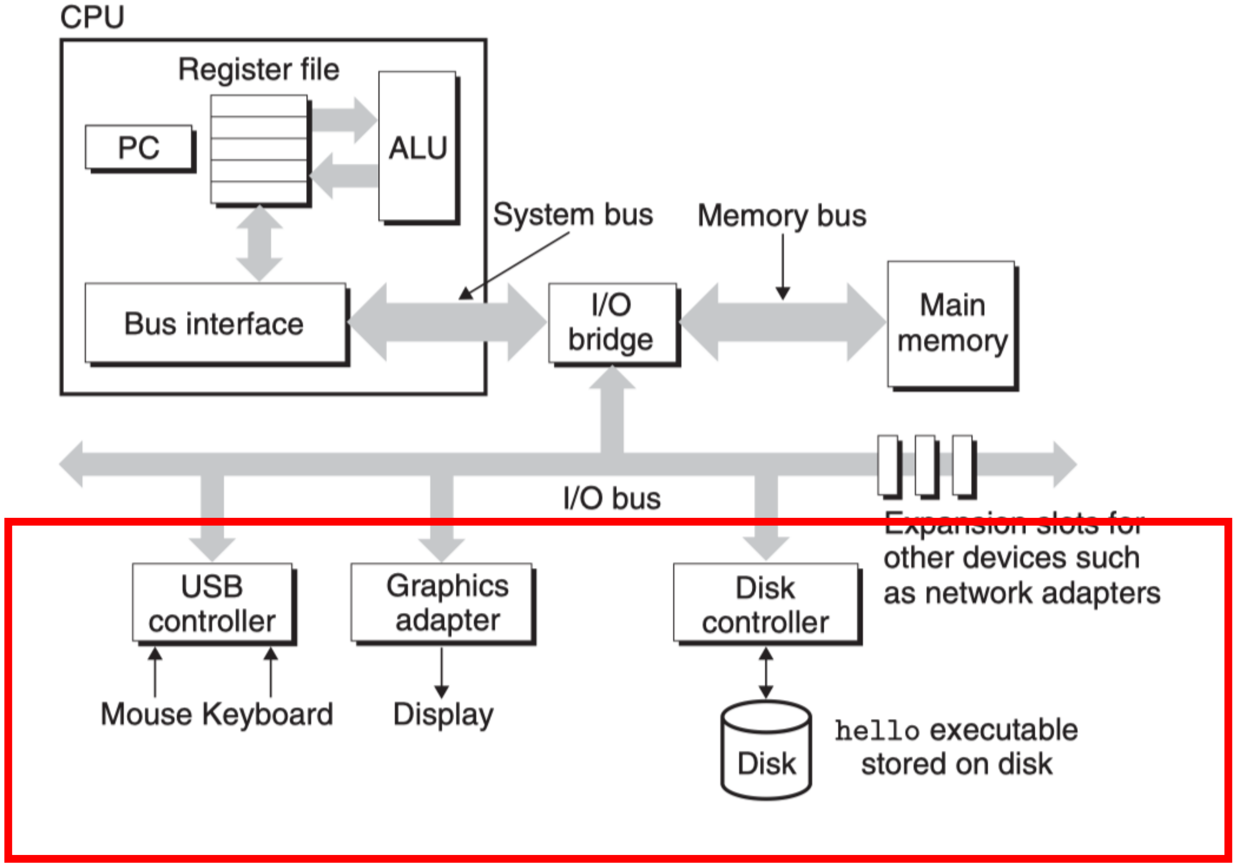
Hardware Organization

- Buses



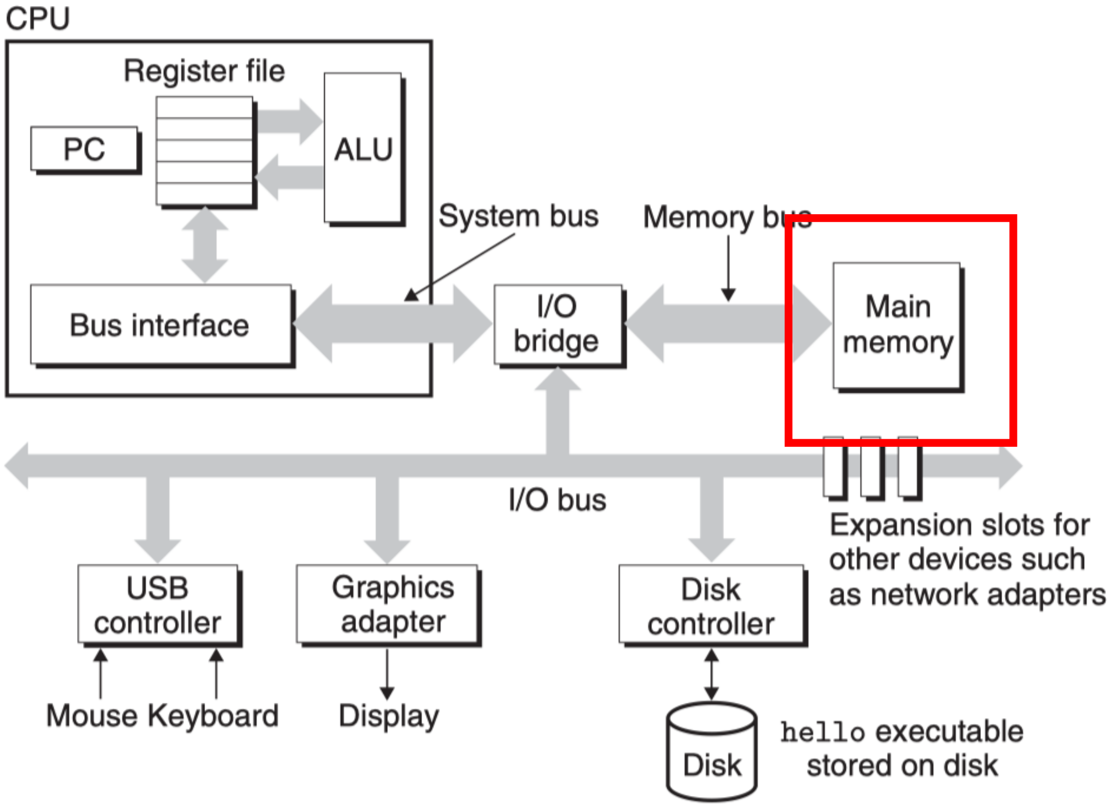
Hardware Organization

- I/O Devices (Chapter 6&10)



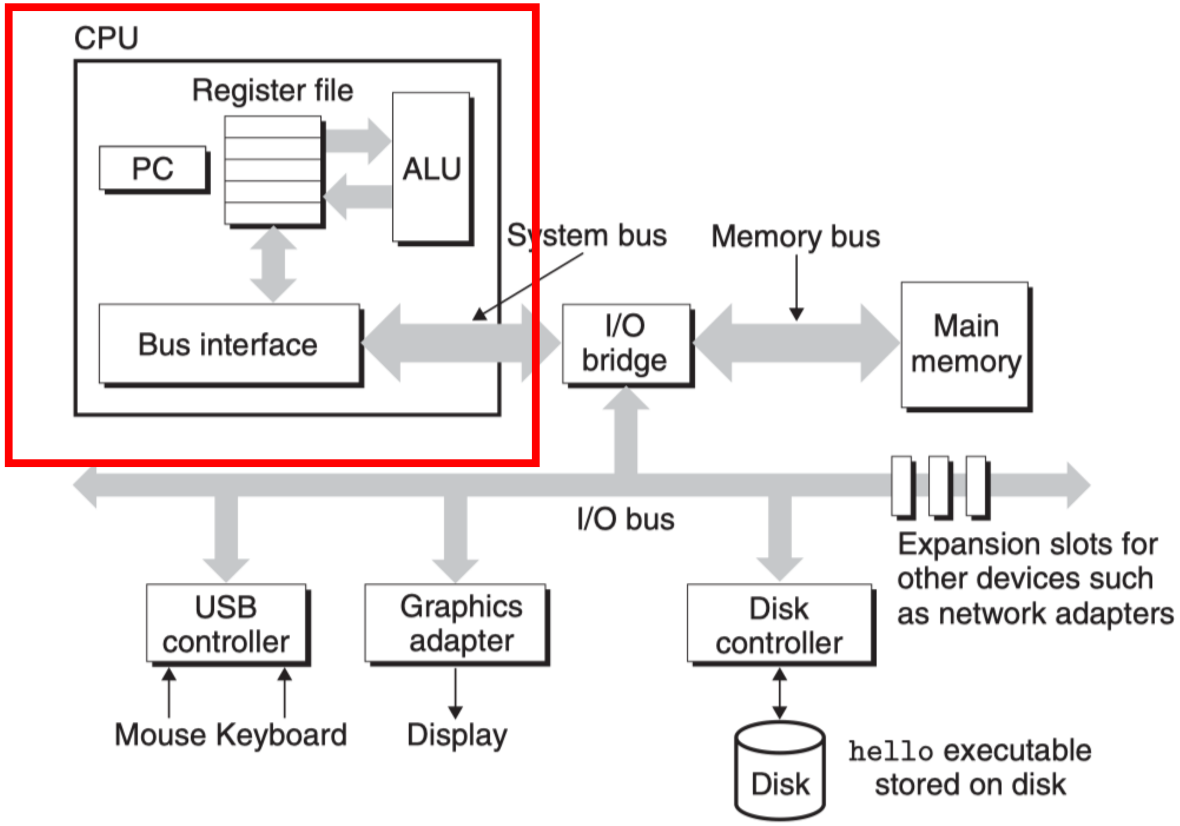
Hardware Organization

- Main Memory (Chapter 6)
  - Temporary storage



Hardware Organization

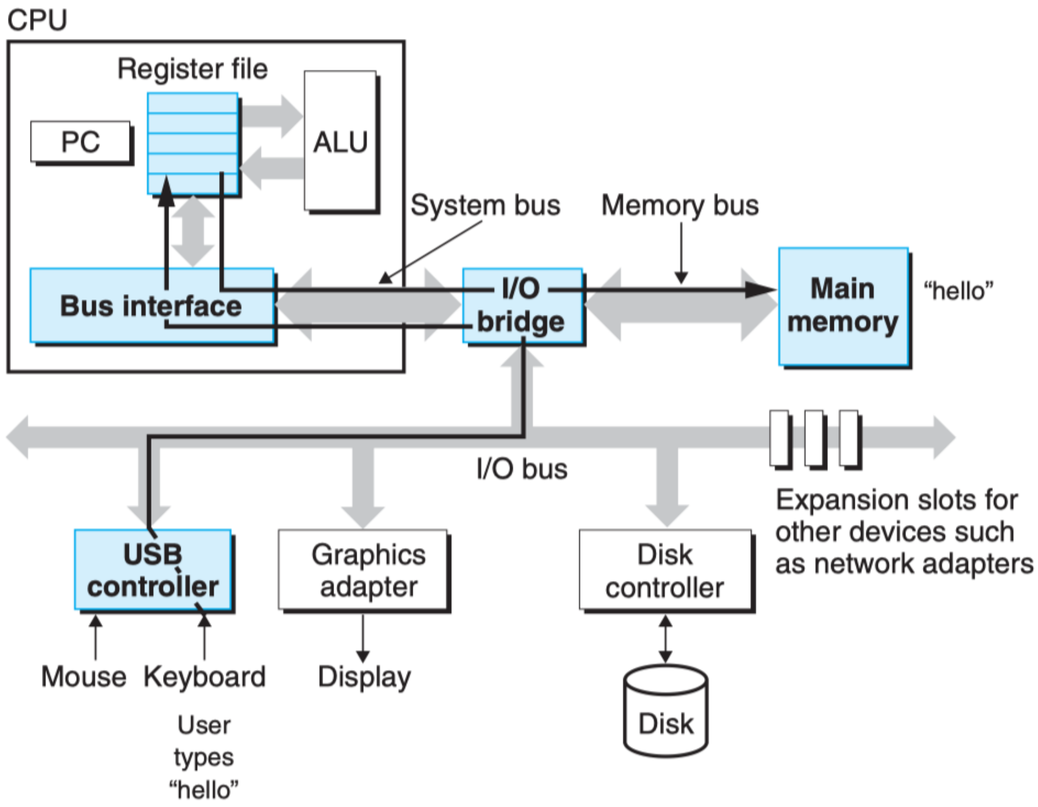
- Processor (Chapter 4)



Executing Program

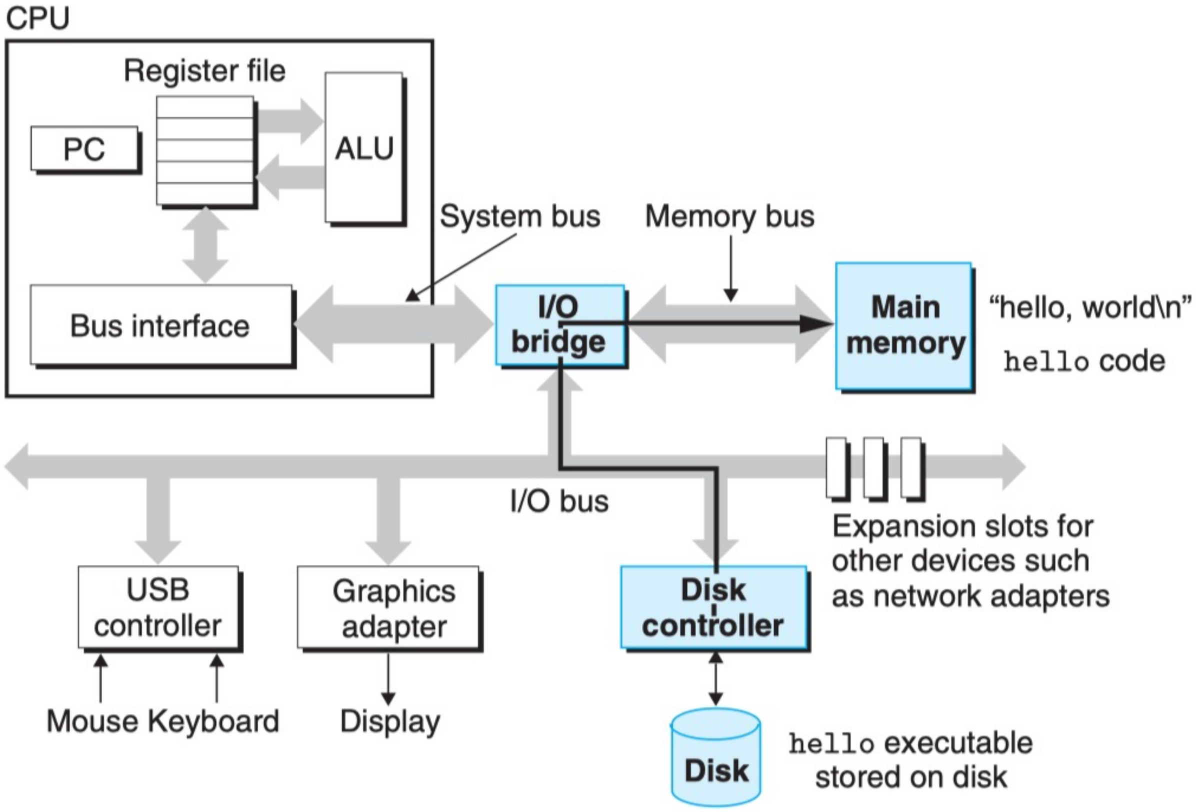
- Shell read "./hello" from keyboard into a register
- Store it into memory

```
unix> ./hello
hello, world
unix>
```



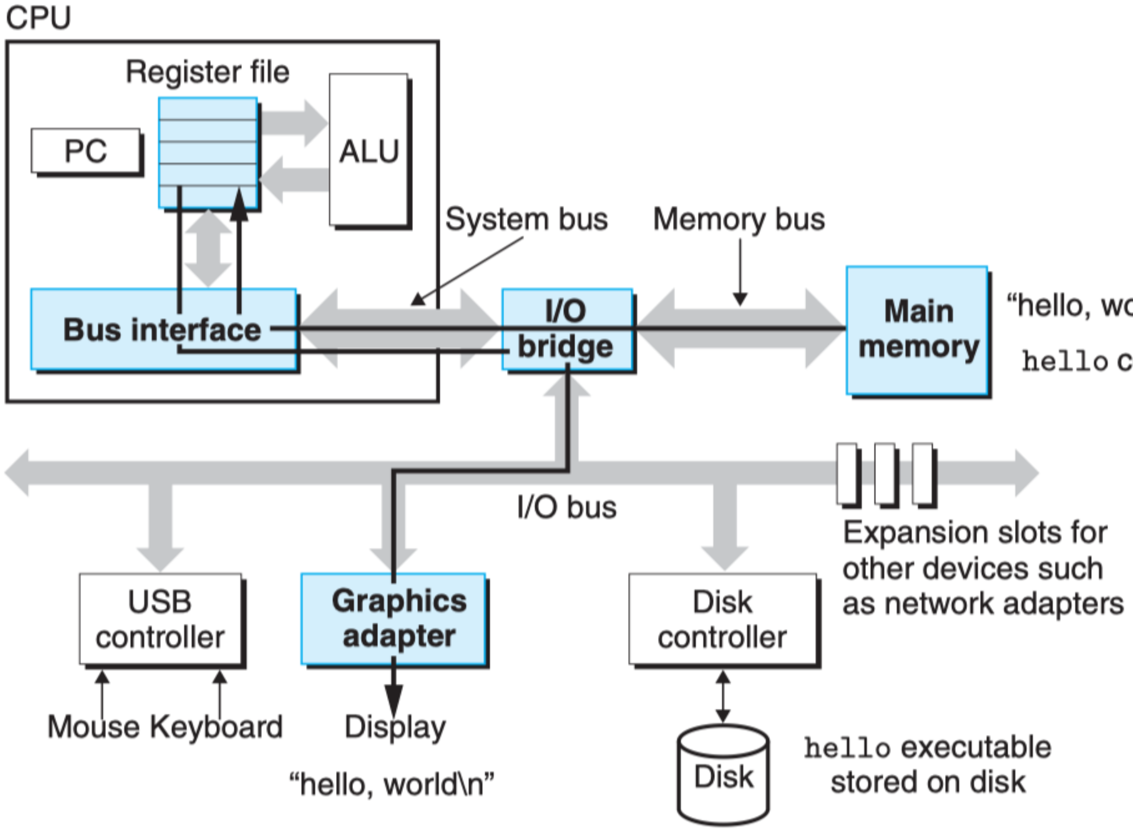
Executing Program

- Load "hello" into main memory
  - Copies the code and data from disk to main memory
  - DMA



Executing Program

- Execute the machine-language instructions
  - Copy "hello, world\n" from memory to the registers
  - Copy from registers to the display device

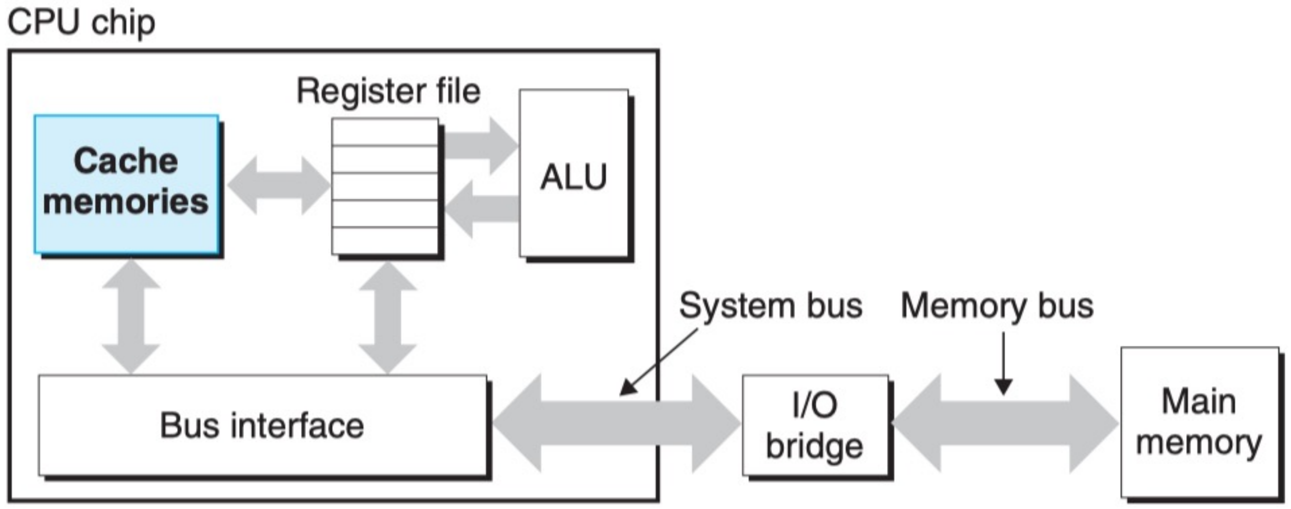


Memory Architecture

- Spends a lot of time moving information from one place to another!
- Disk vs. Main memory
  - 1,000x larger
  - 10,000,000x slower
- Registers vs. Main memory
  - 100s bytes vs. 10s GB
  - 100x faster
- Laws
  - Larger: slower
  - Faster : more expensive

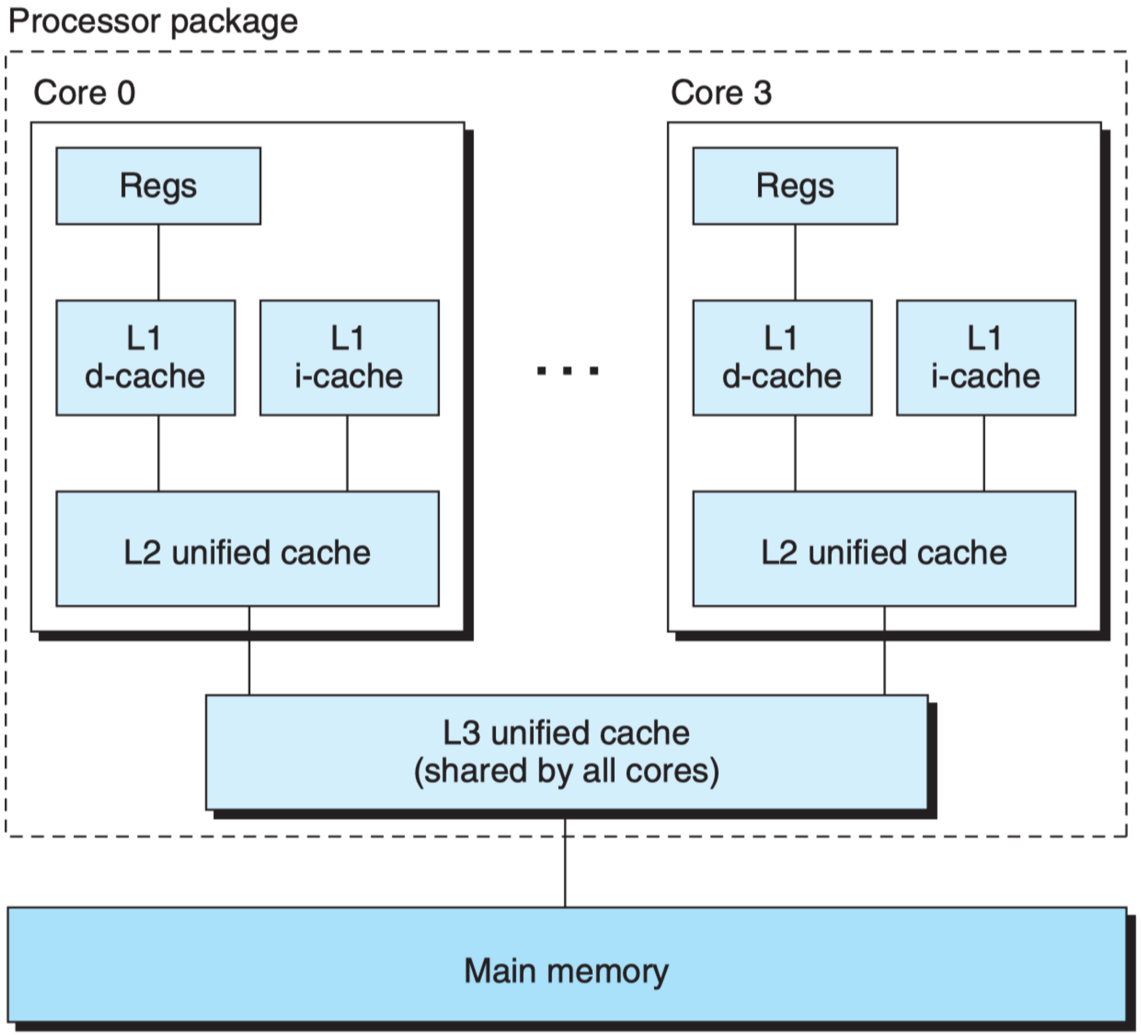
Memory Architecture

- Cache
  - □ SRAM
  - □ 10s MB (Intel i7-11700, 16MB Cache)
  - □ 5x slower than registers
  - □ 5-10x faster than main memory



Memory Architecture

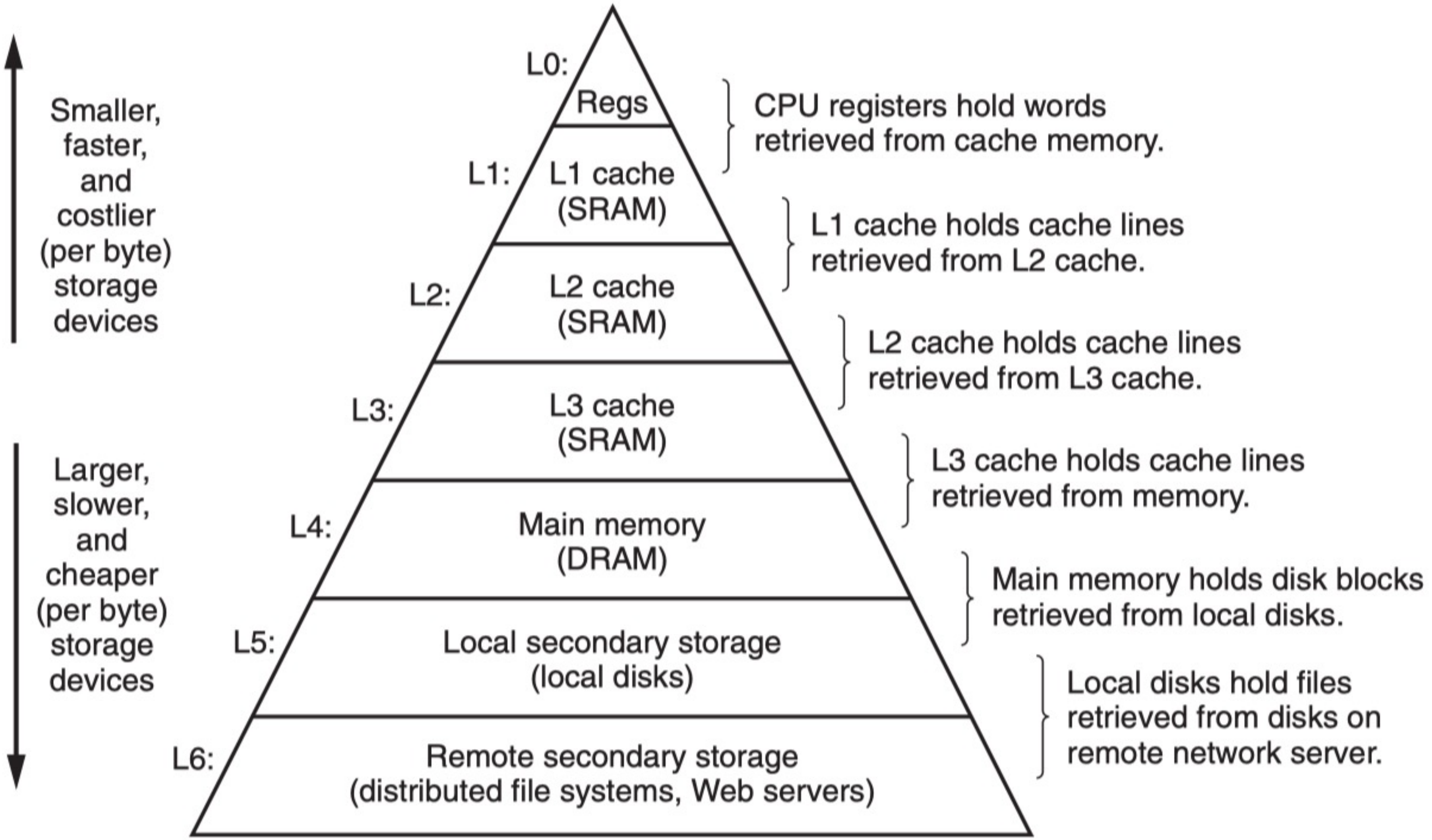
- Cache



Intel Core i7

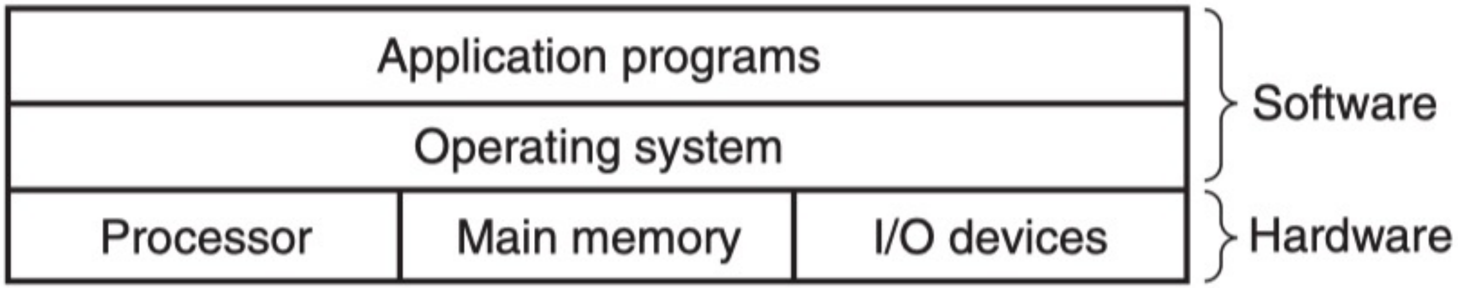
Memory Architecture

- Memory hierarchy
  - □ Speed → Registers/Cache
  - □ Size → Disks


Smaller, faster, and costlier (per byte) storage devices
Larger, slower, and cheaper (per byte) storage devices
L0:
Regs
L1:
L1 cache (SRAM)
L2:
L2 cache (SRAM)
L3:
L3 cache (SRAM)
L4:
Main memory (DRAM)
L5:
Local secondary storage (local disks)
L6:
Remote secondary storage (distributed file systems, Web servers)
CPU registers hold words retrieved from cache memory.
L1 cache holds cache lines retrieved from L2 cache.
L2 cache holds cache lines retrieved from L3 cache.
L3 cache holds cache lines retrieved from memory.
Main memory holds disk blocks retrieved from local disks.
Local disks hold files retrieved from disks on remote network server.

Operating System

- A layer of software between application and hardware
  - □ Protect the hardware
    - ○ Applications can be evil and vulnerable
  - □ Provide applications with simple and uniform mechanisms
    - ○ Low-level hardware devices are quite different from each other



Application programs

Operating system

Processor | Main memory | I/O devices

Software

Hardware

Summary

- Information = bits + context
- Programs are translated by compilers
  - From ASCII text to binary executable file
- Memory: store binary instructions
- Processor: execute binary instructions
- Memory is important
  - Computers spend most of their time copying data
  - Memory hierarchy
    - Speed: register/cache
    - Size: disk
- Operating System: managing hardware