A Brief Tour

CSCI 2330

A Brief Tour

- Information is bits + context

- Programs & Compilation

- Hardware Organization

- Memory, Storage and Cache

- Operating System

Information: bits

```c
#include <stdio.h>

int main() {
    printf("hello world\n");
    return 0;
}
```

Information: bits

```
#include <stdio.h>

int main() {
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}
```

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

nl	ht	p	r	i	n	t	f	(	"	h	e	l	l	o	sp
10	9	112	114	105	110	116	102	40	34	104	101	108	108	111	32

w	o	r	l	d	\	n	"	)	;	nl	ht	r	e	t	u
119	111	114	108	100	92	110	34	41	59	10	9	114	101	116	117

r	n	sp	0	;	nl	}
114	110	32	48	59	10	125

Program Translation

source code

https://godbolt.org

https://godbolt.org/z/uFFa_F

hello.c

pre-processor

hello.i

gcc -E

compiler

hello.s

gcc -S

assembler

hello.o

gcc -c

linker

printf.o

hello

objdump -TC /usr/lib64/libc-2.17.so

executable

Hardware Organization

CPU

Register file

PC

ALU

System bus

Memory bus

Bus interface

I/O bridge

Main memory

"hello"

I/O bus

USB controller

Graphics adapter

Disk controller

Expansion slots for other devices such as network adapters

Mouse Keyboard

Display

Disk

User types "hello"
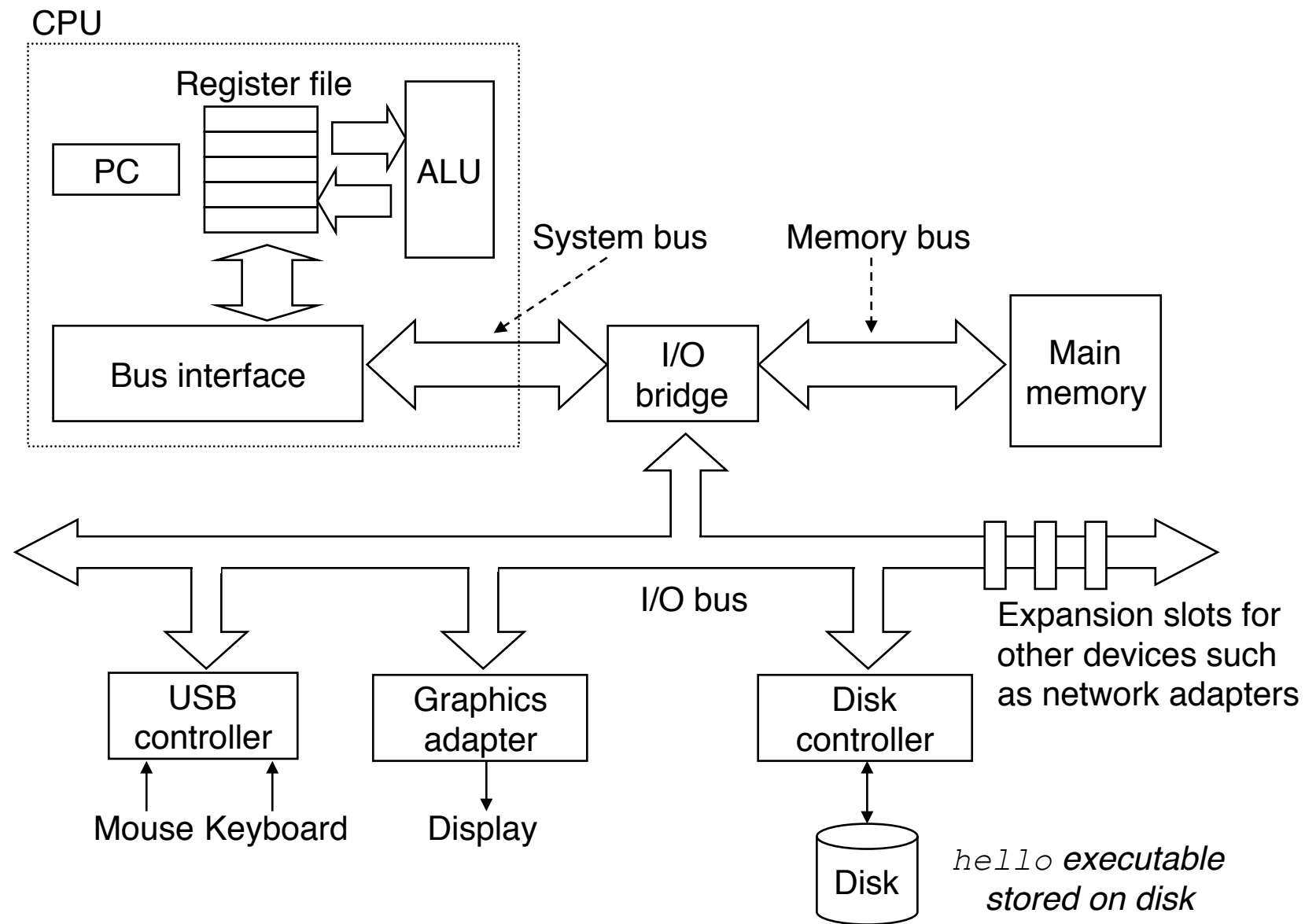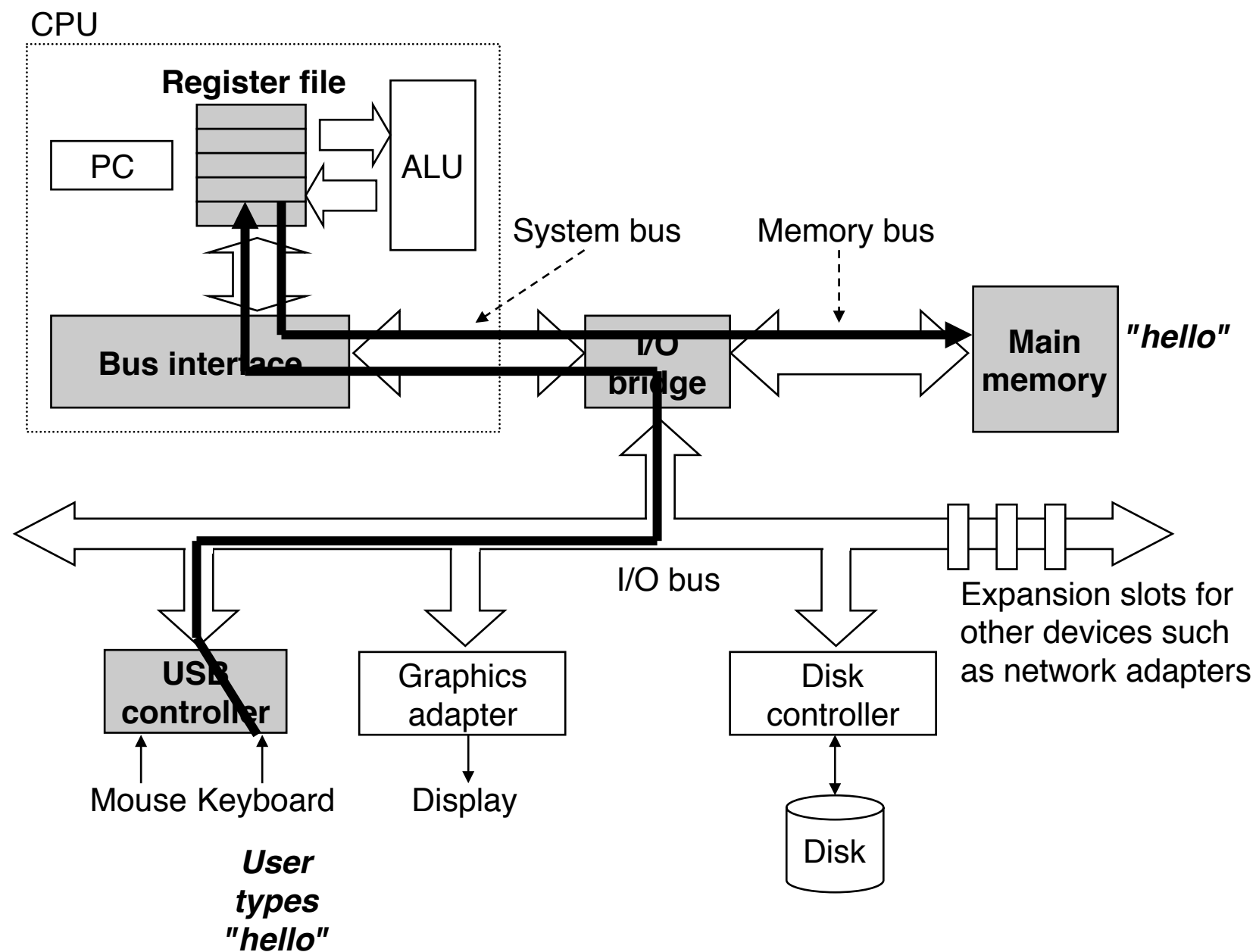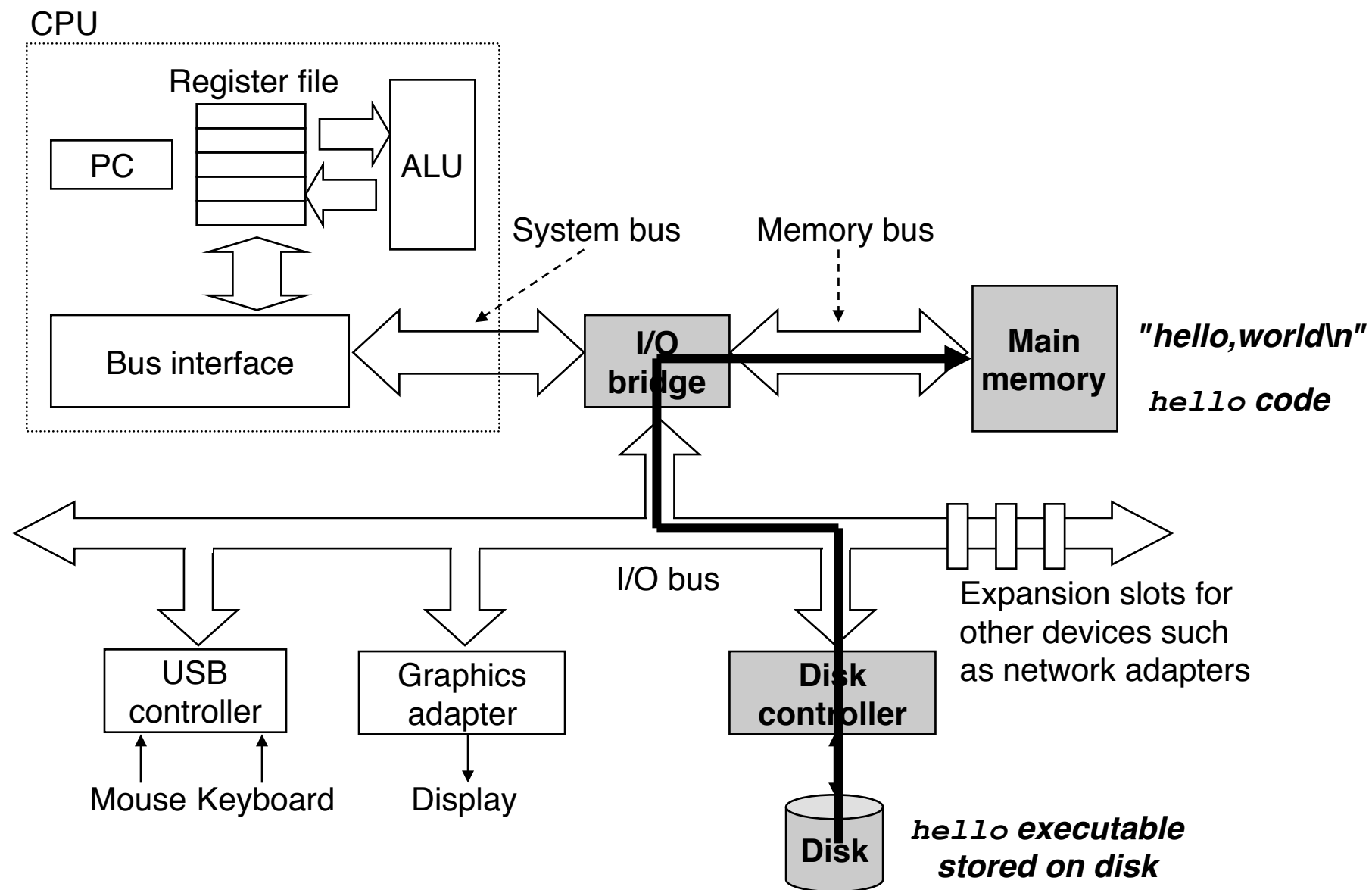
Reading the Command Line

Hardware Organization

Loading Executable

Hardware Organization

CPU

Register file

PC

ALU

System bus

Memory bus

Bus interface

I/O bridge

Main memory *"hello,world\n"*

hello **code**

I/O bus

USB controller

Graphics adapter

Disk controller

Expansion slots for other devices such as network adapters

Mouse Keyboard

Display

"hello,world\n"

Disk

hello **executable stored on disk**
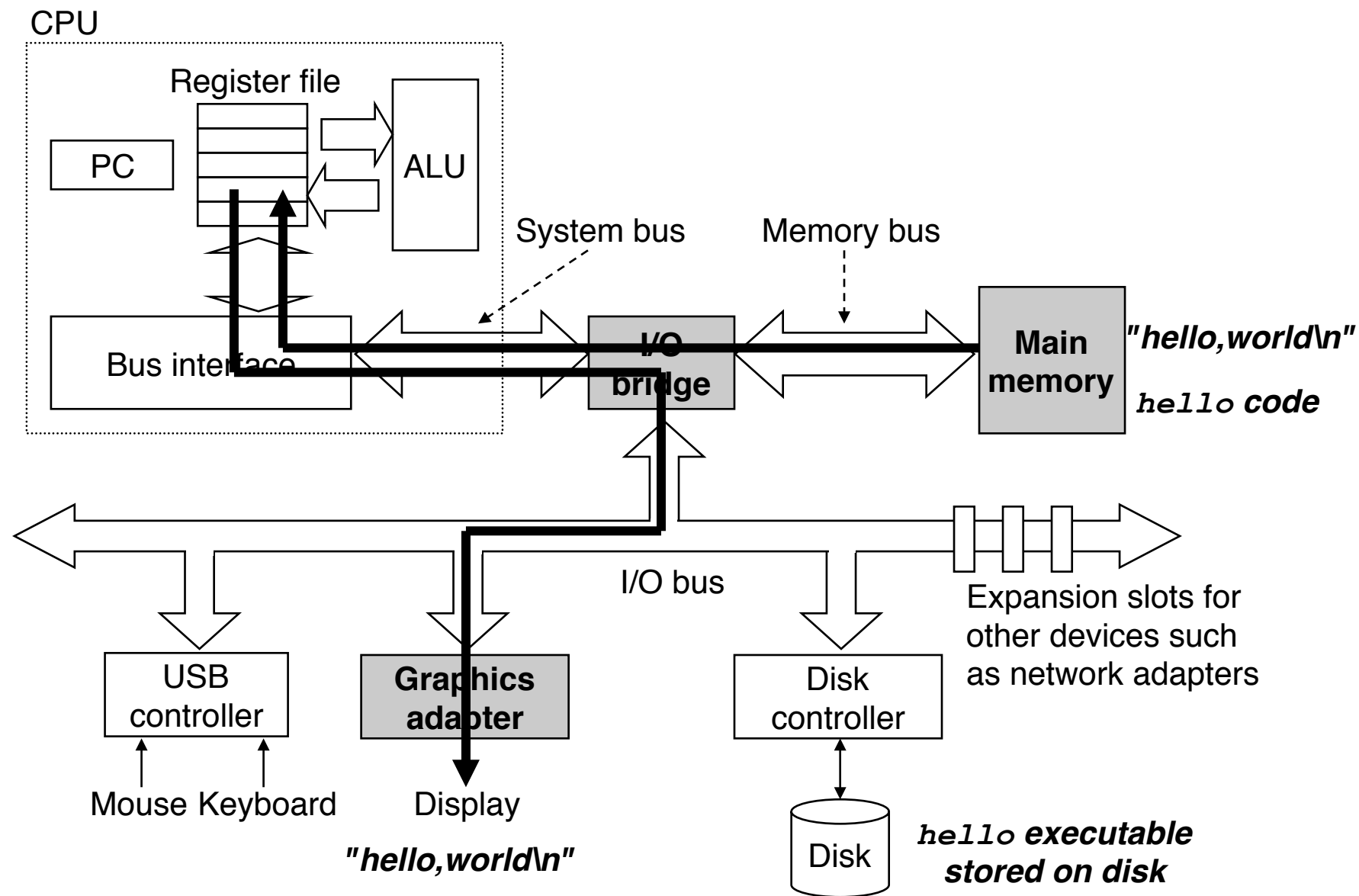
Writing Output

Cache Memory

CPU chip

Register file

Cache memories

ALU

System bus   Memory bus

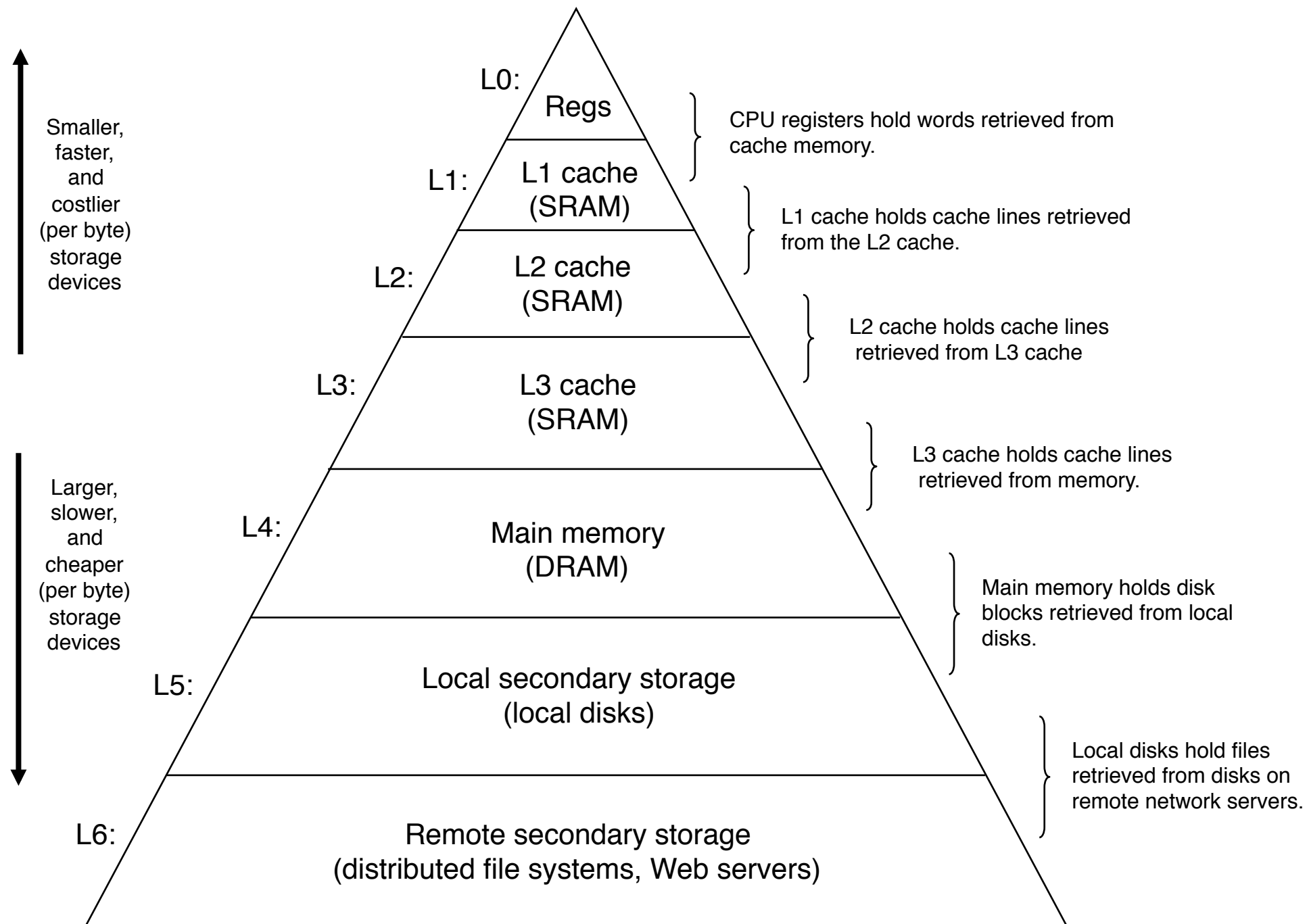Bus interface

I/O bridge
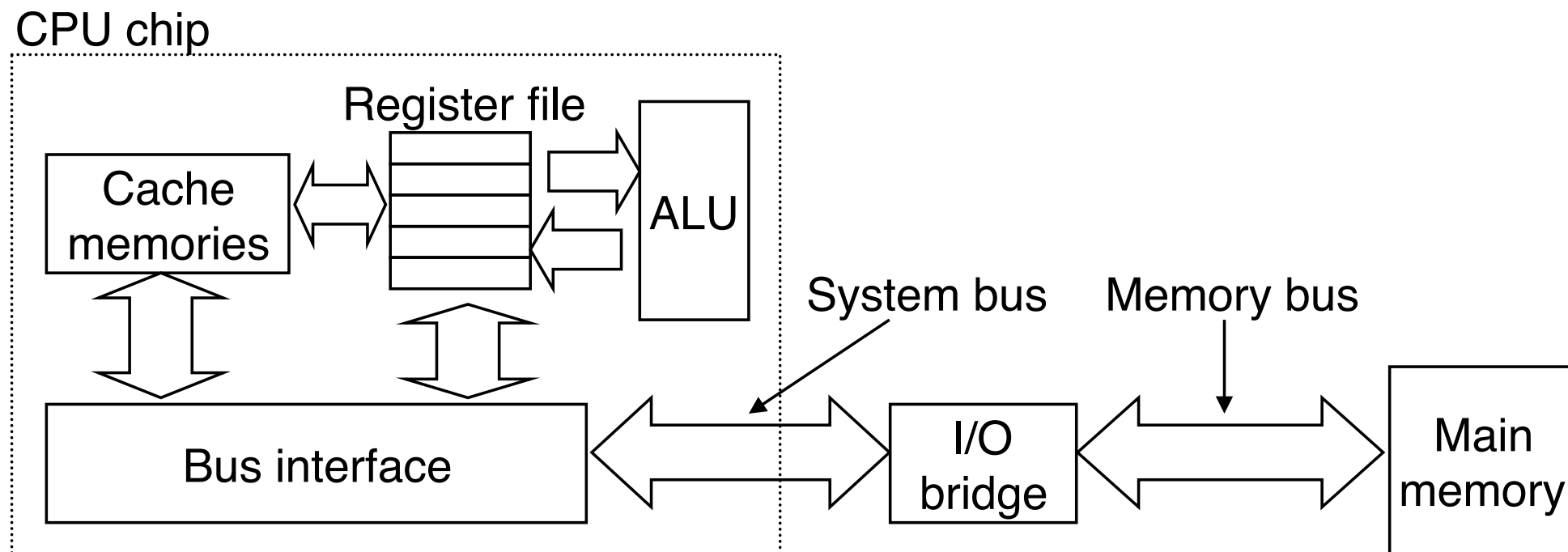
Main memory

- "closer" than Main Memory

- Much faster than Main Memory

- Much more expensive than Main Memory

Memory Hierarchy

Smaller,
faster,
and
costlier
(per byte)
storage
devices

Larger,
slower,
and
cheaper
(per byte)
storage
devices

L0:
Regs

CPU registers hold words retrieved from cache memory.

L1:
L1 cache
(SRAM)

L1 cache holds cache lines retrieved from the L2 cache.

L2:
L2 cache
(SRAM)

L2 cache holds cache lines retrieved from L3 cache

L3:
L3 cache
(SRAM)

L3 cache holds cache lines retrieved from memory.

L4:
Main memory
(DRAM)

Main memory holds disk blocks retrieved from local disks.

L5:
Local secondary storage
(local disks)

Local disks hold files retrieved from disks on remote network servers.

L6:
Remote secondary storage
(distributed file systems, Web servers)

Operating System

- Layer of software between <u>application</u> and <u>hardware</u>

- Manages hardware and all access to it

- When a program runs it's called a <u>process</u>

  - illusion of having own processor

  - illusion of having own memory

- Manages running multiple processes and threads

end