IF2130 – Organisasi dan Arsitektur Komputer

Pengantar Kuliah Sem 1 - 2023

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Tujuan Perkuliahan

- memahami prinsip dasar sistem komputer yang relevan untuk pengembangan perangkat lunak, termasuk representasi bilangan
- memahami dasar organisasi mesin komputer, termasuk di dalamnya prosesor, memori, set instruksi, bahasa assembly, pipelining
- memahami hierarchy memory, termasuk virtual memory dan cache memory,
- memahami aspek yang mempengaruhi performansi sistem komputer, termasuk arsitektur, kompilasi dan sistem operasi

Kegiatan Perkuliahan

- Studi Mandiri
- Tatap Muka
- Tugas
- Ujian

Tindakan Curang

- berbagi kode program, dengan mengkopi, menyalin, melihat, menyediakan file untuk orang lain
- mencari solusi online atau dari kuliah tahun sebelumnya
- membantu teman membuat kode, dengan mendiktekan baris-per-baris

- **Penalti:**
- gagal kuliah, mendapatkan nilai E

- **Solusi:**
- Kerjakan tugas seawal mungkin, jangan menunggu teman lain mendapatkan solusi

Administrasi

- Web kuliah: edunex, MS Teams
- Email dosen:
  - Achmad Imam Kistijantoro (imam@itb.ac.id)
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Ringkasan Silabus

- Pengantar sistem komputer
- Representasi dan manipulasi informasi
- Representasi level mesin untuk sebuah program
- Arsitektur prosesor
- Optimasi performansi program
- Hierarki memori

Pustaka

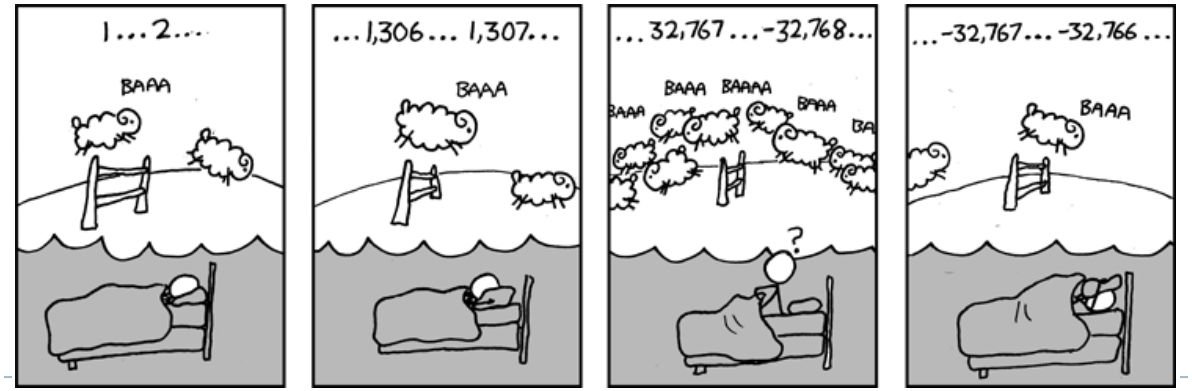
- Randal E. Bryant and David R. O'Hallaron. *Computer Systems: A Programmer's Perspective, 3rd Ed.*, Prentice Hall, 2015.
- Hennessy, J. L. & Patterson, D. A. Computer Architecture, A Quantitative Approach, 4th Edition. *Morgan Kaufmann,* **2006**
- Patterson, D. A. Computer Organization and Design: The Hardware/Software Interface, Fourth Edition. *Morgan Kaufmann,* **2008**

Kasus 1

- Apakah int = integer, dan float = real
- dimana perbedaannya?

- Apakah $x^2 \geq 0$?

- Apakah (x+y)+z = x+(y+z)?



Aritmetika Komputer

- representasi yang terbatas, mengakibatkan adanya sifat tertentu pada komputasi dengan komputer
- operasi integer: ring properties:
  - komutatif, asosiatif, distributif
- operasi floating point: ordering properties
  - monoticity, nilai tanda/sign

Kasus 2

- Apakah perlu memahami bahasa assembly?

- trend: high level language, compiler sudah melakukan job dengan baik

- namun pemahaman assembly adalah kunci untuk memahami model eksekusi level mesin
  - perilaku program saat ada bug
  - performance tuning: pemahaman optimasi yang dilakukan komputer, pemahaman sumber inefisiensi program
  - implementasi software sistem
  - penanganan malware

Kasus 3

- Memory matters!
- Random Access Memory -> tidak selalu uniform

- Memori tidak tak terbatas
  - harus dialokasikan dan dikelola
- bug akibat referensi memori memiliki dampak besar
- performansi memori tidak seragam
  - cache dan virtual memory dapat berpengaruh besar terhadap performansi

Contoh

```
double fun(int i)
{
  volatile double d[1] = {3.14};
  volatile long int a[2];
  a[i] = 1073741824; /* Possibly out of bounds */
  return d[0];
}
```

```
fun(0)  →   3.14
fun(1)  →   3.14
fun(2)  →   3.1399998664856
fun(3)  →   2.0000000061035156
fun(4)  →   3.14, then segmentation fault
```

- Result is architecture specific

Error referensi memori

- C dan C++ tidak menyediakan proteksi memory
  - akses array yang out of bounds
  - invalid pointers
  - salah malloc/free
- Dapat mengakibatkan bug yg menyebalkan

Kasus 4

- Performansi tidak hanya ditentukan oleh perhitungan kompleksitas algoritma

```
void copyij(int src[2048][2048],
            int dst[2048][2048])
{
  int i,j;
  for (i = 0; i < 2048; i++)
    for (j = 0; j < 2048; j++)
      dst[i][j] = src[i][j];
}
```

```
void copyji(int src[2048][2048],
            int dst[2048][2048])
{
  int i,j;
  for (j = 0; j < 2048; j++)
    for (i = 0; i < 2048; i++)
      dst[i][j] = src[i][j];
}
```

4.3ms

81.8ms

2.0 GHz Intel Core i7 Haswell

- memori hierarki
- performansi bergantung pada pola akses

Kasus 5

- komputer tidak hanya melakukan eksekusi program
- perlu akses data in/out
  - I/O system berperan penting terhadap program reliability & performance
- perlu komunikasi dengan pihak lain
  - banyak isu level sistem yang muncul akibat adanya jaringan
    - operasi konkuren
    - penanganan media yang tidak reliabel
    - kompatibilitas
    - isu performansi kompleks

A Tour of Computer Systems

code/intro/hello.c

```
1   #include <stdio.h>
2
3   int main()
4   {
5       printf("hello, world\n");
6   }
```

code/intro/hello.c

Figure 1.1 **The `hello` program.**

#	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

Figure 1.2 **The ASCII text representation of `hello.c`.**

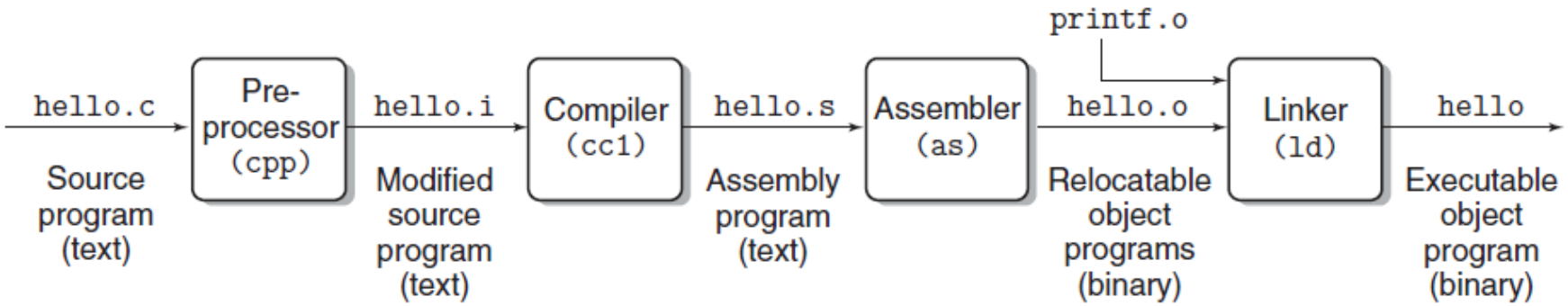


Figure 1.3 **The compilation system.**

Figure 1.4
Hardware organization of a typical system. CPU: Central Processing Unit, ALU: Arithmetic/Logic Unit, PC: Program counter, USB: Universal Serial Bus.

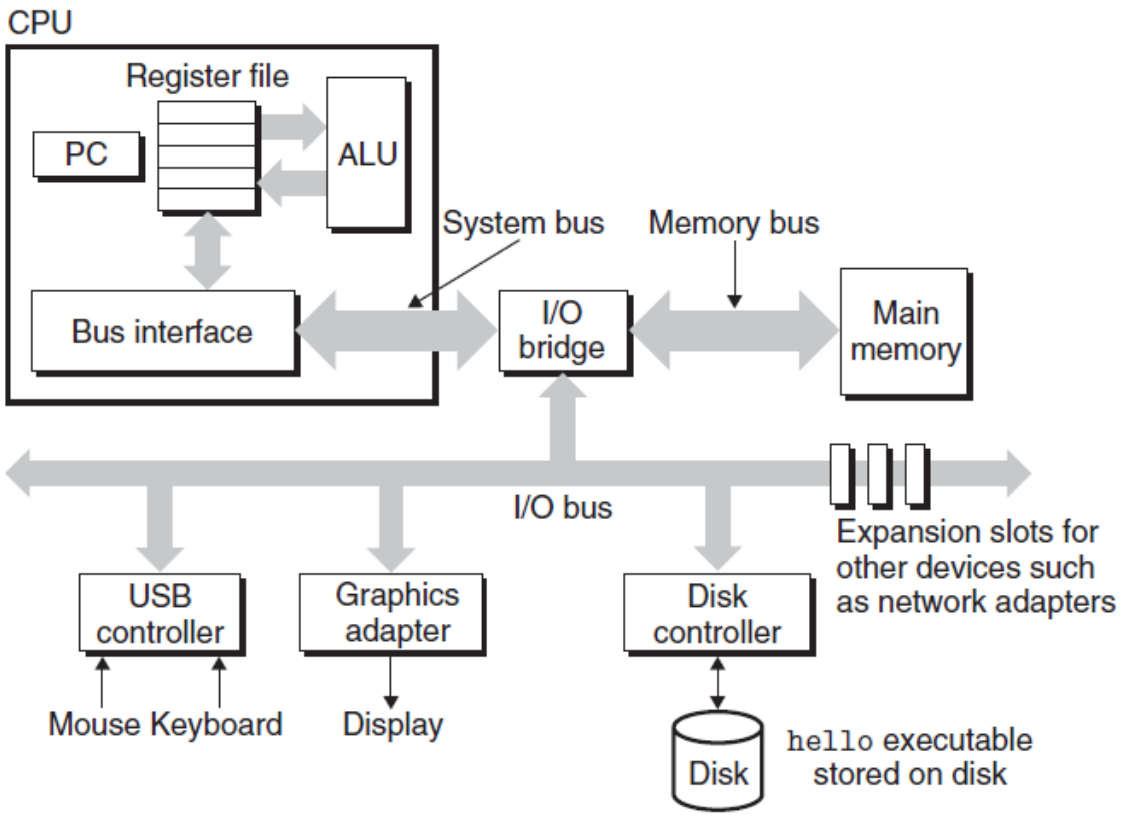
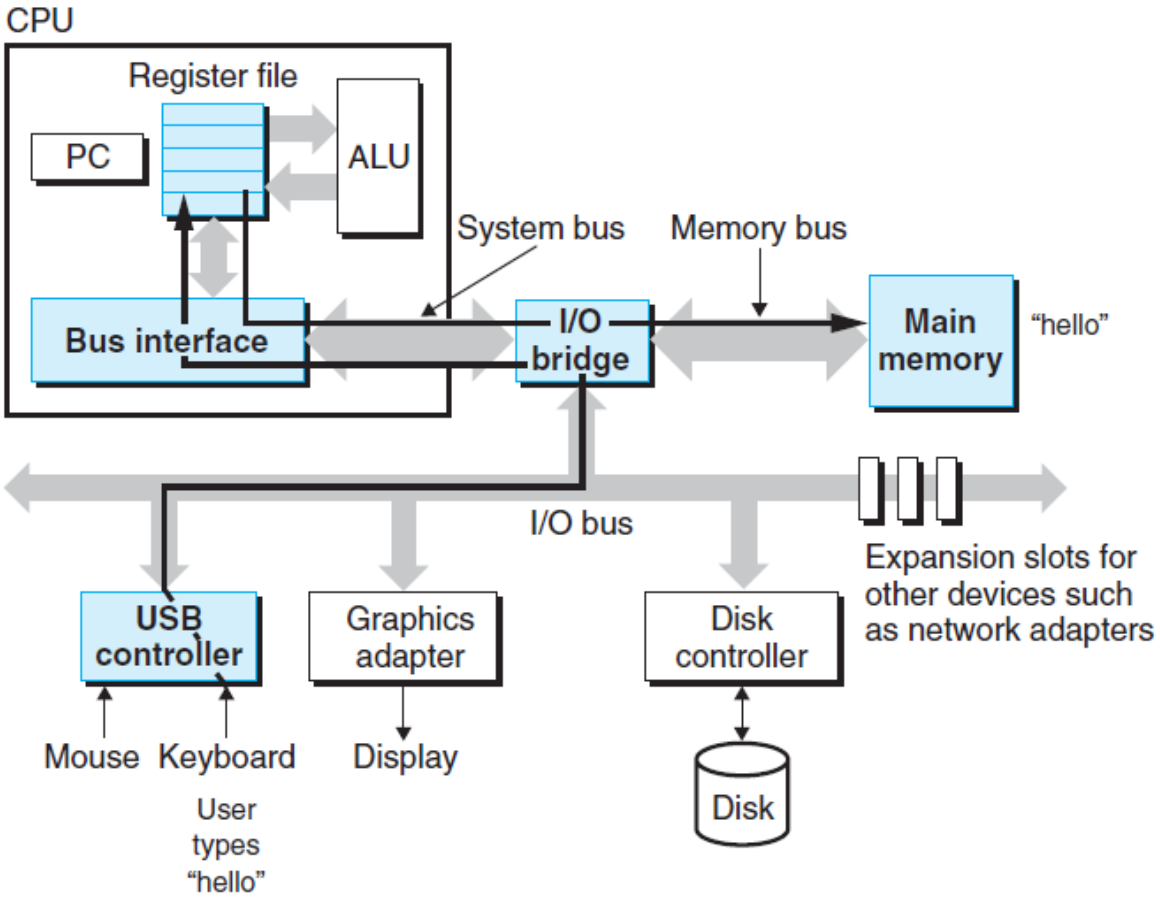


Figure 1.5
Reading the `hello` command from the keyboard.



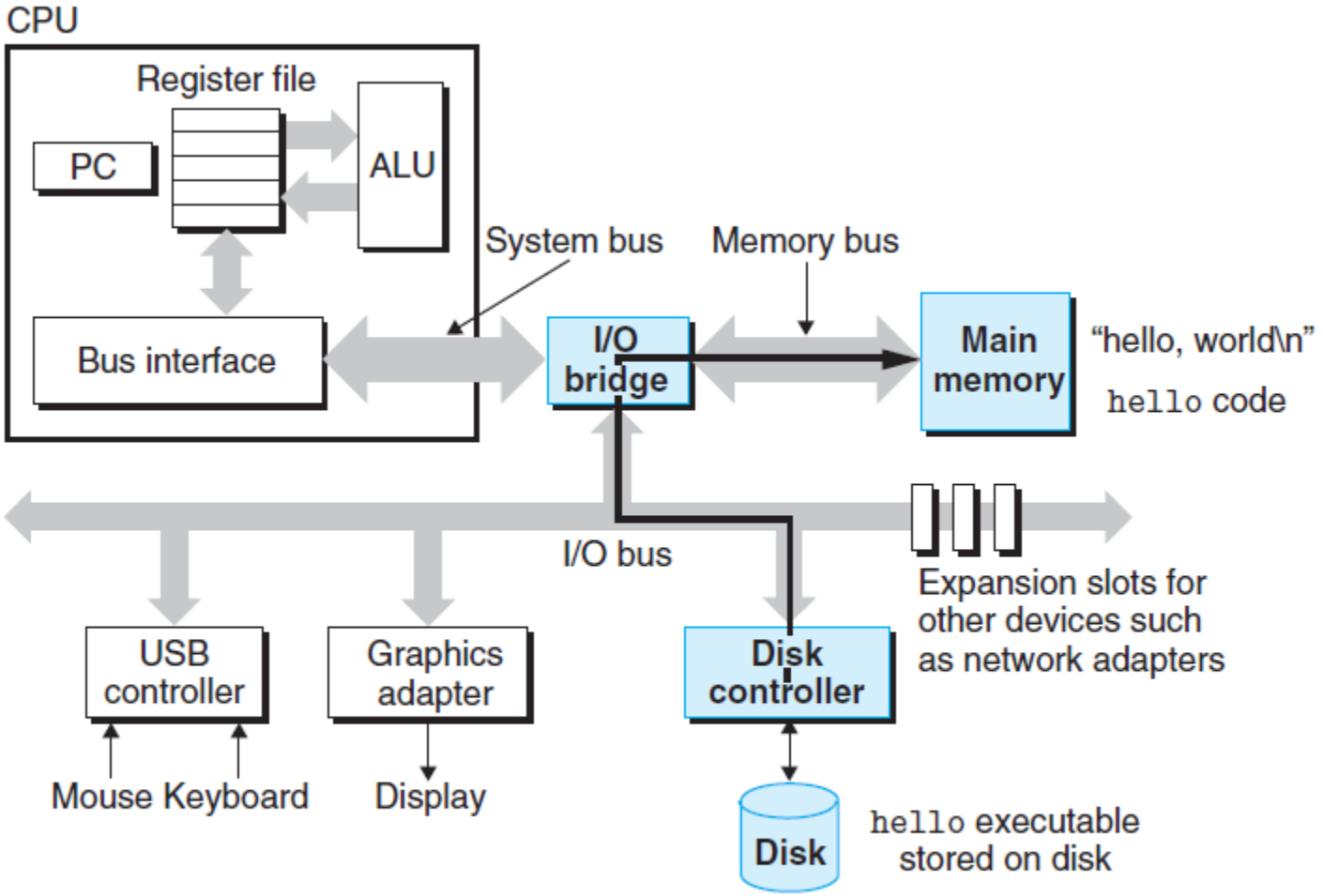


Figure 1.6 **Loading the executable from disk into main memory.**

Figure 1.7
Writing the output string from memory to the display.

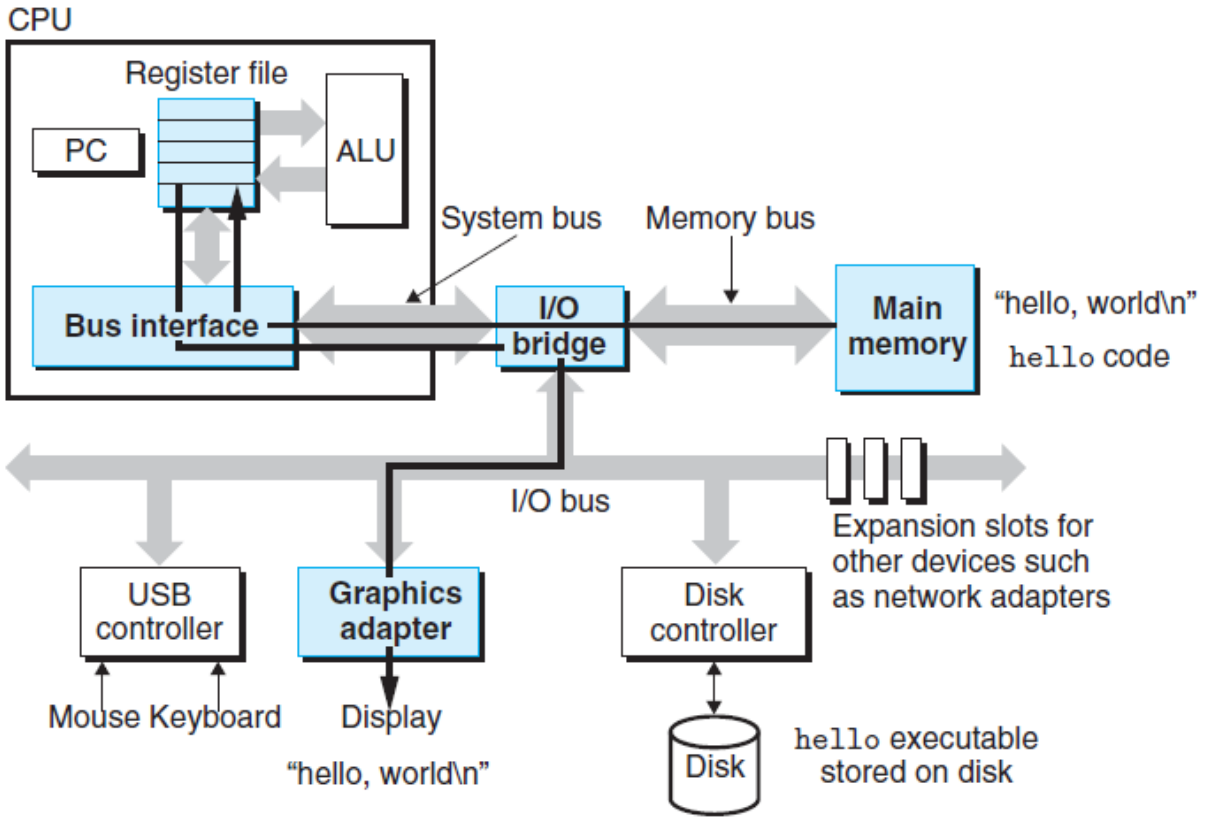
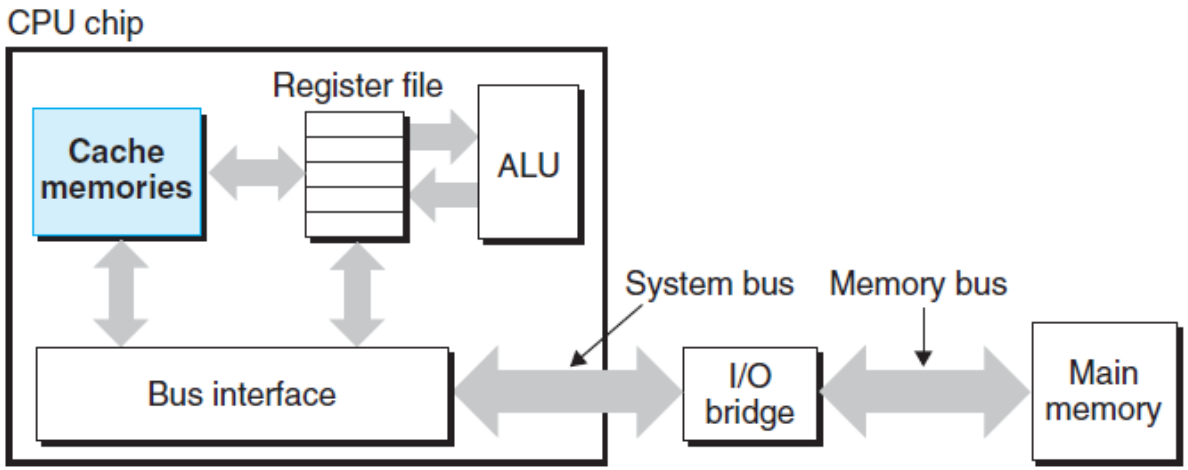


Figure 1.8
Cache memories.



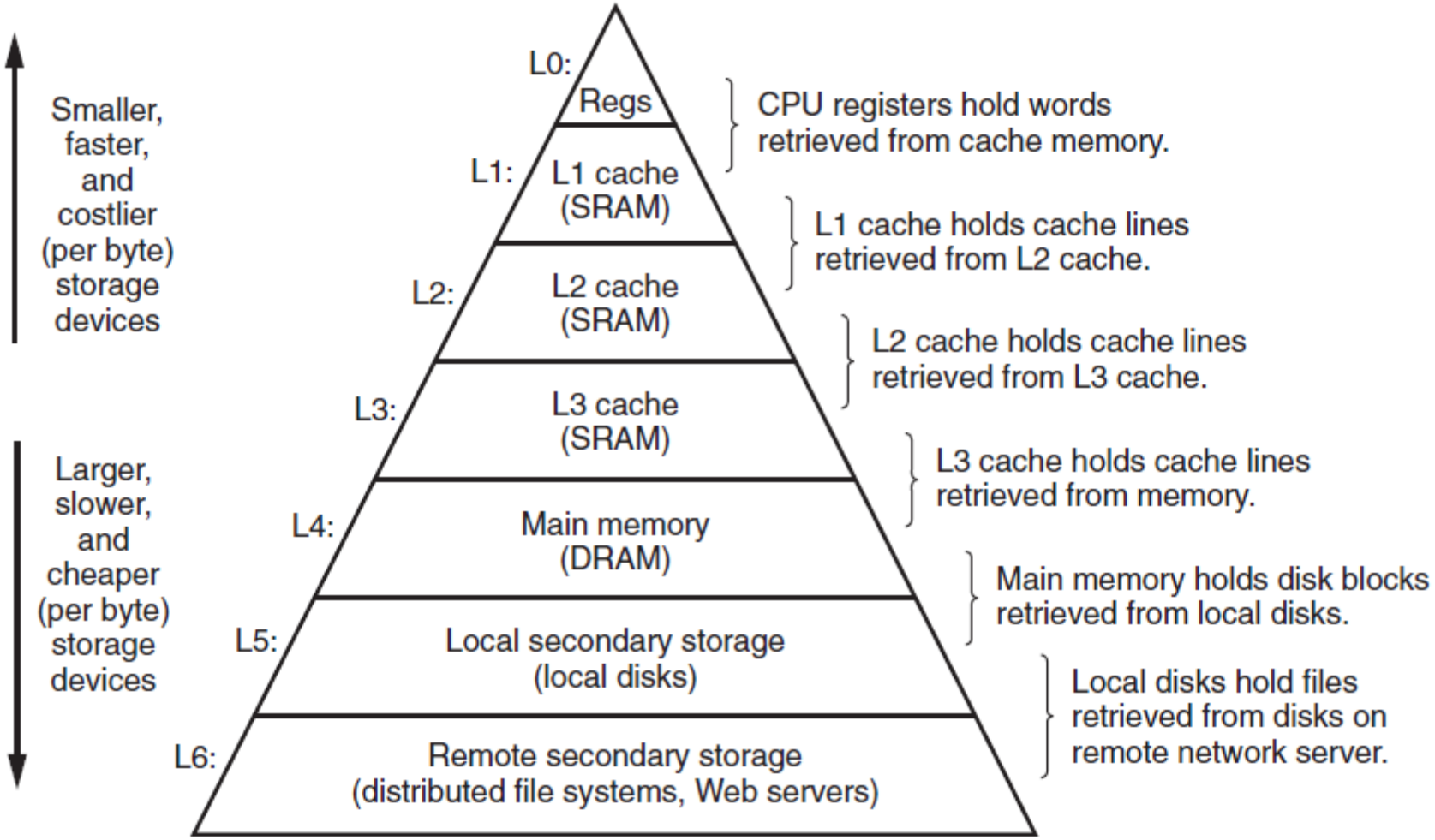


Figure 1.9 **An example of a memory hierarchy.**

OS mengelola hardware

Figure 1.10
Layered view of a computer system.

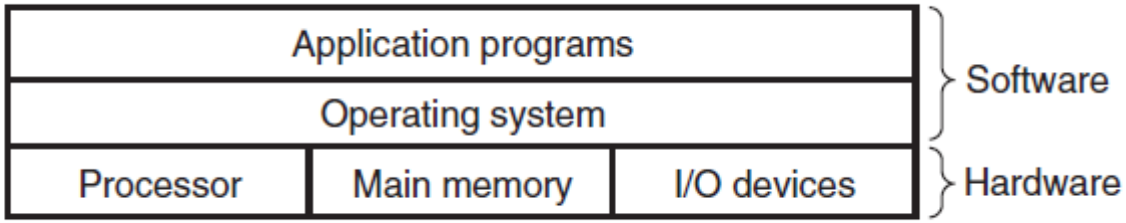
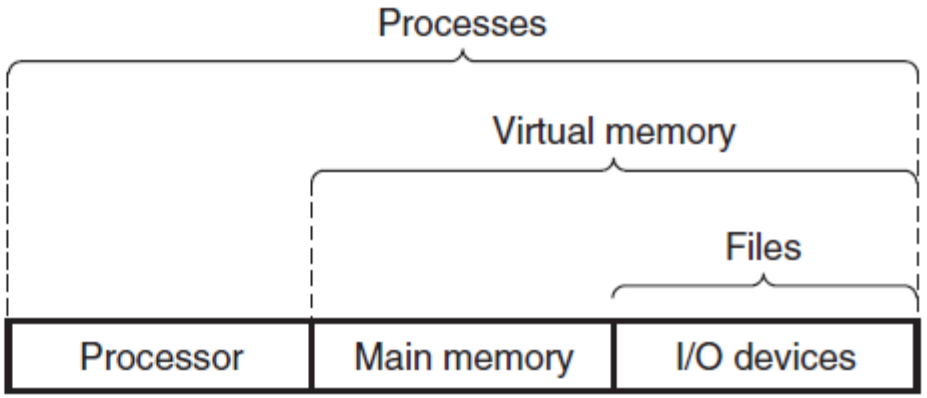
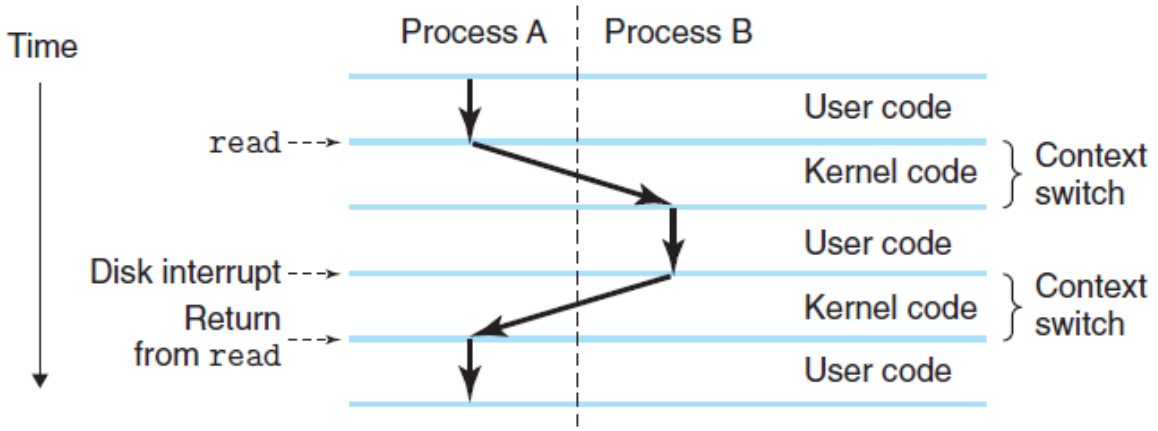


Figure 1.11
Abstractions provided by an operating system.



Process

Figure 1.12
Process context switching.



Virtual Memory

Figure 1.13
Process virtual address space.

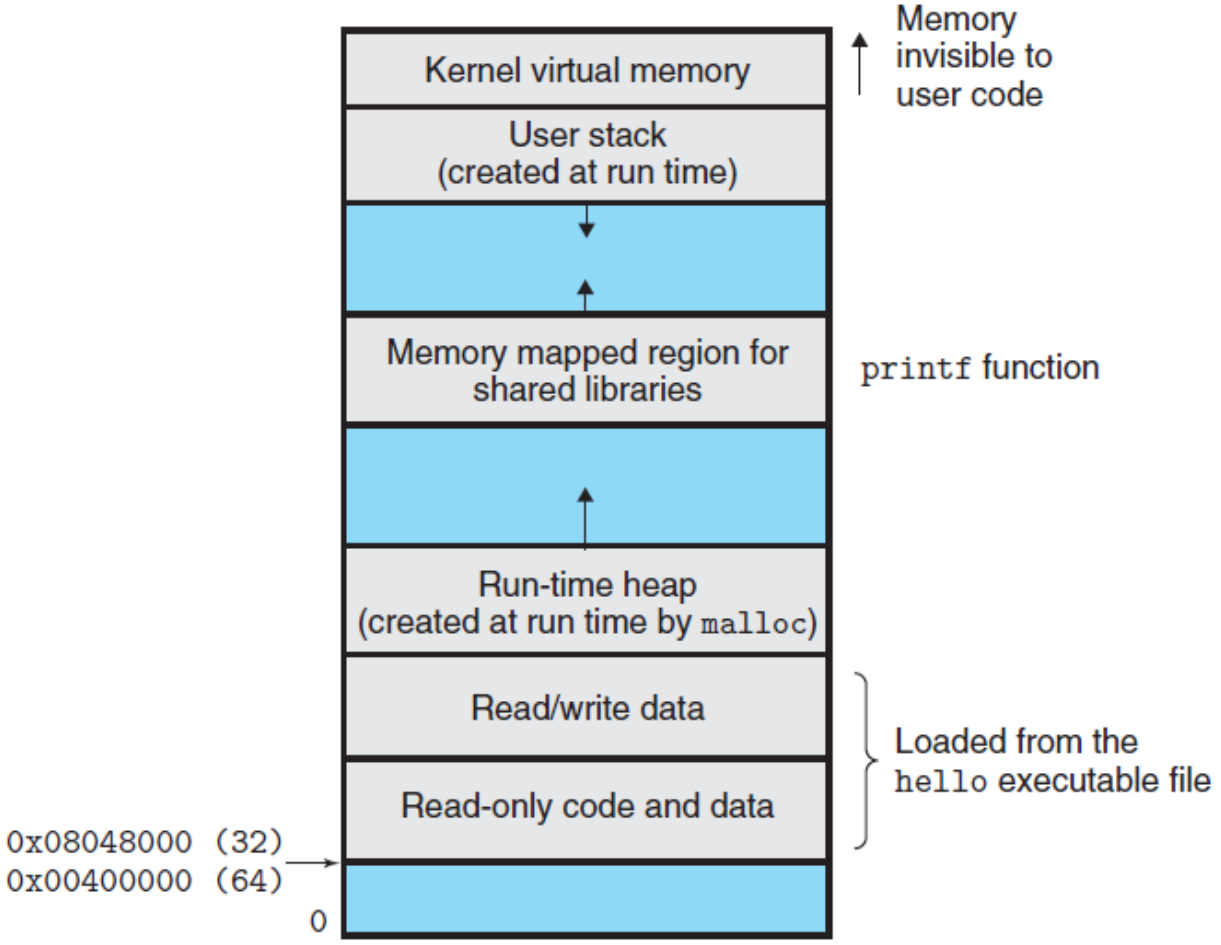
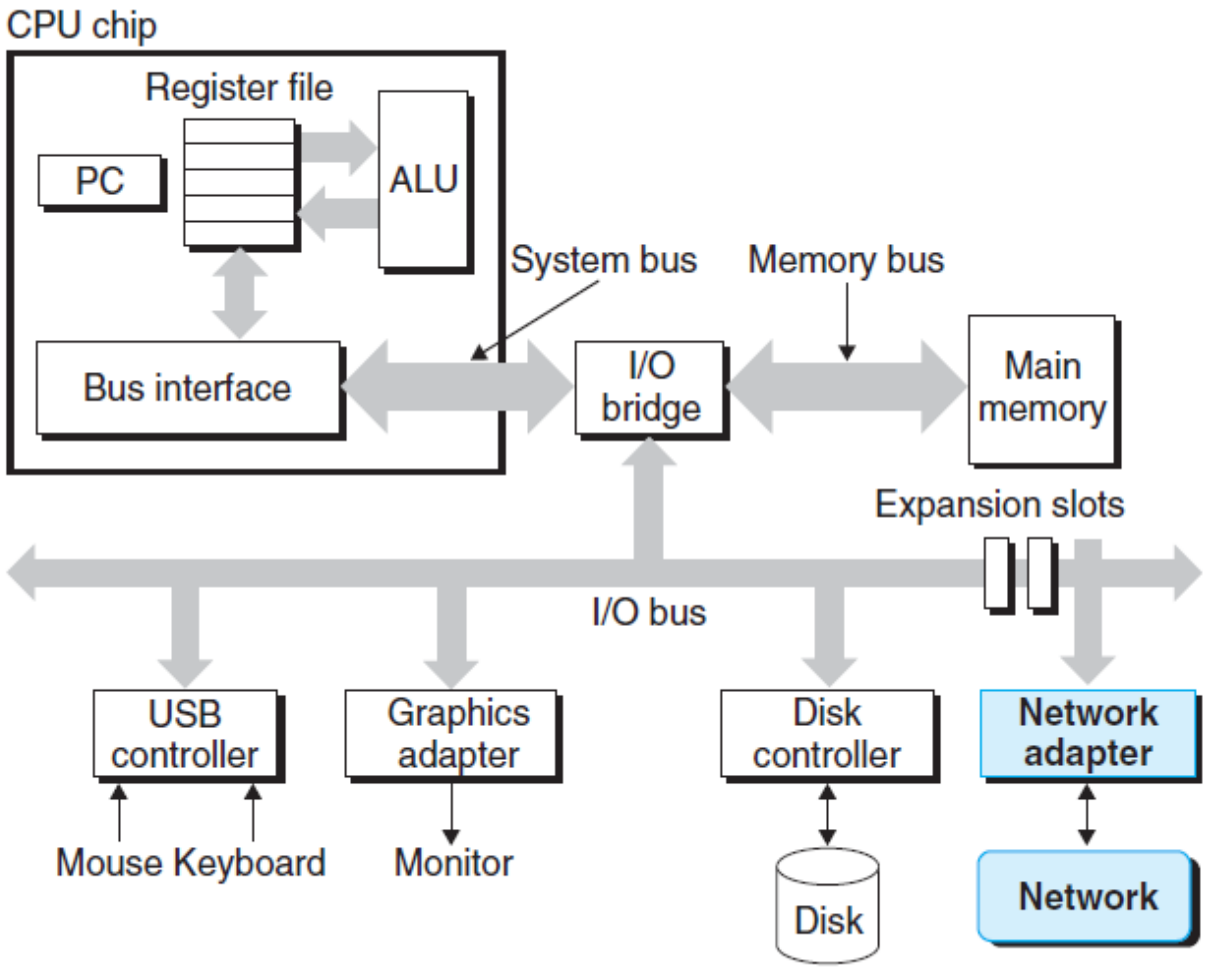


Figure 1.14
A network is another I/O device.



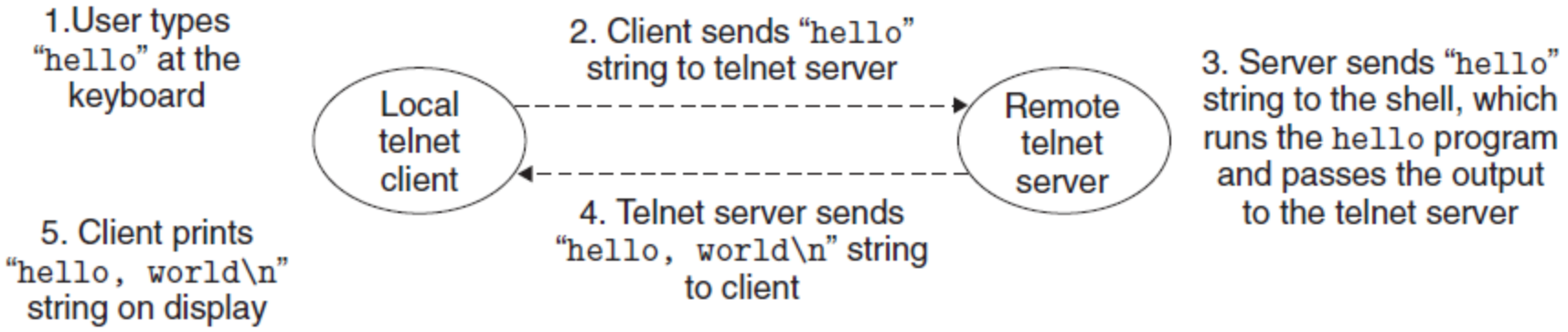


Figure 1.15 **Using telnet to run `hello` remotely over a network.**

Tema penting di komputing

- Konkurensi & paralelisme
  - Thread level parallelism
  - Instruction level parallelism

Figure 1.16
Categorizing different processor configurations. Multiprocessors are becoming prevalent with the advent of multi-core processors and hyperthreading.

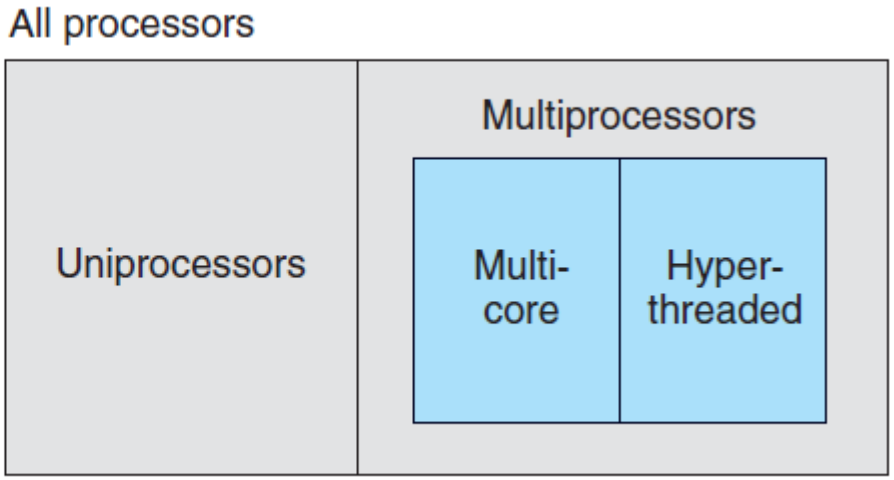
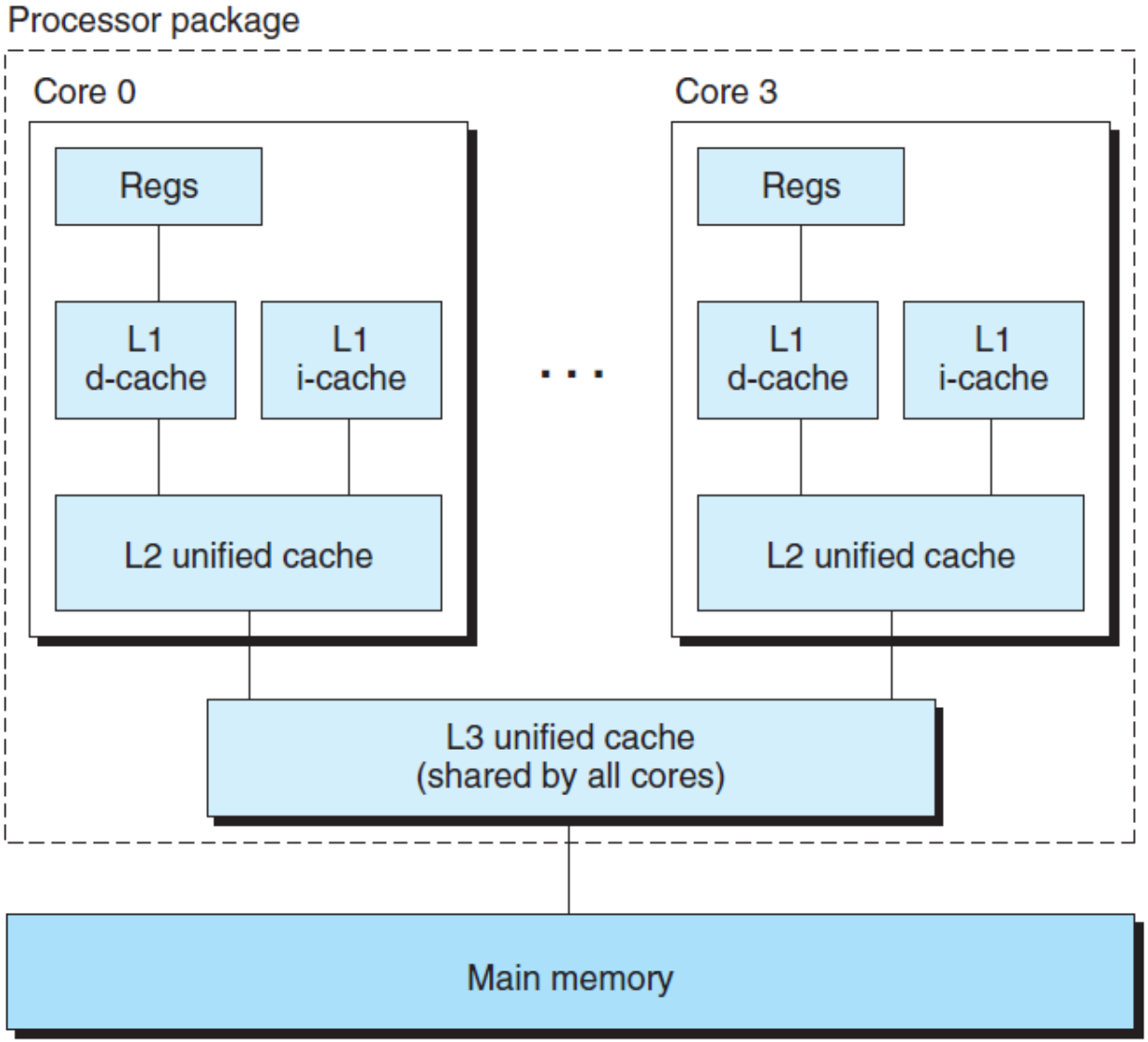


Figure 1.17
Intel Core i7 organization. Four processor cores are integrated onto a single chip.



Tema penting di komputing

- Abstraksi

Figure 1.18
Some abstractions provided by a computer system. A major theme in computer systems is to provide abstract representations at different levels to hide the complexity of the actual implementations.