Computer systems

College of Saint Benedict & Saint John's University

great insights of computer science[1]

Bacon, Leibniz, Boole, Turing, Shannon, & Morse

There are only **two nouns** that a computer has to deal with in order to represent “anything”: 0, 1.

[1]The great insights of computer science / CC BY-SA 3.0

great insights of computer science, cont'd

Turing

There are only **five verbs** that a computer has to perform in order to do "anything":

1. move left one location;
2. move right one location;
3. read symbol at current location;
4. print 0 at current location;
5. print 1 at current location.

great insights of computer science, cont'd

Boehm and Jacopini

There are only **three grammar rules** needed to combine these verbs (into more complex ones) that are needed in order for a computer to do "anything":

1. *sequence*: first do this, then do that;
2. *selection*: IF such-and-such is the case, THEN do this, ELSE do that;
3. *repetition*: WHILE such-and-such is the case DO this.

a simple language

1. two nouns
2. five verbs
3. three grammar rules

`<`	move left one location
`>`	move right one location
`0`	print `0` at current location
`1`	print `1` at current location
`[`	if current location is `0`, then go to instruction after matching `]`
`]`	go to matching `[` instruction

```
1>1>0>1>0<<<<[0>]1
```

a simple language, cont'd

`<`	move left one location
`>`	move right one location
`0`	print `0` at current location
`1`	print `1` at current location
`[`	if current location is `0`, then go to instruction after matching `]`
`]`	go to matching `[` instruction
`^`	add one to the 4-bit number ending at the current location

`^` replaces the sequence `>0<<<<[0>]1`

```
1>1>0>1^
```

abstraction

abstraction

A mechanism and practice to reduce and factor out details so that one can focus on a few concepts at a time.

Abstraction allows program designers to separate categories and concepts related to computing problems from specific instances of implementation.[2]

[2] Abstraction / CC BY-SA 3.0

types of abstraction

data abstraction

The separation of a data type's logical properties from its concrete implementation.

In fact, a data type is a data abstraction.

```
boolean found := false
```

control abstraction

The separation of the behavior of a set of actions from its concrete implementation.

One of the main purposes of programming languages.

```
a := (2 + 3) / 4
```

abstraction levels

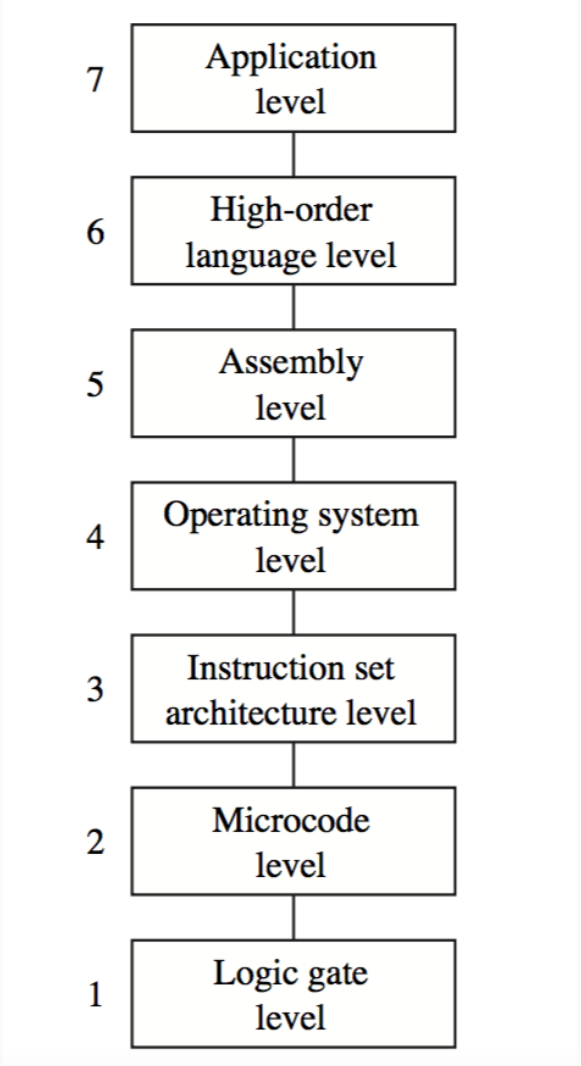
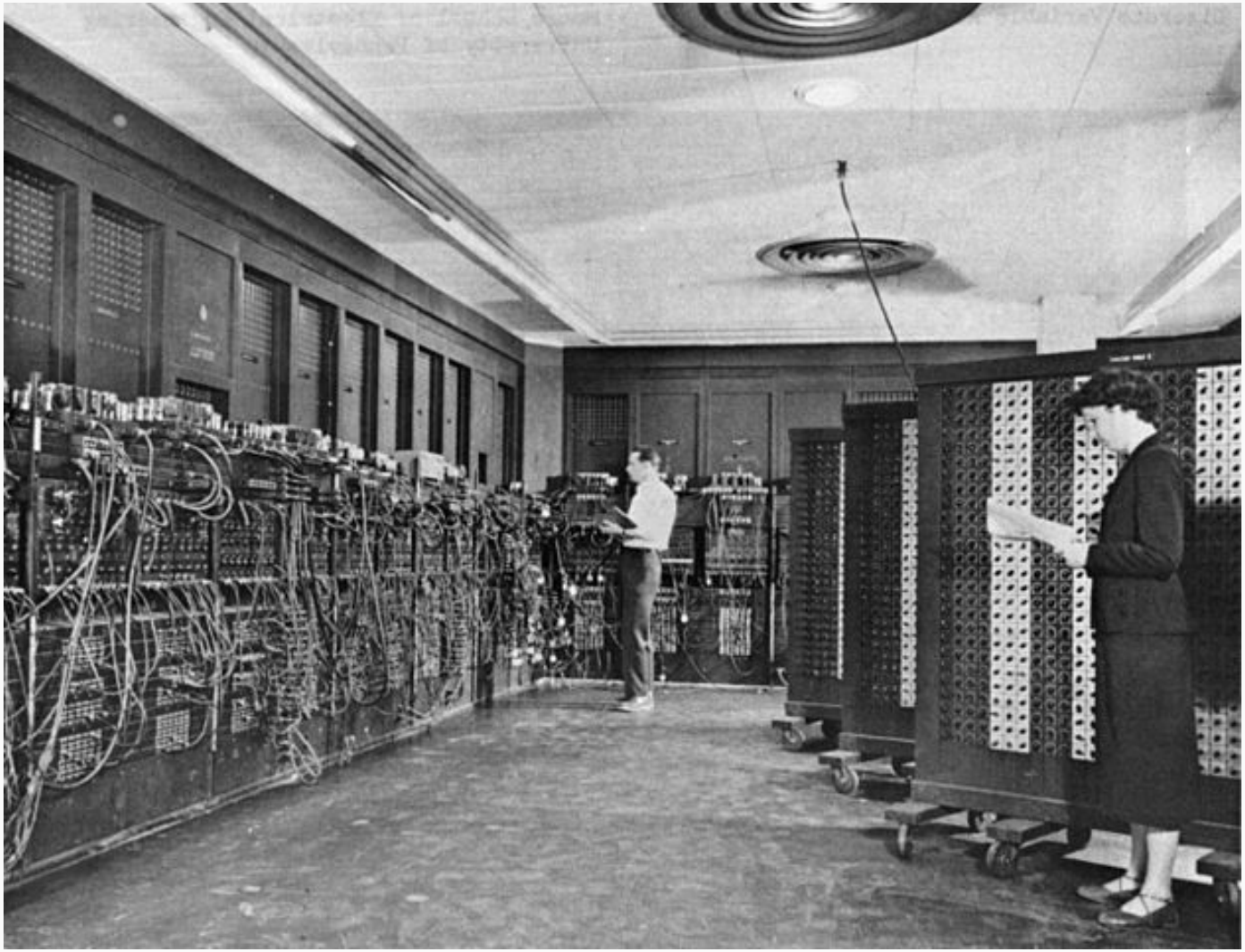


Figure P.1

history of abstraction



U.S. Army Photo / Public Domain

history of abstraction, cont'd

SSEM Manchester museum close up / CC BY 3.0

history of abstraction, cont'd

Commodore Grace M. Hopper, USN / Public Domain

history of abstraction, cont’d

hardware abstraction

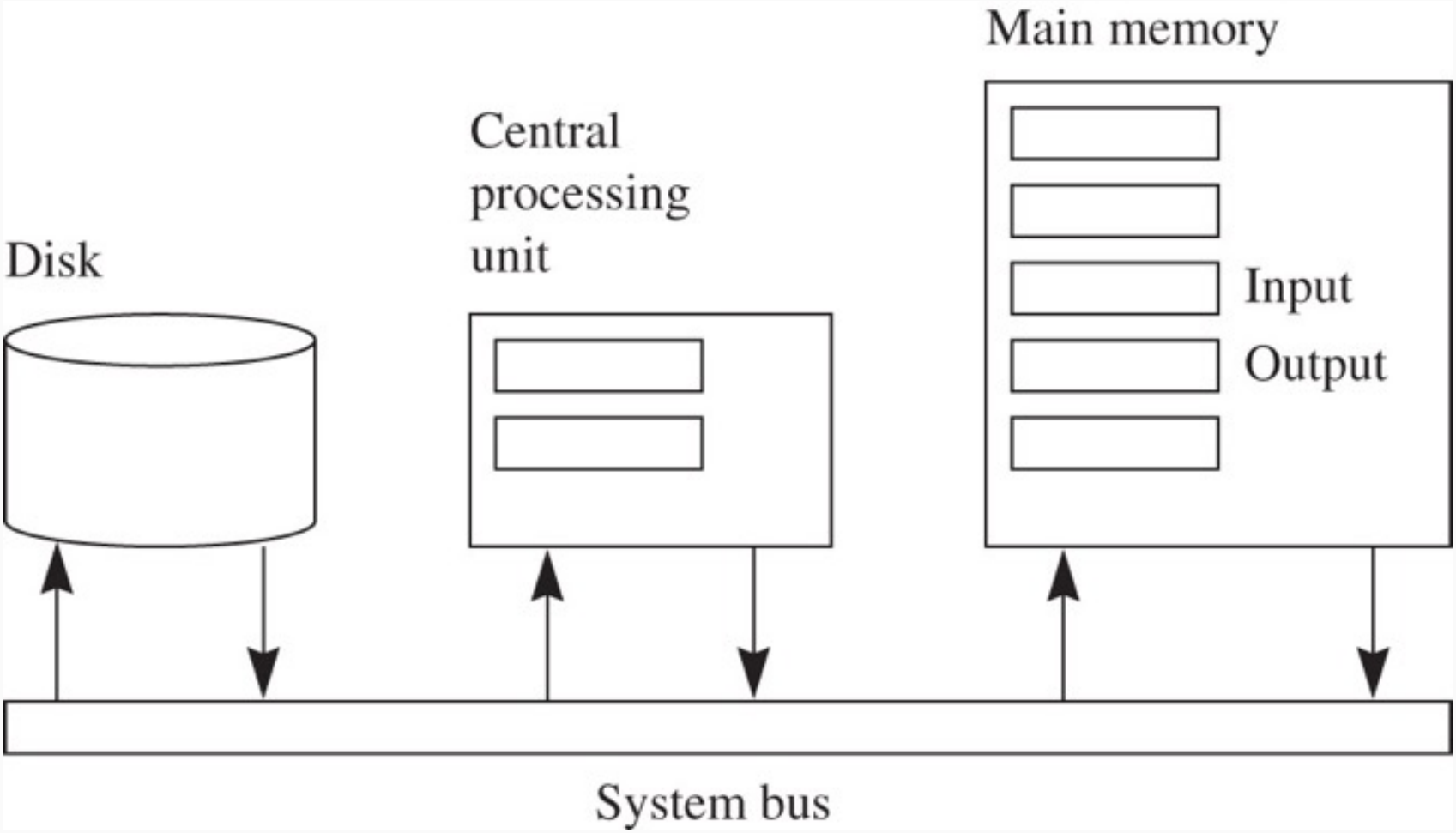
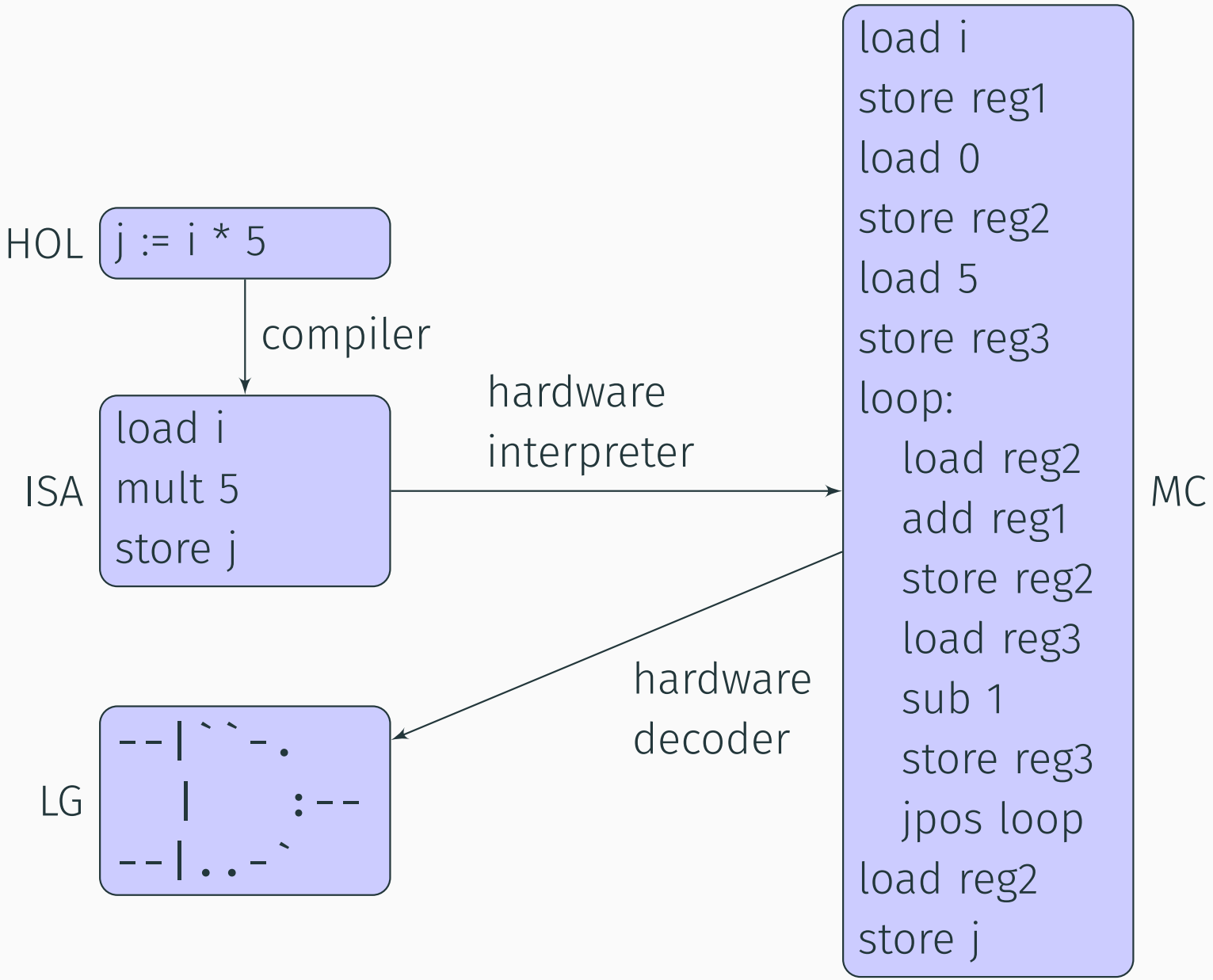


Figure 1.9

hardware abstraction, cont'd



software abstraction

algorithm

a set of *instructions* that, when carried out in the proper sequence, solves a problem in a finite amount of time

program

an algorithm written in a language that is understandable by a computer, i.e., that can be executed on a computer

algorithms

```
while i is greater than or equal to 0
  print i
  subtract 1 from i
```

```
print the numbers from i to 0
```

system performance

$$\frac{\text{time}}{\text{program}} = \frac{\text{instructions}}{\text{program}} \times \frac{\text{cycles}}{\text{instruction}} \times \frac{\text{time}}{\text{cycle}}$$

try it yourself

Suppose your CPU is rated at 2.5 GHz and you execute a program task on your app that requires the execution of 16 million ISA3 instructions. If each ISA3 instruction executes an average of 3.7 MC2 instructions, what is the execution time of the program task in seconds?

bandwidth

$$\text{information} = \frac{\text{information}}{\text{time}} \times \text{time}$$

try it yourself

One of the largest (but not the largest, but very close to it), telecommunications companies in the U.S., offers an internet product called Continuum that promises up to 100 Mb/s for the low price of $45/month. A smaller and slightly less popular telecomm company offers a competing product offering up to 25 Mb/s for $30/month. If I have two devices capable of streaming Netflix HD, which product should I choose? Construct an argument to explain to the customer service representative for the company whose product you do not choose, why.