Lecture 1

Introduction

12 August, 2011

Instructor

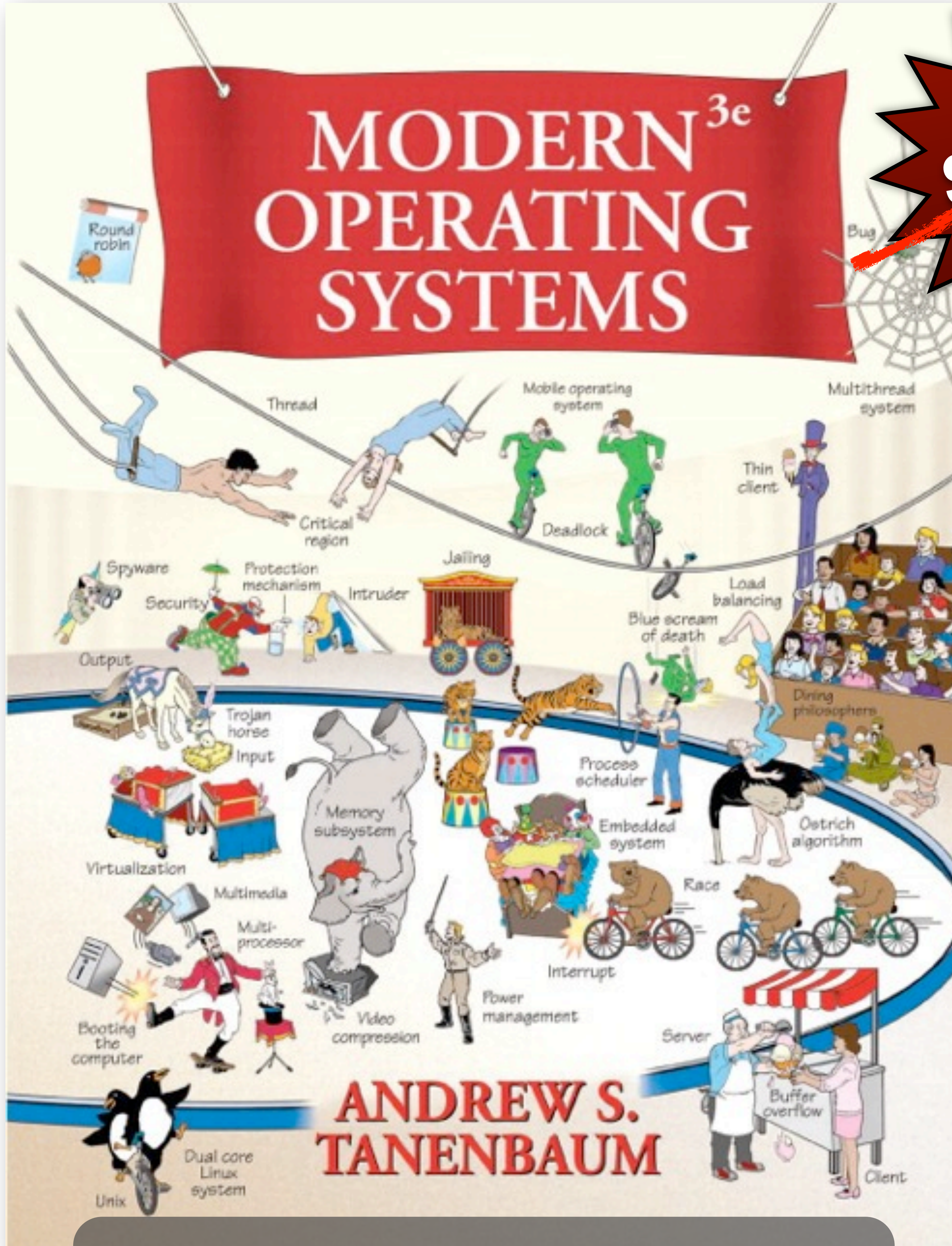
Ooi **Wei Tsang**

`ooiwt@comp.nus.edu.sg`

Office Hour

Fri 4 - 6pm

AS6 05-14



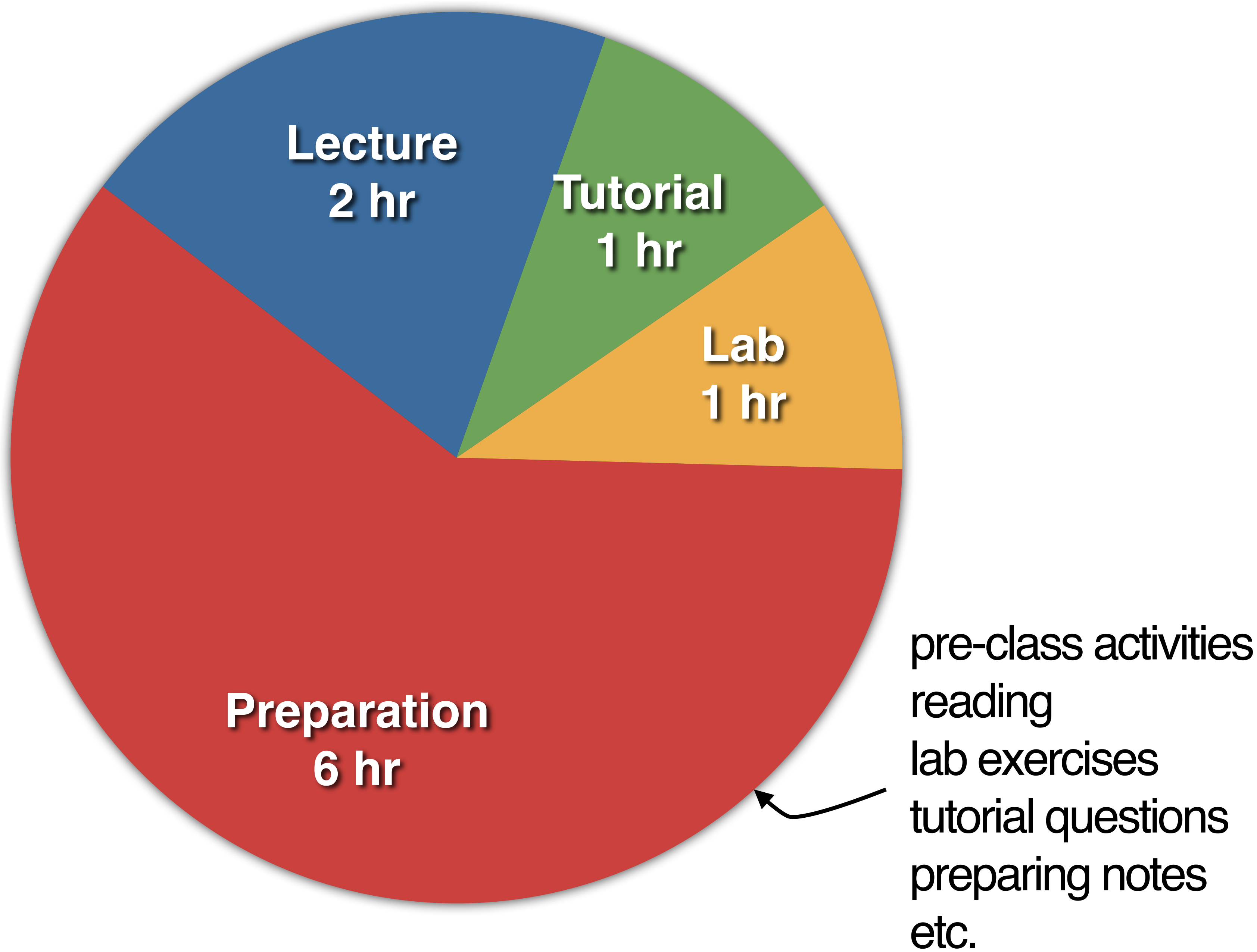
~~$47.90~~

$52.20

Required Textbook

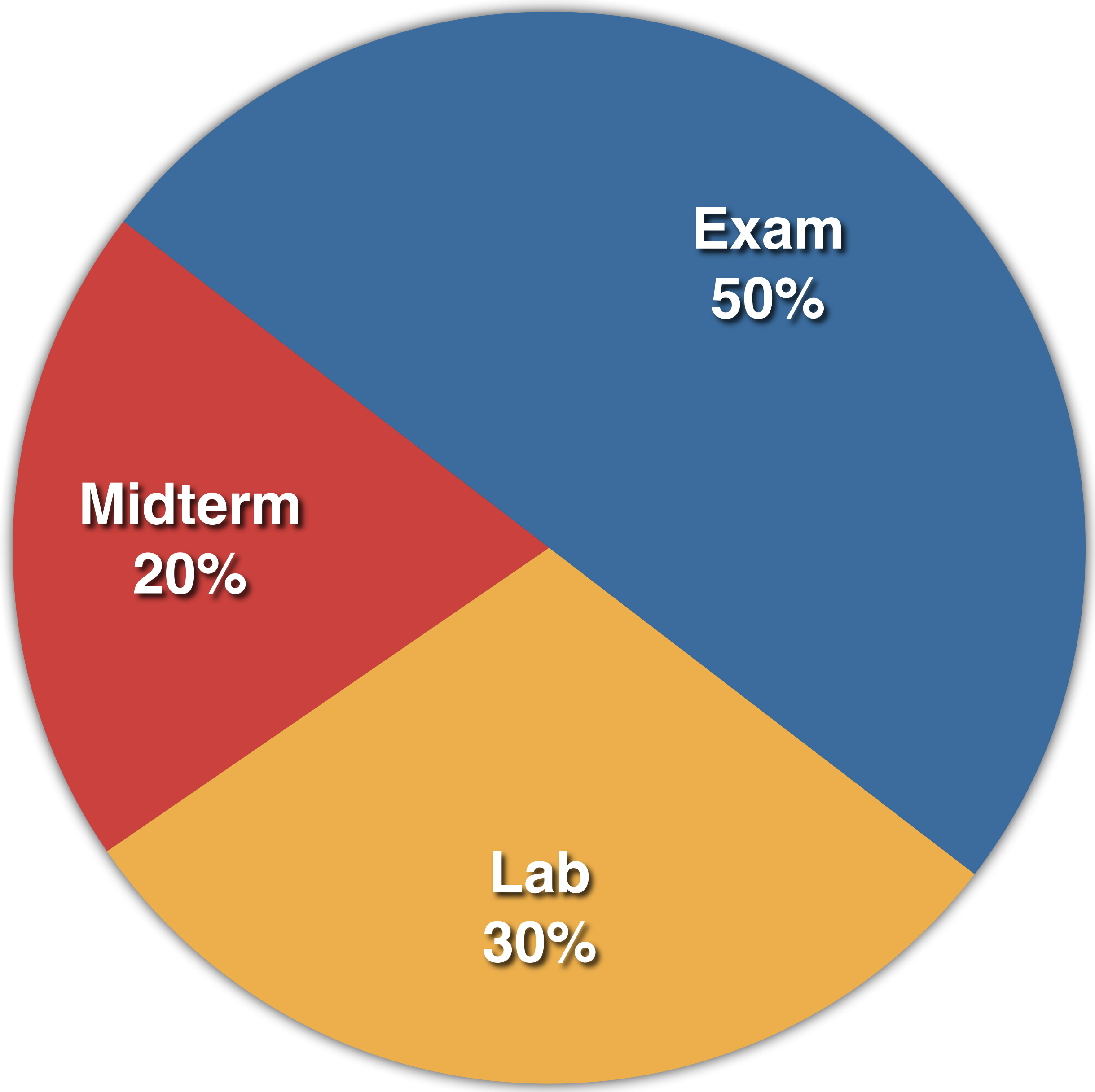
Average Weekly Workload

(your milage may vary)



Note that NUS officially lists the workload as 2-1-1-0-4 which is a typo (it does not add up to 10!)

Assessment



Important Dates

```
    October 2011
Su Mo Tu We Th Fr Sa
                   1
 2  3  4  5  6  7  8
 9 10 11 12 13 14 15
16 17 18 19 20 21 22
23 24 25 26 27 28 29
30 31
```

midterm

```
   November 2011
Su Mo Tu We Th Fr Sa
       1  2  3  4  5
 6  7  8  9 10 11 12
13 14 15 16 17 18 19
20 21 22 23 24 25 26
27 28 29 30
```

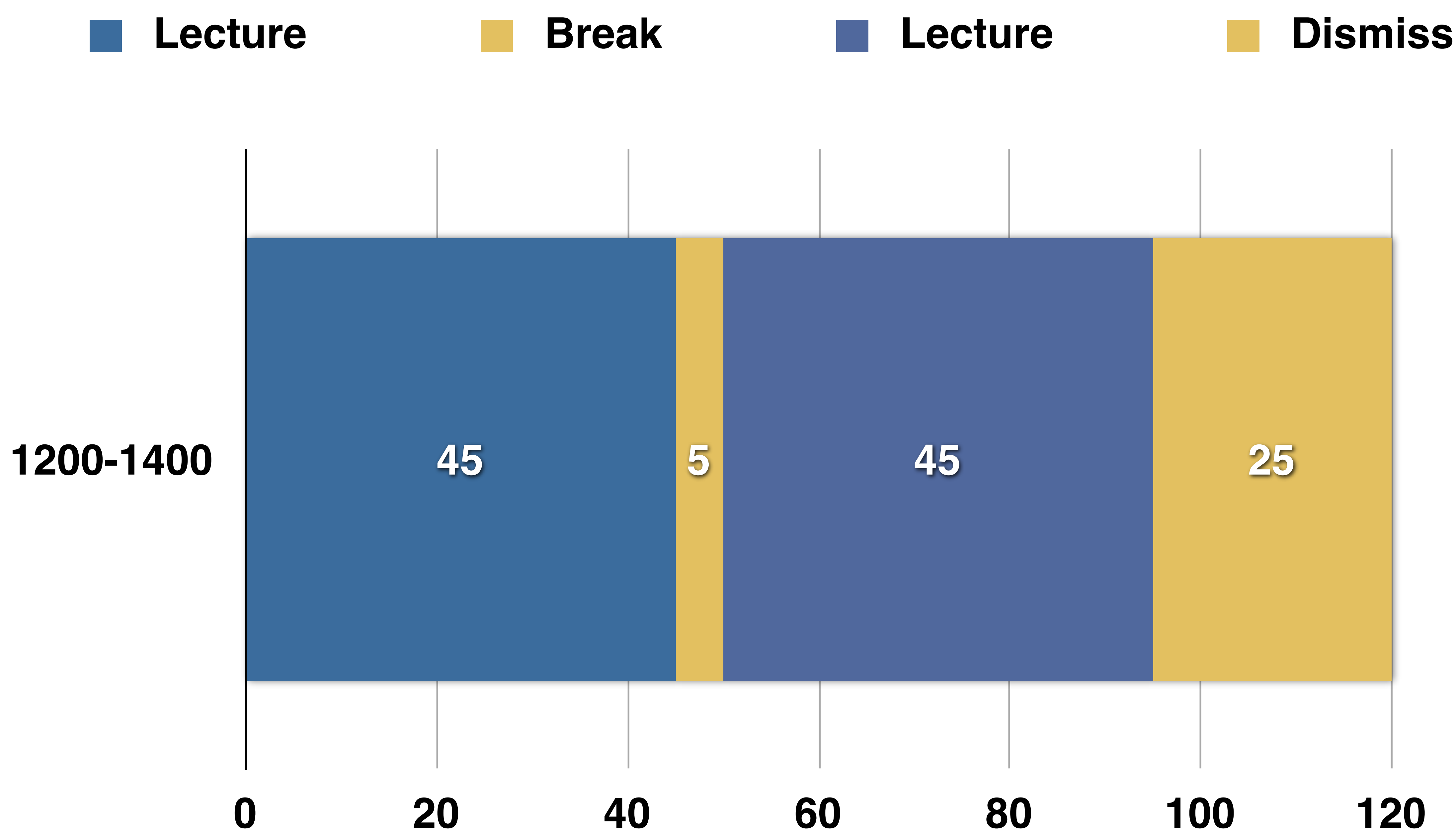
final

midterm and final are

semi-open book

(one 2-sided A4 sheet)

Lecture Format



slides will be posted
1-2 days before lecture
but

no lecture notes

will be provided

students are expected to take notes during lecture

students are expected to read the assigned readings

no “model” answer will be posted

blog.nus.edu.sg/**cs2106**

your responsibility: check for update frequently

(hint: subscribe via email or RSS)

do participate in online discussion

(and use your real name!)

screencast

will be posted

but expect 3-4 days delay and technical glitches do occur

(not a good reason to skip lecture)

pre-class activities

simple activities for you to do / think about before attending lecture.

might help improve your understanding in class

online discussion only

tutorials

a set of questions
asked each week

you are expected to think through the answers before the attending the tutorial sessions

we will discuss **your** answers
during tutorial sessions

we will conclude each discussion
with the correct / best answer

labs

one lab exercise
(almost) every week

can do it at your own time

some are ungraded

lab sessions:

1. lab TAs available for assistance

2. discuss lab answers from past labs

some lab and tutorial questions are meant to let you discover new knowledge yourself

(only if you think through the answers)

warning: I am brutal in penalizing students who do not following instructions **exactly** for lab submissions

feedback

what your seniors from 2010
think of CS2106

31%

find CS2106
“Very Difficult”

Average is 14% for other 2000-level modules

lots of stuff to learn

“The scope of the module is quite large.”

“Too much content in too little time.”

the labs are difficult

".. lab sessions can sometimes be really difficult hence time consuming."

"The weekly labs can be quite stressful."

but useful for learning

“weekly labs ensure that students really understand the concepts introduced in the lecture.”

“Labs are tough, but it is through the labs which I feel I learnt the most from”

“However the labs are also the real place that we actually learn”

independent learning

“The teaching material and most importantly style, is very conducive to independent learning”

“Also get chance to acquire independent learning through reading man page and google search”

“strengths: encourage a LOT of self-study”

what is

CS2106

about?

NOT about how to use

Mac OS X, MS Windows,

Linux etc.

about **basic concepts**
and **design principles**
in OS

many different variations:
for **different OS**
and **different architecture**

but same
concepts and principles

why should I learn

OS ?

I am not going to write another OS!

CS2106 is important because

complex software

abstraction + interface design

concurrency

resource management

understand performance issues

```c
#define SIZE 10000
int a[SIZE][SIZE];

for (i = 0; i < size; i++)
  for (j = 0; j < size; j++)
    a[i][j] = 0;
```

```
#define SIZE 10000
int a[SIZE][SIZE];

for (i = 0; i < size; i++)
  for (j = 0; j < size; j++)
    a[j][i] = 0;
```

My computer is slow. Should I upgrade to

A. a faster CPU
B. more CPU core
B. a faster harddisk
C. a bigger harddisk
D. more memory
E. faster memory

what to learn from OS course (beside OS):

1. **complex systems**
2. **abstraction + interface design**
3. **concurrency**
4. **resource management**
5. **performance issues**

Assumed Background

UNIX and **C**

why UNIX?

(Linux, Mac OS X, Sun OS etc.)

need a **concrete example** for the concepts and principles taught in CS2106 many OS concepts are **cleanly** manifested in UNIX source code are available

why C?

UNIX is written (mostly) in C

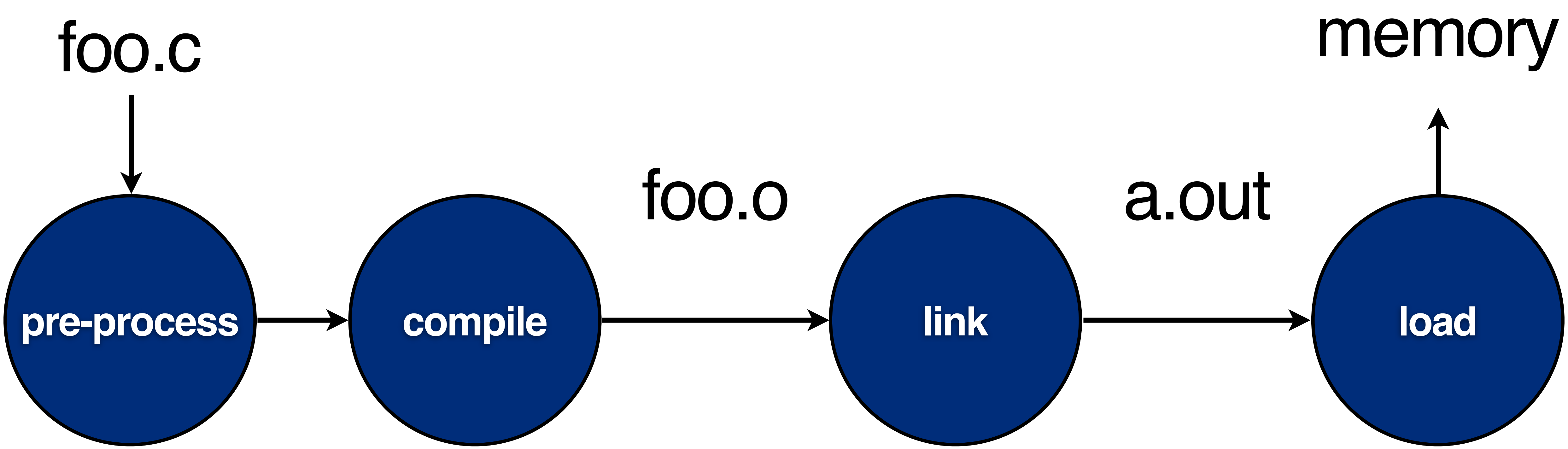
intermediate-level language
(e.g., explicit memory allocation,
bits manipulation)

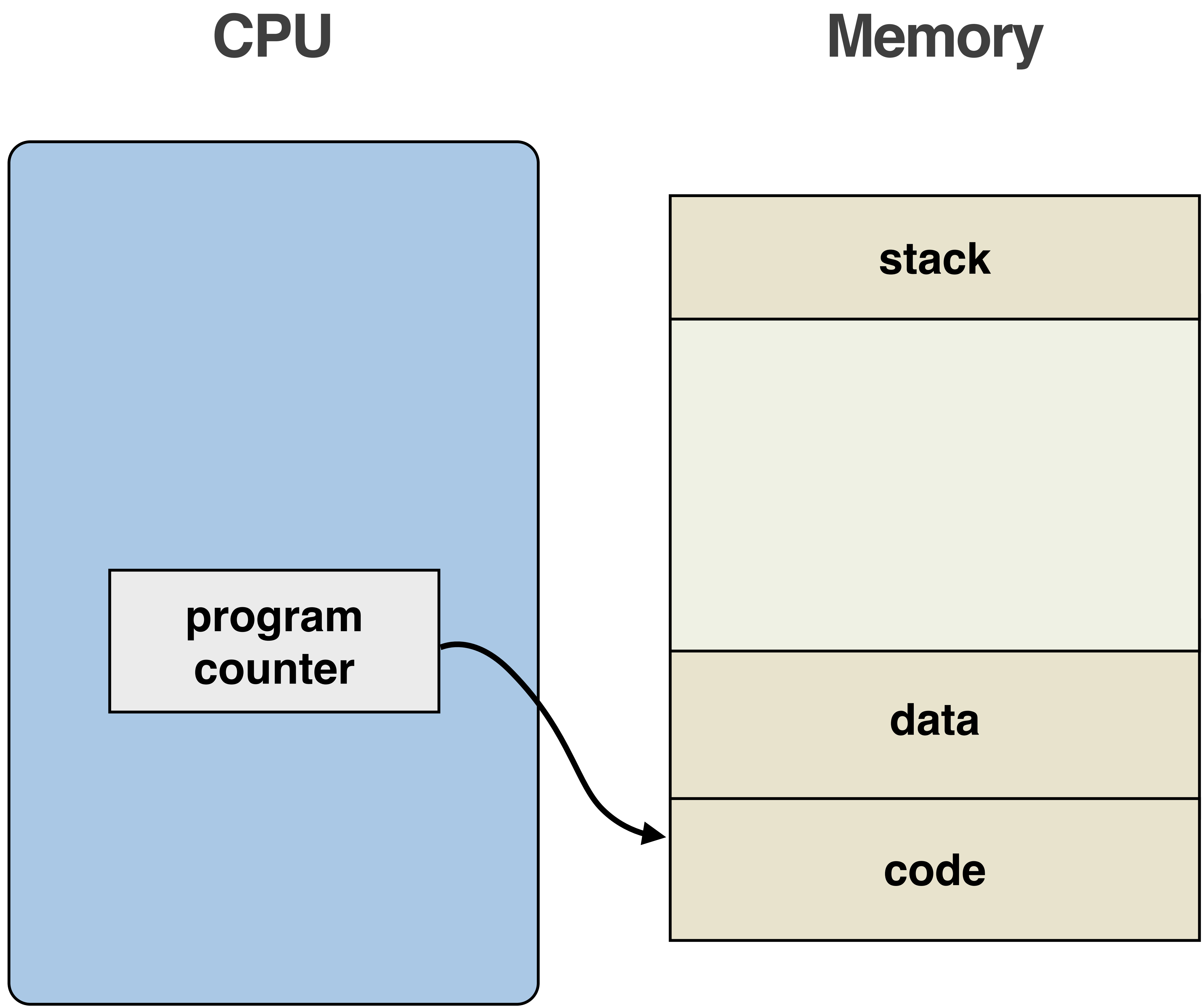
CS2100
Computer
Organization

how a program is executed

a brief review

to build and run a program:




CPU
Memory
stack
program
counter
data
code

Loop:

1. fetch instruction located at PC
2. decode instruction
3. fetch data
4. execute instruction and update PC

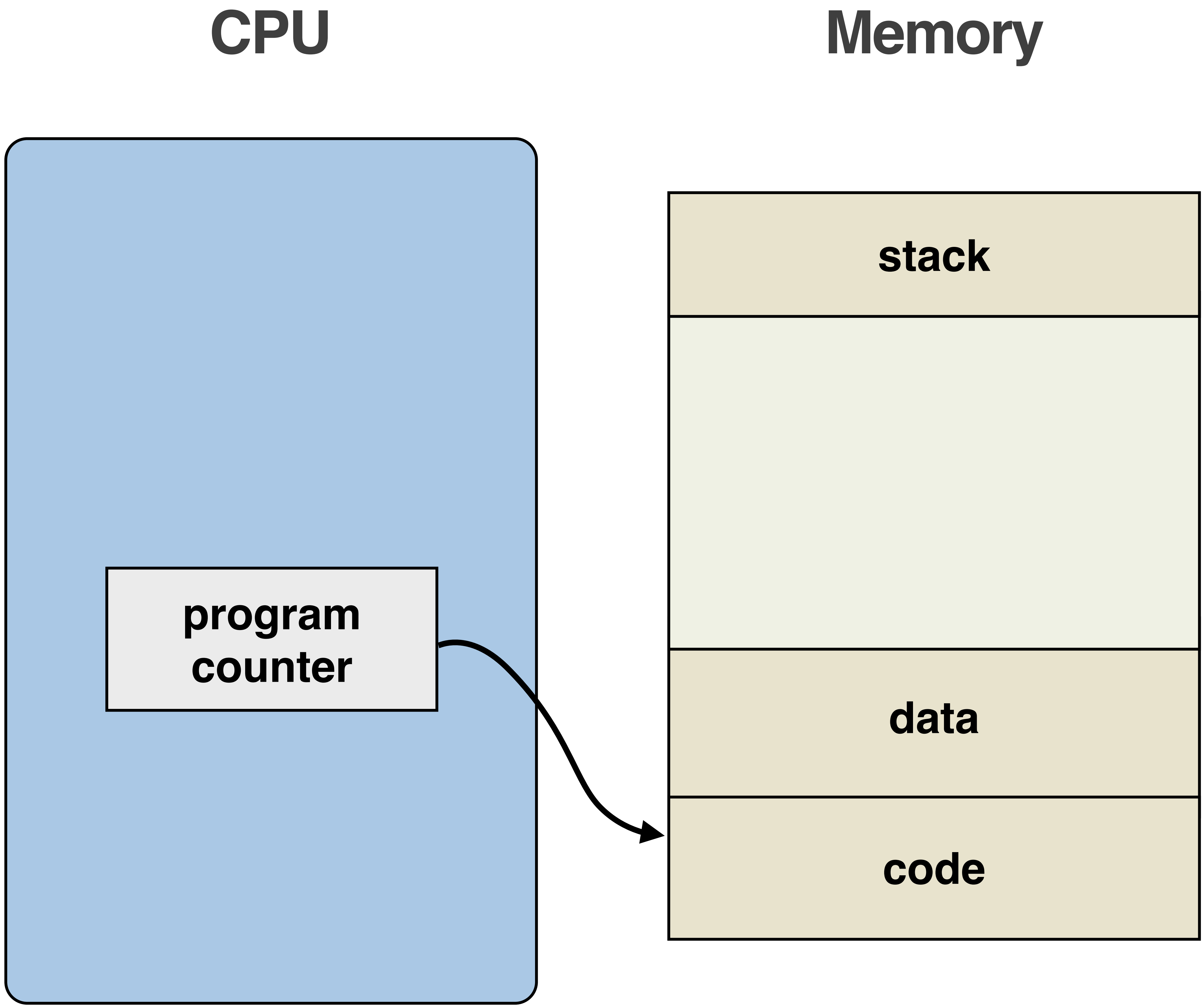
```c
int main()
{
  int x = 1;
  foo(x);
  x = x + 1;
}
```

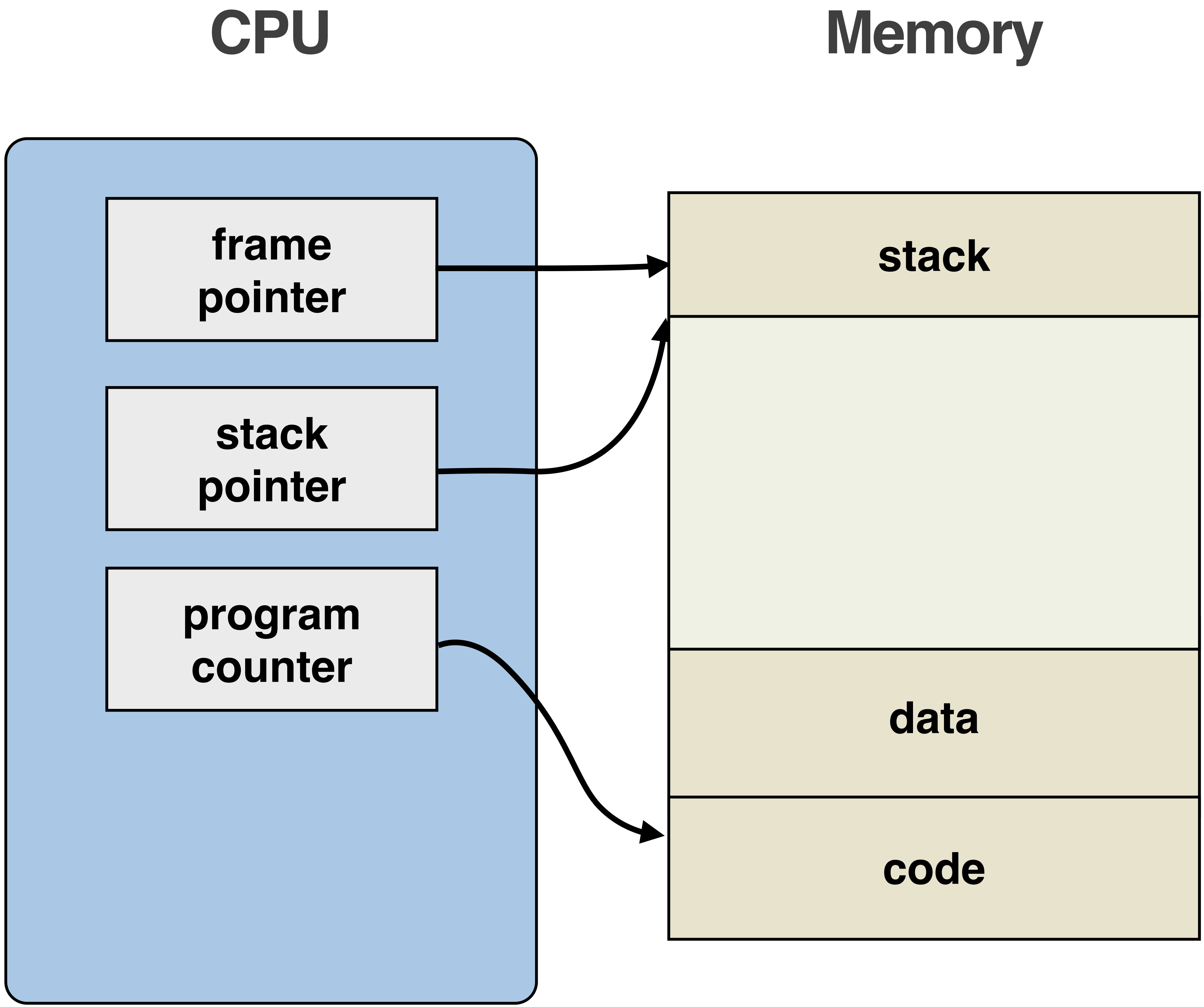
```c
int foo(int x)
{
    :
    :
}
```

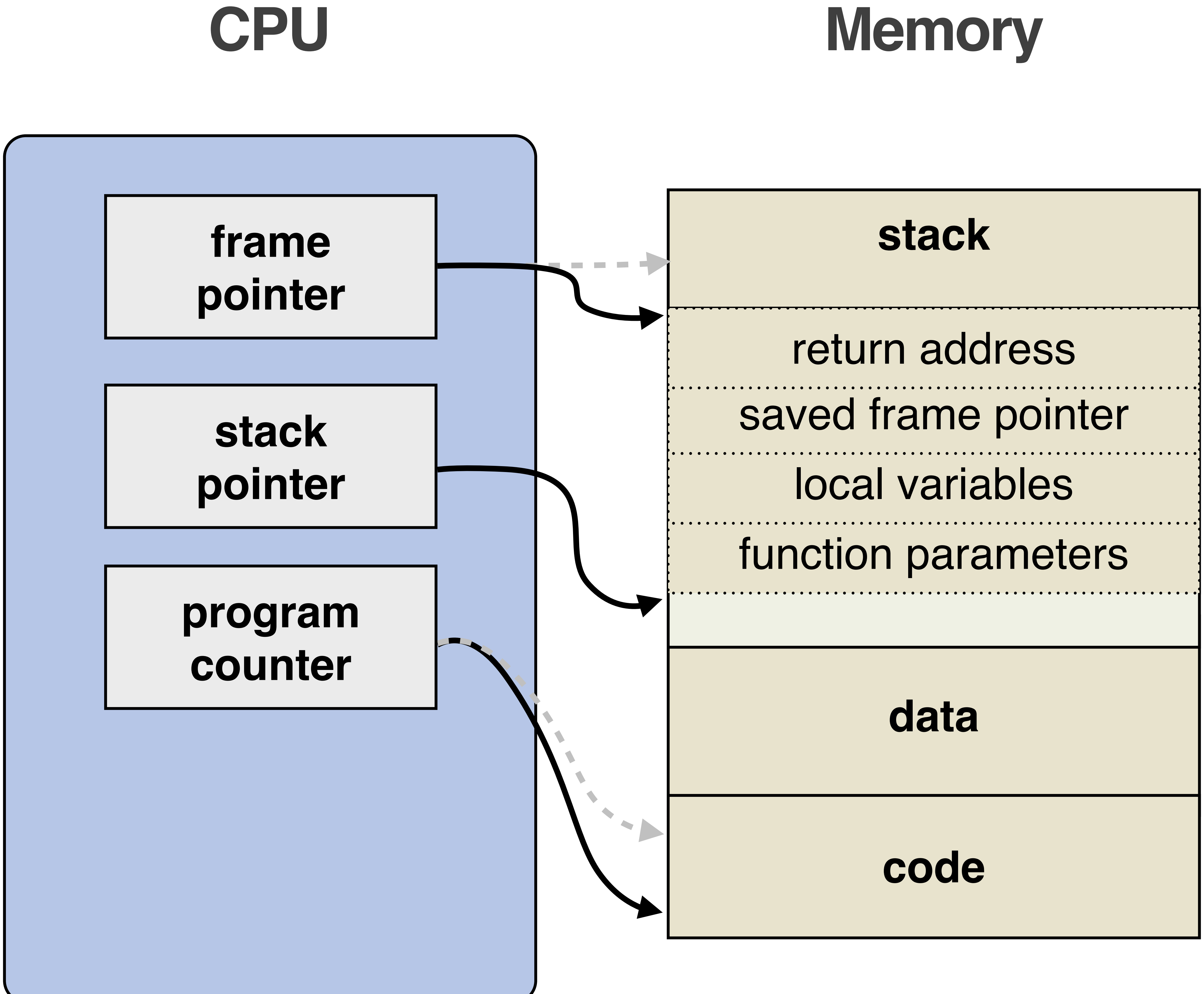
```c
int main()
{
  int x = 1;
  foo(x);
  x = x + 1;
}
```

```c
int foo(int x)
{
   int y = x+1;
   bar(y);
}
```

```c
int bar(int x)
{
     :
     :
}
```

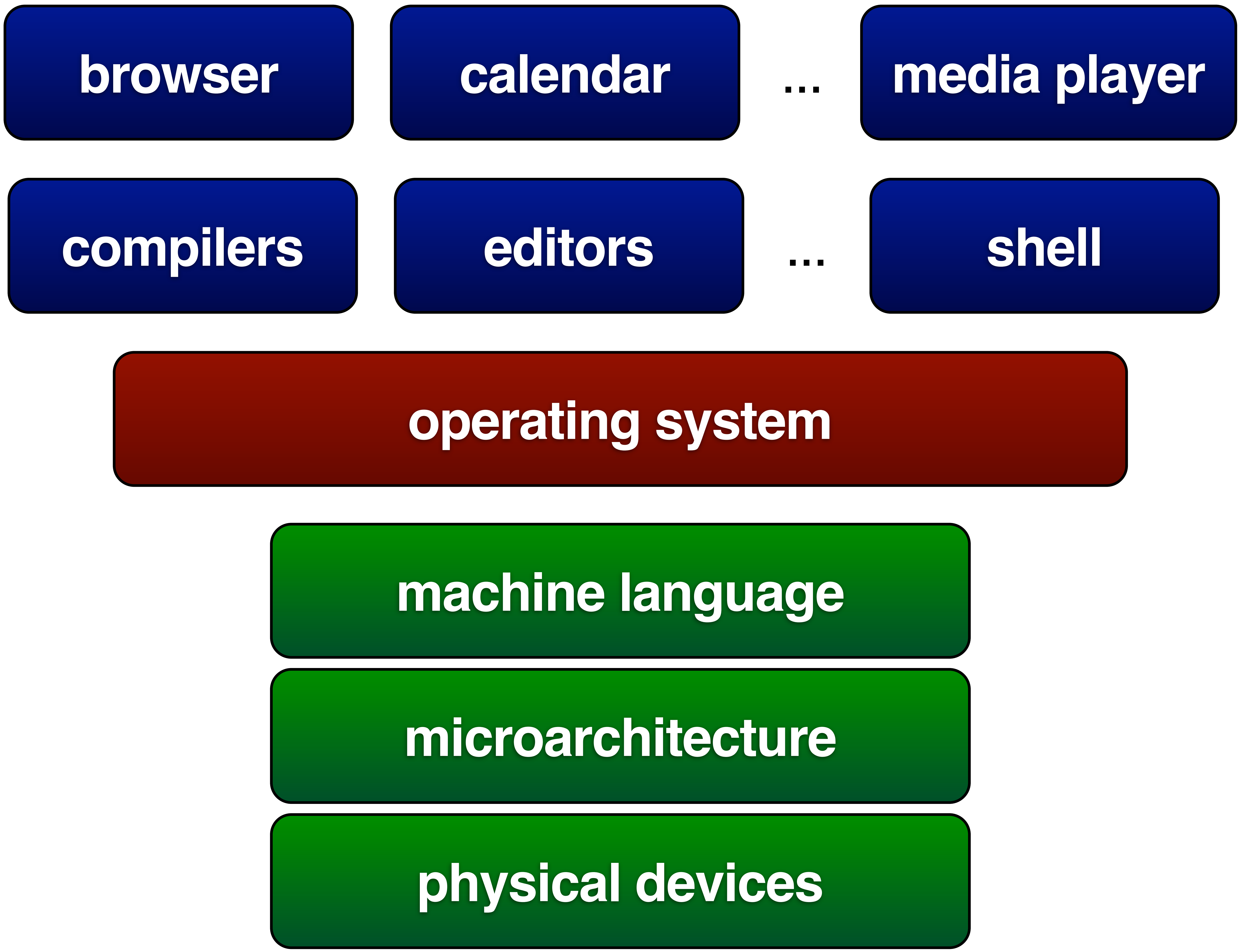

CPU
Memory
program
counter
stack
data
code


CPU
Memory
frame pointer
stack pointer
program counter
stack
data
code


CPU
Memory
frame pointer
stack pointer
program counter
stack
return address
saved frame pointer
local variables
function parameters
data
code

OS

Operating Systems


browser
calendar
...
media player
compilers
editors
...
shell
operating system
machine language
microarchitecture
physical devices

The **OS** is a layer of software that manages processors, storage and I/O devices and provide simple interfaces to the hardware to user programs.

OS

is everywhere

phone, car, robot, router, media player, game console, ..

consider the simple program:

1. read a number from a storage
2. print the number to screen

how to code in a world without OS?

is the number stored on a CD, thumbdrive, harddisk..?

location of the number on the storage?

is another program writing to the number at the same time?

what graphics chip is the system using?

what is the display resolution?

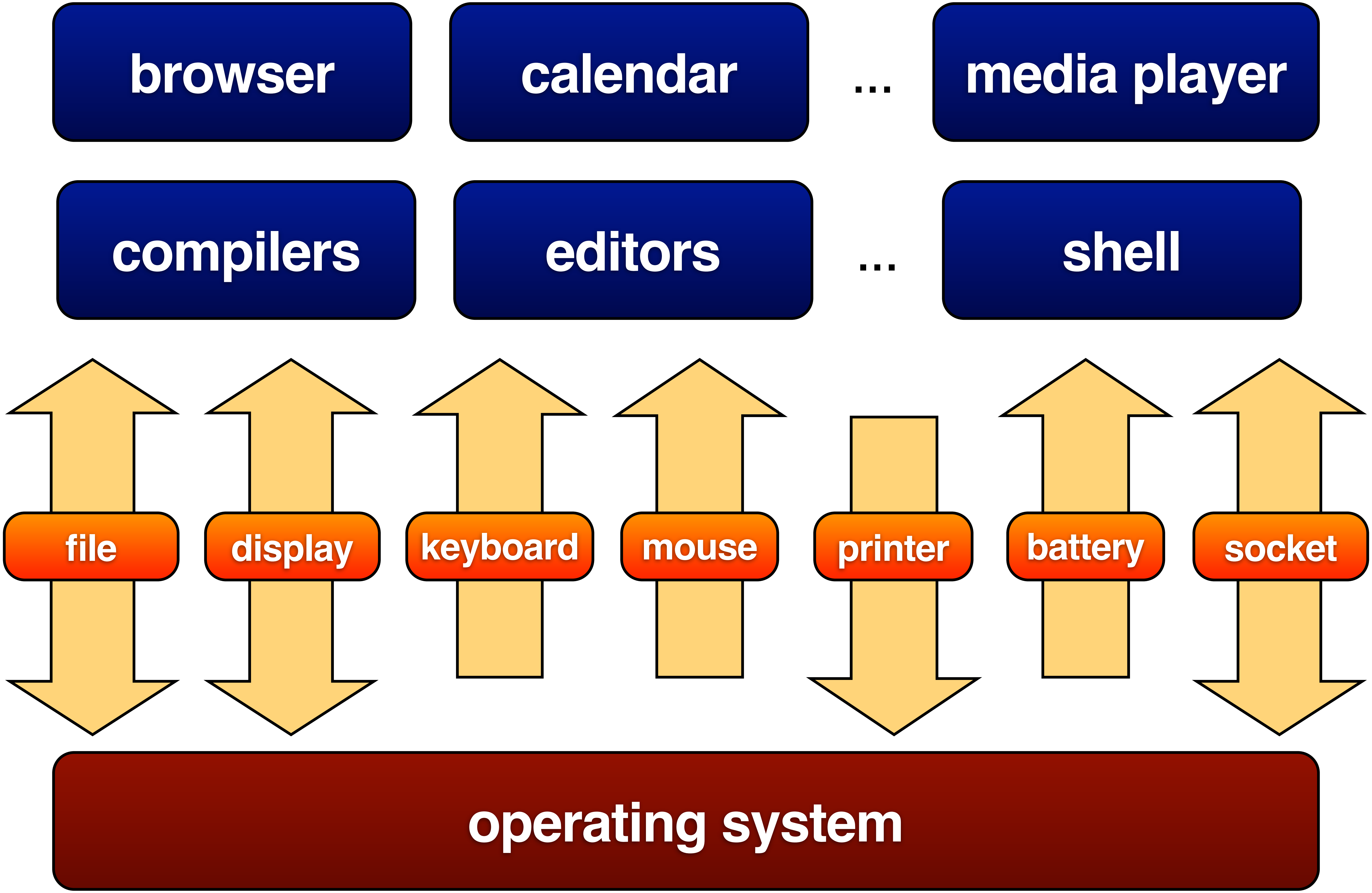
is another process displaying something at the same location?

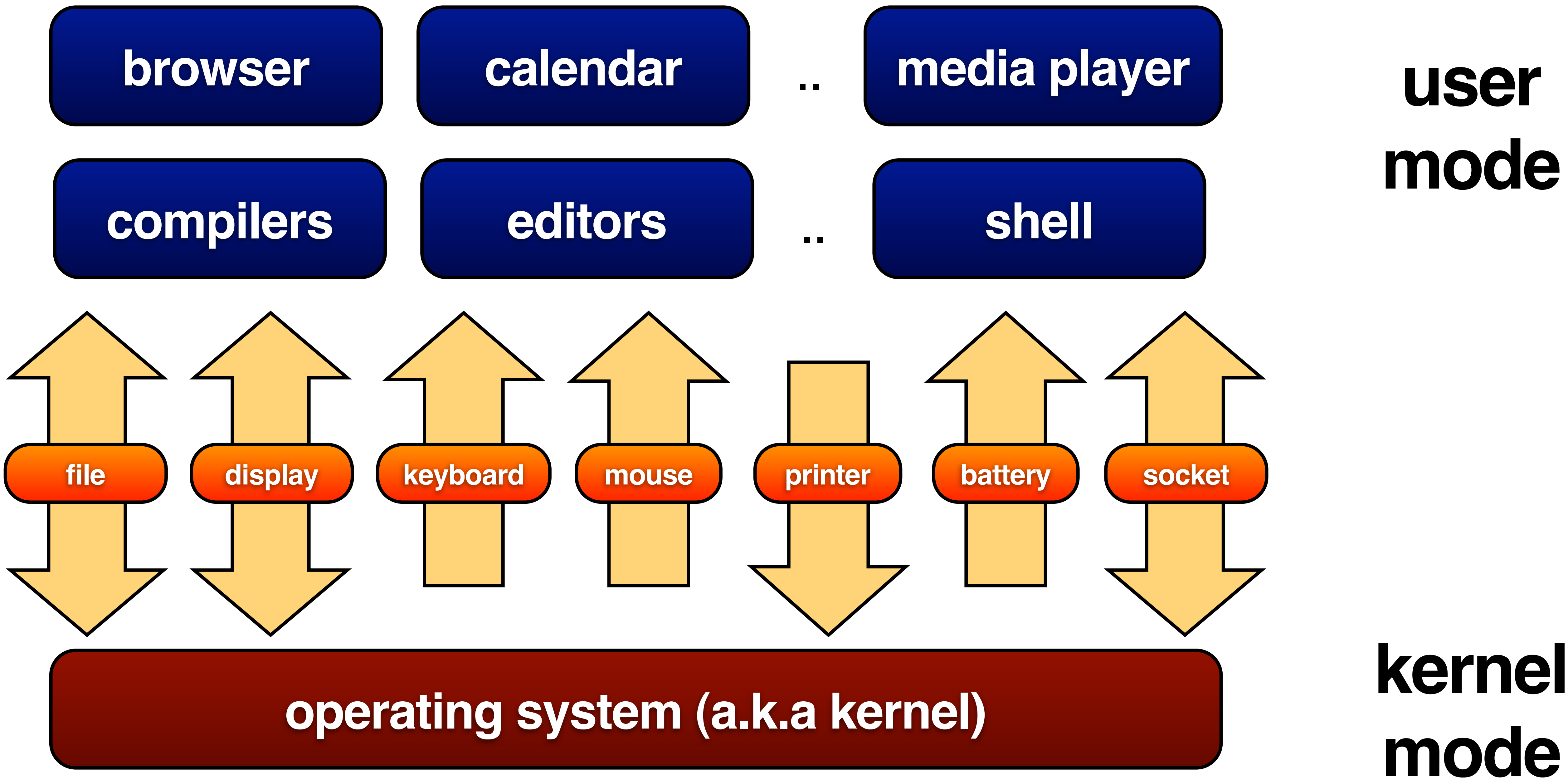
OS hides all these details from programmers

```
x = read_number(“ file.txt ”);
print(x);
```

OS

as an extended machine


browser
calendar
...
media player
compilers
editors
...
shell
file
display
keyboard
mouse
printer
battery
socket
operating system


browser
calendar
..
media player
compilers
editors
..
shell
file
display
keyboard
mouse
printer
battery
socket
operating system (a.k.a kernel)
user mode
kernel mode

interfaces provided by OS
are known as **system calls**

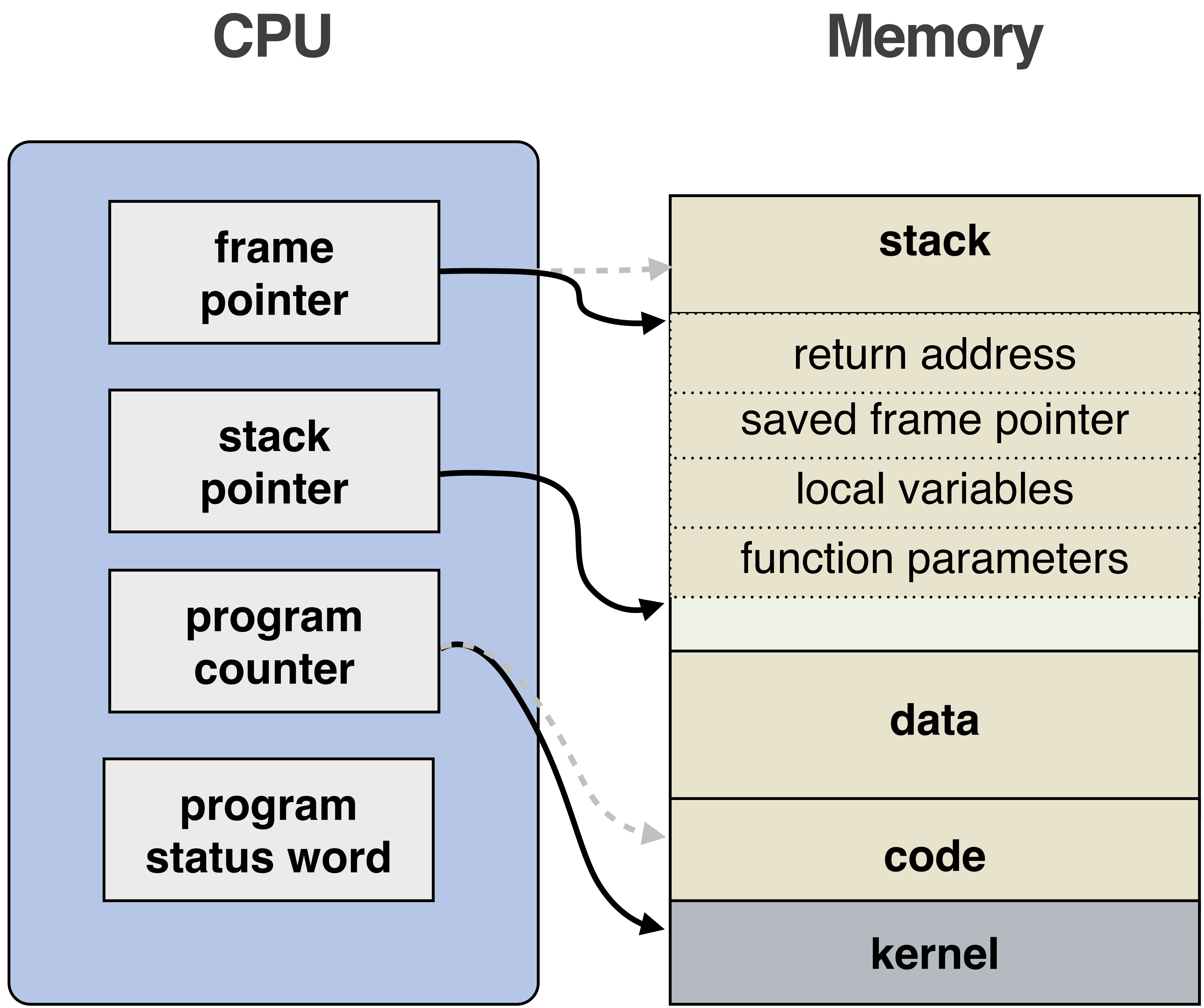
a bit in the **program status word (PSW)** keeps track of the current mode (user or kernel mode) a system call is similar to a procedure call except:

1.
a special instruction sets the **kernel** mode bit in PSW **before** executing the system call

2.
a special instruction sets the **user** mode bit in PSW **after** executing the system call

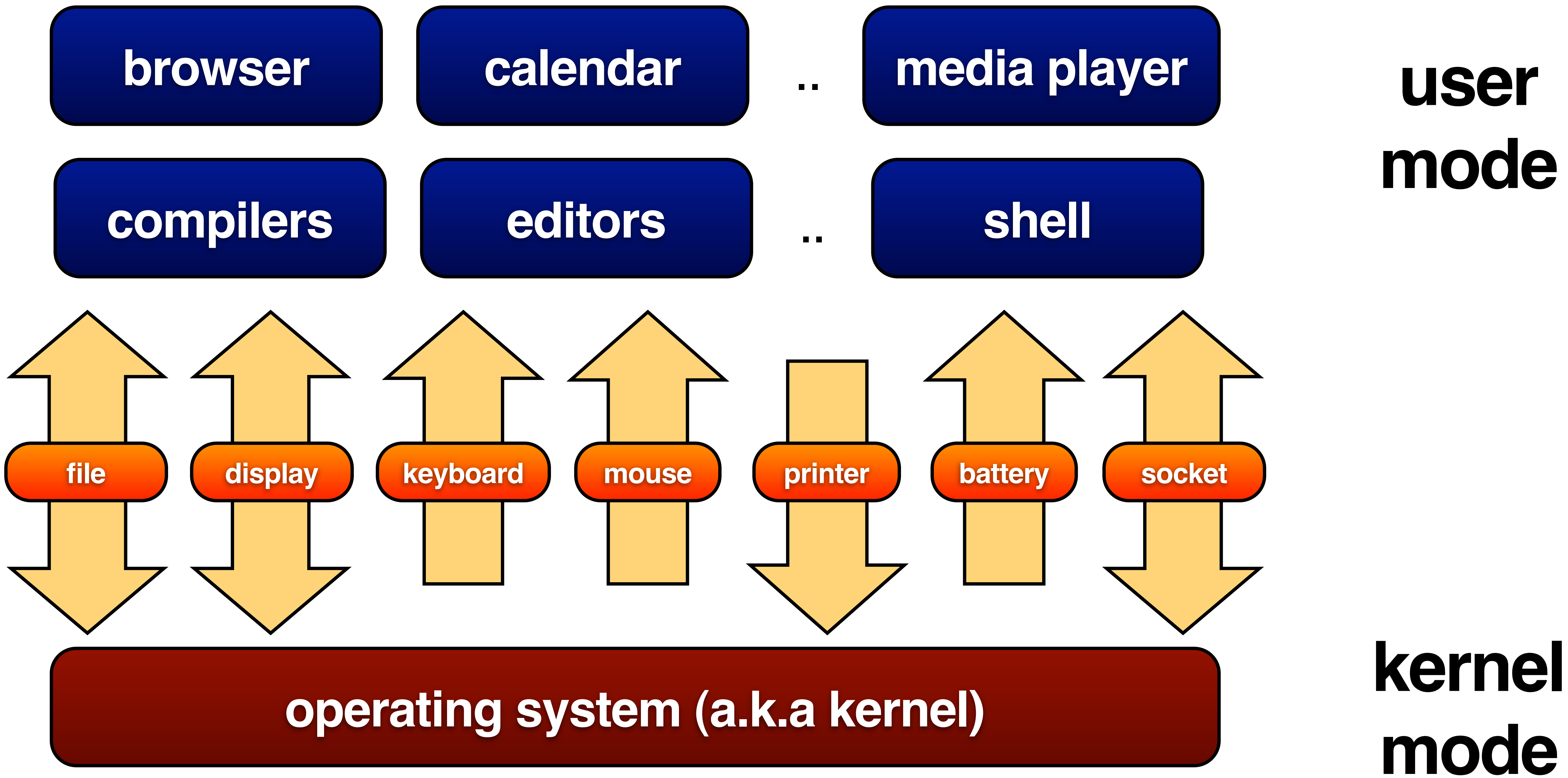
3.
CPU executes the OS “system call handler” for a given system call

(more details later..)

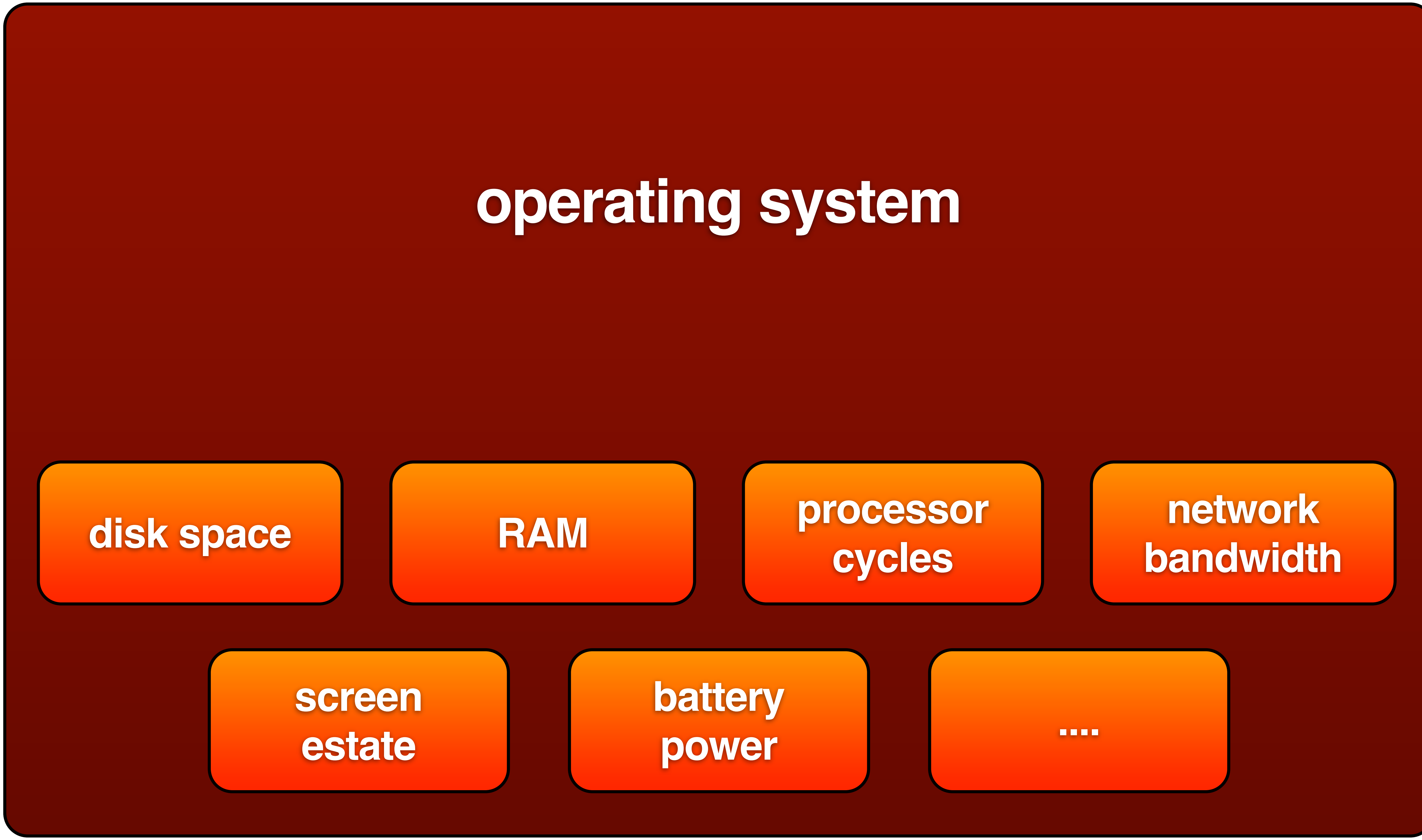

CPU
Memory
frame pointer
stack pointer
program counter
program status word
stack
return address
saved frame pointer
local variables
function parameters
data
code
kernel

In **user** mode, certain privileged instructions cannot be executed, certain addresses cannot be accessed etc.

In **kernel** mode, there is no restriction.


browser
calendar
..
media player
compilers
editors
..
shell
file
display
keyboard
mouse
printer
battery
socket
operating system (a.k.a kernel)
user mode
kernel mode

OS
as a resource manager


operating system
disk space
RAM
processor cycles
network bandwidth
screen estate
battery power
....

suppose that

the computer runs **one task at a time,** always completing it before running another task ?

a task always have full use of all resources.

not efficient since not all resources are fully utilized at all time (e.g., CPU is idle when I/O is performed).

suppose that

the computer keeps multiple tasks in the memory. When the running task is idle, switch to another task (**multi-programming**) now, resources are shared among the tasks.

how does CPU switch from one task to another?

how to prevent one task from corrupting the memory of another task?

what if there are multiple users using the system, and there is one CPU intensive task?

The computer keeps multiple tasks in the memory and switch between them frequently (regardless of whether the task is idle) (**time-sharing**)

time-multiplexing: CPU, printer

space-multiplexing: memory, disk, screen

OS

is an **extended machine**

and

a **resource manager**