Welcome to CS4411/5411 Practicum in Operating Systems

"What I cannot create, I do not understand."

— Richard Feynman

Course staff

Instructors

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PhD Candidate

Office hours: Thursday, 6pm-9pm, Gates 437

Lorenzo Alvisi

Tisch University Professor

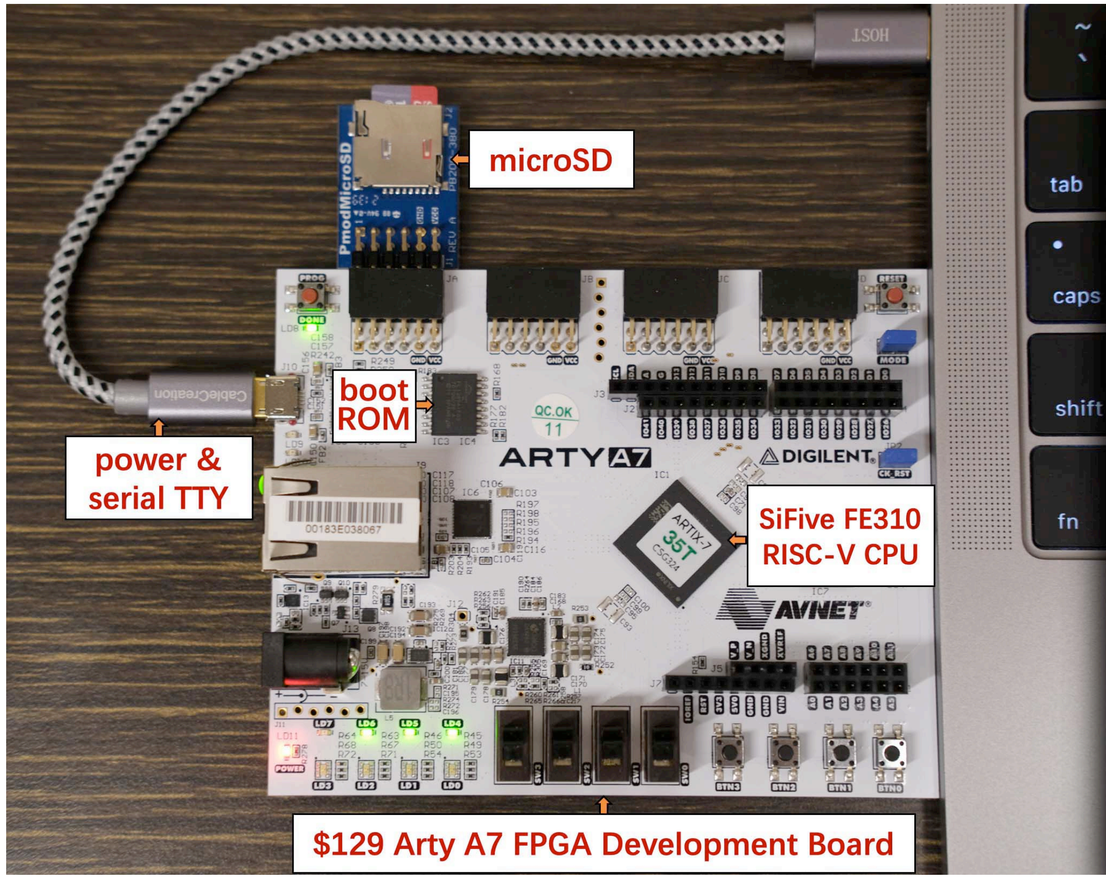
Teaching Assistants

Justin Lee and Oliver Matte

I wish to bring you the fun of building operating systems.

How to have fun?

- No exam
- No textbook
- 6 coding projects
  - the last one is optional
  - 3 running on Linux/Mac
  - 3 running on a RISC-V board
  - More about these later



Communications

- Website:
  - https://www.cs.cornell.edu/courses/cs4411/2022fa/
- CMSx
  - distribute projects; submit solutions
- Ed Discussion
- For time-sensitive matters: cs4411-staff@cornell.edu
- For sensitive matters: cs4411-prof@cornell.edu

Teamwork

- P0: individually
- P1-P5: teams of 2-3 students
  - real-world softwares are built by teams
  - learn how to collaborate, trust and respect
- P1 will be released on Sep 9
  - two-week time to find teammates

Slip days

- No penalty
- 2 per project, 5 in total
- If you need any accommodation, let us know.

Academic Integrity

- Each team has one submission.
- Do not share code with other teams.
- All submitted code must be your own.
- Put your code in *private* repositories.
- Violations will be prosecuted.

Grading

- No “curve”
- CS4411/5411 is not a competition.
- Final grade is a weighted sum of all the projects.

Project	Weight	Project	Weight
P0	1	P1	2
P2	2	P3	2
P4	3	P5	0

Any questions?

Next, demo time.

OS, big and small

- Earth and Grass Operating System (EGOS)
  - written by Robbert van Renesse
  - with rich functionalities: a compiler inside!
- EGOS-2000
  - written by Yunhao Zhang
  - https://github.com/yhzhang0128/egos-2000
  - with very few lines of code: only 2000 in total!

Learning tips

- Earth and Grass Operating System (EGOS)
  - with very rich functionalities
  - Try to explore what functionalities an OS could have
- EGOS-2000
  - with very few lines of code
  - Try to read every line of code

What?	Lines of Code (LOC)
SD card driver	222
Exception Handling	48
Memory Management	106
Kernel (scheduler + syscall)	358
File System	339
Applications	264
Library	262
Makefile	54
Board-specific tools	172
Other	175

Read every line of code?

What?	Lines of Code (LOC)	Projects
SD card driver	222	**P5 (optional)**
Exception Handling	48	**P3**
Memory Management	106	**P3**
Kernel (scheduler + syscall)	358	**P0, P1, P2**
File System	339	**P4**
Applications	264	**P3**
Library	262	**P3**
Makefile	54	
Board-specific tools	172	
Other	175	

High-level Keywords

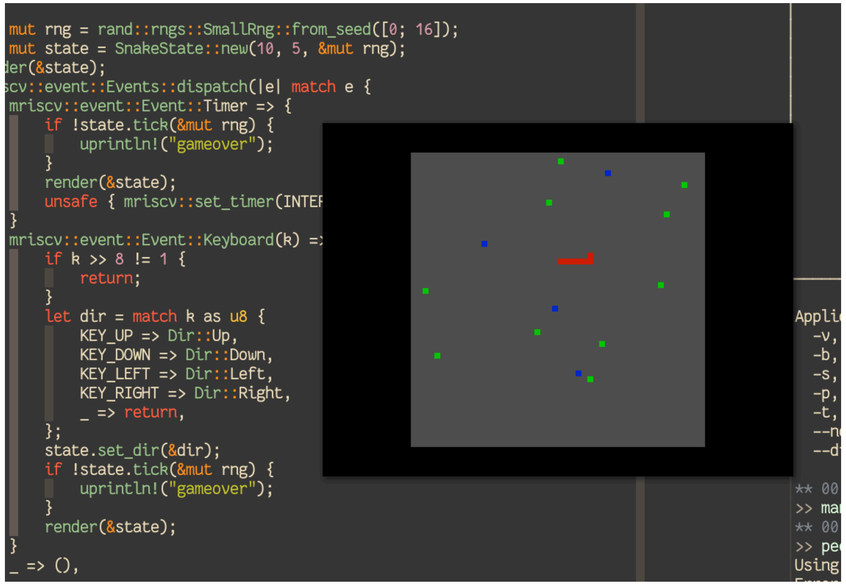
- P0
  - memory and pointer
  - instead of object and reference in Java or Python
- P1
  - context, thread and context-switch
- P2
  - timer interrupt, scheduling and priority

High-level Keywords

- P3
  - privilege level/mode
  - control and status registers (CSR)
  - memory exceptions and system call
- P4
  - layering design: inode layer and directory layer
- P5
  - I/O bus and memory-mapped bus controller

More fun after this semester

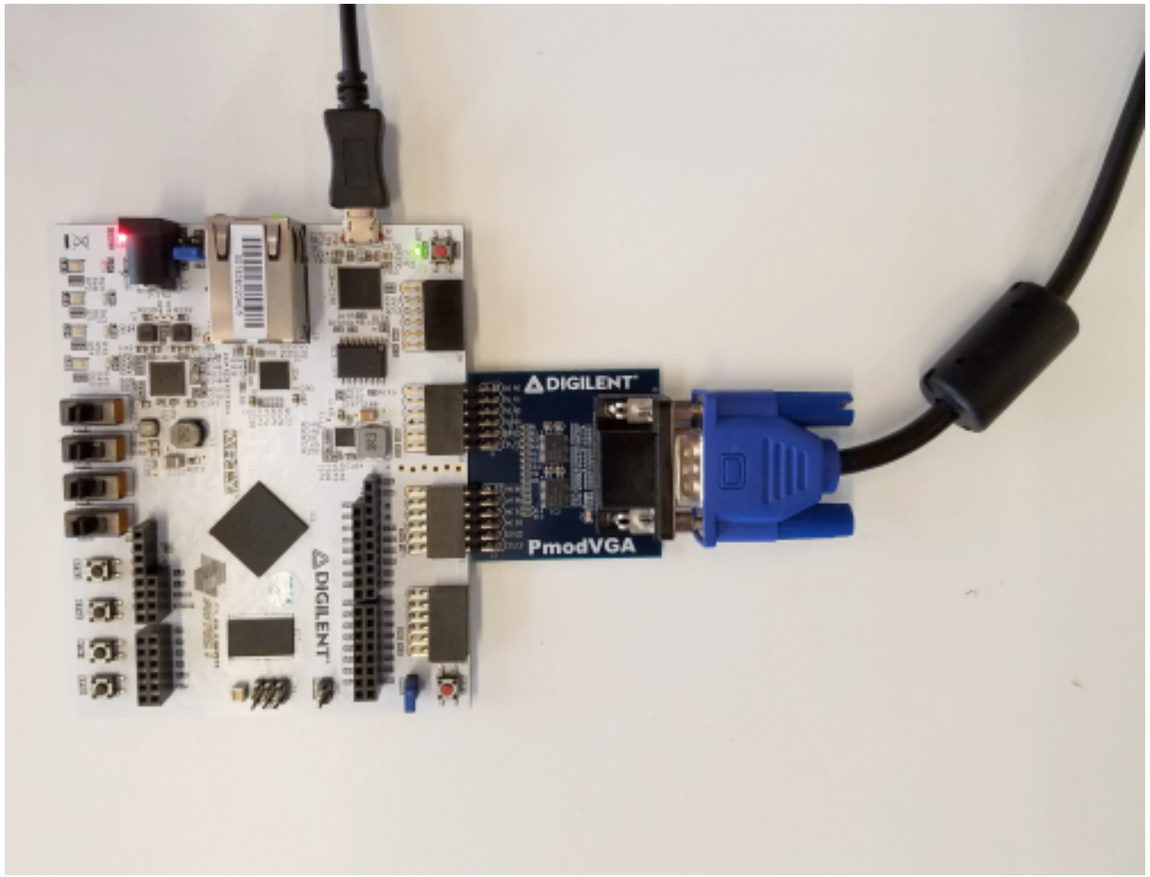
- Future work #1
  - A minimal RISC-V processor that can run egos-2000
  - Thanks to Ted Yin and Adrian Sampson



Picture from: https://github.com/Determinant/mriscv

More fun after this semester

- Future work #2
  - Graphic User Interface



Picture from: https://digilent.com/reference/learn/programmable-logic/tutorials/arty-pmod-vga-demo/start

Homework

- P0 has been released on CMSx
  - Due on Sep. 9
  - Read `README`, `Makefile` and `queue.h`
  - Modify and submit `queue.c` and `test_queue.c`

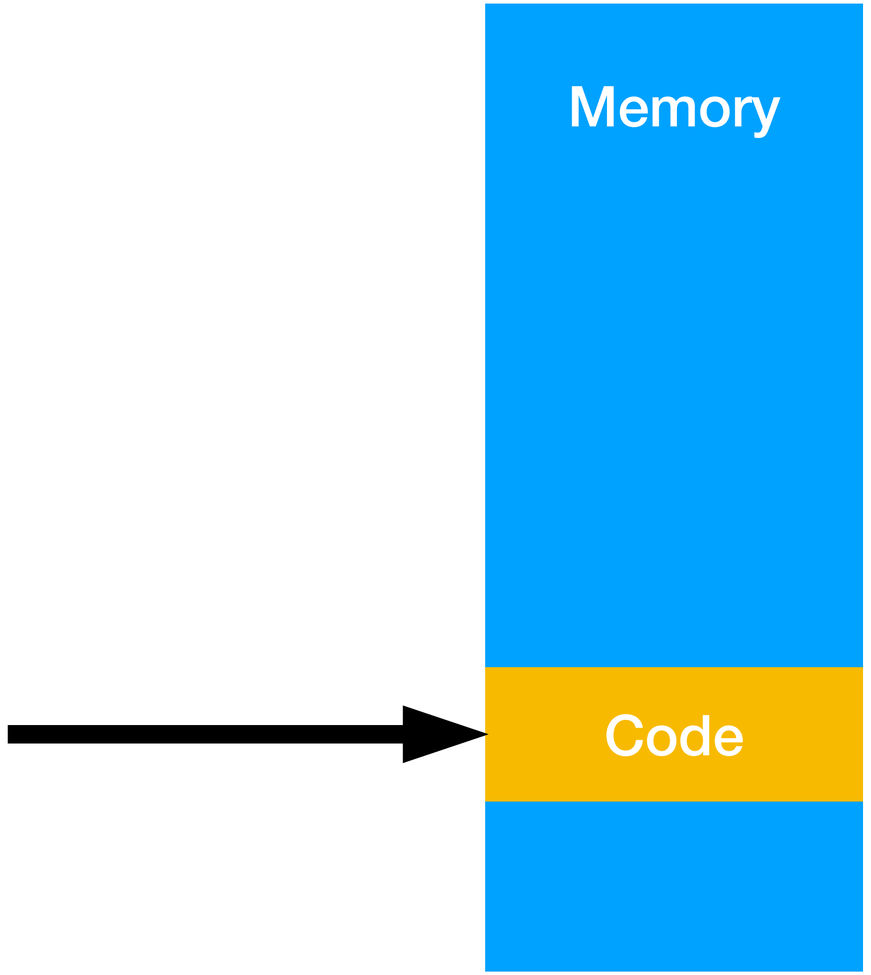
- Next lecture
  - Memory and C Programming

Memory and C 101

```
// standard library for input/output
#include <stdio.h>

int main() {
      printf(“Hello World!\n”);
      return 0;
}
```

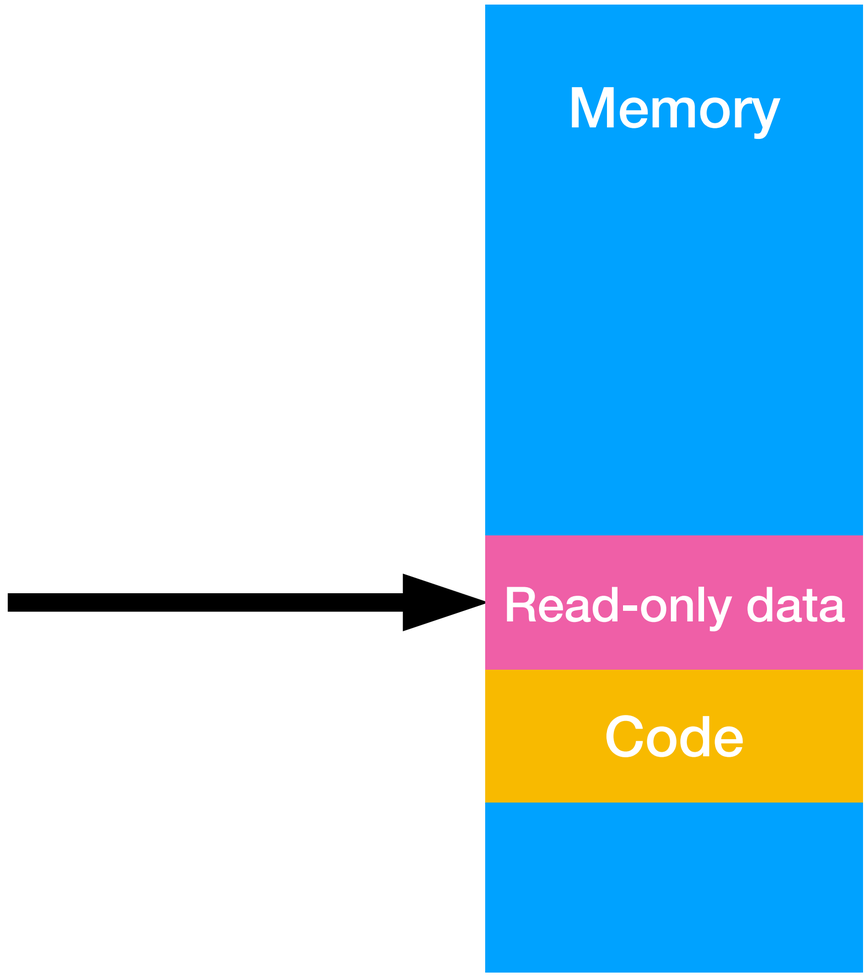
Compile to machine code

```
#include <stdio.h>

int main() {
      printf(“Hello World!\n”);
      return 0;
}
```



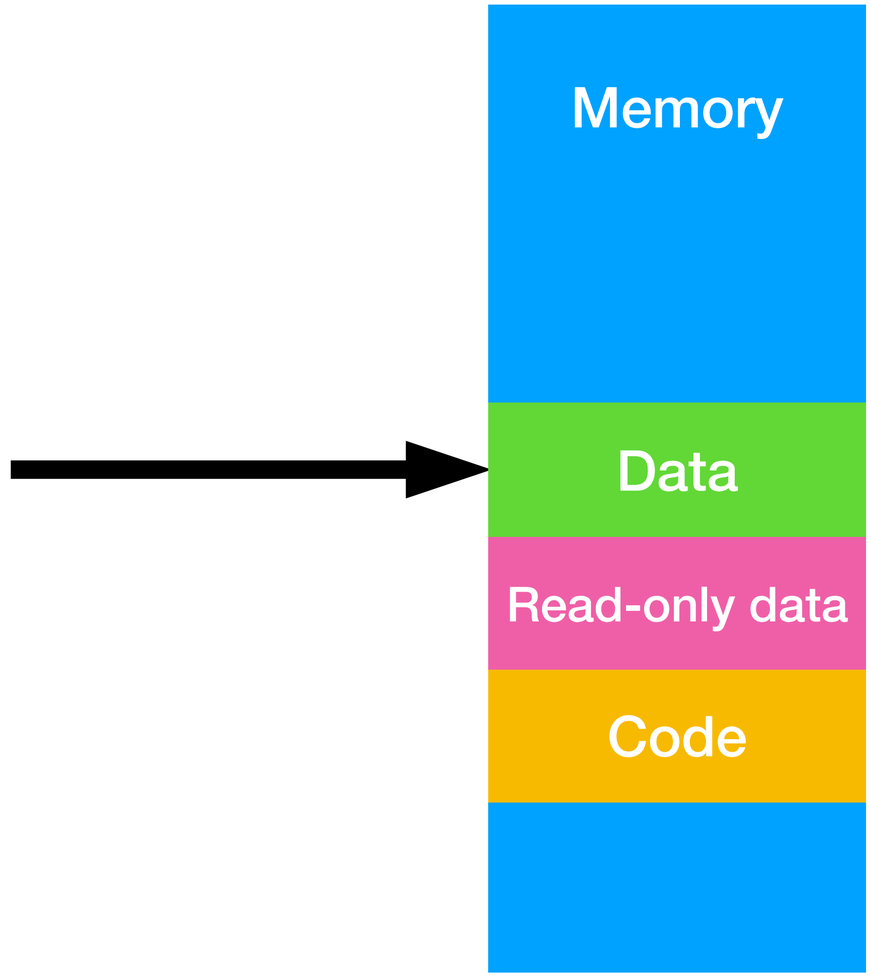
And some read-only data

```
#include <stdio.h>

int main() {
      printf(“Hello World!\n”);
      return 0;
}
```



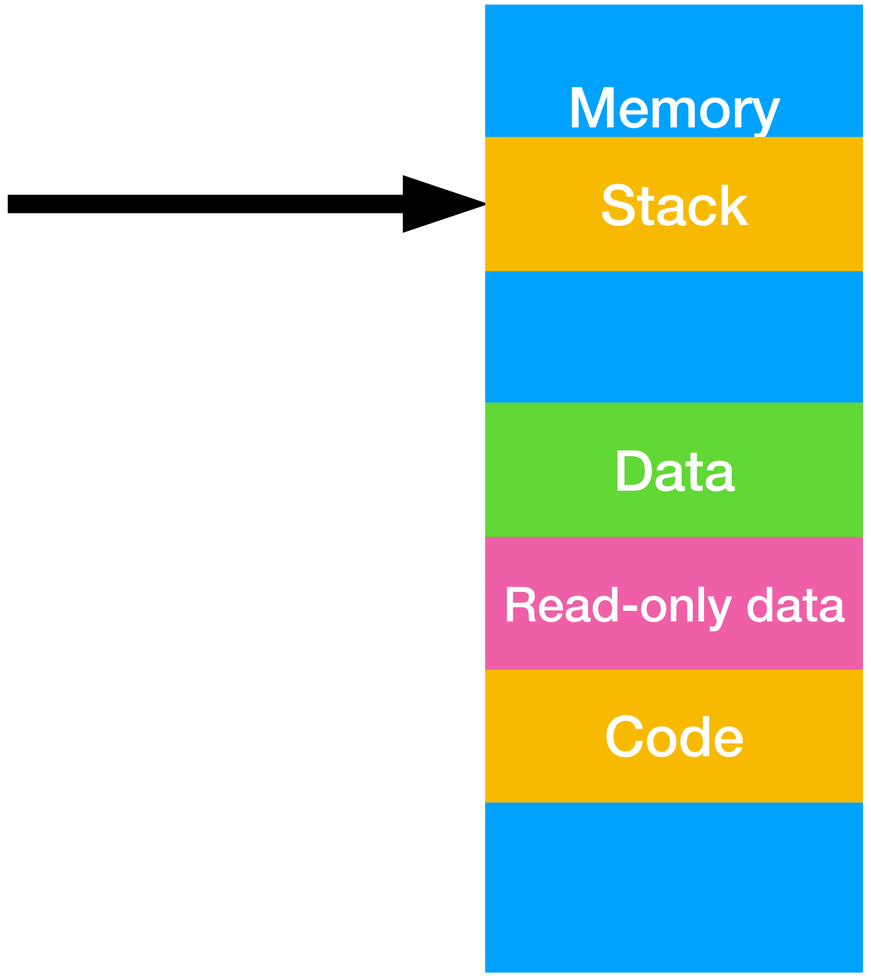
Global variable in the data section

```
#include <stdio.h>

int global_variable = 0xab;

int main() {
      printf(“Hello World!\n”);
      return 0;
}
```



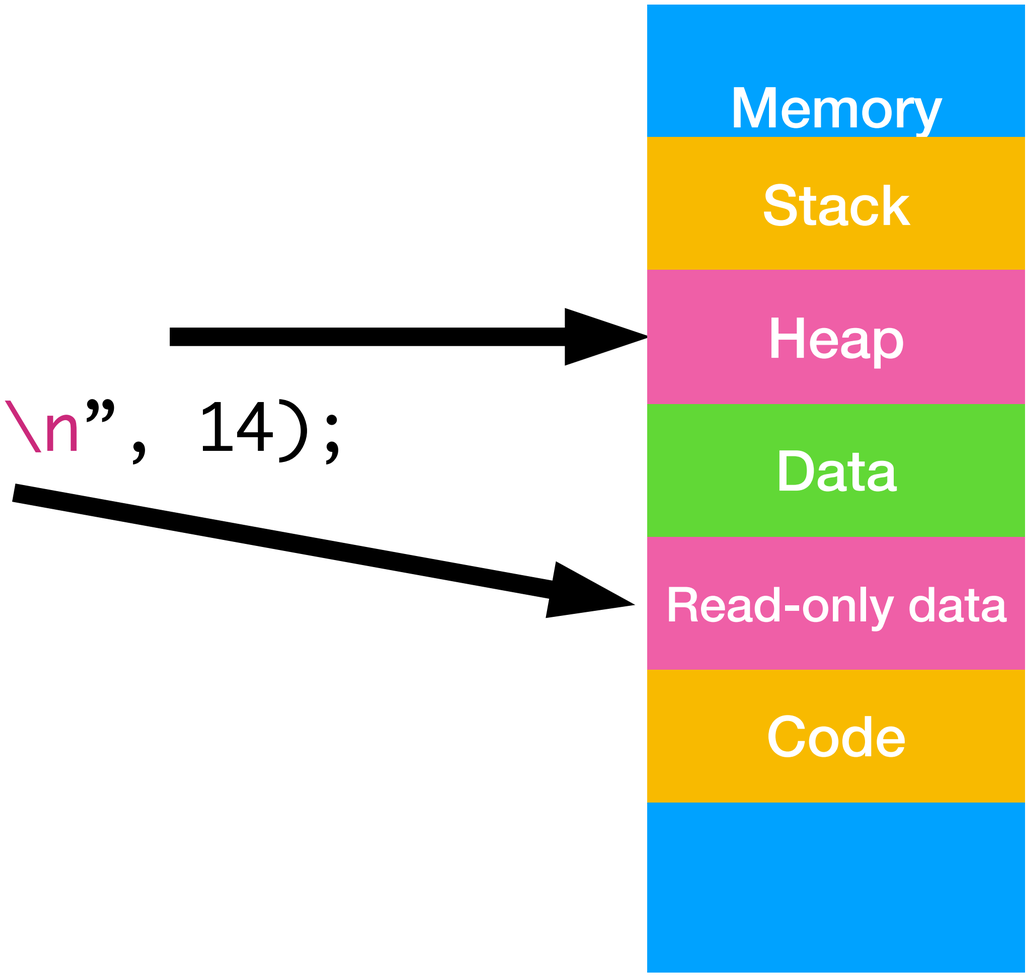
Local variable in the stack frame

```
#include <stdio.h>
int main() {
      int local_variable = 0xcd;
      printf(“Hello World!\n”);
      return 0;
}
```



Dynamically allocation on the heap

```
int main() {
        char* str = malloc(14);
        memcpy(str, “Hello World!\n”, 14);
        printf(“%s”, str);
        return 0;
}
```



Key of C Programming

- Machine code is in the code section
- Variables can be in
  - the read-only data section
  - the data section
  - the stack section
  - the heap section
- The key
  - understand (1) where is the variable and (2) how many bytes