Welcome + Threads + Processes

Problem Solving Lab for CS111

Stanford CS111ACE, Spring 2026

Slides adapted from Trip Master's slides

Attendance: tinyurl.com/cs111ace-section1-spr26

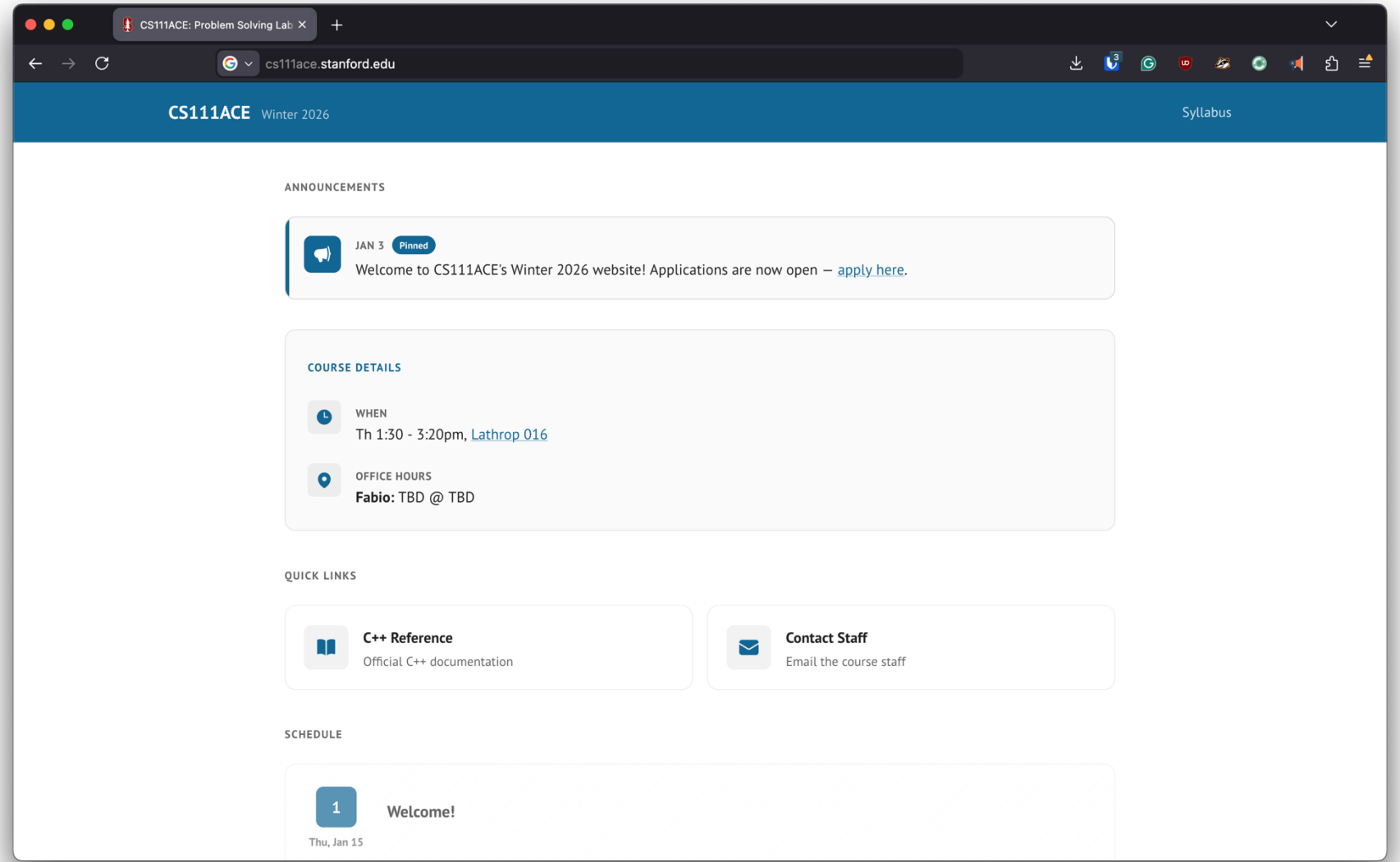
Hello there!

- MSCS (AI), BSCS (Systems)
- I enjoy teaching; section led (CS198) and taught CS106L in the past
- I spend my free time trying to cook, working out, and hanging out with friends!

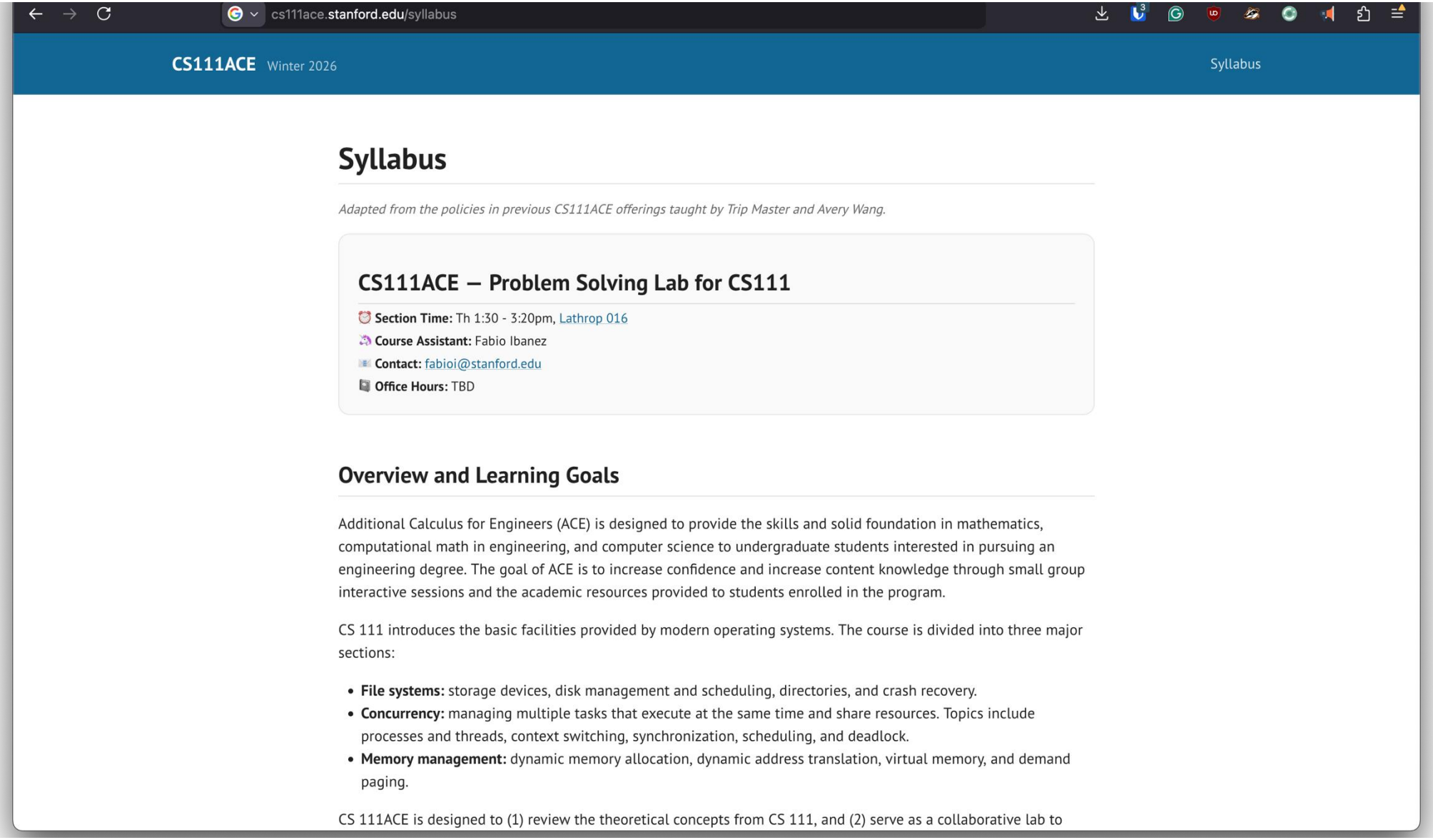
Icebreaker

- What’s your name
- Favorite hobby

What’s CS111ACE about?



All course materials will be posted at cs111ace.stanford.edu



cs111ace.stanford.edu/syllabus

Attendance

- As per the syllabus, you are allowed **1 unexcused absence**, no questions asked, and **1 excused absence**, where you must let me know in advance.

- Other absences beyond ***must*** be approved directly by the Lead ACE CAs, Bryant Perkins (bperk25) and Alka Panda (alkap)

- Being more than 15 minutes late or departing early without notifying me in advance will count as an absence

Honor Code

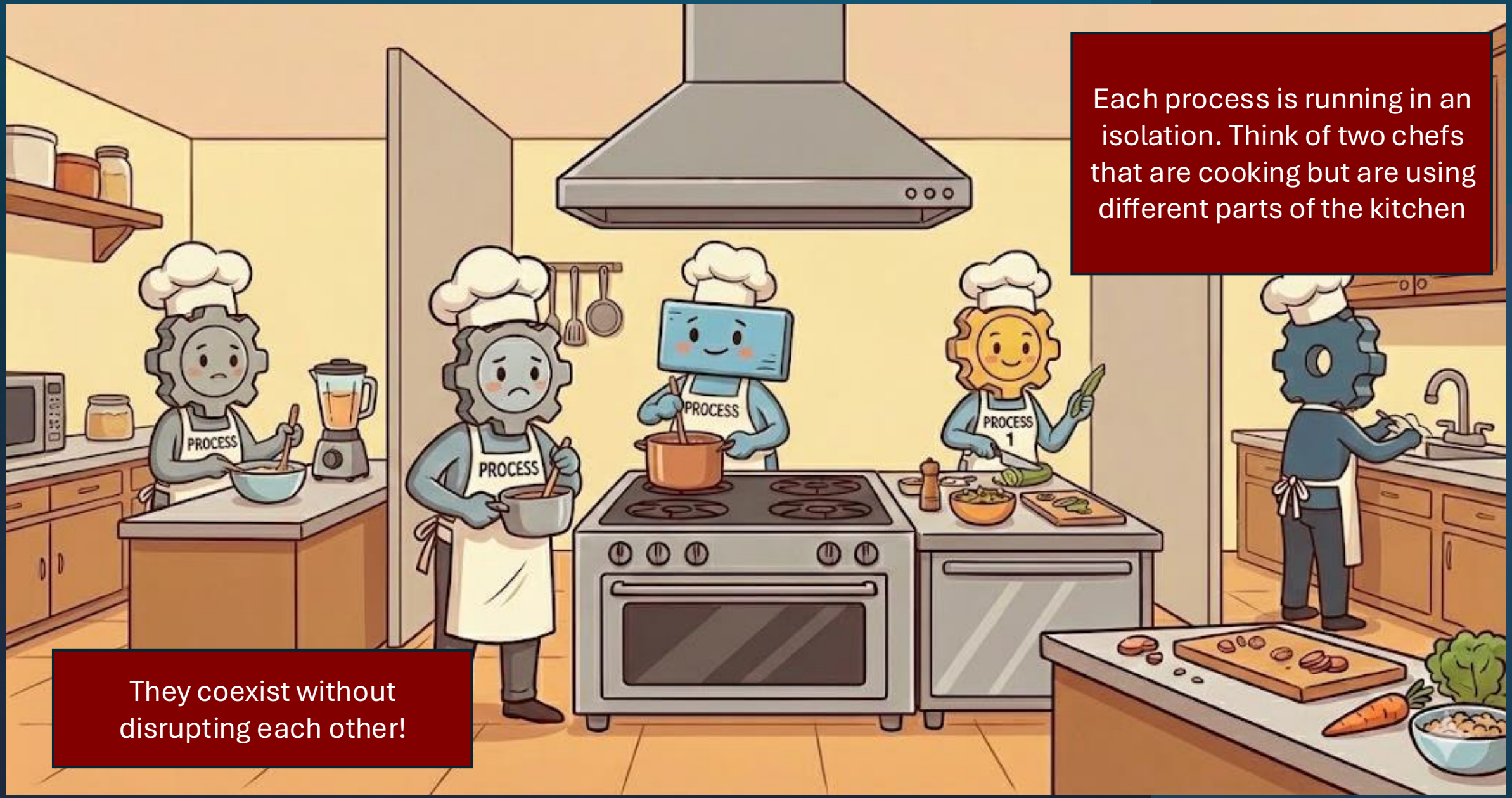
- CS111 ACE takes the Honor Code very seriously. Please see the updated Honor Code linked here
- As mentioned in the syllabus, the entire CS111 staff including me cannot look at your code directly.
- Please be doubly certain that you review CS111's collaboration policy here
- I was told to inform you that: filling out an attendance survey and not being in an ACE section is an honor code violation

Class norms

- Take space, make space
- Avoid unrelated jargon & discussion during section– I'm happy to talk about things outside of the scope of the class offline ☺
- Please respect each other
- Normalize asking questions, and asking me to clarify things if unclear – I'm very happy to do this

What questions can I answer?

Multiprocessing



Made by Nano Banana

How do we Create a Process?

```
void spawn_child()
{
  auto pidOrZero = fork();
  if (pidOrZero == 0)
  {
    printf("I am the child process\n");
  }
  else
  {
    printf("I am the parent process\n");
  }
}
```

- We can use the fork() system call
- fork returns either 0 if it's the child process, or the pid of the child if it's the parent

Caveat

```
void spawn_child()
{
  auto pidOrZero = fork();
  if (pidOrZero == 0)
  {
    printf("I am the child process\n");
  }
  else
  {
    printf("I am the parent process\n");
  }
}
```

- The parent must wait for the child process after it spawns it
- How does it do that?

pid_t waitpid(pid_t pid, int* status, int options)

- The waitpid function allows a parent to *clean up* the child process that it created

- Returns
  1. the pid of the child process that it *reaped*
  2. -1 if there was an issue cleaning up (i.e. there are no children to *reap*/clean up)

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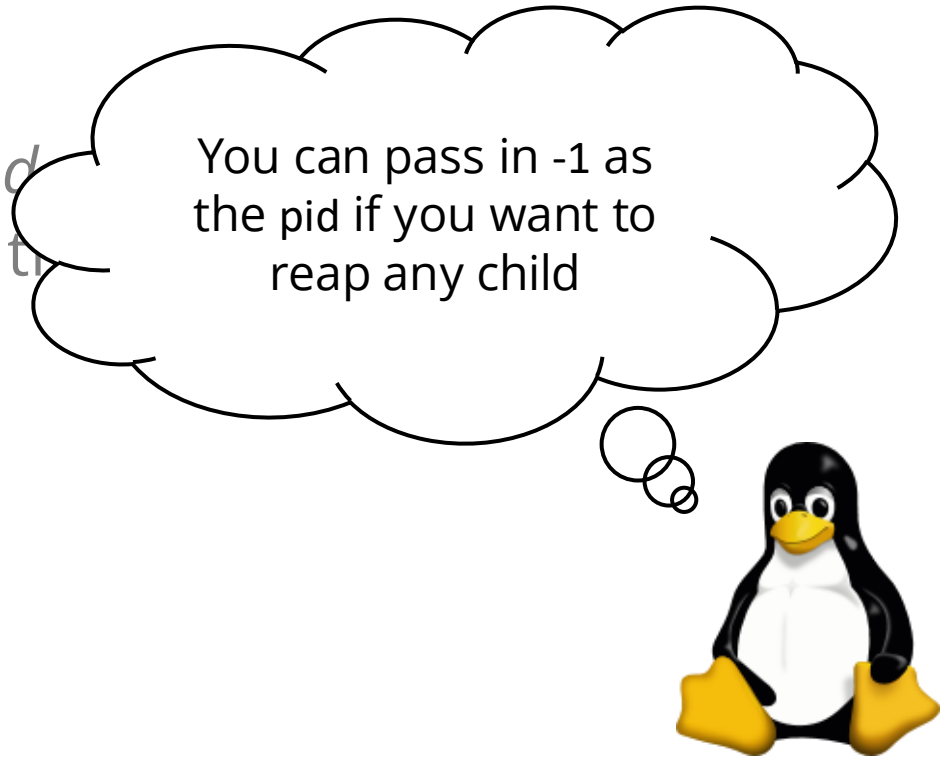

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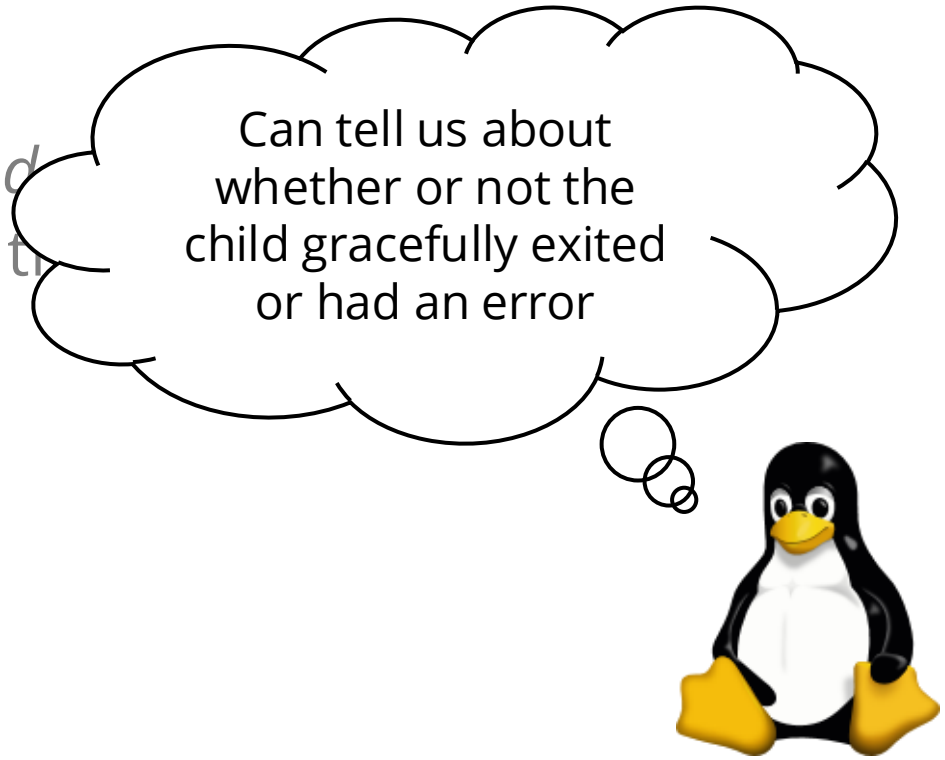

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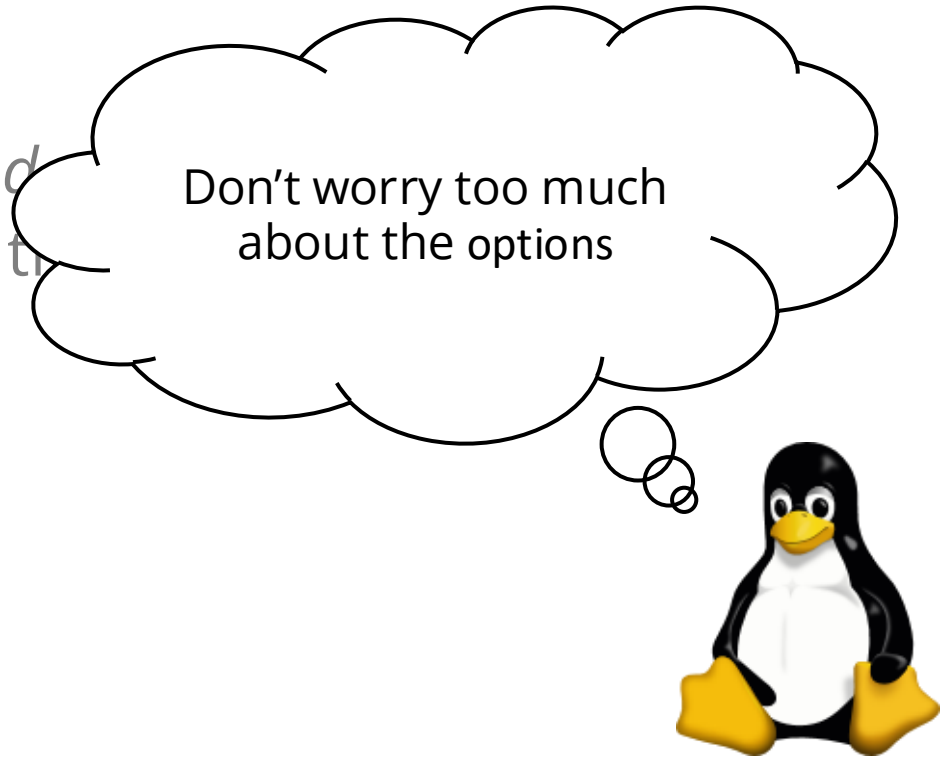


What questions can I answer?

What happens (Think-pair-share)?

```
void spawn_and_wait_for_child()
{
  auto pidOrZero = fork();
  printf("Hi from the %s pid: %d\n", (pidOrZero == 0 ? "child" : "parent"), pidOrZero);

  int status;
  if (pidOrZero != 0) {
    waitpid(-1, &status, 0);
    }
}
```

- What order do the “Hello” statements print in?
- What happens if I remove the last line?
- What happens if I remove the **if** check on the penultimate line?

int execvp(const char * path, char *argv[])

- Another system call that allows you the run the program at the path `path`
- Passes `argv` as the arguments to that program
- The process in which `execvp` is called is completely consumed unless an error occurs

Parent process (PID = 4567

Parent process waits using waitpid for the child process

Child process (PID = 0)

execvp

time

Parent process (PID = 4567

Extra practice

```
int main(void)
{
    int* stuff = malloc(sizeof(int)*1);
    *stuff = 5;
    pid_t pid = fork();
    printf("The last digit of pi is %d\n", *stuff);
    if (pid == 0)
        *stuff = 6
}
```

Extra practice

What will C print?

```
int main(void)
{
    char** argv = (char**) malloc(3*sizeof(char*));
    argv[0] = "/bin/ls";
    argv[1] = ".";
    argv[2] = NULL;
    for (int i = 0; i < 10; i++) {
        printf("%d\n", i);
        if (i == 3)
            execv("/bin/ls", argv);
    }
}
```

What questions can I answer?

Processes

- Isolated virtual addresses
- Can run external programs (fork-exec)
- Hard to coordinate multiple tasks within the same program

Threads

- Share virtual address space (threads can refer to the same memory)
- Can’t run external programs as easily
- Can coordinate multiple tasks within one program

What is Multithreading?

How do we run code?

Source Code

```
#include <iostream>

void task(const std::string& name) {
    for (int i = 0; i < 3; ++i)
        std::cout << name << " says " << i << std::endl;
}

int main() {
    task("A");
    task("B");
    return 0;
}
```

Runs on

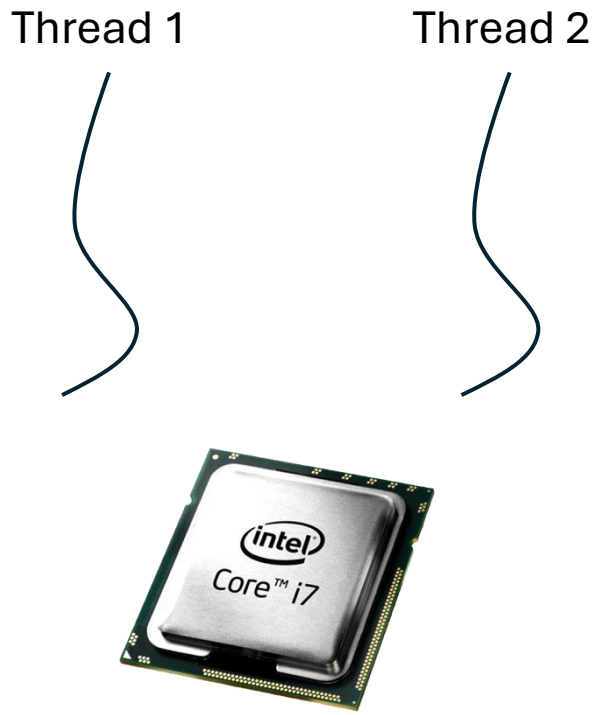
A multithreaded approach

```cpp
#include <iostream>
#include <thread>

void task(const std::string& name) {
   for (int i = 0; i < 3; ++i)
      std::cout << name << " says " << i << std::endl;
}
int main() {
   std::thread t1(task, "A");
   std::thread t2(task, "B");

   t1.join();
   t2.join();

   return 0;
}
```




WASH
Speed Queen
Commercial Washer

Multithreading

- Allows you to run multiple functions in *one* program concurrently

- Each thread runs within the same process, so they **share a virtual address space**.
  - A byproduct of this is that communication between threads is trivial
  - This also means that if two threads try to use the same resource (memory, file descriptors, streams, etc.), at the same time, it can have undefined behavior

- Each thread runs performs its function independently of the other

Revisiting our code

```cpp
#include <iostream>
#include <thread>

void task(const std::string& name) {
   for (int i = 0; i < 3; ++i)
      std::cout << name << " says " << i << std::endl;
}
int main() {
   std::thread t1(task, "A");
   std::thread t2(task, "B");

   t1.join();
   t2.join();

   return 0;
}
```

Possible Orderings

A says 0 B says 0 A says 1 B says 1 A says 2 B says 2	A says 0 A says 1 A says 2 B says 0 B says 1 B says 2
A says 0 B says 0 B says 1 A says 1 B says 2 A says 2	B says 0 B says 1 B says 2 A says 0 A says 1 A says 2

Revisiting our code

```cpp
#include <iostream>
#include <thread>

void task(const std::string& name) {
   for (int i = 0; i < 3; ++i)
      std::cout << name << " says " << i << std::endl;
}
int main() {
   std::thread t1(task, "A");
   std::thread t2(task, "B");

   t1.join();
   t2.join();

   return 0;
}
```

Another Possible Ordering

```
B says A says 0
B says 1
B says 2
0
A says 1
A says 2
```

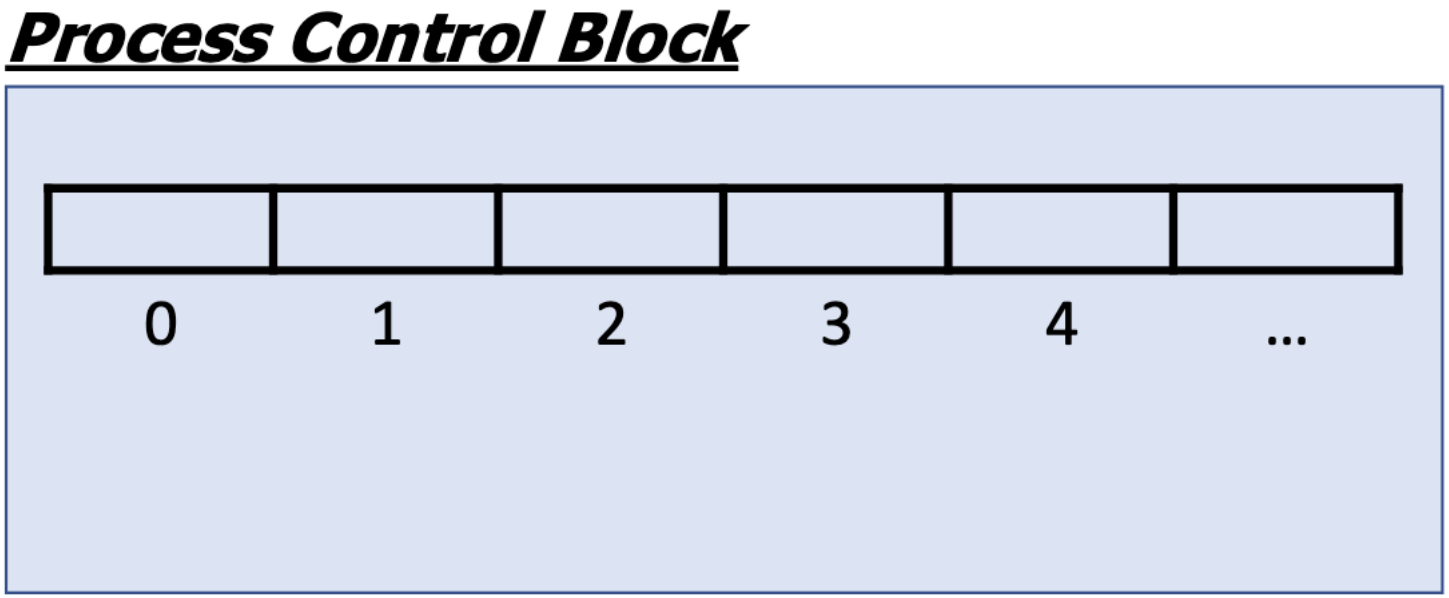
What happened here? 🤔

If two threads try to use the same resource at the same time, it can have undefined behavior

What questions can I answer?

How do we switch between running threads

Process Control Block (PCB)

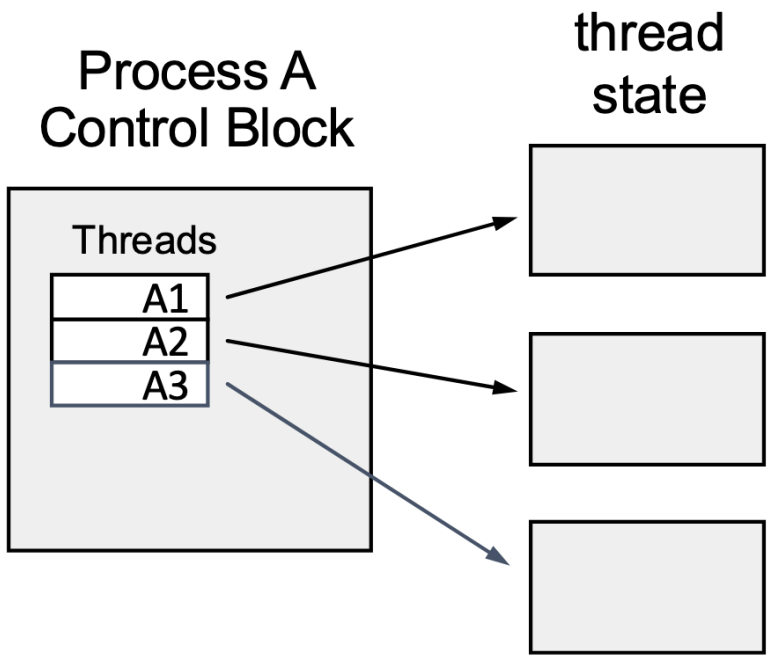


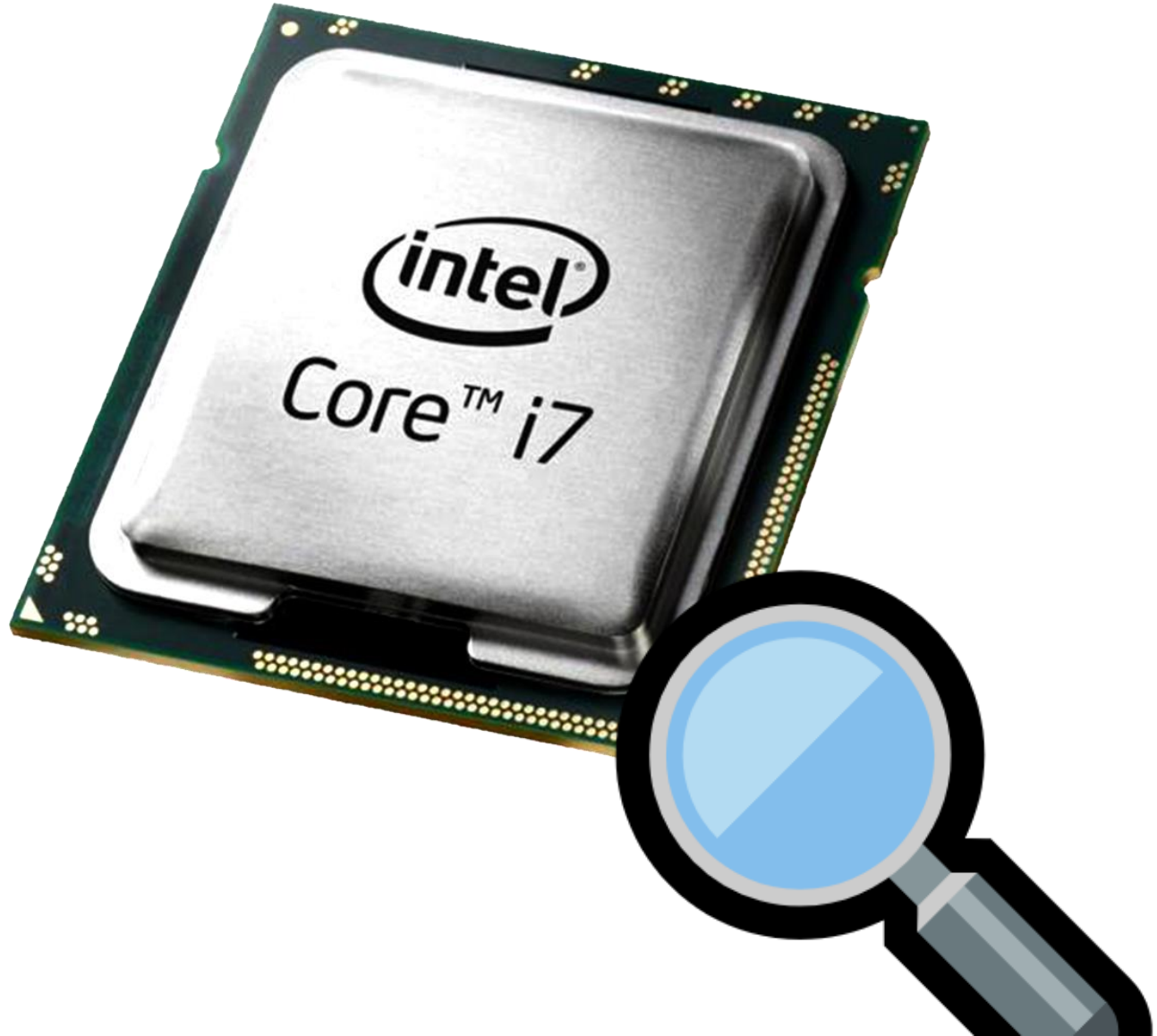
Remember this thing that we discussed a few weeks back?

The Process Control Block (PCB)

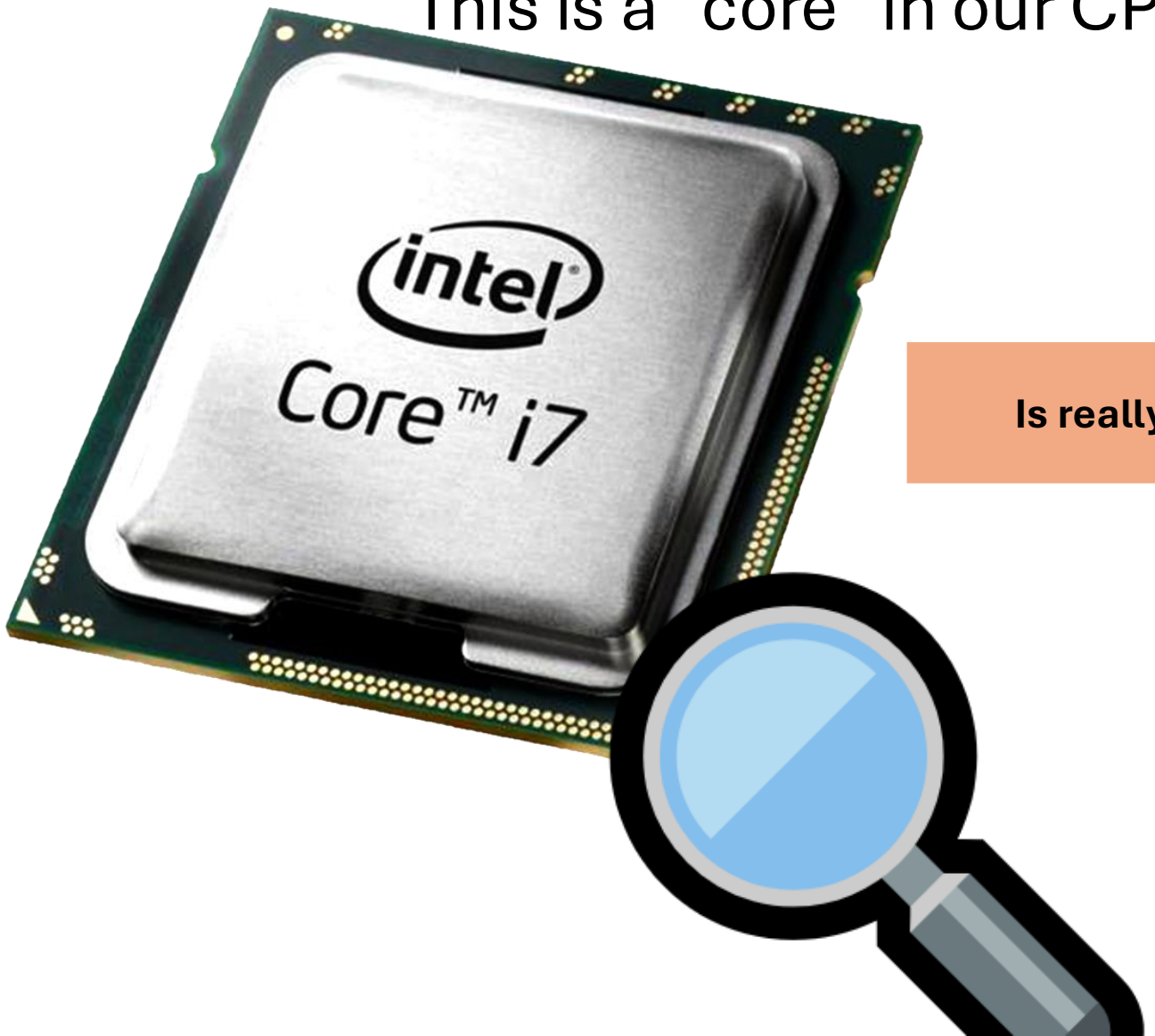
- Contains information about the *state* of each thread that is running in a process

- We use this information to switch between running threads

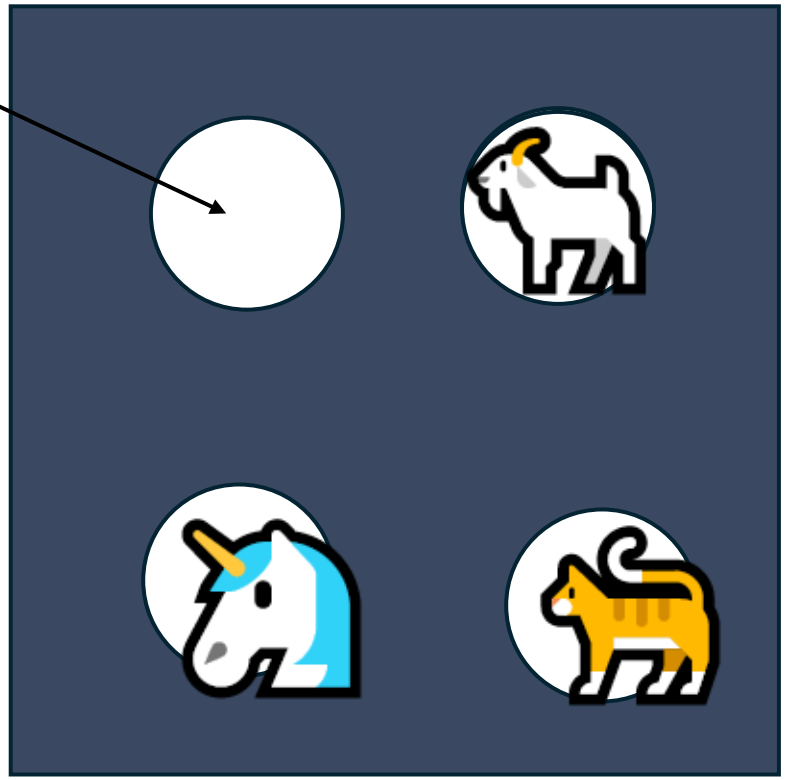



intel
Core™ i7

This is a “core” in our CPU that can run a thread



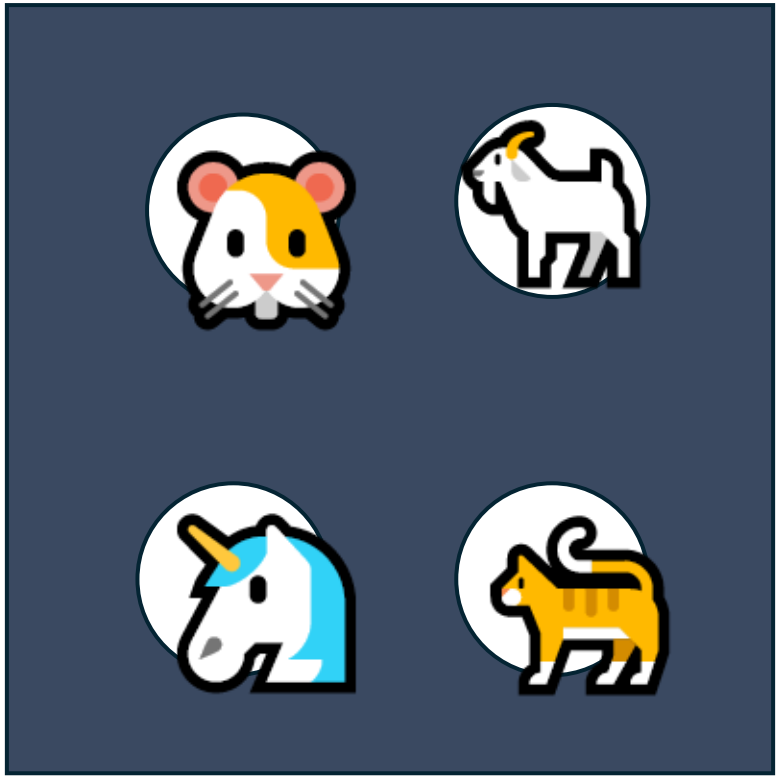
Is really



Each animal is a thread

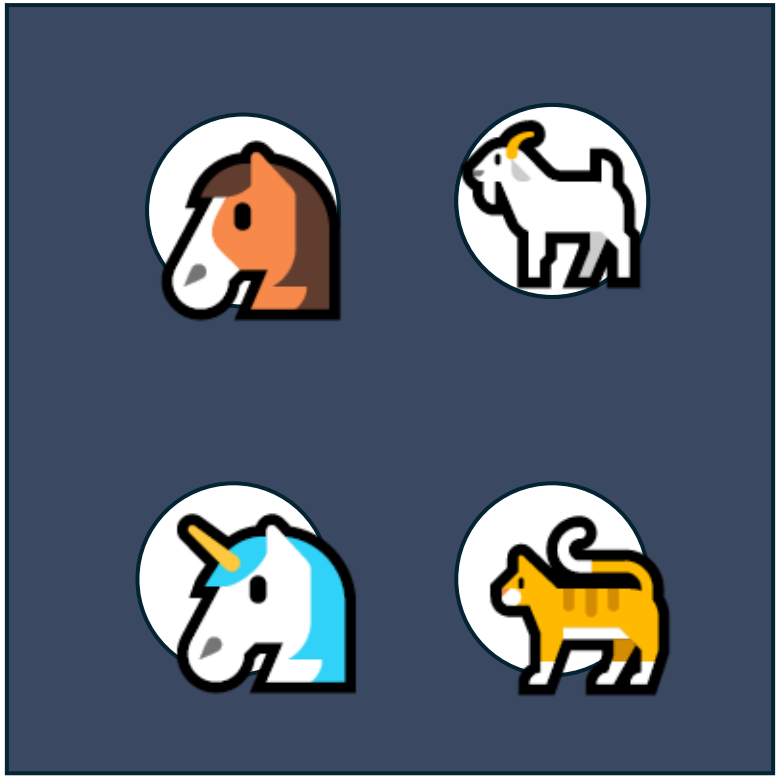
Context Switching

Dispatcher



Context Switching

Dispatcher



Scheduler vs Dispatcher

A scheduler

- The part of the OS that decides what thread to run next

- It is different from a dispatcher which performs the context switch, which is all we've talked about up until now.

What are the reasons that a thread leaves a core?

1. The thread is done running

2. The thread “traps” into the OS
   - If a thread invokes something that only the OS can do, the OS *has* to step in
     - System Calls, Errors, or Page Faults

3. The thread is interrupted
   - Example: a timer, or a disk operation is completed

4. A thread yields to the core; i.e. the thread waits