Process Creation

2024 Winter ECE 353: Systems Software
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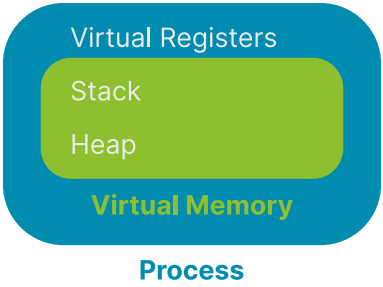
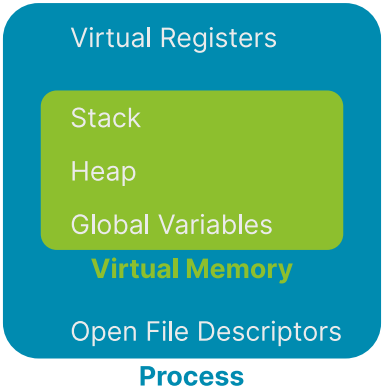
Lecture 4
2.0.0

Recall: A Process is an Instance of a Running Program



We Can Add More to a Process



A Process Control Block (PCB) Contains All Information

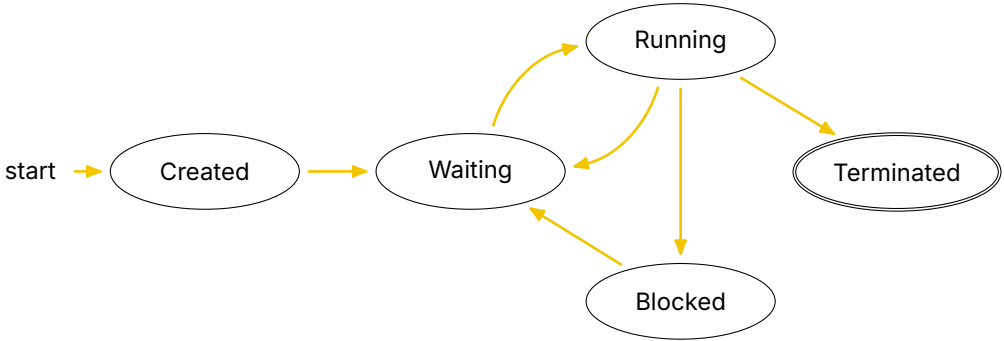
Specifically, in Linux, this is the `task_struct` you can browse on GitHub

It contains:

- Process state
- CPU registers
- Scheduling information
- Memory management information
- I/O status information
- Any other type of accounting information

Each process gets a unique process ID (pid) to keep track of it

Process State Diagram (You Could Rename Waiting to Ready)



You Can Read Process State Using the "proc" Filesystem

There's a standard `/proc` directory (on Linux) that represents the kernel's state
These aren't real files, they just look like it!

Every directory that's a number (process ID) in `/proc` represents a process

There's a file called `status` that contains the state (used for Lab 1)

We Could Create Processes from Scratch

We load the program into memory and create the process control block
(this is what Windows does)

Unix decomposes process creation into more flexible abstractions

Instead of Creating a New Process, We Could Clone It

Pause the currently running process, and copy it's PCB into a new one
    This will reuse all of the information from the process, including variables!

Distinguish between the two processes with a parent and child relationship
    They could both execute different parts of the program together

We could then allow either process to load a new program and setup a new PCB

`fork` Creates a New Process, A Copy of the Current One

`int fork(void)` as the following API:

- Returns the process ID of the newly created child process
  - -1: on failure
  - 0: in the child process
  - >0: in the parent process

There are now 2 processes running

Note: they can access the same variables, but they're separate

Operating system does "copy on write" to maximize sharing

On POSIX Systems, You Can Find Documentation Using `man`

We'll be using the following APIs:

- `fork`
- `execve`
- `wait` (next lecture)

You can use `man <function>` to look up documentation,
or `man <number> <function>`
  2: System calls
  3: Library calls

`fork-example.c` Has One Process Execute Each Branch

```
int main(int argc, char *argv[]) {
  pid_t returned_pid = fork();
  if (retured_pid == -1) {
    int err = errno;
    perror("fork failed");
    return err;
  }
  if (returned_pid == 0) {
    printf("Child returned pid: %d\n", returned_pid);
    printf("Child pid: %d\n", getpid());
    printf("Child parent pid: %d\n", getppid());
  }
  else {
    printf("Parent returned pid: %d\n", returned_pid);
    printf("Parent pid: %d\n", getpid());
    printf("Parent parent pid: %d\n", getppid());
  }
  return 0;
}
```

`execve` Replaces the Process with Another Program, and Resets

`execve` has the following API:

- `pathname`: Full path of the program to load
- `argv`: Array of strings (array of characters), terminated by a null pointer
  Represents arguments to the process
- `envp`: Same as `argv`
  Represents the environment of the process
- Returns an error on failure, does not return if successful

`execve-example.c` Turns the Process into `ls`

```c
int main(int argc, char *argv[]) {
  printf("I'm going to become another process\n");
  char *exec_argv[] = {"ls", NULL};
  char *exec_envp[] = {NULL};
  int exec_return = execve("/usr/bin/ls", exec_argv, exec_envp);
  if (exec_return == -1) {
    exec_return = errno;
    perror("execve failed");
    return exec_return;
  }
  printf("If execve worked, this will never print\n");
  return 0;
}
```

The Operating System Creates Processes

The operating system has to:

- Maintain process control blocks, including state
- Create new processes
- Load a program, and re-initialize a process with context