

CS 111: Operating System Principles

Lecture 5

Process API

1.0.1

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Linux Terminology Is Slightly Different

You can look at a process' state by reading `/proc/<pid>/state`

Replace `<pid>` with the process ID

R: Running and runnable [Running and Waiting]

S: Interruptible sleep [Blocked]

D: Uninterruptible sleep [Blocked]

T: Stopped

Z: Zombie

The kernel lets you explicitly stop a process to prevent it from running

You or another process must explicitly continue it

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

We'll be using the following APIs:

- `execve`
- `fork`
- `wait`

You can use `man <function>` to look up documentation,
or `man <number> <function>`

2: System calls

3: Library calls

execve Loads Another Program, and Replaces Process with A New One

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

```
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;
}
```

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

fork 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

fork-example.c Has One Process Execute Each Branch

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

orphan-example.c The Parent Exits Before the Child, init Cleans Up

```
int main(int argc, char *argv[]) {
    pid_t pid = fork();
    if (pid == -1) {
        int err = errno;
        perror("fork failed");
        return err;
    }
    if (pid == 0) {
        printf("Child parent pid: %d\n", getppid());
        sleep(2);
        printf("Child parent pid (after sleep): %d\n", getppid());
    }
    else {
        sleep(1);
    }
    return 0;
}
```


zombie-example.c The Parent Monitors the Child To Check Its State

```
pid_t pid = fork();  
// Error checking  
if (pid == 0) {  
    sleep(2);  
}  
else {  
    // Parent process  
    int ret;  
    sleep(1);  
    printf("Child process state: ");  
    ret = print_state(pid);  
    if (ret < 0) { return errno; }  
    sleep(2);  
    printf("Child process state: ");  
    ret = print_state(pid);  
    if (ret < 0) { return errno; }  
}
```

You Need to Call `wait` on Child Processes

`wait` as the following API:

- `status`: Address to store the wait status of the process
- Returns the process ID of child process
 - 1: on failure
 - 0: for no blocking calls with no child changes
 - >0: the child with a change

The wait status contains a bunch of information, including the exit code

Use `man wait` to find all the macros to query wait status

You can use `waitpid` to wait on a specific child process

wait-example.c Blocks Until The Child Process Exists, and Cleans Up

```
int main(int argc, char *argv[]) {
    pid_t pid = fork();
    if (pid == -1) {
        return errno;
    }
    if (pid == 0) {
        sleep(2);
    }
    else {
        printf("Calling wait\n");
        int wstatus;
        pid_t wait_pid = wait(&wstatus);
        if (WIFEXITED(wstatus)) {
            printf("Wait returned for an exited process! pid: %d, status: %d\n",
                wait_pid, WEXITSTATUS(wstatus));
        }
    }
    return 0;
}
```

We Used System Calls to Create Processes

You should be comfortable with:

- `execve`
- `fork`
- `wait`

This includes understanding processes and their relationships