Operating System Concepts

Lecture 6: Process Control

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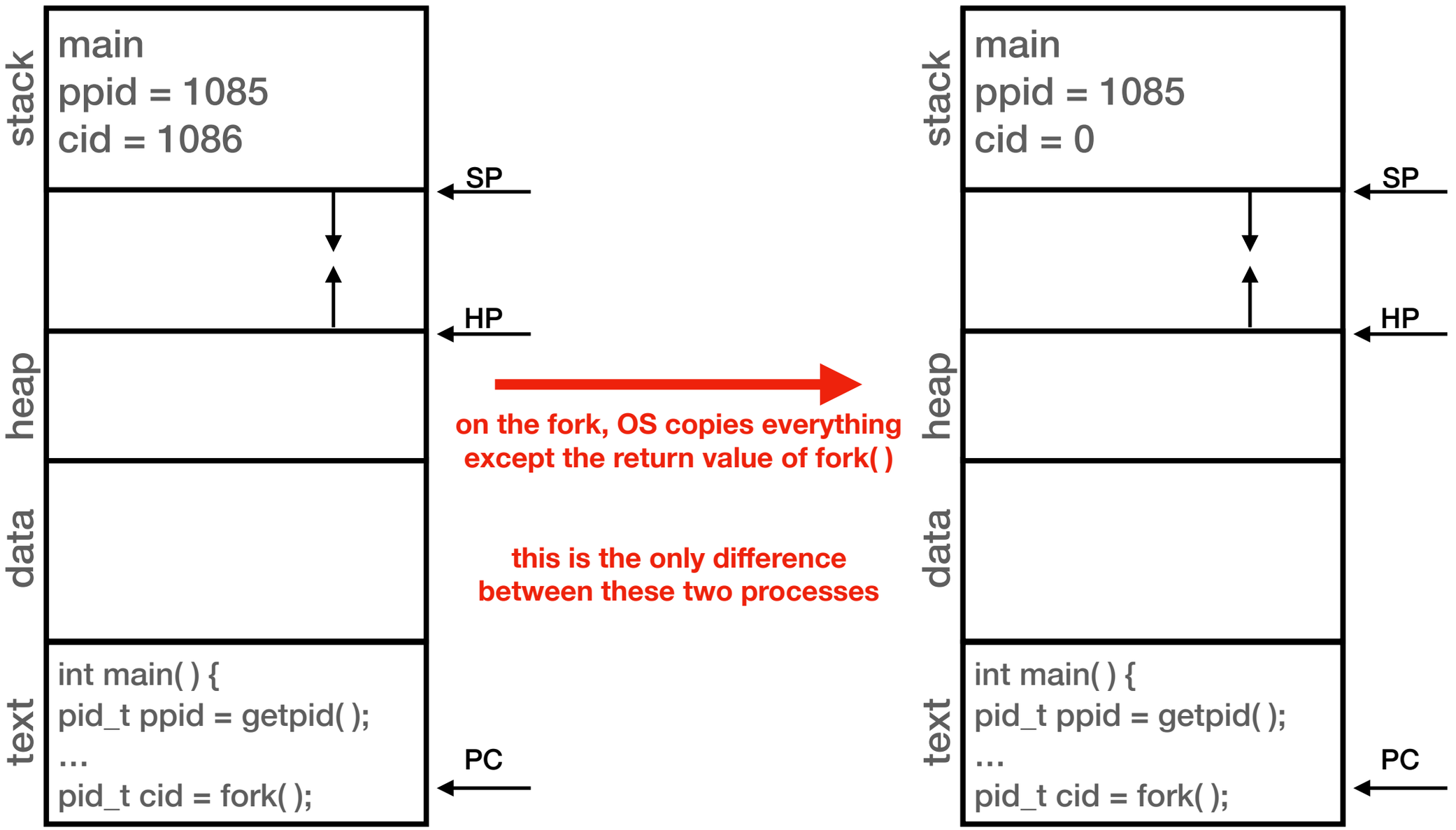
MWF 12:00-12:50 VVC 2 215

Today's class

- Process Control
  - How to create a new process?
  - How to terminate a process?
- Examples

What happens on a fork?

```
pid_t cid = fork( );
```



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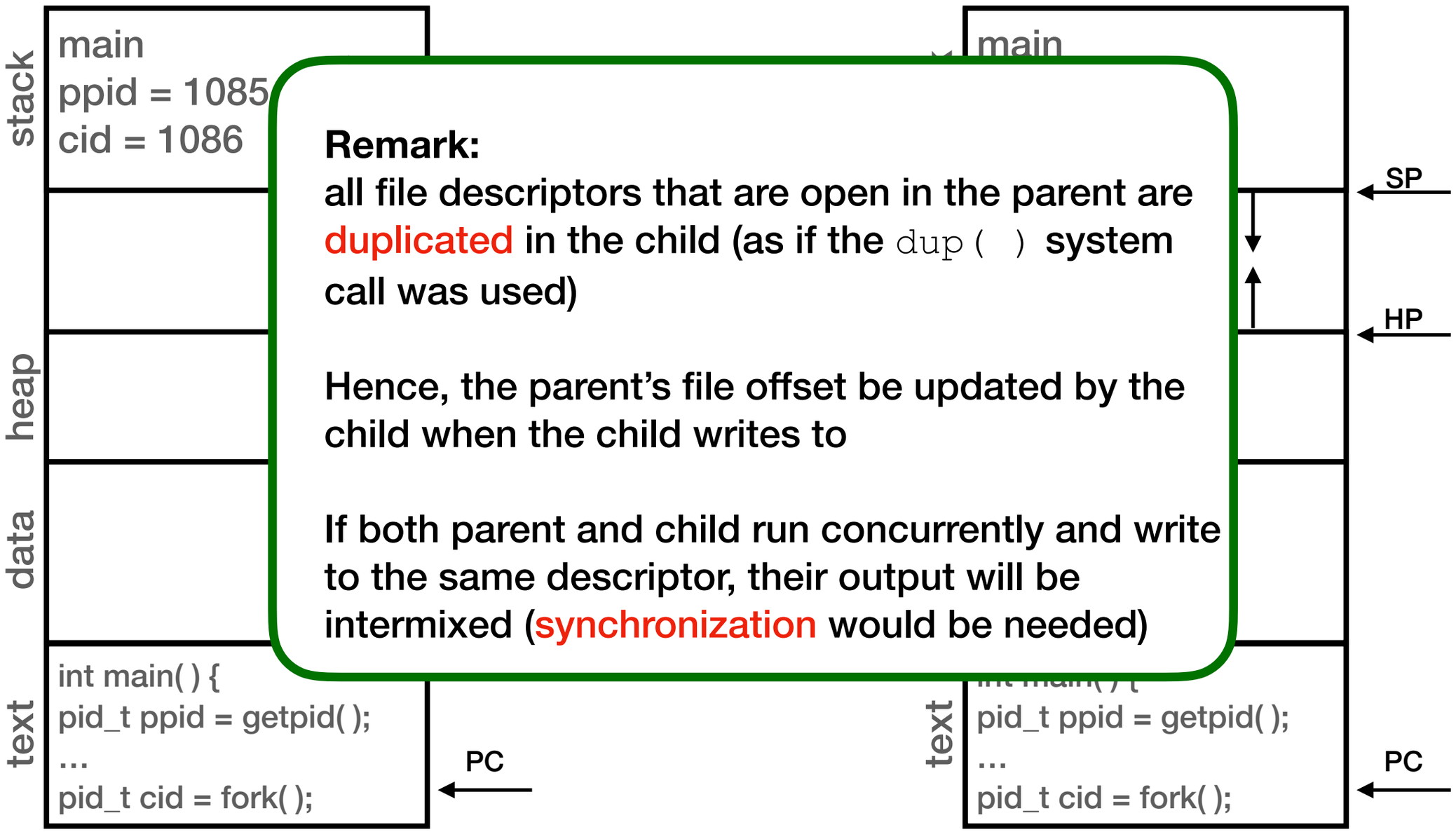

Terminating a process

- Process termination is the ultimate resource reclamation by the OS
  - closes all open files, connections, etc.
  - deallocates memory and most of the OS structures supporting the process
  - checks if parent is alive
    - if so, holds the **exit status** until parent requests it; in this case, process does not really die, but it enters the zombie state (**WHY?**)
    - If not, it deallocates all data structures; the process is dead at this point
  - cleans up all waiting zombies

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- a process can terminate a child using the `kill( )` system call
  - `kill(cid, SIGKILL)`

Waiting for the child process to terminate

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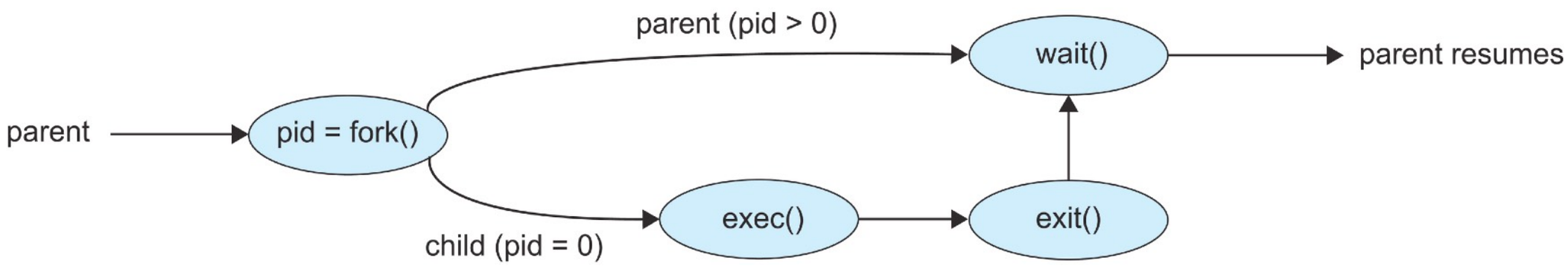

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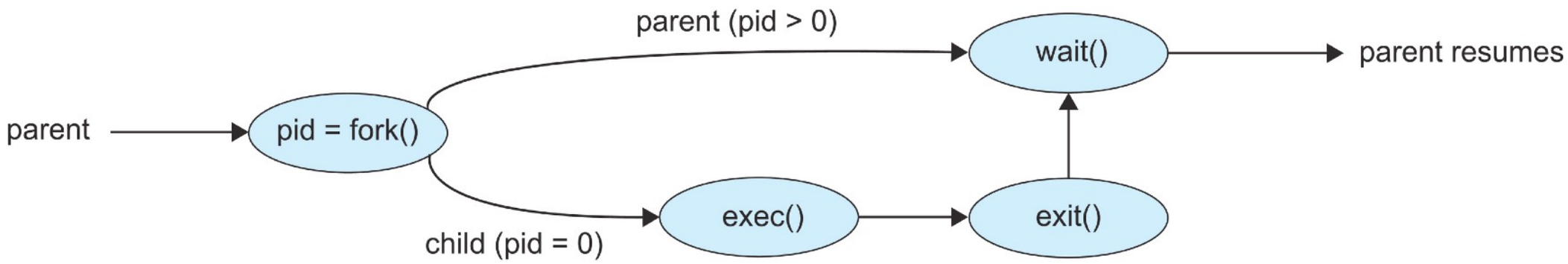

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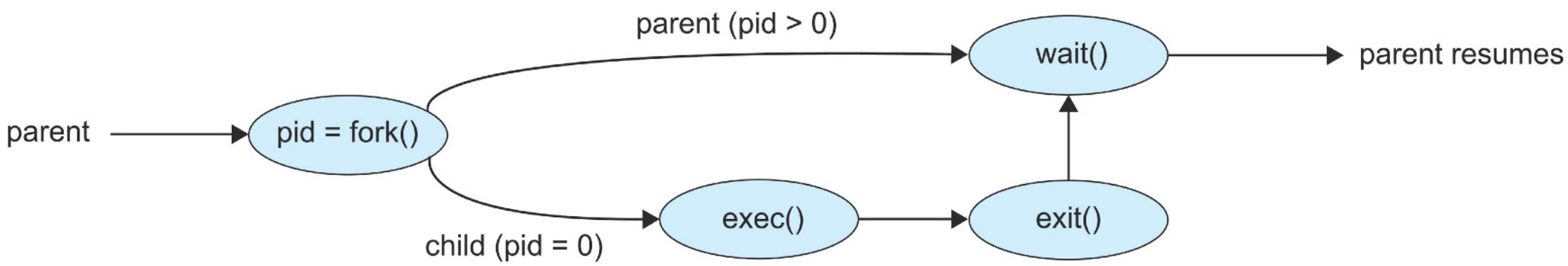

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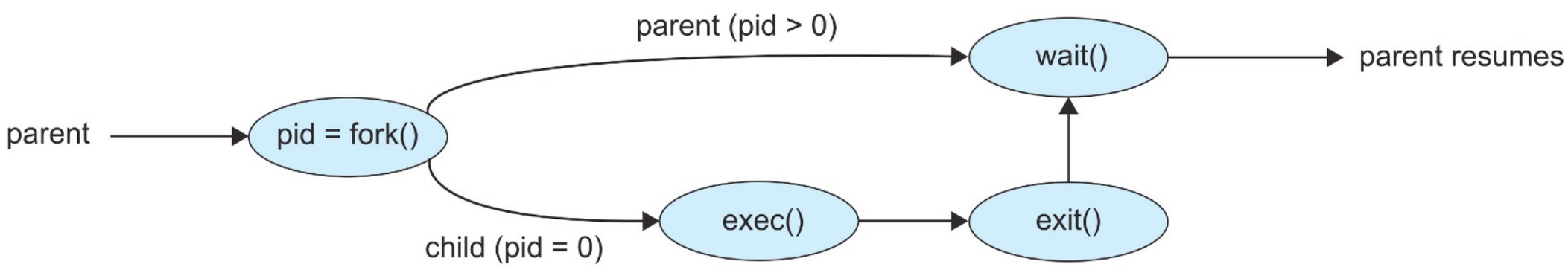

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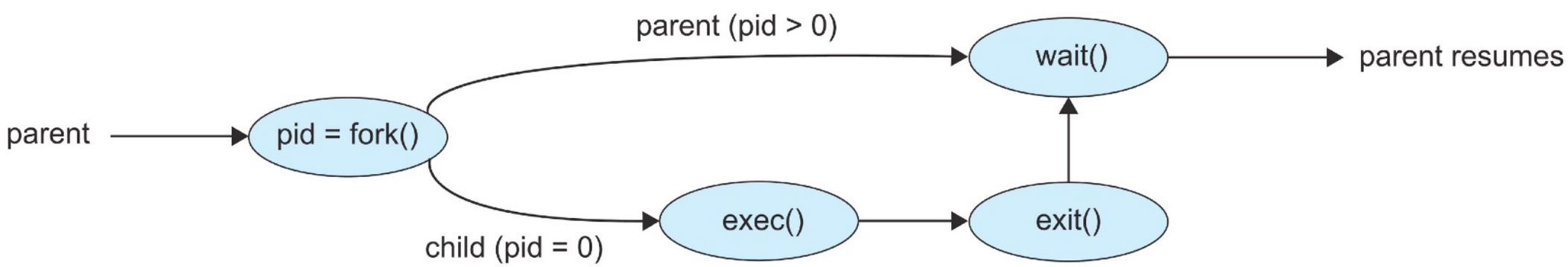

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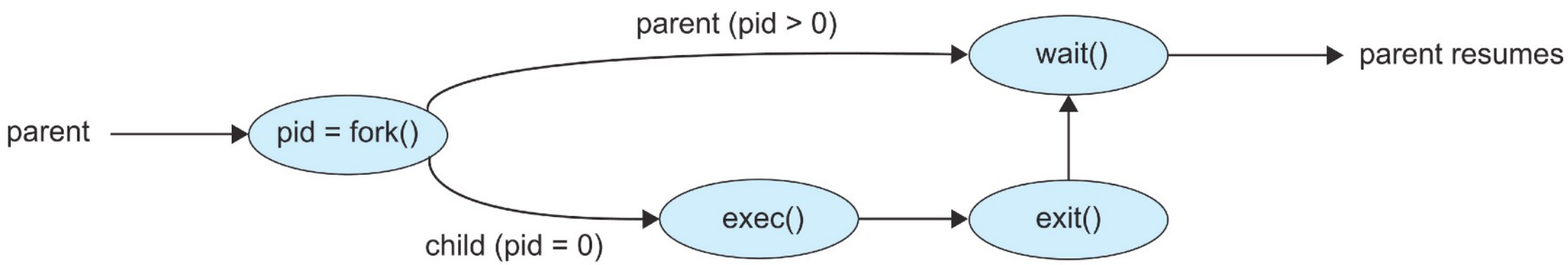
  - if there are no children alive, `wait( )` returns immediately
  - also, if there are zombies waiting for their parents, `wait( )` returns one of the exit statuses immediately (and deallocates the zombie)



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    - you can check this `if(getppid( ) == 1)`
  - the `init` process periodically calls `wait( )` allowing the exit status of any orphaned process to be collected and their process table entries be deleted

Fork example

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <sys/types.h>

int main() {
      ...
      pid_t ppid = getpid();                  // store parent's pid
      pid_t pid = fork();                     // create a child
      if(pid == 0){                           // child continues here
        printf("Child pid: [%d]\n", getpid());
        ...
      } else if (pid > 0) {                   // parent continues here
        printf("Parent pid: [%d] Child pid: [%d]\n", ppid, pid);
        ...
      } else {
        perror("fork failed!");
        exit(1);
      }
      …
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Run the `ps` command to check the processes' IDs

Combining fork and wait

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#include <sys/types.h>
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        …
        pid_t cpid = wait(&child_status);
      } else {
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      }
      …
}
```

Combining fork and exec

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#include <sys/wait.h>

main() {
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      pid_t ppid = getpid();              // store parent's pid
      pid_t pid = fork();                 // create a child
      if(pid == 0){                       // child continues here
         status = execl("/bin/ls", arg0, arg1, …); // mark the end with a null pointer
        /* exec doesn't return when it works.
            so if we got here, it must have failed! */
        perror("exec failed!");
      } else if (pid > 0) {               // parent continues here
        ...
        cpid = wait(&status);             // pass NULL if not interested in exit status
        if (WIFEXITED(status))
            printf("child exit status was %d\n", WEXITSTATUS(status));
      } else {
        perror("fork failed!");
      }
      ...
}
```

Parent can kill its child!

```
#include <signal.h>
#include <unistd.h>
#include <stdio.h>

main() {
      ...
      int ppid = getpid();                  // store parent's pid
      int pid = fork();                     // create a child
      if(pid == 0){                         // child continues here
            sleep(10);                      // child sleeps for 10 seconds
            ...
            exit(0);
      }
      else {                                // parent continues here
        ...
        printf( "Type any character to kill the child.\n" );
        char answer[10];
        gets(answer);
        if ( !kill(pid, SIGKILL) ) {
          printf("Killed the child.\n");
        }
      }
}
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    - the `sleep( )` system call puts a process on a timer queue waiting for some number of seconds, supporting alarm functionality

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- the `killall` command sends an arbitrary signal to processes based on process name

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- `pstree` displays a tree of processes

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- when you log in to a machine running UNIX, you create a shell process
- every command launched in the shell is a child of the shell process and is an implicit `fork( )` and `exec( )` pair
- the separation of `fork( )` and `exec( )` enables features like input/output redirection, pipes, etc.
  - the shell runs code after the call to `fork( )` and before the call to `exec( )`

Summary

- OS creates, deletes, suspends, and resumes processes
- OS allocates resources to active processes
  - memory, I/O devices, files
- OS schedules processes
  - context switches between them
- OS supports **interprocess communication** and provides **synchronization** mechanisms

Homework

- Compile and run the examples available on eClass