15213 Recitation Section C

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Outline

- Process
- Signals
- Reaping Child Processes
- Race Hazard

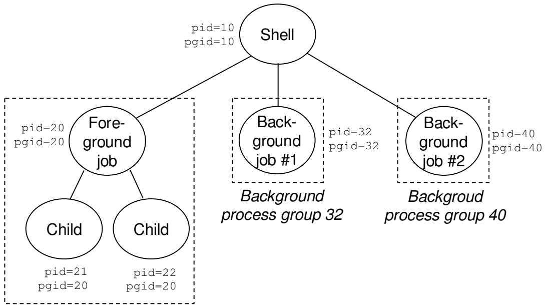
Process Concept

- An instance of running program
- Multiple processes run “concurrently” by time slicing
  - What is time slicing?
  - Preemptive scheduler of OS: it can stop a program at any point!

Process IDs & Process Groups

- A process has its own, unique process ID
  - **`pid_t getpid();`**
- A process belongs to exactly one process group
  - **`pid_t getpgrp();`**
- A new process belongs to which process group?
  - Its parent’s process group
- A process can make a process group for itself and its children
  - **`pid_t pid = getpid();`**
  - **`setpgid(0, 0);`**
  - **`getpgrp()` → `-pid`**

Process Tree for Shell



Foreground process group 20

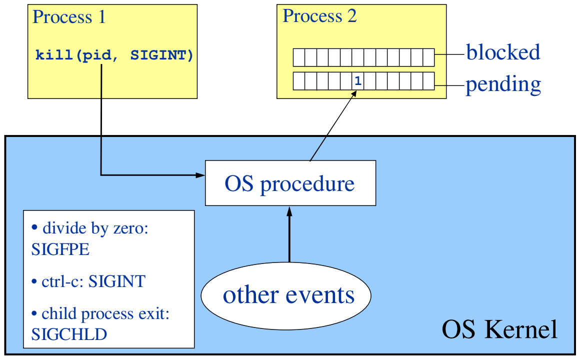
Signals

- Section 8.5 in text
  - Read at least twice … really!
- A signal tells our program that some event has occurred
- Can we use signals to count events?
  - No

Important Signals (Fig 8.23)

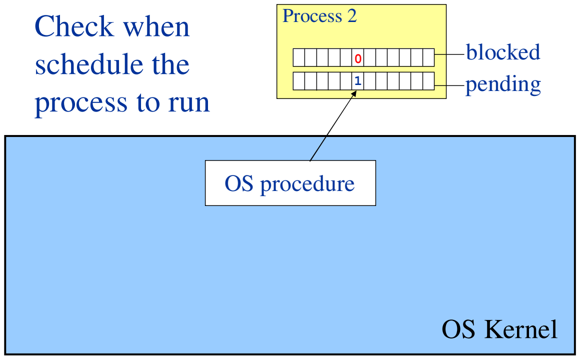
- SIGINT
  - Interrupt signal from terminal (ctrl-c)
- SIGTSTP
  - Stop signal from terminal (ctrl-z)
- SIGCHLD
  - A child process has stopped or terminated

Signals: sending



Signals: receiving

Check when schedule the process to run



Receiving a Signal

- Default action
  - The process terminates [and dumps core]
  - The process stops until restarted by a SIGCONT signal
  - The process ignore the signal
- Can modify (additional action)
  - "Handle the signal"
    - `void sigint_handler(int sig);`
    - `signal(SIGINT, sigint_handler);`

Reaping Child Process

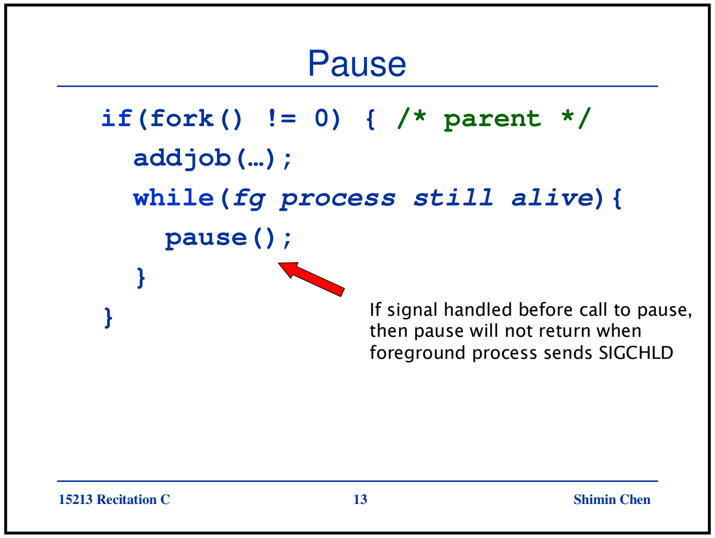
- Child process becomes zombie when terminates
  - Still consume system resources
  - Parent performs reaping on terminated child
  - `wait()` `waitpid()`
- Straightforward for reaping a single child
- Tricky for Shell implementation!
  - multiple child processes
  - both foreground and background

Reaping Child Process

- Two waits
  - `sigchld_handler`
  - `eval`: for foreground processes
- One wait
  - `sigchld_handler`
  - But what about foreground processes?

Busy Wait

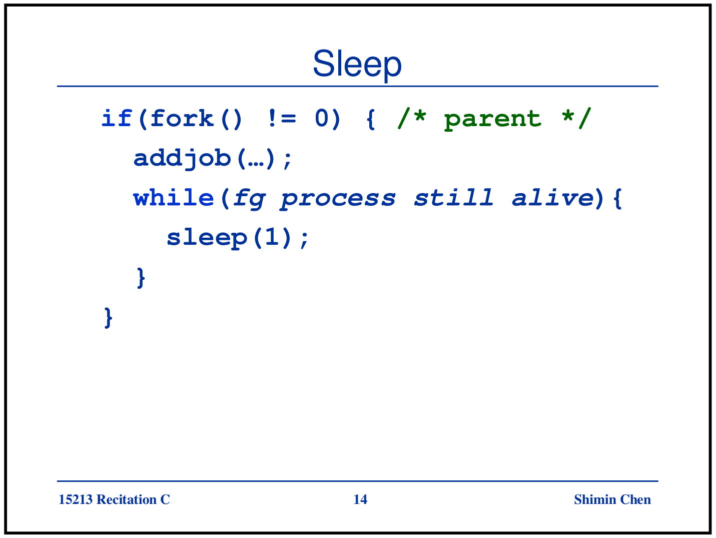
```
if(fork() != 0) { /* parent */
  addjob(…);
  while(fg process still alive){
    /* do nothing */
  }
}
```



Pause

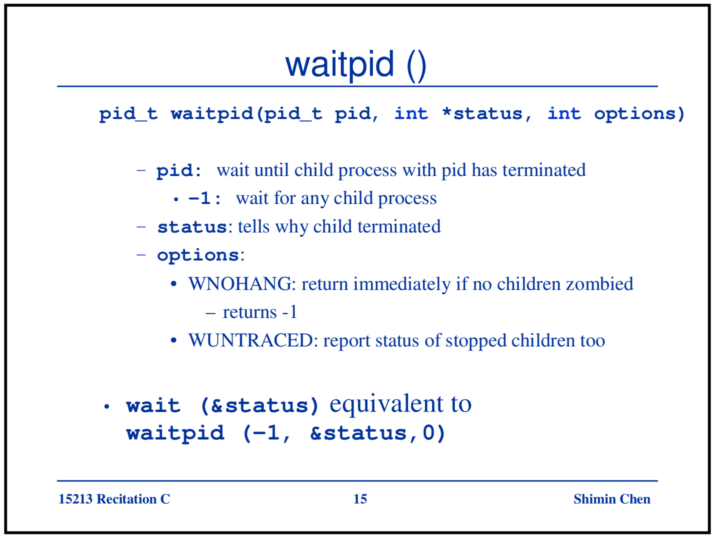
```
if(fork() != 0) { /* parent */
  addjob(…);
  while(fg process still alive){
    pause();
  }
}
```

If signal handled before call to pause, then pause will not return when foreground process sends SIGCHLD



Sleep

```
if(fork() != 0) { /* parent */
  addjob(…);
  while(fg process still alive){
    sleep(1);
  }
}
```

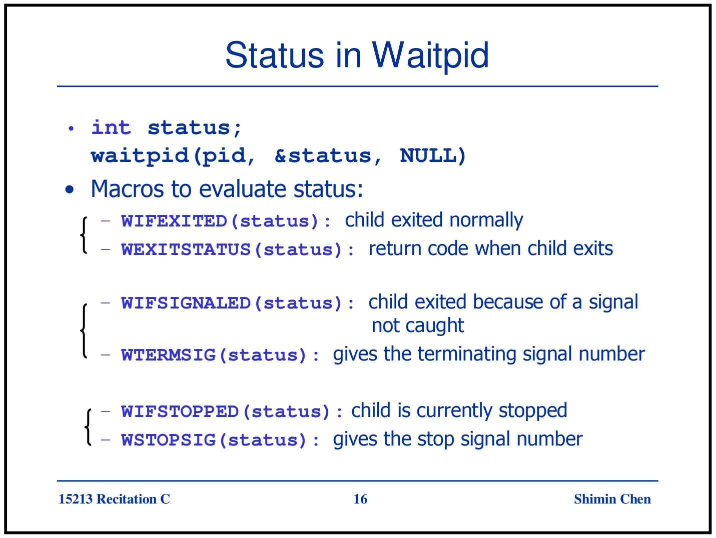


waitpid ()

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

- **pid:** wait until child process with pid has terminated
  - **-1:** wait for any child process
- **status**: tells why child terminated
- **options**:
  - WNOHANG: return immediately if no children zombied
    - returns -1
  - WUNTRACED: report status of stopped children too

- **wait (&status)** equivalent to **waitpid (-1, &status,0)**



Status in Waitpid

- **int status;**
  waitpid(pid, &status, NULL)
- Macros to evaluate status:
  - **WIFEXITED(status):** child exited normally
  - **WEXITSTATUS(status):** return code when child exits

  - **WIFSIGNALED(status):** child exited because of a signal not caught
  - **WTERMSIG(status):** gives the terminating signal number

  - **WIFSTOPPED(status):** child is currently stopped
  - **WSTOPSIG(status):** gives the stop signal number

Man page

- Check man page for details of a system call:
  - man waitpid

Race Hazard

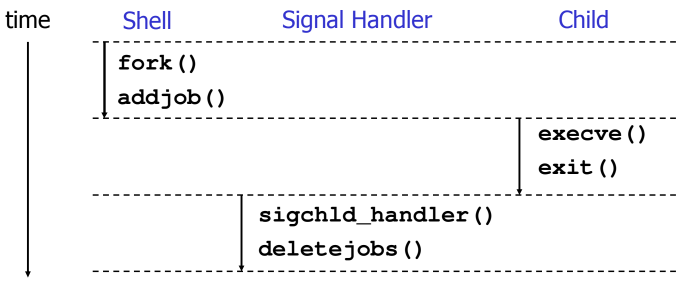
- A data structure is shared by two pieces of code that can run concurrently
- Different behaviors of program depending upon how the schedule interleaves the execution of code.

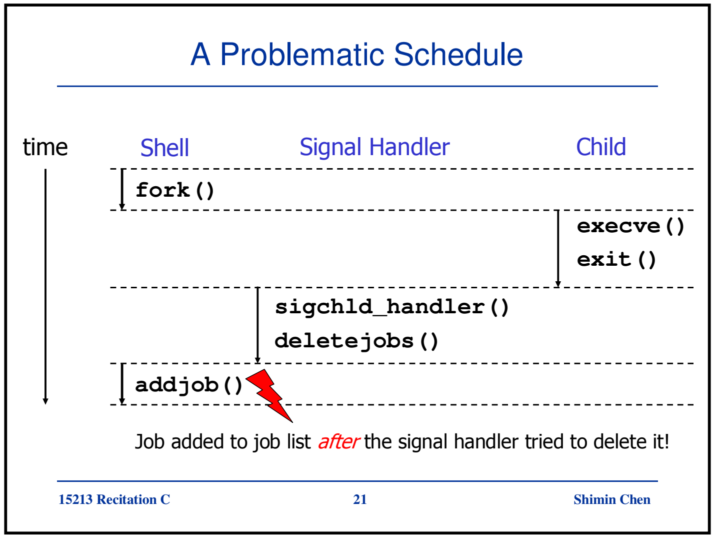
eval & sigchld_handler Race Hazard

```
sigchld_handler() {
  pid = waitpid(…);
  deletejob(pid);
}

eval() {
  pid = fork();
  if(pid == 0)
  { /* child */
    execve(…);
  }
  /* parent */
  /* signal handler might run BEFORE addjob() */
  addjob(…);
}
```

An Okay Schedule





A Problematic Schedule

time

Shell | Signal Handler | Child

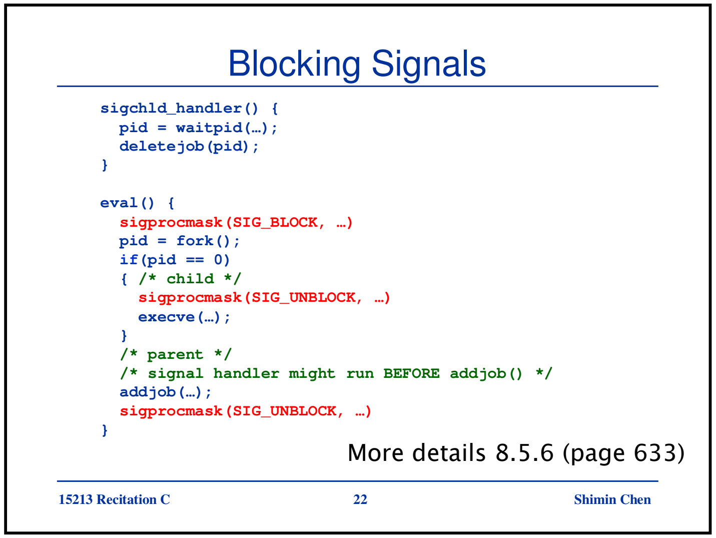
`fork()`

`execve()`
`exit()`

`sigchld_handler()`
`deletejobs()`

`addjob()`

Job added to job list *after* the signal handler tried to delete it!

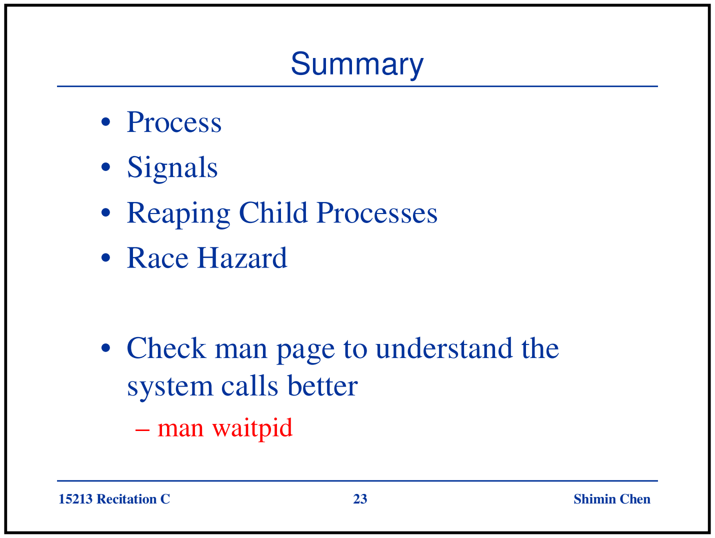


Blocking Signals

```
sigchld_handler() {
  pid = waitpid(…);
  deletejob(pid);
}

eval() {
  sigprocmask(SIG_BLOCK, …)
  pid = fork();
  if(pid == 0)
  { /* child */
    sigprocmask(SIG_UNBLOCK, …)
    execve(…);
  }
  /* parent */
  /* signal handler might run BEFORE addjob() */
  addjob(…);
  sigprocmask(SIG_UNBLOCK, …)
}
```

More details 8.5.6 (page 633)



Summary

- Process
- Signals
- Reaping Child Processes
- Race Hazard

- Check man page to understand the system calls better
  - man waitpid