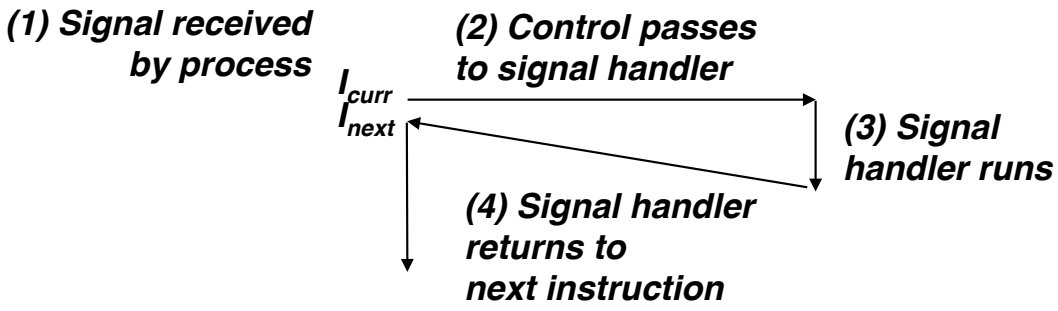
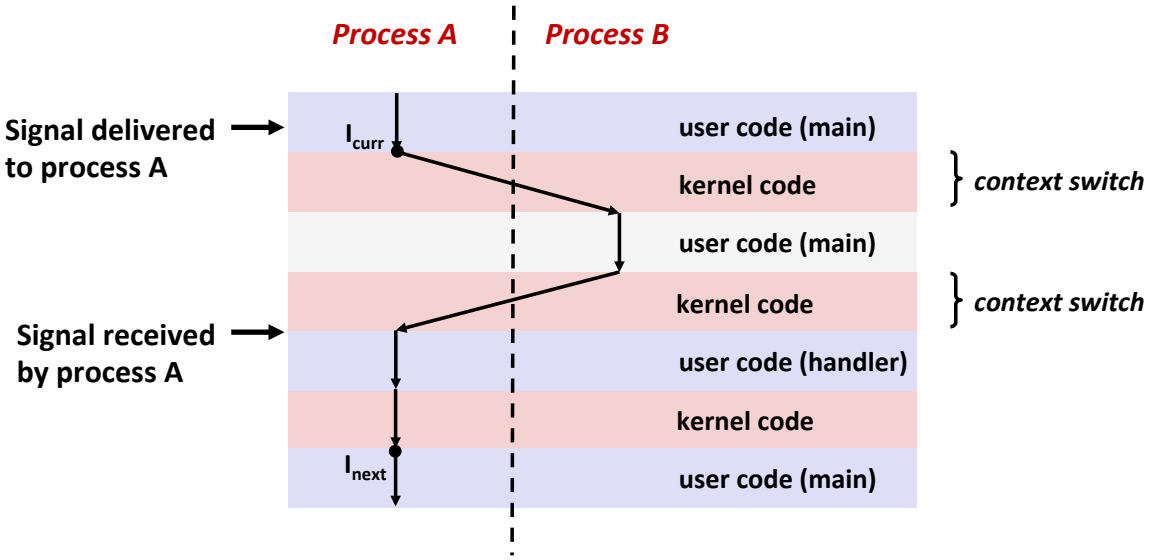
Signals

ID	Name	Corresponding Event	Default Action	Can Override?
2	SIGINT	Interrupt (Ctrl-C)	Terminate	Yes
9	SIGKILL	Kill process (immediately)	Terminate	**No**
11	SIGSEGV	Segmentation violation	Terminate & Dump	Yes
14	SIGALRM	Timer signal	Terminate	Yes
15	SIGTERM	Kill process (politely)	Terminate	Yes
17	SIGCHLD	Child stopped or terminated	Ignore	Yes
18	SIGCONT	Continue stopped process	Continue (Resume)	No
19	SIGSTOP	Stop process (immediately)	Stop (Suspend)	**No**
20	SIGTSTP	Stop process (politely)	Stop (Suspend)	Yes

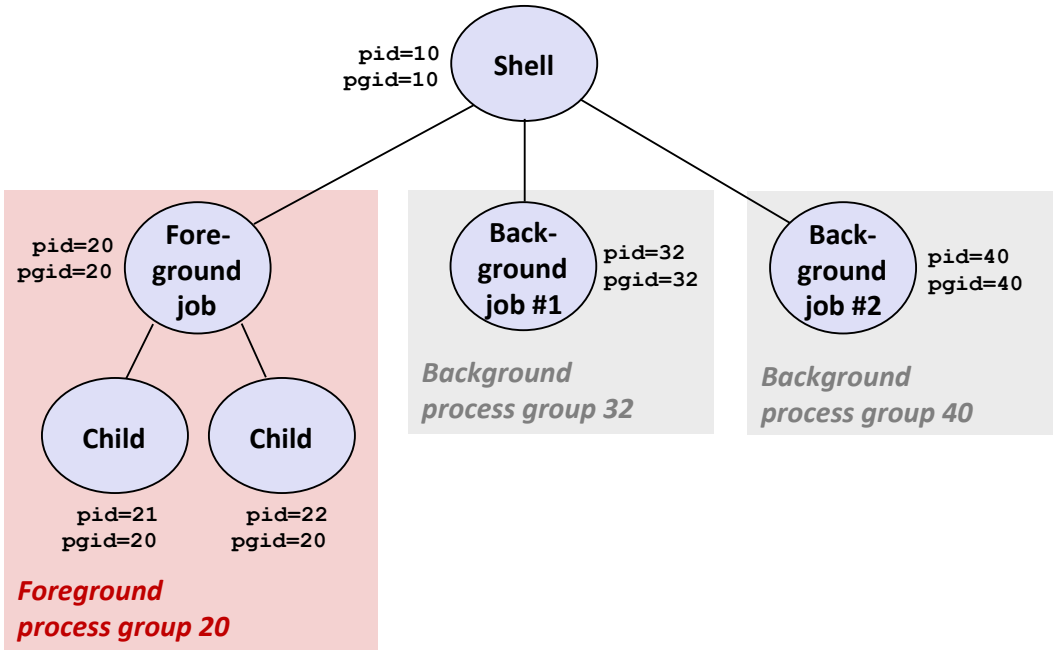
Signal Control Flow



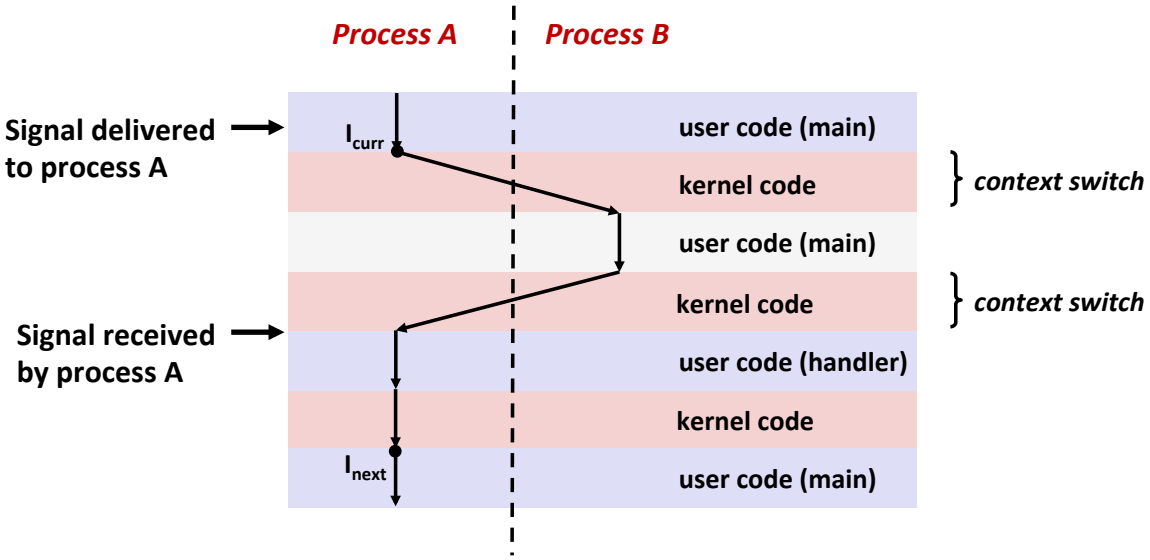
Signal Handler Control Flow



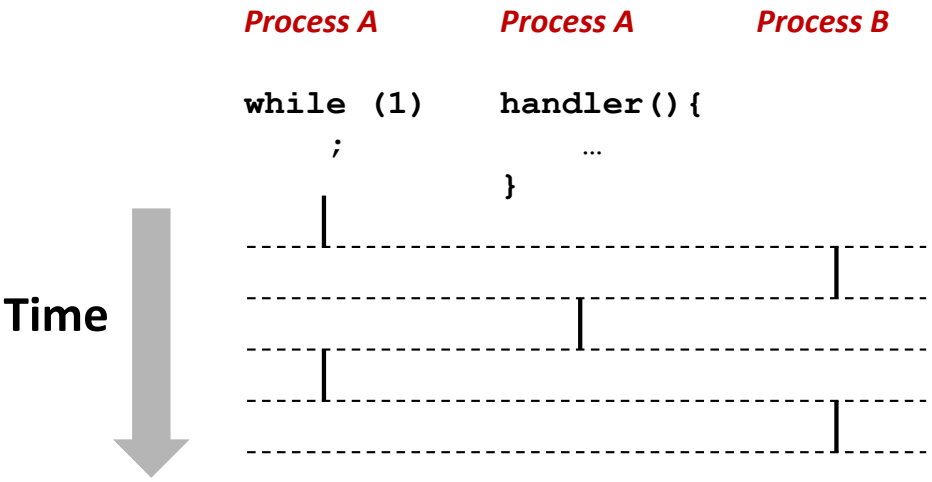
Process Groups



Signal Handler Control Flow



Signal Handler as Concurrent Flow



Concurrency Example (1)

```c
int main(int argc, char** argv) {
    int pid;

    Signal(SIGCHLD, handler);
    initjobs(); /* Initialize the job list */

    while (1) {
        if ((pid = fork()) == 0) { /* Child */
            execve("/bin/date", argv, NULL);
        }
        addjob(pid);  /* Add child to job list */
    }
    exit(0);
}
```

```c
void handler(int sig) {
    pid_t pid;

    while ((pid = waitpid(-1, NULL, 0)) > 0) { /* Reap child */
        deletejob(pid); /* Delete the child from the job list */
    }
    if (errno != ECHILD)
        unix_error("waitpid error");
}
```


Concurrency Example (2)

```c
int main(int argc, char** argv) {
    int pid;
    sigset_t mask_all, prev_all;
    sigfillset(&mask_all);
    Signal(SIGCHLD, handler);
    initjobs(); /* Initialize the job list */
    while (1) {
        if ((pid = fork()) == 0) { /* Child */
            execve("/bin/date", argv, NULL);
        }
        sigprocmask(SIG_BLOCK, &mask_all, &prev_all);
        addjob(pid);  /* Add child to the job list */
        sigprocmask(SIG_SETMASK, &prev_all, NULL);
    }
    exit(0);
}
```

```c
void handler(int sig) {
    sigset_t mask_all, prev_all;
    pid_t pid;
    sigfillset(&mask_all);
    while ((pid = waitpid(-1, NULL, 0)) > 0) { /* Reap child */
        sigprocmask(SIG_BLOCK, &mask_all, &prev_all);
        deletejob(pid); /* Delete child from job list */
        sigprocmask(SIG_SETMASK, &prev_all, NULL);
    }
    if (errno != ECHILD)
        unix_error("waitpid error");
}
```

Concurrency Example (3)

```
int main(int argc, char** argv) {
    int pid;
    sigset_t mask_all, mask_one, prev_one;

    sigfillset(&mask_all);
    sigemptyset(&mask_one);
    sigaddset(&mask_one, SIGCHLD);
    Signal(SIGCHLD, handler);
    initjobs(); /* Initialize the job list */

    while (1) {
        sigprocmask(SIG_BLOCK, &mask_one, &prev_one); /* Block SIGCHLD */
        if ((pid = fork()) == 0) { /* Child process */
            sigprocmask(SIG_SETMASK, &prev_one, NULL); /* Unblock SIGCHLD */
            execve("/bin/date", argv, NULL);
        }
        sigprocmask(SIG_BLOCK, &mask_all, NULL); /* Parent process */
        addjob(pid);  /* Add the child to the job list */
        sigprocmask(SIG_SETMASK, &prev_one, NULL);  /* Unblock SIGCHLD */
    }
    exit(0);
}
```

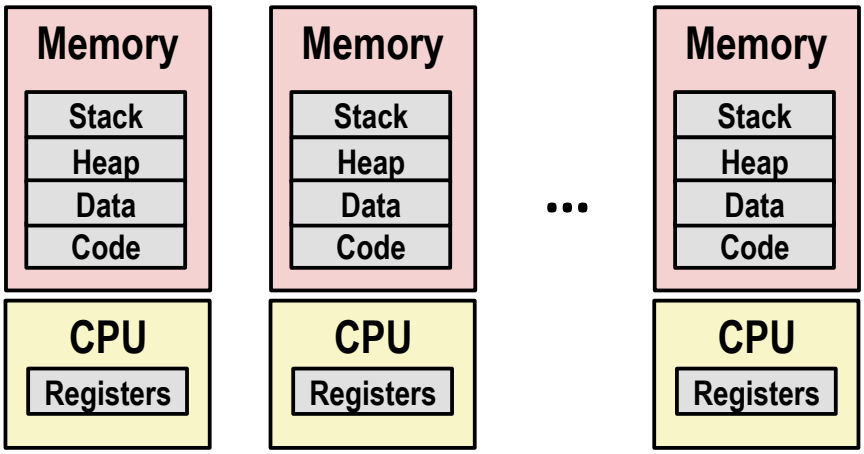

Key System Calls

- **`fork`** – Create a new process
- **`execve`** – Run a new program

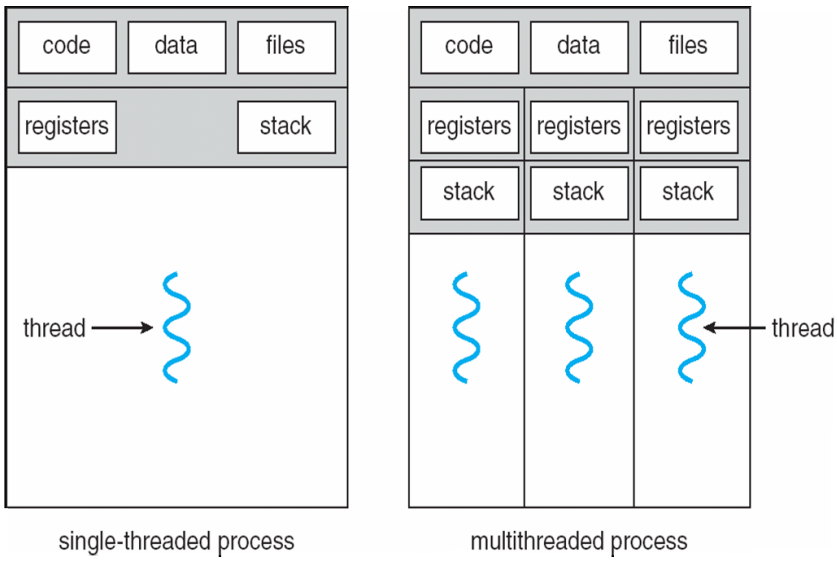
- **`kill`** – Send a signal
- **`waitpid`** – Wait for and/or reap child process
- **`setpgid`** – Set process group ID

- **`sigprocmask`** – Block or unblock signals
  - **`sigemptyset`** – Create empty signal set
  - **`sigfillset`** – Add every signal number to set
  - **`sigaddset`** – Add signal number to set
  - **`sigdelset`** – Delete signal number from set
  - **`sigsuspend`** – Wait until signal received

Processes



Threads



Thread Example

```c
/*
 * hello.c - Pthreads "hello, world" program
 */

void* thread(void* vargp);

int main() {

    pthread_t tid;
    pthread_create(&tid, NULL, thread, NULL);
    pthread_join(tid, NULL);
    exit(0);
}
```

hello.c

Thread ID

Thread attributes (usually NULL)

Thread routine

*Thread arguments (void *p)*

*Return value (void **p)*

```c
void* thread(void* vargp) { /* thread routine */
    printf("Hello, world!\n");
    return NULL;
}
```

hello.c