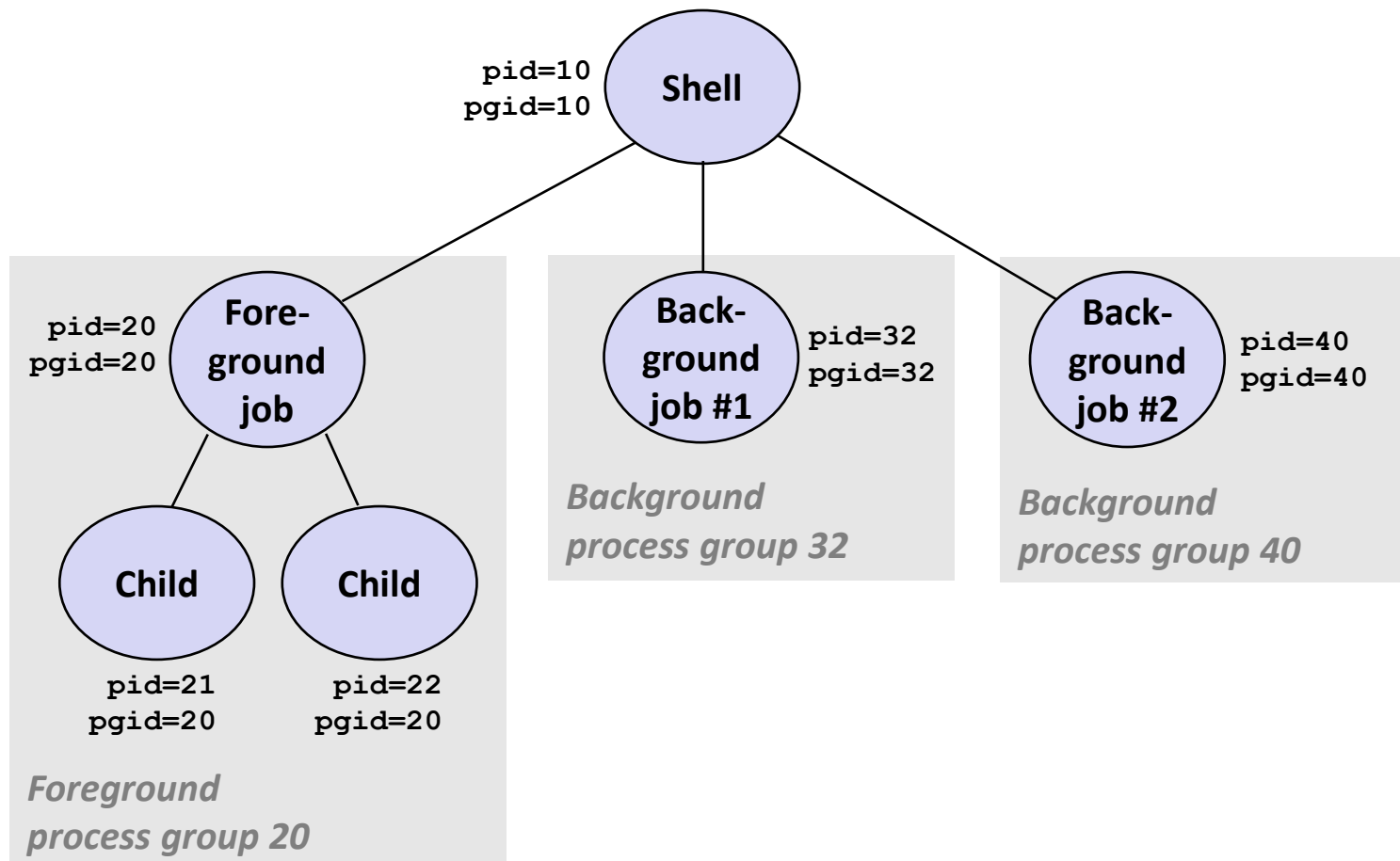


Exceptional Control Flow:

Signals: Sending

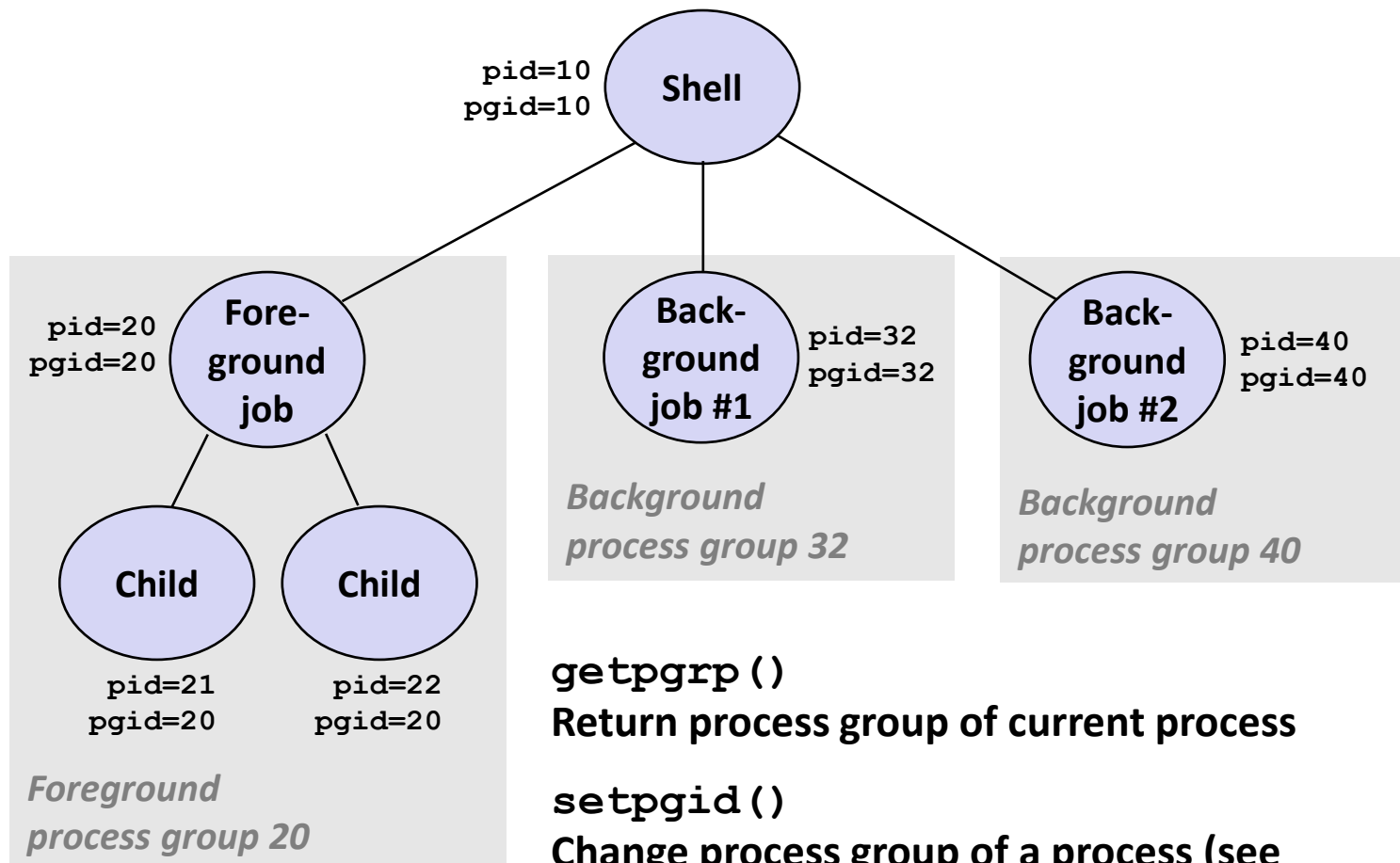
Sending Signals: Process Groups

- Every process belongs to exactly one process group



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- Every process belongs to exactly one process group



Sending Signals with `/bin/kill` Program

- `/bin/kill` program
sends arbitrary signal to a
process or process group

- Examples

```
linux> ./forks 16
Child1: pid=24818 pgrp=24817
Child2: pid=24819 pgrp=24817

linux> ps
  PID TTY          TIME CMD
 24788 pts/2        00:00:00 tcsh
 24818 pts/2        00:00:02 forks
 24819 pts/2        00:00:02 forks
 24820 pts/2        00:00:00 ps
linux> /bin/kill -9 -24817
linux> ps
  PID TTY          TIME CMD
 24788 pts/2        00:00:00 tcsh
 24823 pts/2        00:00:00 ps
linux>
```

Sending Signals with `/bin/kill` Program

- `/bin/kill` program
sends arbitrary signal to a
process or process group

- Examples

- `/bin/kill -9 24818`
Send SIGKILL to process 24818

```
linux> ./forks 16
Child1: pid=24818 pgrp=24817
Child2: pid=24819 pgrp=24817

linux> ps
  PID TTY          TIME CMD
 24788 pts/2        00:00:00 tcsh
 24818 pts/2        00:00:02 forks
 24819 pts/2        00:00:02 forks
 24820 pts/2        00:00:00 ps
linux> /bin/kill -9 -24817
linux> ps
  PID TTY          TIME CMD
 24788 pts/2        00:00:00 tcsh
 24823 pts/2        00:00:00 ps
linux>
```

Sending Signals with `/bin/kill` Program

- `/bin/kill` program
sends arbitrary signal to a
process or process group

■ Examples

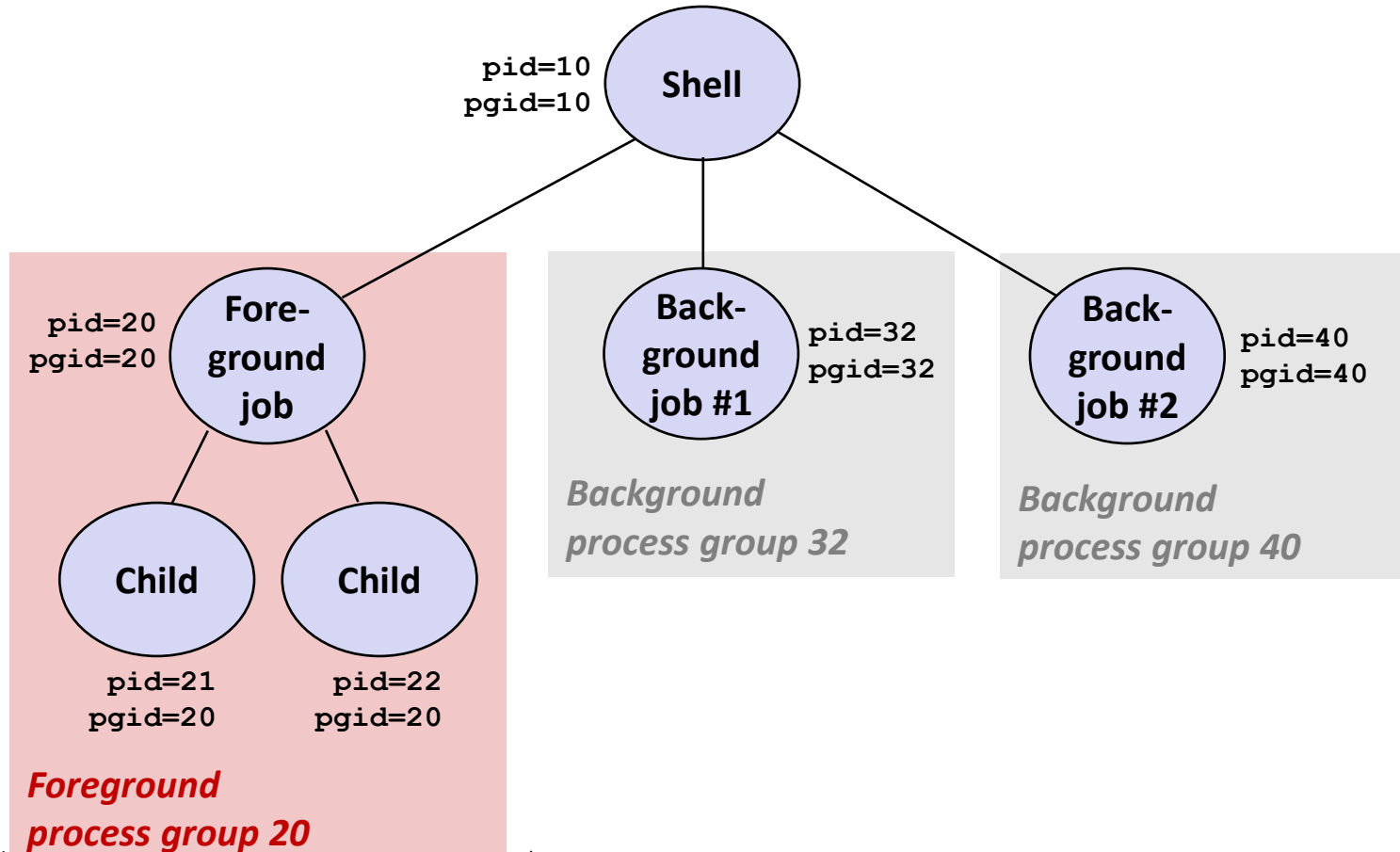
- `/bin/kill -9 24818`
Send SIGKILL to process 24818
- `/bin/kill -9 -24817`
Send SIGKILL to every process
in process group 24817

```
linux> ./forks 16
Child1: pid=24818 pgrp=24817
Child2: pid=24819 pgrp=24817

linux> ps
  PID TTY          TIME CMD
 24788 pts/2        00:00:00 tcsh
 24818 pts/2        00:00:02 forks
 24819 pts/2        00:00:02 forks
 24820 pts/2        00:00:00 ps
linux> /bin/kill -9 -24817
linux> ps
  PID TTY          TIME CMD
 24788 pts/2        00:00:00 tcsh
 24823 pts/2        00:00:00 ps
linux>
```

Sending Signals from the Keyboard

- Typing ctrl-c (ctrl-z) causes the kernel to send a SIGINT (SIGTSTP) to every job in the foreground process group.
 - SIGINT – default action is to terminate each process
 - SIGTSTP – default action is to stop (suspend) each process



Example of `ctrl-c` and `ctrl-z`

```
linux> ./forks 17
Child: pid=28108 pgrp=28107
Parent: pid=28107 pgrp=28107
<types ctrl-z>
Suspended
linux> ps w
```

PID	TTY	STAT	TIME	COMMAND
27699	pts/8	Ss	0:00	-tcsh
28107	pts/8	T	0:01	./forks 17
28108	pts/8	T	0:01	./forks 17
28109	pts/8	R+	0:00	ps w

```
linux> fg
./forks 17
<types ctrl-c>
linux> ps w
```

PID	TTY	STAT	TIME	COMMAND
27699	pts/8	Ss	0:00	-tcsh
28110	pts/8	R+	0:00	ps w

STAT (process state) Legend:

First letter:

S: sleeping

T: stopped

R: running

Second letter:

s: session leader

+: foreground proc group

See “man ps” for more details

Sending Signals with `kill` Function

```
void fork12()
{
    pid_t pid[N];
    int i;
    int child_status;

    for (i = 0; i < N; i++)
        if ((pid[i] = fork()) == 0) {
            /* Child: Infinite Loop */
            while(1)
                ;
        }

    for (i = 0; i < N; i++) {
        printf("Killing process %d\n", pid[i]);
        kill(pid[i], SIGINT);
    }

    for (i = 0; i < N; i++) {
        pid_t wpid = wait(&child_status);
        if (WIFEXITED(child_status))
            printf("Child %d terminated with exit status %d\n",
                    wpid, WEXITSTATUS(child_status));
        else
            printf("Child %d terminated abnormally\n", wpid);
    }
}
```

forks.c