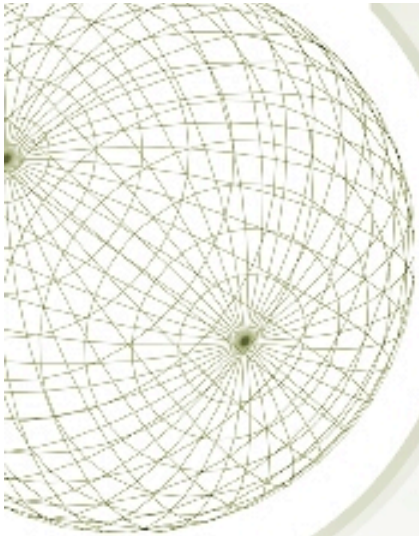

213 Recitation

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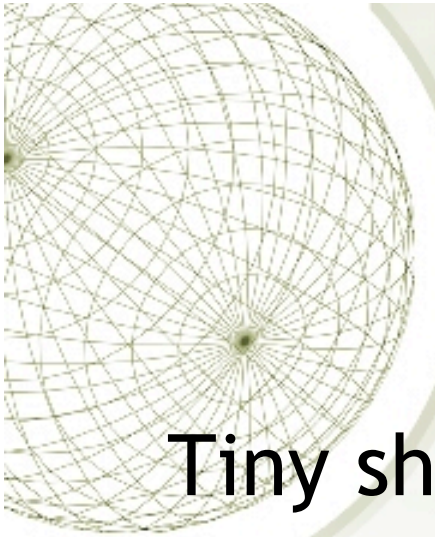
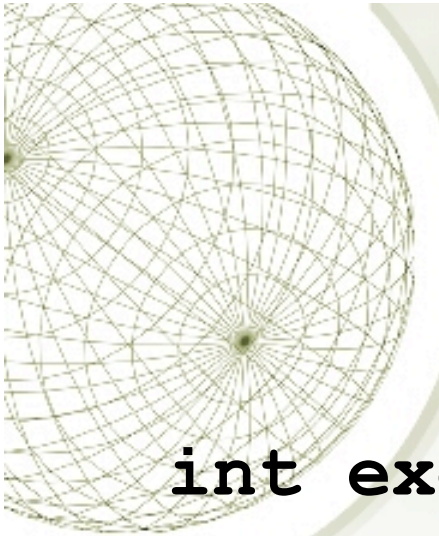


Outline

Tiny shell hints

- Executing programs
- Understanding process tree
- Reap all child processes
- Avoid race hazard
- I/O redirection



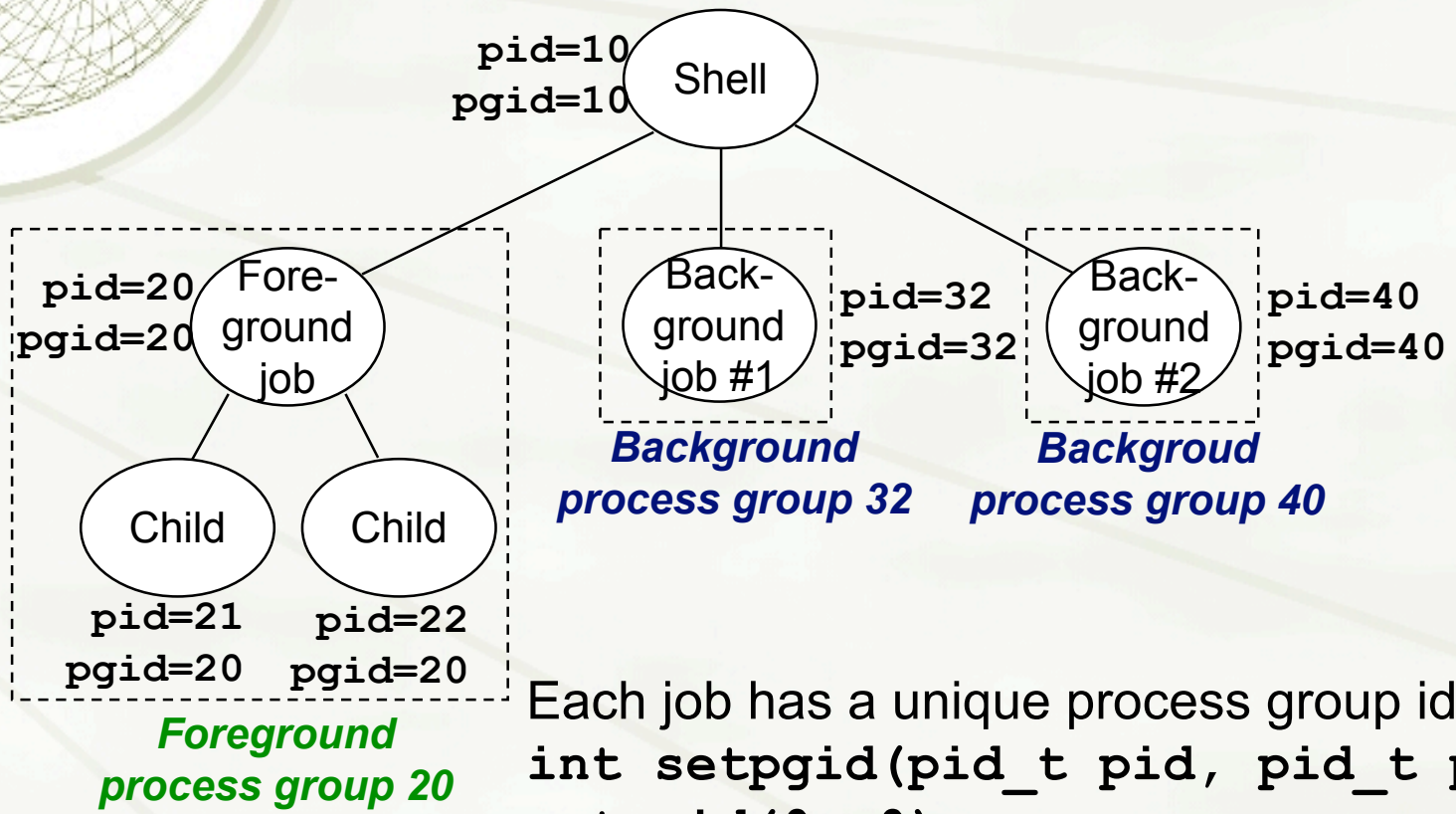
Execute program

```
int execve(const char *fname,
           char *const argv[],
           char *const envp[]);
```

Examples:

```
execve("/bin/ls", NULL, NULL);
execve("./mytest", argv, envp);
```

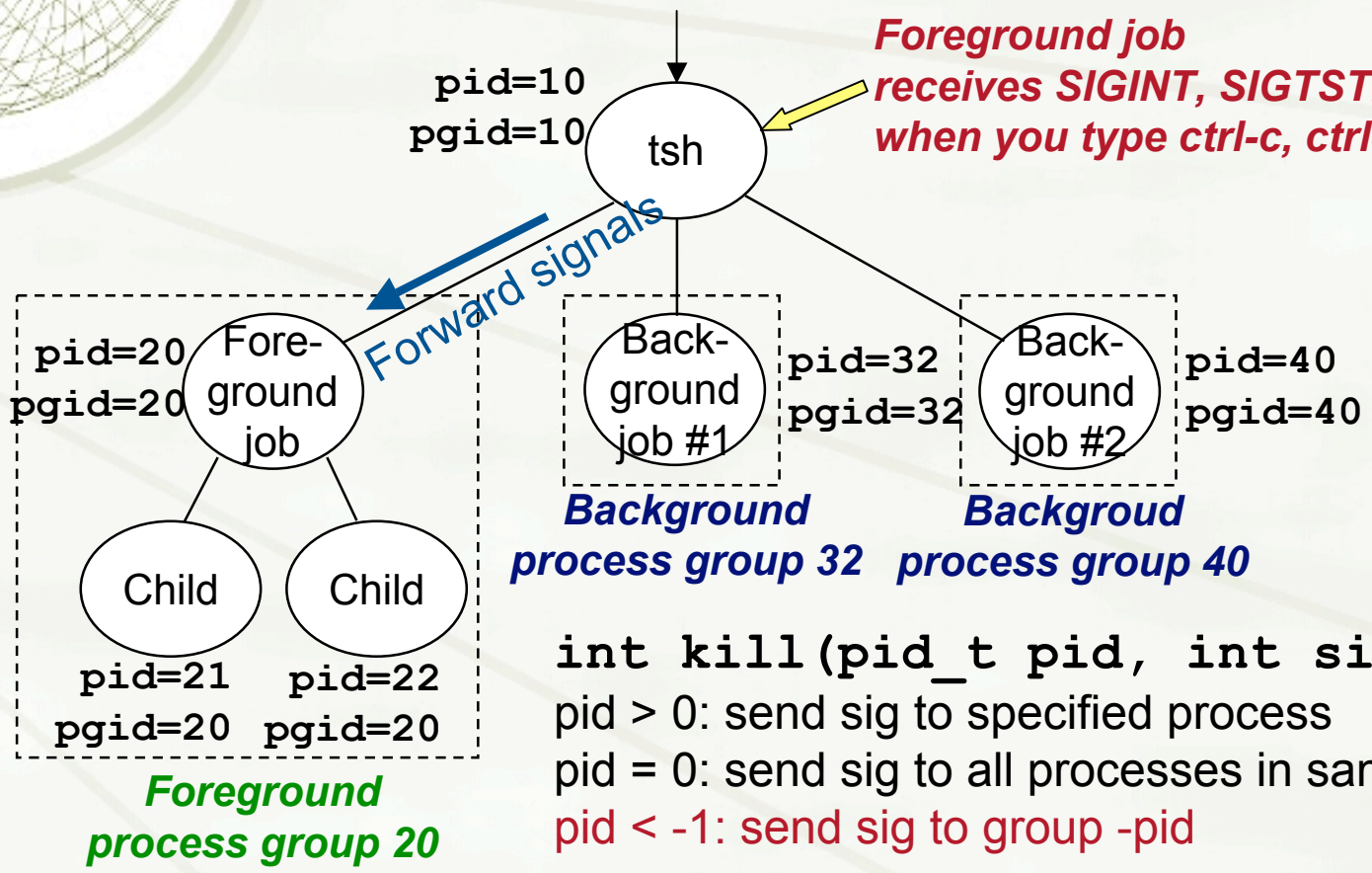
Process tree for a shell



Each job has a unique process group id

```
int setpgid(pid_t pid, pid_t pgid);
setpgid(0, 0);
```

Process tree for a shell

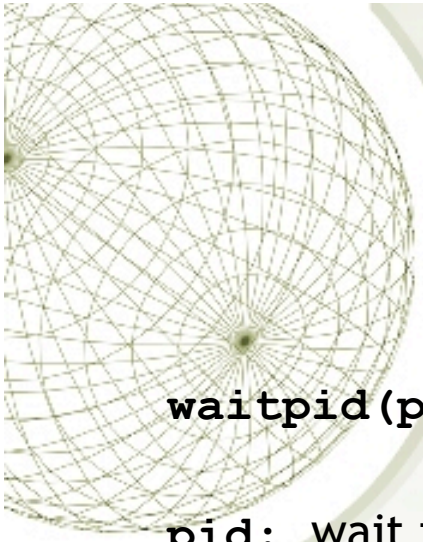



```
int kill(pid_t pid, int sig)
```

pid > 0: send sig to specified process

pid = 0: send sig to all processes in same group

pid < -1: send sig to group -pid



Reaping child process

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

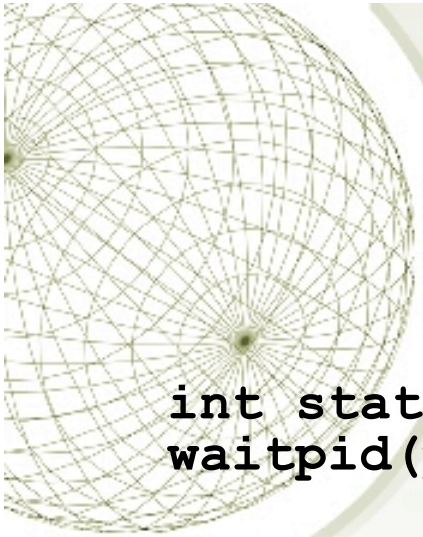
- **`pid:`** wait for child process with pid (process id or group id)
  - **`-1:`** wait for any child process

- **`status:`** tell why child terminated

- **`options:`**
  - **`WNOHANG:`** return immediately if no children zombied
  - **`WUNTRACED:`** report status of terminated or stopped children

In Lab 4, use:**`waitpid(-1, &status, WNOHANG|WUNTRACED)`**

In **`sigchld_handler()`**: **`while ((c_pid = waitpid(…)) > 0)`**



Reaping child process

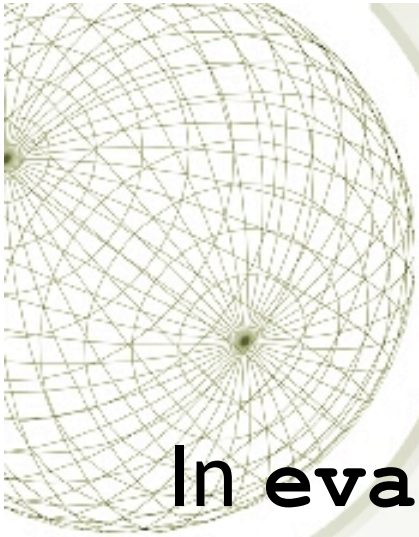
```
int status;
waitpid(pid, &status, WNOHANG|WUNTRACED)
```

What to check in sigchld_handler:

- **`WIFEXITED(status)`:**
  - child exited normally (the child finished, and quit normally on its own)
  - **`WEXITSTATUS(status)`:** returns code when child exits
- **`WIFSIGNALED(status)`:**
  - child exited because a signal is not caught (SIGINT, or typing CTRL-C)
  - **`WTERMSIG(status)`:** gives the terminating signal number
- **`WIFSTOPPED(status)`:**
  - child is stopped by the receipt of a signal (SIGSTOP, or typing CTRL-Z)
  - **`WSTOPSIG(status)`:** gives the stop signal number

Reaping child process

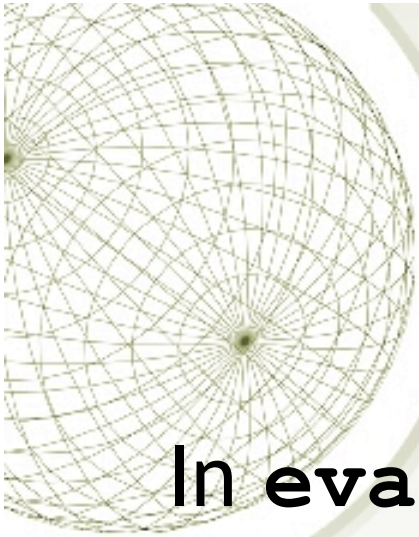
- Where to put **`waitpid(…)`**?
  - **`eval()`** vs. **`sigchld_handler()`**
- In **`sigchld_handler()`**: for both
- **`eval()`** should wait for a fg job



Busy wait for a fg job

In **eval()**:

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



Sleep

In **eval()**:

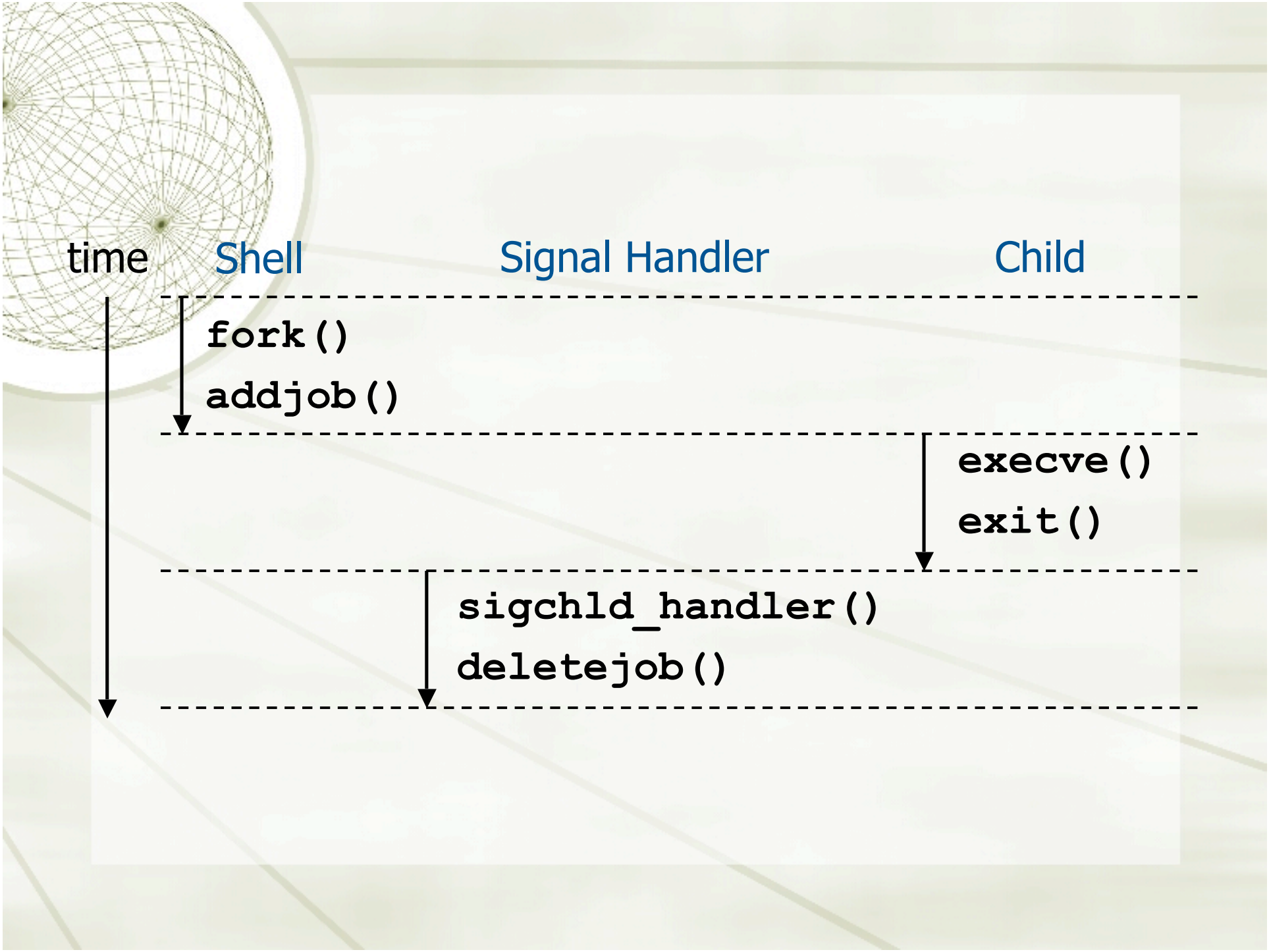
```
if(fork() != 0) { /* parent */
   addjob(…);
   while(fg process still alive){
      sleep(1);
   }
}
```

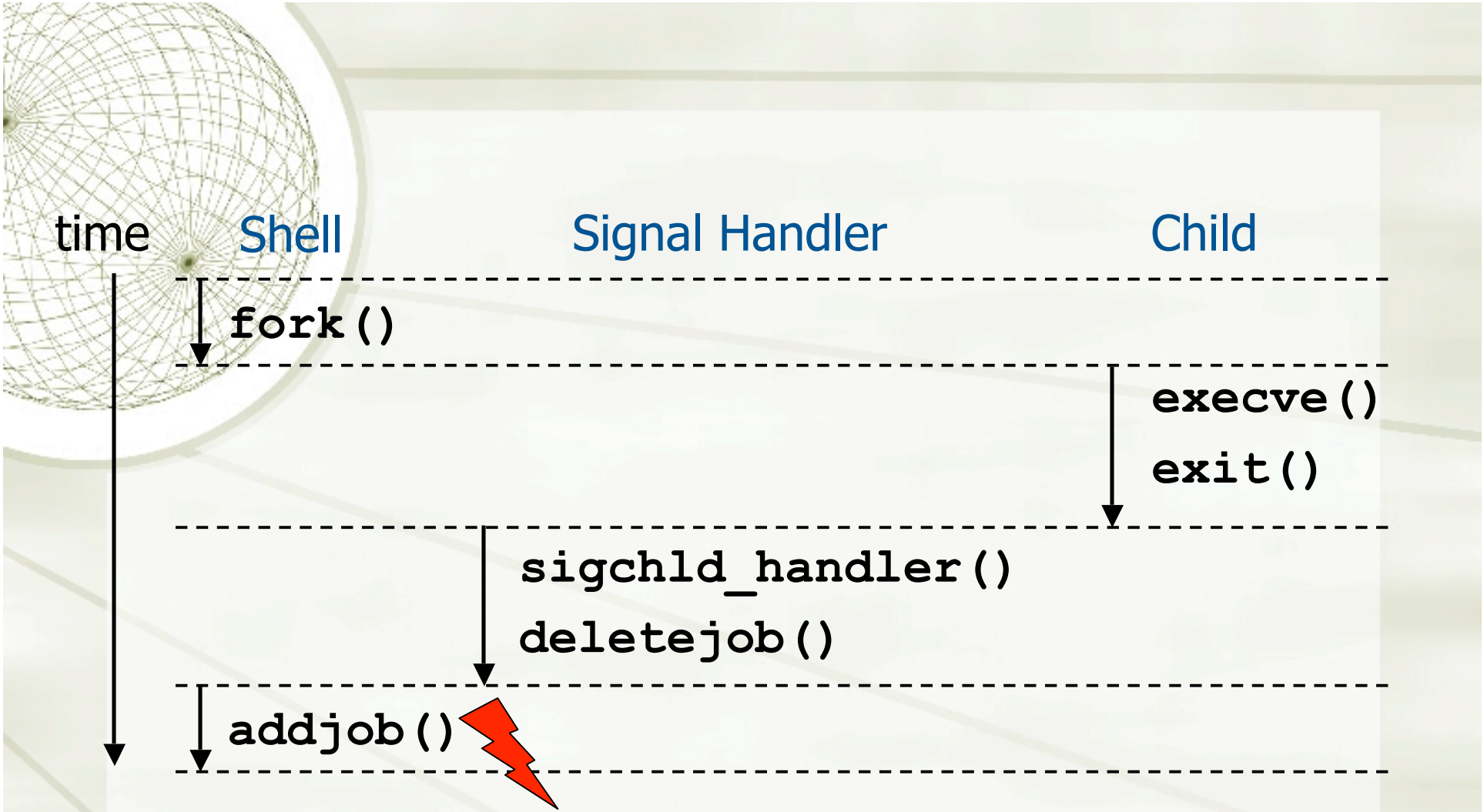
Race hazard

- 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.

An example of race hazard

```
sigchld_handler() {
  while ((pid = waitpid(…)) > 0){
    deletejob(pid);
  }
}
eval() {
  pid = fork();
  if(pid == 0)
  { /* child */
    execve(…);
  }
  /* parent */
  /* signal handler may run BEFORE addjob()*/
  addjob(…);
}
```


time
Shell
Signal Handler
Child
fork()
addjob()
execve()
exit()
sigchld_handler()
deletejob()



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

Solution: 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, …)
}
```

I/O redirection

- Do it before call execve() in child process

```
eval() {
  pid = fork();
  if(pid == 0)
  { /* child */
    /* Redirect I/O */
    if (redirect_input)
       dup2(…);/* redirect STDIN */
    if (redirect_output)
      dup2(…);/* redirect STDOUT */

    execve(…);
  }
  addjob(…);
}
```

dup2(int oldfd, int newfd)

- Covered in Chapter 11
  oldfd: old file descriptor
  newfd: new file descriptor
- Dup2 makes newfd be a copy of the oldfd

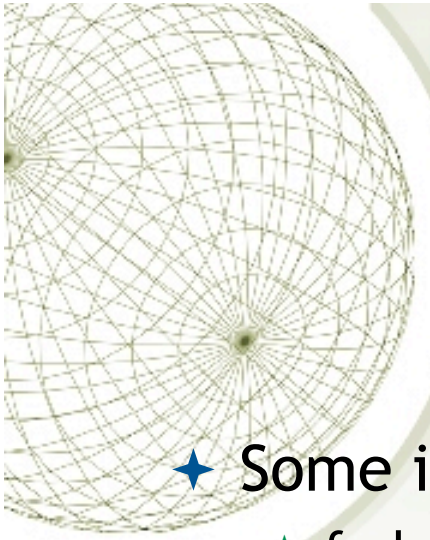
Some examples:

Get input from in_fd instead of standard input

```
dup2(in_fd, STDIN_FILENO);
```

Print output to out_fd instead of standard output

```
dup2(out_fd, STDOUT_FILENO);
```



Reminders

- Some important system calls:
  - fork, execve, waitpid, sigprocmask, setpgid, kill
  - Check man pages for details about system calls
    - man 2 kill
- Check return values of all system calls

- STEP by STEP
  - Test your shell by typing commands first
  - Each trace worth the same (work on easy ones first!)
- **Start tomorrow!**