Shells

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Multitasking (1)

- **System runs many processes concurrently.**
  - Process: executing program
    - State consists of memory image + register values + PC
  - Continually switches from one process to another
    - Suspend process when it needs I/O resource or timer event occurs
    - Resume process when I/O available or given scheduling priority
  - Appears to user(s) as if all processes executing simultaneously
    - Even though most systems can only execute one process at a time
    - Except possibly with lower performance than if running alone

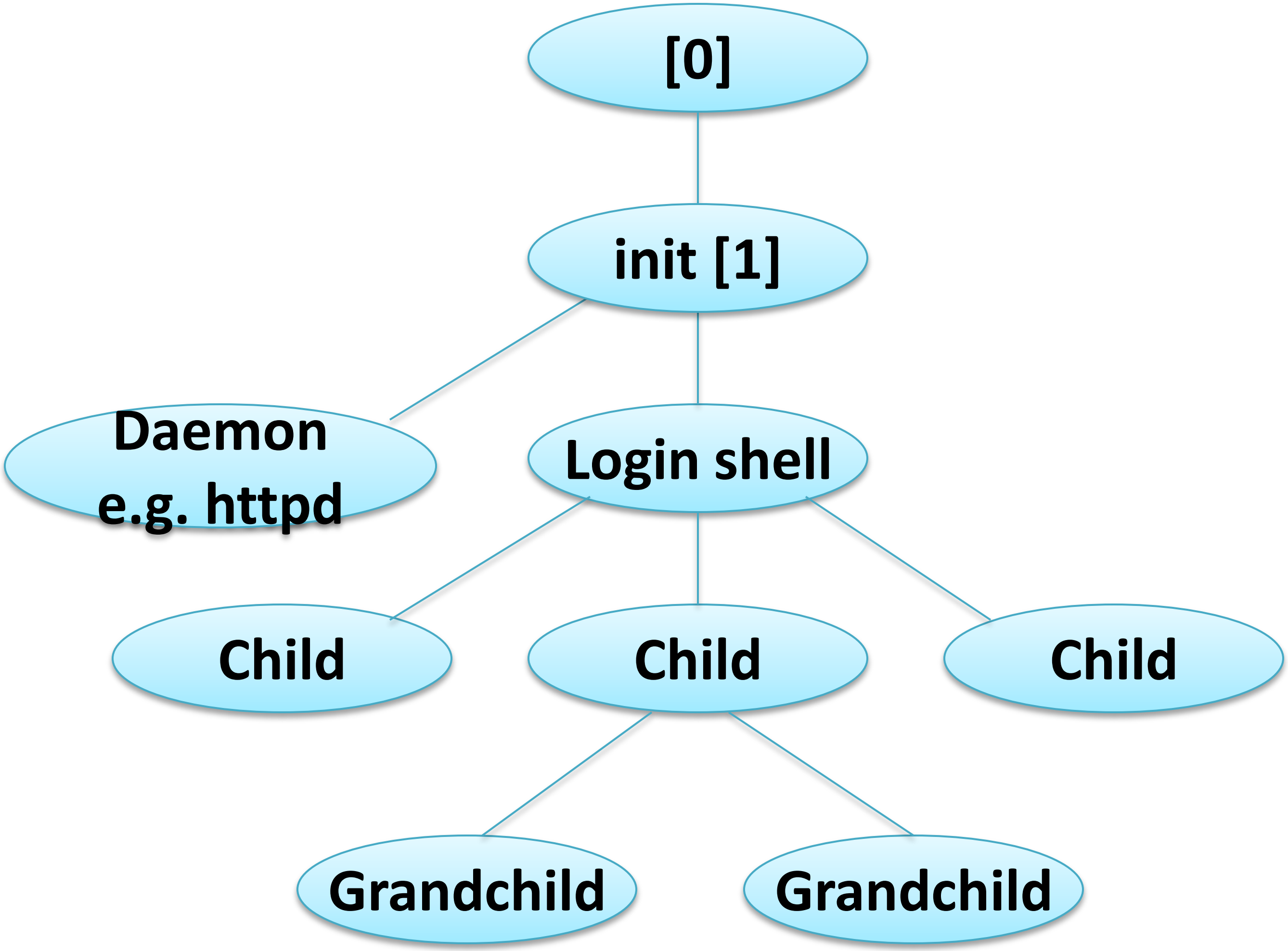
Multitasking (2)

- **Programmer's model of multitasking**
  - **fork()** spawns new process
    - Called once, returns twice
  - **exit()** terminates own process
    - Called once, never returns
    - Puts it into "zombie" status
  - **wait()** and **waitpid()** wait for and reap terminated children
  - **execl()** and **execve()** run a new program in an existing process
    - Called once, (normally) never returns

Multitasking (3)

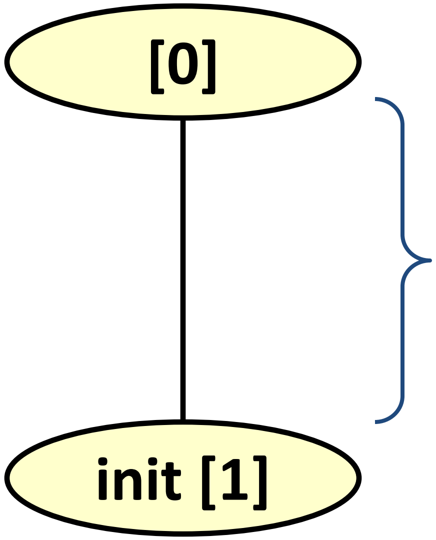
- **Programming Challenges**
  - Understanding the nonstandard semantics of the functions.
  - Avoiding improper use of system resources.
    - "Fork bombs"
    - Zombie processes not reaped by parents, etc.

Unix Process Hierarchy



Unix Startup: Step 1

1. Pushing reset button loads the PC with the address of a small bootstrap program.
2. Bootstrap program loads the boot block (disk block 0).
3. Boot block program loads kernel binary (e.g., /boot/vmlinux)
4. Boot block program passes control to kernel.
5. Kernel handcrafts the data structures for process 0.

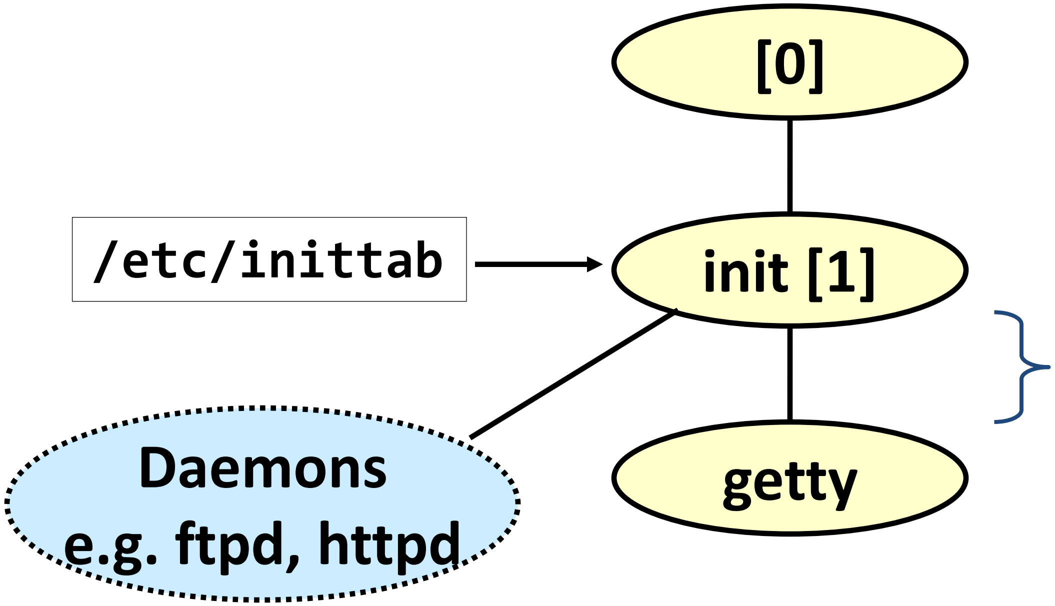


Process 0: handcrafted kernel process

Process 0 forks child process 1

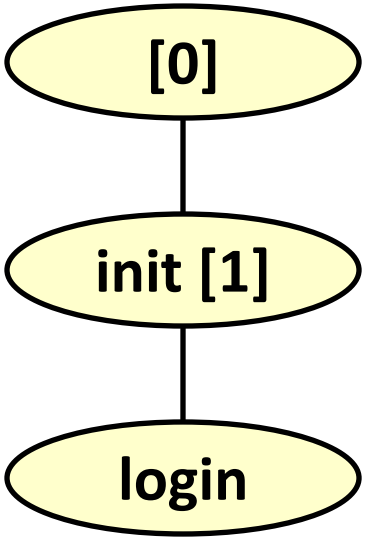
Child process 1 execs `/sbin/init`

Unix Startup: Step 2



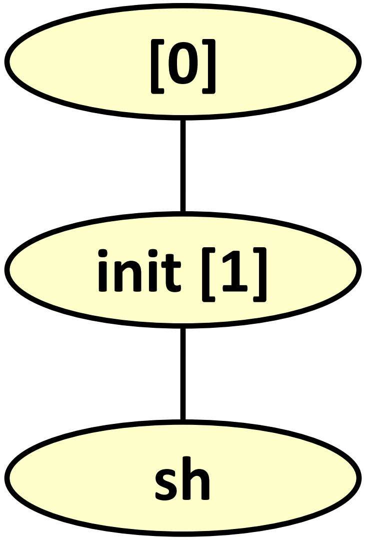
init forks and execs daemons per **/etc/inittab**, and forks and execs a **getty** program for the console

Unix Startup: Step 3



The **getty** process execs a **login** program

Unix Startup: Step 4



login reads login and passwd.
if OK, it execs a *shell*.
if not OK, it execs another getty

Shell

- **Definition**
  - An application program that runs programs on behalf of the user
    - sh: Original Unix Bourne Shell
    - csh: BSD Unix C Shell
    - tcsh: Enhanced C Shell
    - bash: Bourne-Again Shell

```
int main()
{
    char cmdline[MAXLINE];

    while (1) {
        /* read */
        printf("> ");
        fgets(cmdline, MAXLINE,
               stdin);
        if (feof(stdin))
            exit(0);

        /* evaluate */
        eval(cmdline);
    }
}
```

Execution is a sequence of read/evaluate steps

Simple Shell Example (1)

```
void eval(char *cmdline) {
    char *argv[MAXARGS]; /* argv for execve() */
    int bg;              /* should the job run in bg or fg? */
    pid_t pid;           /* process id */

    bg = parseline(cmdline, argv);
    if (!builtin_command(argv)) {
        if ((pid = fork()) == 0) {   /* child runs user job */
            if (execve(argv[0], argv, environ) < 0) {
                printf("%s: Command not found.\n", argv[0]);
                exit(0);
            }
        }
        if (!bg) {   /* parent waits for fg job to terminate */
           int status;
            if (waitpid(pid, &status, 0) < 0)
                unix_error("waitfg: waitpid error");
        }
        else         /* otherwise, don’t wait for bg job */
            printf("%d %s", pid, cmdline);
    }
}
```

Simple Shell Example (2)

- **Problem with Simple Shell example**
  - Shell correctly waits for and reaps foreground jobs.
  - But what about background jobs?
    - Will become zombies when they terminate.
    - Will never be reaped because shell (typically) will not terminate.
    - Creates a memory leak that will eventually crash the kernel when it runs out of memory.
- **Solution**
  - Reaping background jobs requires a mechanism called a signal.

Summary

- **Shell**
  - Command line interpreter
  - User-level program
  - Text vs. Graphical