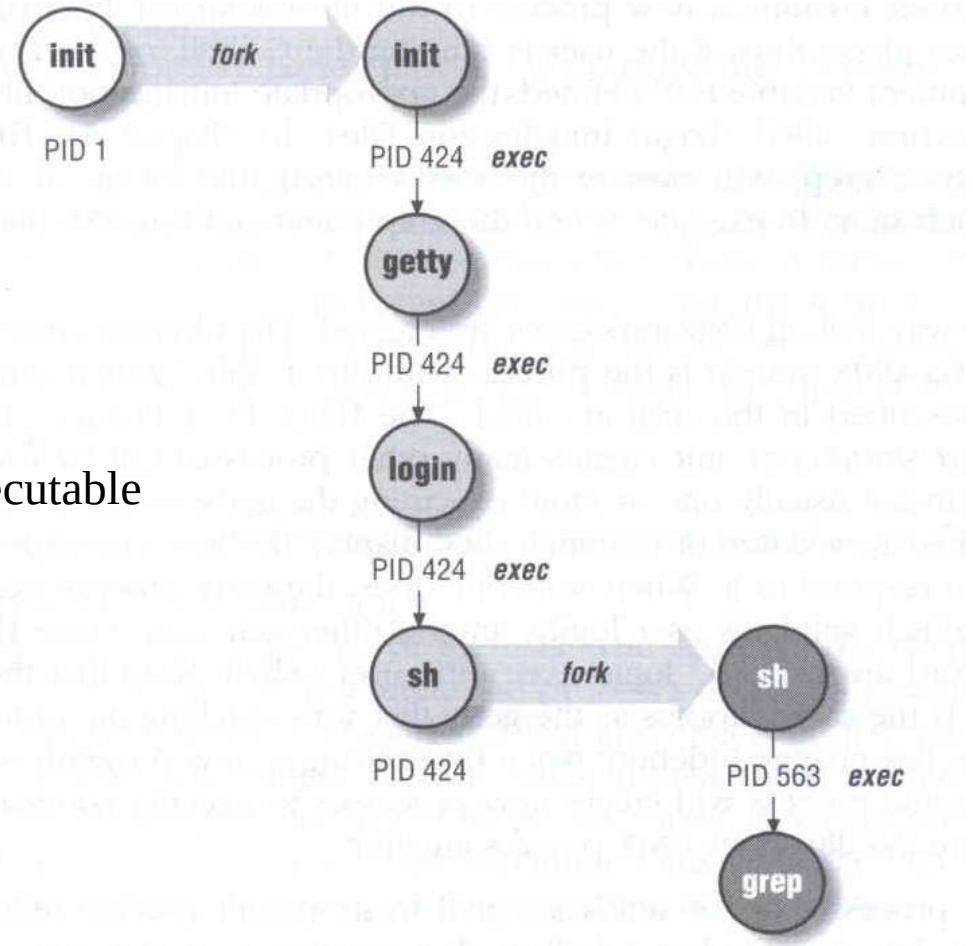
Chapter 6
Controlling Processes

Program to Process

- Program is dead
  - Just lie on disk
  - grep is a program
    - /usr/bin/grep
    - % file /usr/bin/grep
      - ELF 32-bit LSB executable
- When you execute it
  - It becomes a process
- Process is alive
  - It resides in memory



Components of a Process

- An address space in memory
  - Code and data of this process
- A set of data structures within the kernel
  - Used to monitor, schedule, trace, ..., this process
    - Owner, Group (Credentials)
    - Current status
    - VM space
    - Execution priority (scheduling info)
    - Information of used resource
    - Resource limits
    - Syscall vector
    - Signal actions

Attributes of the Process

- PID, PPID
  - Process ID and parent process ID
- UID, EUID
  - User ID and Effective user ID
- GID, EGID
  - Group ID and Effective group ID
- Niceness
  - The suggested priority of this process

Attributes of the process – PID and PPID

- PID – process id
  - Unique number assigned for each process in increasing order when they are created
- PPID – parent PID
  - The PID of the parent from which it was cloned
  - UNIX uses fork-and-exec model to create new process

```c
#include <stdio.h>
#include <unistd.h>

int main(void)
{
    int pid,i;

    pid = fork();
    if (pid == 0) {
        for (i=0;i<12;i++) {
            printf("I am a child process, my pid is %d, parent pid is %d\n",getpid(),getppid());
            sleep(1);
        }
        exit(1);
    }
    else if (pid > 0) {
        for (i=0;i<10;i++) {
            printf(" I am a parent process, my pid is %d, parent pid is %d\n",getpid(),getppid());
            sleep(1);
        }
    }
    else if (pid < 0)
        printf(" Sorry .....I can't fork my self\n");

    return 0;
}
```

Process Lifecycle

- fork
  - child has the same program context – fork(2)
- exec
  - child use exec to change the program context – execve(2)
- exit
  - child use _exit to tell kernel that it is ready to die and this death should be acknowledged by the child's parent – _exit(2)
- wait
  - parent use wait to wait for child's death
  - If parent died before child, this orphan process will have init as it's new parent – wait(2)

Attributes of the process – UID、GID、EUID and EGID

- UID, GID, EUID, EGID
  - The effective uid and gid can be used to enable or restrict the additional permissions
  - Effective uid will be set to
    - Real uid if setuid bit is off
    - The file owner's uid if setuid bit is on

Ex:

/etc/master.passwd is "root read-write only" and /usr/bin/passwd is a "setuid root" program

```
sabsd [/etc] -wutzh- ls -al | grep passwd
-rw-------   1 root  wheel      2946 Sep 24 00:26 master.passwd
-rw-r--r--   1 root  wheel      2706 Sep 24 00:26 passwd
sabsd [/usr/bin] -wutzh- ls -al /usr/bin/passwd
-r-sr-xr-x   2 root  wheel      5860 Sep 17 15:19 passwd
```

Signal

- A way of telling a process something has happened
- Signals can be sent
  - among processes as a means of communication
  - by the terminal driver to kill, interrupt, or suspend process
    - <Ctrl-C>、<Ctrl-Z>
    - bg, fg
  - by the administrator to achieve various results
    - With kill
  - by the kernel when a process violate the rules, such as divide by zero

Signal – Actions when receiving signal

- Depend on whether there is a designated handler routine for that signal
  1. If yes, the handler is called
  2. If no, the kernel takes some default action
- "Catching" the signal
  - Specify a handler routine for a signal within a program
- Two ways to prevent signals from arriving
  1. Ignored
     - Just discard it and there is no effect to process
  2. Blocked
     - Queue for delivery until unblocked
     - The handler for a newly unblocked signal is called only once

Signal – FreeBSD signals

- signal(3) or see /usr/include/sys/signal.h

FreeBSD

#	Name	Description	Default	Catch	Block	Dump core
1	SIGHUP	Hangup	Terminate	☑	☑	⊘
2	SIGINT	Interrupt (^C)	Terminate	☑	☑	⊘
3	SIGQUIT	Quit	Terminate	☑	☑	☑
9	SIGKILL	Kill	Terminate	⊘	⊘	⊘
10	SIGBUS	Bus error	Terminate	☑	☑	☑
11	SIGSEGV	Segmentation fault	Terminate	☑	☑	☑
15	SIGTERM	Soft. termination	Terminate	☑	☑	⊘
17	SIGSTOP	Stop	Stop	⊘	⊘	⊘
18	SIGTSTP	Stop from tty (^Z)	Stop	☑	☑	⊘
19	SIGCONT	Continue after stop	Ignore	☑	⊘	⊘

Signal – Send signals: kill

- kill(1) – terminate or signal a process
- % kill [-signal] pid
  - Ex:
    - First, find out the pid you want to kill
      (ps, top, sockstat, lsof…)
    - % kill –l (list all available signals)
    - % kill 49222
    - % kill –TERM 49222
    - % kill –15 49222
  - killall(1)
    - kill processes by name
    - % killall tcsh
    - % killall -u wutzh

Niceness

- How kindly of you when contending CPU time
  - High nice value ➔ low priority
- Inherent Property
  - A newly created process inherits the nice value of its parent
    - Prevent processes with low priority from bearing high-priority children
- Root has complete freedom in setting nice value
  - Use nice to start a high-priority shell to beat berserk process

Niceness – nice and renice

- nice format
  - OS nice : % /usr/bin/nice [range] utility [argument]
  - csh nice : % nice [range] utility [argument]
    - % nice +10 ps -l
- renice format
  - % renice [prio | -n incr] [–p pid] [–g gid] [-u user]
    - % renice 15 –u wutzh

System	Prio. Range	OS nice	csh nice	renice
FreeBSD	-20 ~ 20	-incr | -n incr	+prio | -prio	prio | -n incr
Red Hat	-20 ~ 20	-incr | -n incr	+prio | -prio	prio
Solaris	0 ~ 39	-incr | -n incr	+incr | -incr	prio | -n incr
SunOS	-20 ~ 19	-incr	+prio | -prio	prio

Process States

- man ps and see "state" keyword

State	Meaning
I	Idle
R	Runnable
S	Sleeping
T	Stopped
Z	Zombie
D	in Disk

ps command (BSD、Linux)

- ps

```
sabsd [/home/wutzh] -wutzh- ps
  PID  TT  STAT      TIME COMMAND
52363  p0  Ss     0:00.01 -tcsh (tcsh)
52369  p0  R+     0:00.00 ps
```

- ps aux

```
sabsd [/home/wutzh] -wutzh- ps aux
USER       PID %CPU %MEM   VSZ   RSS  TT  STAT STARTED      TIME COMMAND
wutzh    52362  0.0  0.4  6536  3852  ??  S     5:02PM   0:00.01 sshd: wutzh@ttyp0 (sshd)
root     52380  0.0  0.3  3756  3224  ??  Ss    5:08PM   0:00.00 sendmail: accepting connections (s
smmsp    52384  0.0  0.3  3644  2968  ??  Ss    5:08PM   0:00.00 sendmail: Queue runner@00:30:00 fo
```

- ps auxww

```
sabsd [/home/wutzh] -wutzh- ps auxww
USER       PID %CPU %MEM   VSZ   RSS  TT  STAT STARTED      TIME COMMAND
wutzh    52362  0.0  0.4  6536  3864  ??  S     5:02PM   0:00.02 sshd: wutzh@ttyp0 (sshd)
root     52380  0.0  0.3  3756  3224  ??  Ss    5:08PM   0:00.00 sendmail: accepting connections (sendmail)
smmsp    52384  0.0  0.3  3644  2968  ??  Ss    5:08PM   0:00.00 sendmail: Queue runner@00:30:00 for
/var/spool/clientmqueue (sendmail)
```

ps command – Explanation of ps –aux (BSD、Linux)

Field	Contents
USER	Username of the process's owner
PID	Process ID
%CPU	Percentage of the CPU this process is using
%MEM	Percentage of real memory this process is using
VSZ	Virtual size of the process, in kilobytes
RSS	Resident set size (number of 1K pages in memory)
TT	Control terminal ID
STAT	Current process status: R = Runnable D = In disk (or short-term) wait I = Sleeping (> 20 sec) S = Sleeping (< 20 sec) T = Stopped Z = Zombie Additional Flags: > = Process has higher than normal priority N = Process has lower than normal priority < = Process is exceeding soft limit on memory use A = Process has requested random page replacement S = Process has asked for FIFO page replacement V = Process is suspended during a **vfork** E = Process is trying to **exit** L = Some pages are locked in core X = Process is being traced or debugged s = Process is a session leader (head of control terminal) W = Process is swapped out + = Process is in the foreground of its control terminal
STARTED	Time the process was started
TIME	CPU time the process has consumed
COMMAND	Command name and arguments[a]

ps command (BSD、Linux)

Use these options with shell scripts

- ps −j

```
sabsd [/home/wutzh] -wutzh- ps -j
USER     PID  PPID  PGID   SID JOBC STAT  TT       TIME COMMAND
wutzh 52363 52362 52363 52363    0 Ss    p0    0:00.03 -tcsh (tcsh)
wutzh 52458 52363 52458 52363    1 R+    p0    0:00.00 ps -j
```

- ps −o

```
sabsd [/home/wutzh] -wutzh- ps -o uid,pid,ppid,%cpu,%mem,command
  UID   PID  PPID %CPU %MEM COMMAND
 1001 52363 52362  0.0  0.3 -tcsh (tcsh)
 1001 52462 52363  0.0  0.1 ps -o uid,pid,ppid,%cpu,%mem,command
```

- ps -L

```
sabsd [/home/wutzh] -wutzh- ps -L
%cpu %mem acflag acflg args blocked caught comm command cpu cputime emuletime f
flags ignored inblk inblock jid jobc ktrace label lim lockname login logname
lstart lwp majflt minflt msgrcv msgsnd mwchan ni nice nivcsw nlwp nsignals nsigs
nswap nvcsw nwchan oublk oublock paddr pagein pcpu pending pgid pid pmem ppid pri
re rgid rgroup rss rtprio ruid ruser sid sig sigcatch sigignore sigmask sl start
stat state svgid svuid tdev time tpgid tsid tsiz tt tty ucomm uid upr uprocp user
usrpri vsize vsz wchan xstat
```

top command

```
last pid: 52477;  load averages:  0.01,  0.05,  0.02        up 0+19:38:37  17:23:38
29 processes:  1 running, 28 sleeping
CPU states:  0.4% user,  0.0% nice,  0.0% system,  0.0% interrupt, 99.6% idle
Mem: 19M Active, 308M Inact, 113M Wired, 88K Cache, 111M Buf, 556M Free
Swap: 1024M Total, 1024M Free

  PID USERNAME      THR PRI NICE   SIZE    RES STATE    TIME   WCPU COMMAND
  697 root            1  76    0  3784K  2728K select   0:02  0.00% sshd
  565 root            1  76    0  1468K  1068K select   0:00  0.00% syslogd
  704 root            1   8    0  1484K  1168K nanslp   0:00  0.00% cron
```

- Various usage
  - top –q — run top and renice it to -20
  - top –u — don't map uid to username
  - top –U*username* — show process owned by user
- Interactive command
  - o — change display order (cpu, res, size, time)
  - u — show only processes owned by user ("+" means all)
  - ? — Listing available options

Runaway process

- Processes that use up excessive system resource or just go berserk
  - kill –TERM for unknown process
  - renice it to a higher nice value for reasonable process