

Controlling Processes

tsaimh (2022-2023, CC BY-SA)

wangth (2017-2021, CC BY-SA)

? (1996-2016)

國立陽明交通大學資工系資訊中心

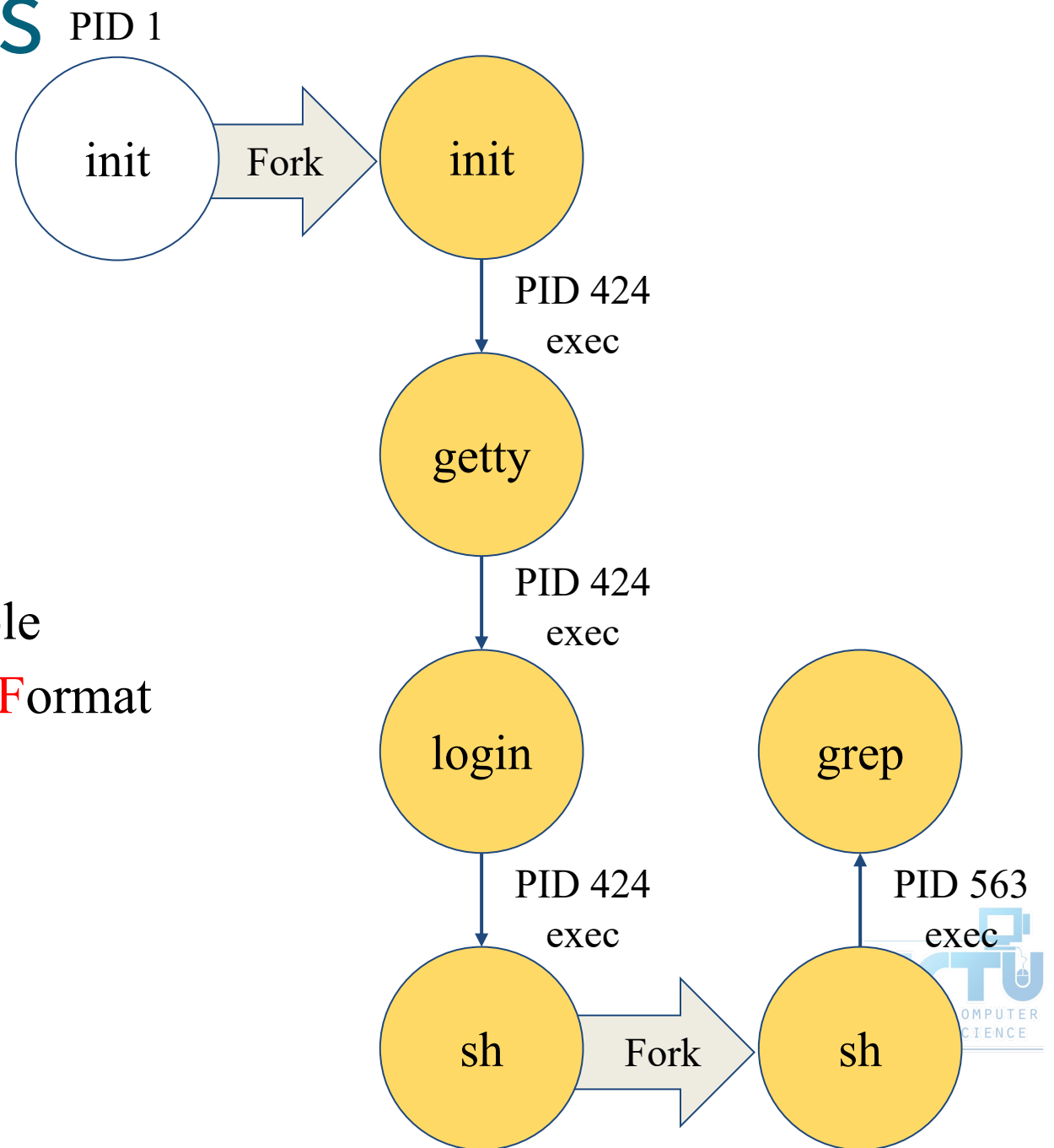
Information Technology Center of Department of Computer Science, NYCU

Handbook and Manual pages

- Official guide and be found at
 - <https://www.freebsd.org/doc/en/books/handbook/basics-processes.html>
 - https://www.freebsd.org/doc/zh_TW/books/handbook/basics-processes.html

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
 - Executable and Linkable Format
- 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

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
int main(){
    int pid, i;

    pid = fork();
    if(pid ==0) {
        for (int i=0; i<5; i++)
        {
            printf("I am child, pid is %d, ppid is %d\n",
                getpid(), getppid());

            sleep(1);
        }
        exit(1);
    }else if (pid >0) {
        for (int i=0; i<5; i++)
        {
            printf("I am parent, pid is %d, ppid is %d\n",
                getpid(),getppid());

            sleep(1);
        }
    }else if (pid < 0)
        printf("Something wrong while forking\n");
    return 0;
}
```

```
I am parent, pid is 1485, ppid is 1125
I am child, pid is 1486, ppid is 1485
I am parent, pid is 1485, ppid is 1125
I am child, pid is 1486, ppid is 1485
I am parent, pid is 1485, ppid is 1125
I am child, pid is 1486, ppid is 1485
I am child, pid is 1486, ppid is 1485
I am parent, pid is 1485, ppid is 1125
I am child, pid is 1486, ppid is 1485
I am parent, pid is 1485, ppid is 1125
```

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

```
% ls -al /etc | 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
% 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\(1\)](#)
 - By the kernel when a process violate the rules
 - divide by zero
 - Illegal memory access

Signal – Actions when receiving signal

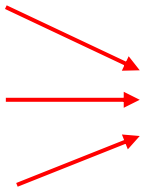
- Depend on whether there is a designated handler routine for that signal
 - If yes, the handler is called
 - If no, the kernel takes some default action
- "Catching" the signal
 - Specify a handler routine for a signal within a program
- Two ways to prevent signals from arriving
 - Ignored
 - Just discard it and there is no effect to process
 - 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 tsaimh
- the same
- 

Niceness

- How kindly of you when contending CPU time
 - High nice value → low priority
 - Related to CPU time quantum
- 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\(1\)](#) format
 - OS nice : `$ /usr/bin/nice [range] utility [argument]`
 - csh nice(built-in) : `$ nice [range] utility [argument]`
 - `$ nice +10 ps -l`
- [renice\(8\)](#) format
 - `$ renice [prio | -n incr] [-p pid] [-g gid] [-u user]`
 - `$ renice 15 -u chwong`

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

cpuset command (1/2)

- A system may have more than one CPU core
- How many CPU resource a process can use
- [cpuset\(1\)](#)

cpuset command (2/2)

- To see how many CPUs on your machine

- \$ cpuset -g

```
$ cpuset -g  
pid -1 mask: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15
```

- Run commands with less CPUs

- \$ cpuset -l cpus cmd

```
$ cpuset -l 8-15 ./hw1.out
```

- Change number of CPUs for current processes

- \$ cpuset -l cpus -p pid

```
$ cpuset -l 8-15 -p 5566
```

- Combine with nice

- \$ cpuset -l 8-15 /usr/bin/nice -n 20 cmd

Process States

- man "ps" and see "state" keyword

State	Meaning
I	Idle (20+ second)
R	Runnable
S	Sleeping (~20 second)
T	Stopped
Z	Zombie
D	in Disk

ps command (BSD 、 Linux)

- ps

```
$ ps
  PID TT  STAT      TIME COMMAND
52363 p0  Ss      0:00.01 -tcsh (tcsh)
52369 p0  R+      0:00.00 ps
```

- ps aux

```
$ ps aux
USER          PID %CPU %MEM    VSZ   RSS  TT  STAT STARTED      TIME COMMAND
tsaimh      52362  0.0  0.4  6536  3852  ??   S    5:02PM    0:00.01 sshd: tsaimh@tty0 (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

```
$ ps auxww
USER          PID %CPU %MEM    VSZ   RSS  TT  STAT STARTED      TIME COMMAND
tsaimh      52362  0.0  0.4  6536  3864  ??   S    5:02PM    0:00.02 sshd: tsaimh@tty0 (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 process's owner
PID	Process ID
%CPU	Percentage of the CPU this process is using
%MEM	Percentage of the real memory this process is using
VSZ	Virtual size of process, in kilobytes
RSS	Resident set size (number of 1K pages in memory)
TT	Control terminal ID
STAT	Current process status: <ul style="list-style-type: none">• R = Runnable• I = Sleeping (> 20 sec)• S = Sleeping (< 20 Sec)• T = Stopped• D = In disk (or short-term) wait• Z = Zombie
	Additional Flags: <ul style="list-style-type: none">• > = Process has higher than normal priority• N = Process has lower than normal priority• < = Process is exceeding soft limit on memory ues• 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 ro debugged• s = Process is a session leader (head of controller 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

ps command (BSD 、 Linux)

- **ps -j**

*Use these options in shell scripts

```
$ ps -j
USER      PID  PPID  PGID   SID  JOBC  STAT  TT      TIME  COMMAND
tsaimh 52363 52362 52363 52363    0  Ss    p0      0:00.03 -tcsh (tcsh)
tsaimh 52458 52363 52458 52363    1  R+    p0      0:00.00 ps -j
```

- **ps -o**

```
$ 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**

```
$ 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 oublek oublek 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)
- m show IO information
- ? Listing available options

htop command

```
1 [ | 0.7%] Tasks: 41, 0 thr; 1 running
2 [ 0.0%] Load average: 0.12 0.12 0.11
3 [ 0.0%] Uptime: 5 days, 07:53:08
4 [ 0.0%]
Mem[|||||] 414/4071MB
Swp[ 0/1023MB]

PID USER PRI NI VIRT RES SHR S CPU% MEM% TIME+ Command
822 root 144 0 14512 2076 0 S 0.0 0.0 0:00.00 | /usr/libexec/getty Pc ttyv3
821 root 144 0 14512 2076 0 S 0.0 0.0 0:00.00 | /usr/libexec/getty Pc ttyv2
820 root 144 0 14512 2076 0 S 0.0 0.0 0:00.00 | /usr/libexec/getty Pc ttyv1
819 root 145 0 14512 2076 0 S 0.0 0.0 0:00.00 | /usr/libexec/getty Pc ttyv0
817 root 120 0 14532 2092 0 S 0.0 0.1 0:00.42 | /usr/sbin/automountd
809 root 120 0 14532 2108 0 S 0.0 0.1 0:22.28 | /usr/sbin/autounmountd
804 root 120 0 54436 15108 0 S 0.0 0.4 0:54.36 | /usr/sbin/bsnmpd -p /var/run/snmpd.pid
789 root 120 0 18736 2864 0 S 0.0 0.1 0:06.17 | /usr/sbin/inetd -wW -C 60
763 root 120 0 16616 2336 0 S 0.0 0.1 0:03.28 | /usr/sbin/cron -s
759 root 120 0 61224 7024 0 S 0.0 0.2 0:00.23 | /usr/sbin/sshd
88530 root 137 0 86492 10996 0 S 0.0 0.3 0:00.14 | sshd: chchang2222 [priv]
88535 chchang22 120 0 86492 11032 0 S 0.0 0.3 0:00.00 |   | sshd: chchang2222@pts/1
88536 chchang22 120 0 17848 4960 0 S 0.0 0.1 0:00.14 |   | /bin/bash -l
42469 root 120 0 90588 11088 0 S 0.0 0.3 0:01.09 | sshd: tawei [priv]

lp F2Setup F3Search F4Filter F5Sorted F6Collap F7Nice -F8Nice +F9Kill F10Quit
```

- A better top
 - Install it from sysutils/htop

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

Appendix

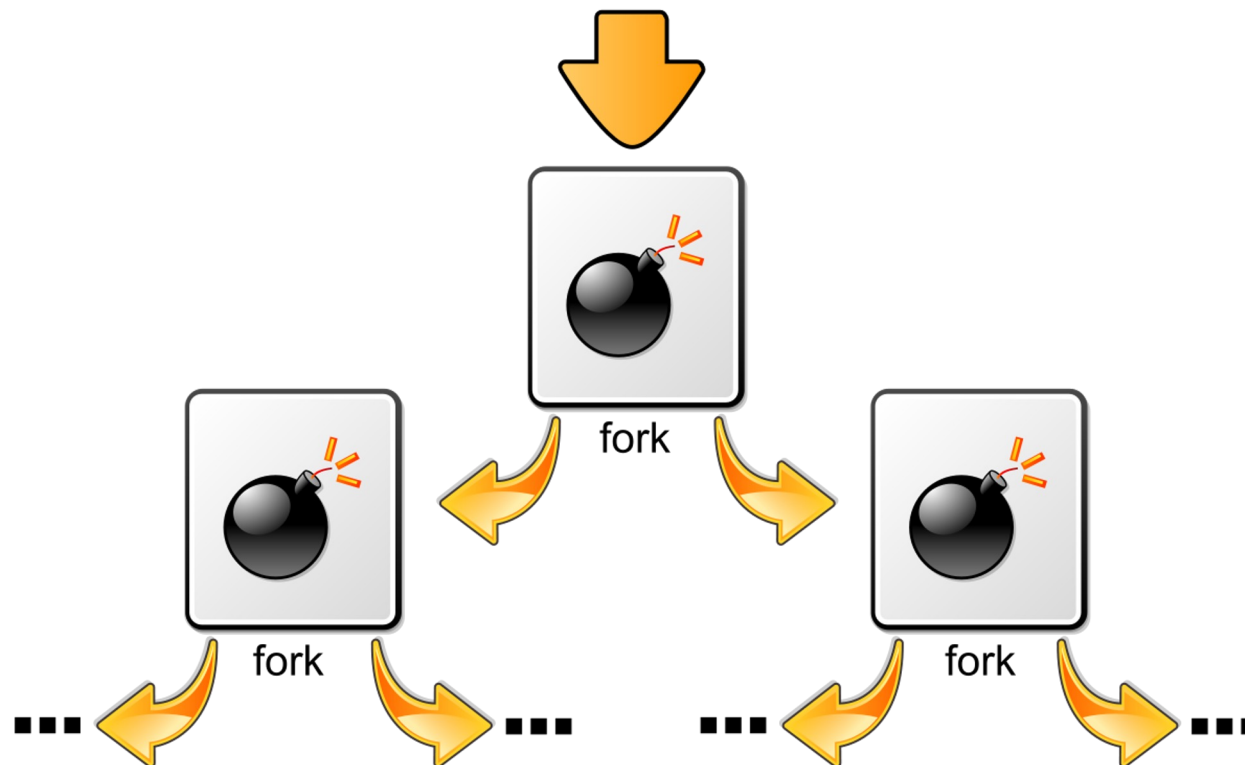
Fork Bomb

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Information Technology Center of Department of Computer Science, NYCU

Fork Bomb

- A process forking out of control



Cited from [wiki](#)

Fork Bomb

- A process forking out of control

```
last pid: 14928; load averages: 53.07, 53.10, 53.08
210 processes: 55 running, 154 sleeping, 1 zombie
CPU:  0.0% user, 49.7% nice,  0.1% system,  0.0% interrupt, 50.1% idle
Mem:  38M Active, 760M Inact, 2904M Wired, 40K Cache, 255M Buf, 4220M Free
ARC:  2047M Total, 572M MFU, 897M MRU, 16K Anon, 16M Header, 562M Other
Swap: 4096M Total, 4096M Free
```

PID	USERNAME	THR	PRI	NICE	SIZE	RES	STATE	C	TIME	WCPU	COMMAND
4224		1	97	20	19760K	2924K	RUN	11	65:04	16.70%	fork1
4241		1	96	20	19760K	2924K	RUN	8	64:37	16.06%	fork1
4220		1	96	20	19760K	2924K	RUN	8	65:05	15.97%	fork1
6332		1	96	20	19760K	2924K	RUN	10	105:20	15.87%	fork1
4087		1	96	20	19760K	2924K	RUN	11	66:08	15.87%	fork1
4054		1	96	20	19760K	2924K	RUN	15	67:43	15.67%	fork1
4086		1	96	20	19760K	2924K	RUN	10	66:30	15.67%	fork1
6329		1	96	20	19760K	2924K	RUN	13	105:17	15.58%	fork1
4090		1	96	20	19760K	2924K	RUN	12	66:28	15.58%	fork1
4244		1	96	20	19760K	2924K	RUN	13	64:51	15.58%	fork1
4001		1	96	20	19760K	2924K	RUN	13	68:11	15.48%	fork1
4084		1	96	20	19760K	2924K	CPU13	13	66:24	15.48%	fork1
4242		1	96	20	19760K	2924K	RUN	13	65:04	15.48%	fork1
4225		1	96	20	19760K	2924K	RUN	9	65:00	15.48%	fork1
4221		1	96	20	19760K	2924K	RUN	11	64:52	15.48%	fork1
4243		1	96	20	19760K	2924K	RUN	8	64:48	15.48%	fork1

Fork Bomb –

How to create a fork bomb

- C/C++

```
#include <unistd.h>

int main(void) {
    while(1)
        fork();
    return 0;
}
```

- Perl

```
fork while fork
```

- Windows

```
%0 | %0
```

- Bash (Shell script)

```
:(){ :|:& };;:
```

```
# Define function
forkbomb() {
    # Run twice with pipe
    forkbomb|forkbomb &
}
;
# Start the fork bomb
forkbomb
```

DON'T DO THAT!!!!

Fork Bomb (1/2)

- How to deal with fork bomb
 - Just kill all of them
 - `$ killall -KILL bombName`
- When you have no more resource to fork your shell
 - `$ exec killall -KILL bombName`
 - That shell will become "killall", and never goes back
- "killall" isn't an atomic command
 - More bombs may be created when killing them
 - Run multiple "killall"

Fork Bomb (2/2)

- Prevent fork bomb
 - Limit the maximum number of processes for a specific user
- /etc/login.conf

```
43      :maxproc-cur=256:\n44      :maxproc-max=512:\n
```