Controlling Processes and the File System

Portions courtesy Ellen Liu

Outline

- Controlling processes (2)
  - Signals and the `kill` command
  - Process monitoring: states, niceness, memory, `ps`, `top`, `uptime`
- The Filesystem
  - Pathnames
  - Mounting and umounting filesystems
  - File tree organization
  - File types

Signals

- Process-level interrupt requests
- Dozens of them, use "`kill -l`" to list them
- They can be sent
  - among processes as a means to communicate
  - by terminal to kill, interrupt, suspend processes
  - by kernel when encountering e.g., division by zero
  - by kernel to notify. e.g., data arrived on an I/O channel

Upon Receiving a Signal

- A process can "catch it", i.e., designate a signal handler routine to handle it
  - Handler is called. Upon completion, resume (continue) process execution
- A process can also request to block (and then unblock) or ignore signals.
- Otherwise, kernel takes default actions on behalf of the process
  - Generate core dump, or terminate the process

Core dump: a process' memory image, for debugging

Common Signals

#	Name	Description
2	INT	Interrupt (when type ctrl-C)
3	QUIT	Quit
9	KILL	Kill
11	SEGV	Segmentation fault
15	TERM	Software termination

….

The `Kill` Command: Send Signals

- Can send any signals to a process by process owner or the superuser

  `$kill 8021` 8021 is the PID

- Default is the SIGTERM, i.e., `kill -TERM`
- SIGTERM may not always terminate a process, `kill -9 8081` sends SIGKILL
  - SIGTERM may be blocked by a process
  - SIGKILL is a signal that can’t be blocked by processes

Process States

- **Runnable:** The process can be executed
- **Sleeping:** The process is waiting for some resources
- **Zombie:** terminated but not reaped by its parent
- **Stopped:** The process is suspended (not allowed to execute) or traced

Use the “ps” command to view a process’ state

Nice and Renice: Scheduling Priority

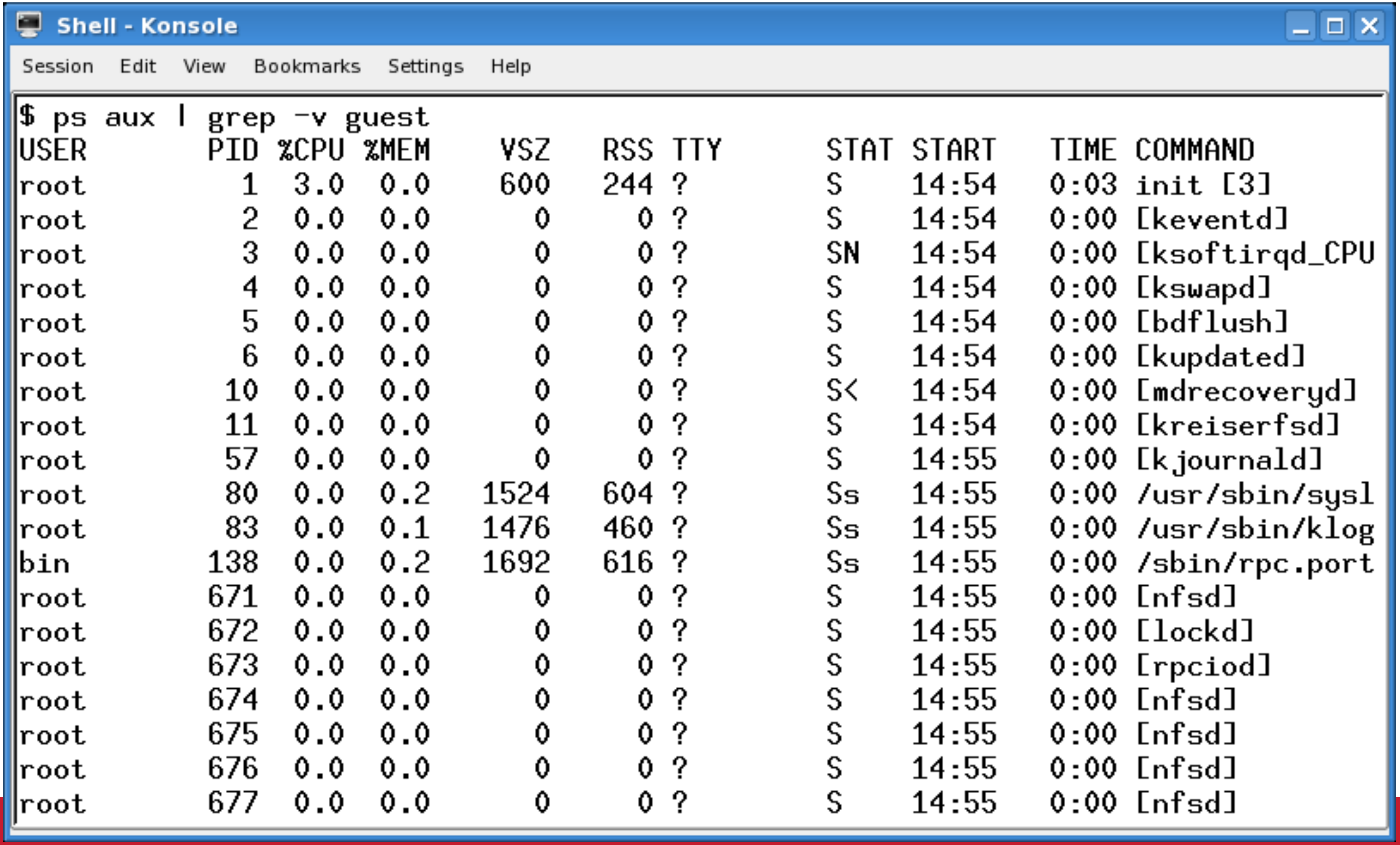
- Kernel does *process scheduling*: *which one do I run next among the Runnable processes?*
- Process "niceness" affects the scheduling priority
  - A high nice value means a low priority
  - A low nice value means a high priority
  - In Linux, the range is [-20, 19]
- Owner of a process can increase its nice value but cannot lower it

  `$nice +19 ./myjob10` starts myjob10, and sets it to the lowest priority

The ps Command: Monitor Processes

- Sysadmin’s main tool for monitoring processes
- Shows a process’
  - PID, PPID, UID,
  - control terminal, priority,
  - memory consumption,
  - CPU time used,
  - current status
- **a**: all processes, **x**: even those without terminal, **u**: user oriented output format

Output of “ps aux”



```
$ ps aux | grep -v guest
USER        PID %CPU %MEM   VSZ  RSS TTY      STAT START   TIME COMMAND
root          1  3.0  0.0   600  244 ?        S    14:54   0:03 init [3]
root          2  0.0  0.0     0    0 ?        S    14:54   0:00 [keventd]
root          3  0.0  0.0     0    0 ?        SN   14:54   0:00 [ksoftirqd_CPU
root          4  0.0  0.0     0    0 ?        S    14:54   0:00 [kswapd]
root          5  0.0  0.0     0    0 ?        S    14:54   0:00 [bdflush]
root          6  0.0  0.0     0    0 ?        S    14:54   0:00 [kupdated]
root         10  0.0  0.0     0    0 ?        S<   14:54   0:00 [mdrecoveryd]
root         11  0.0  0.0     0    0 ?        S    14:54   0:00 [kreiserfsd]
root         57  0.0  0.0     0    0 ?        S    14:55   0:00 [kjournald]
root         80  0.0  0.2  1524  604 ?        Ss   14:55   0:00 /usr/sbin/sysl
root         83  0.0  0.1  1476  460 ?        Ss   14:55   0:00 /usr/sbin/klog
bin         138  0.0  0.2  1692  616 ?        Ss   14:55   0:00 /sbin/rpc.port
root        671  0.0  0.0     0    0 ?        S    14:55   0:00 [nfsd]
root        672  0.0  0.0     0    0 ?        S    14:55   0:00 [lockd]
root        673  0.0  0.0     0    0 ?        S    14:55   0:00 [rpciod]
root        674  0.0  0.0     0    0 ?        S    14:55   0:00 [nfsd]
root        675  0.0  0.0     0    0 ?        S    14:55   0:00 [nfsd]
root        676  0.0  0.0     0    0 ?        S    14:55   0:00 [nfsd]
root        677  0.0  0.0     0    0 ?        S    14:55   0:00 [nfsd]
```

Memory Consumed by a Process

- **%MEM**: % of physical (real) memory consumed
- **VSZ**: total amount of virtual memory allocated to the process
- **RSS**: Resident set size (portion of VSZ, i.e., number of pages that are currently in real memory)

- Virtual memory -> physical memory + some disk space
- Managed by pages

Other Commands

- ps gives only a one-time snapshot of the system
- `top`: provides a regularly updated summary of active processes and their resource consumption
  - By default, every 10 second
- `uptime`: show the up time, the number of users, the load averages (average numbers of runnable processes) over 1, 5, and 15-minute intervals

Read their man pages

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  - Pathnames
  - Mounting and umounting filesystems
  - File tree organization
  - File types

The Filesystem

- Represent and organize the system's storage resources, as well as other types of objects – e.g., processes, audio devices, serial ports …
- Four main components
  - A namespace: name and organize things in a hierarchy
  - An API: system calls to navigate/manipulate objects
  - A security model: scheme to protect/hide/share objects
  - An implementation: software that ties logical model to the hardware

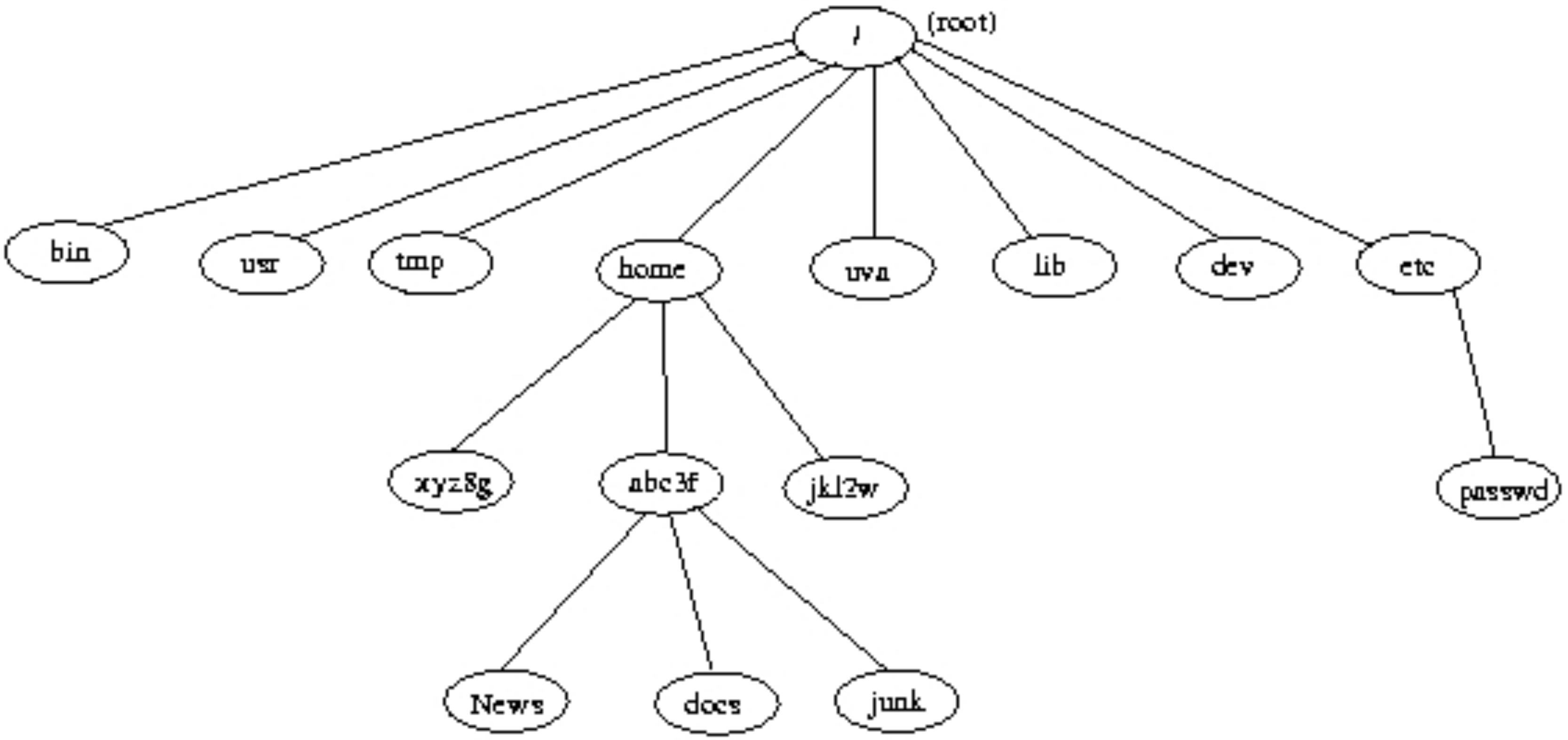
Pathnames

- The filesystem is a single unified hierarchy that starts at the directory /, and continues downward through subdirectories
  - /: the root directory
- Pathname: the list of directories that must be traversed to locate a file plus that file's filename
  - Absolute paths: start from root. E.g., /tmp/foo
  - Relative paths: start from current directory. E.g., cse311/A1
  - Terms pathname, filename, path are interchangeable

Pathnames (cont'd)

- Filesystem can be arbitrarily deep
- Each pathname must be <= 255 characters
  - For longer ones, cd to an intermediate directory first, then use a relative pathname
- Filenames
  - Must not contain slash "/" character
  - Spaces are permitted, though not recommended. E.g., `$less "My excellent file.txt"`

A Portion of the UNIX File Tree



Mounting A filesystem

- Smaller filesystems – each consists of one directory and its subdirectories and files
- Smaller filesystems are attached to the tree with the "mount" command
  - Mount maps a directory in the tree (called mounting point) to the root of the newly attached filesystem
  - `$mount /dev/sda4 /users` install the filesystem stored on the disk partition /dev/sda4 under the path / users.
  - To see the filesystem content, use `ls /users`

Umounting A Filesystem

- Filesystems are detached with the "umount" command
  - E.g., `$umount /users`
  - E.g.2, `$umount /mnt/usb` if to umount a USB key device if it was mounted to `/mnt/usb`
- The filesystem can not be busy, i.e., no open files or processes with current directories located there

Organization of the File Tree

- Every distribution or flavor has slight difference
- Root filesystem: root directory and a small set of files and subdirectories
  - /bin: core OS commands
  - /boot: kernel and files needed to load the kernel
  - /dev: entries for devices, e.g., disks, printers, ...
  - /etc: critical startup and configuration files
  - /home: default home directories for users
  - /tmp: temporary files

More Standard Directories

- /lib: libraries, and parts of the C compiler
- /mnt: temporary mount points for removable media
- /proc: information about all running processes
- /root: home directory of the superuser
- /usr/bin: most commands and executables
- /usr/include: header files for C compiler
- /usr/lib: more libraries
- /usr/sbin: less essential commands for sysadmins
- /var: log files, accounting info; change rapidly
- ...

File Types (7 of them)

Regular files	-	editors,cp	rm
Directories	d	mkdir	rmdir
Character device files	c	mknod	rm
Block device files	b	mknod	rm
Local domain sockets	s	socket(2)	rm
Named pipes (FIFOs)	p	mknod	rm
Symbolic links	l	ln –s	rm

```
$ls –l
-rw------- 1 yliu csstaff 4529 Jul 15 2010 todo
```

File Types (cont'd)

- **Regular files**: a series of bytes. Text, data, executable, libraries, etc.
- **Directories:** "." refers to itself, ".." refers to its parent directory. `$cd ..` go to parent dir
- **Device files:** used for hardware, peripherals.
  - Characterized by two numbers: major and minor device numbers. Major device number identifies a device driver. Minor tells the driver the actual unit.

    E.g., the first serial port /dev/tty0 has 4,0

File Types (even more)

- **Local domain socket**: for connections between processes in local host
  - A filesystem object, not a network port
  - Also called UNIX domain socket
- **Named pipes:** similar to above. Both for IPC (inter-process communication)
- **Symbolic links:** also called “soft links”