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Other words: task, job

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Note to think about later: Web browsers use OS process protection and isolation mechanisms to provide tab protection and isolation

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It uses this information to schedule and protect the process

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Real OSs will have more states than this, but these are the important ones

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In real OSs, these sets will will not be simple lists. They might be arranged in priority order, or might be some more sophisticated datastructure: e.g., a pair of lists, one for real-time processes and the other for non-real-time; or a tree

Processes

Example: in Unixes, processes are arranged in *trees*

```
systemd-+-ModemManager---2*[{ModemManager}]
        |-NetworkManager---2*[{NetworkManager}]
        |-Thunar---3*[{Thunar}]
        |-accounts-daemon---2*[{accounts-daemon}]
        |-agetty
        |-atd
        |-auditd---{auditd}
        |-avahi-daemon
        |-chrome-+-2*[cat]
        |        |-chrome-+-chrome-+-chrome---12*[{chrome}]
        |        |        |        |-chrome---19*[{chrome}]
        |        |        |        |-3*[chrome---11*[{chrome}]]
        |        |        |        |-chrome---15*[{chrome}]
        |        |        |        |-chrome---17*[{chrome}]
        |        |        |        |-chrome---16*[{chrome}]
        |        |        |        |-chrome---10*[{chrome}]
        |        |        |        `-chrome---23*[{chrome}]
        |        |        `-nacl_helper
        |        |-chrome-+-chrome
        |        |        `-7*[{chrome}]
```

Processes

Trees allow easy manipulation of whole bunches of (usually related) processes in a simple way

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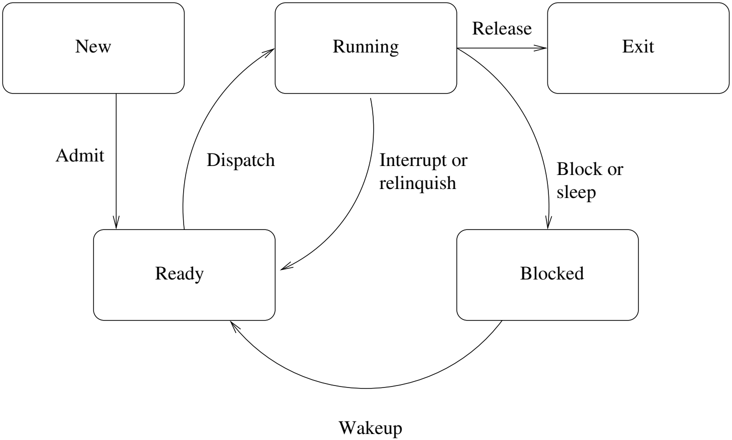
There is a standard *finite state machine* that describes the allowed transitions between states

Processes



Process State Transitions

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5. Or a timer interrupt may arise. In any of these three cases the OS moves the process to the Ready state

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And to make it clear: it's not the processes moving themselves between the states, it's the OS moving them between the sets of processes in each state

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Exercise Write a program that voluntarily relinquishes occasionally

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- New. For a process just created, perhaps code and data are not yet loaded into memory. The OS datastructures needed to manage the process must be created and filled in
- Exit. For a process that has just finished. Some tidying up is usually needed after a process ends, such as closing files or reclaiming memory or other resources it used

Processes

A real example:

```
USER        PID  PPID PRI %CPU %MEM STAT      TIME COMMAND
rjb        3974  4831  22  0.0  0.1 R+    00:00:00 ps
rjb        4495  4831  24  0.0  2.0 S     00:01:11 emacs
rjb        4538  4530  23  0.0  0.2 Ss+   00:00:00 bash
rjb        4540  4534  24  0.0  0.2 Ss    00:00:00 bash
rjb        4664  4556  21  0.0  0.6 S+    00:00:08 pine
rjb        4831  4829  24  0.0  0.2 Ss+   00:00:00 bash
rjb        7839  4831  15  0.0  0.1 Ss    00:00:00 firefox
rjb        7851  7839  14  0.0  0.1 S     00:00:00 run-mozilla.sh
rjb        7856  7851  24  0.2 16.6 Sl    00:31:47 firefox-bin
rjb       14880     1  16  0.0  3.1 Dsl   00:06:43 recollindex
```

Example processes under Linux

Processes

- S. Sleeping: like blocked (interruptible sleep; waiting for an event like a timer or other interrupt)
- D. Disk wait (uninterruptible sleep; waiting for requested I/O)
- R. Running or ready to run
- It is hard to catch new and exiting processes

(s: session leader; +: foreground process group; l: multithreaded)

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- CPU, MEM, TIME. How much of these resources this process is using

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This collection of data a process needs is called the *process control block*, or PCB

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And will be retrieved from the PCB when the process next gets scheduled to run

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Again, the process might not start running immediately, as there could be some higher priority process that must run first

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A user process that wants a new process will ask the OS to create one (using a syscall)

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- The new process can now be scheduled

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For example, “no permission to exec that program”

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Exercise The question arises: if processes are created by other processes, how do we get started? Read about the *bootstrapping problem*