Lecture 6:

Processes I: The Basics

`www.cl.cam.ac.uk/Teaching/2001/OSFounds/`

Today's Lecture

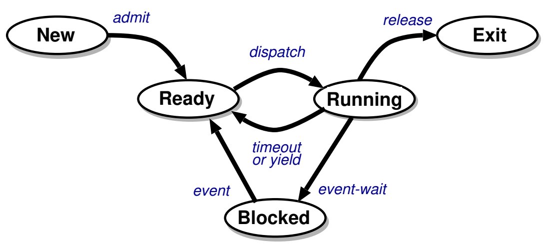
Today we'll cover:

- What is a process?
  - Concepts,
  - Process states.
- What OS support do we need?
  - Process control blocks,
  - Context switching,
  - Scheduling.
- The life of a process

Process Concept

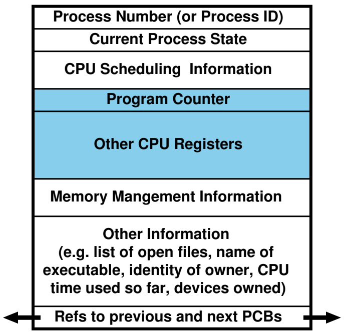
- From a user's point of view, the operating system is there to execute programs:
  - on batch system, refer to **jobs**
  - on interactive system, refer to **processes** (we'll use both terms fairly interchangeably)
- Process $\neq$ Program:
  - a program is **static**, while a process is **dynamic**
  - in fact, a process $\triangleq$ "a program in execution"
- (Note: "program" here is pretty low level, i.e. native machine code or *executable*)
- Process includes:
  1. program counter
  2. stack
  3. data section
- Processes execute on **virtual processors**

Process States



- As a process executes, it changes **state**:
  - **New**: the process is being created
  - **Running**: instructions are being executed
  - **Ready**: the process is waiting for the CPU (and is prepared to run at any time)
  - **Blocked**: the process is waiting for some event to occur (and cannot run until it does)
  - **Exit**: the process has finished execution.
- The **operating system** is responsible for maintaining the state of each process.

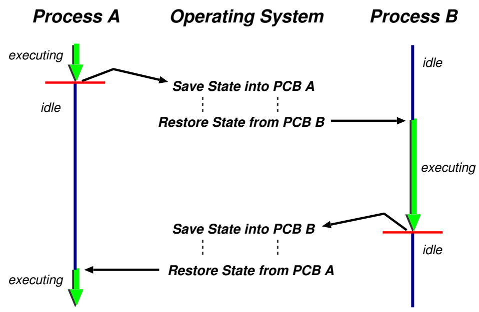
Process Control Block



OS maintains information about every process in a data structure called a **process control block** (PCB):

- Unique process identifier
- Process state (*Running*, *Ready*, etc.)
- CPU scheduling & accounting information
- Program counter & CPU registers
- Memory management information
- . . .

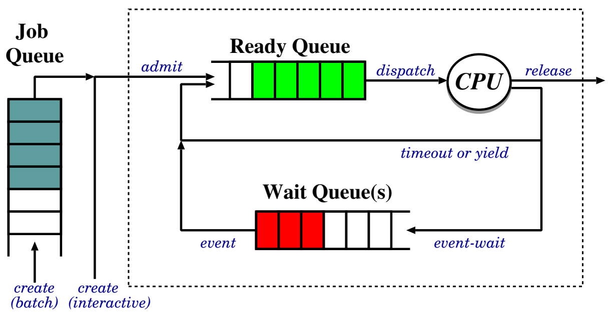
Context Switching



- **Process Context** = machine environment during the time the process is actively using the CPU.

  i.e. context includes program counter, general purpose registers, processor status register, . . .
- To switch between processes, the OS must:
  a) save the context of the currently executing process (if any), and
  b) restore the context of that being resumed.
- Time taken depends on h/w support.

Scheduling Queues



- Job Queue: batch processes awaiting admission.
- Ready Queue: set of all processes residing in main memory, ready and waiting to execute.
- Wait Queue(s): set of processes waiting for an I/O device (or for other processes)
- Long-term & short-term schedulers:
  - **Job scheduler** selects which processes should be brought into the ready queue.
  - **CPU scheduler** selects which process should be executed next and allocates CPU.

Process Creation

- Nearly all systems are **hierarchical**: parent processes create children processes.
- Resource sharing:
  - parent and children share all resources.
  - children share subset of parent's resources.
  - parent and child share no resources.
- Execution:
  - parent and children execute concurrently.
  - parent waits until children terminate.
- Address space:
  - child duplicate of parent.
  - child has a program loaded into it.
- e.g. Unix:
  - `fork()` system call creates a new process
  - all resources shared (child is a clone).
  - `execlp()` system call used to replace the process' memory space with a new program.
- NT/2000: `CreateProcess()` system call includes name of program to be executed.

```
#include <stdio.h>

void main(int argc, char *argv[])
{
int pid;

   pid = fork();

   if (pid < 0) {
     fprintf(stderr, "Fork failed");
     exit(-1);
   }
   else if (pid == 0) {
          execlp("/bin/ls","ls",NULL);
   }
   else {
        wait(NULL);
        printf("Child complete");
        exit(0);
   }
}
```


Process Termination

- Process executes last statement and asks the operating system to delete it (**exit**):
  - return data from child to parent (**wait**)
  - process' resources are deallocated by the OS.
- Process performs an illegal operation, e.g.
  - makes an attempt to access memory to which it is not authorised,
  - attempts to execute a privileged instruction
- Parent may terminate execution of child processes (**abort**, **kill**), e.g. because
  - child has exceeded allocated resources
  - task assigned to child is no longer required
  - parent is exiting ("cascading termination") (many operating systems do not allow a child to continue if its parent terminates)
- e.g. Unix has `wait()`, `exit()` and `kill()`
- e.g. NT/2000 has `ExitProcess()` for self and `TerminateProcess()` for others.

Process Blocking

- In general a process blocks on an **event**, e.g.
  - an I/O device completes an operation,
  - another process sends a message
- Assume OS provides some kind of general-purpose blocking primitive, e.g. `await()`.
- Need care handling *concurrency* issues, e.g.

```
if(no key being pressed) {
   await(keypress);
   print("Key has been pressed!\n");
}
// handle keyboard input
```

  What happens if a key is pressed at the first '{' ?
- (This is a *big* area.)
- In this course we'll generally assume that problems of this sort do not arise.

Summary

You should now understand:

- What a process is,
- Process states and PCBs,
- Scheduling queues,
- Stages of Process lifecycle.

Next lecture: Processes II: CPU scheduling

Background Reading:

- Silberschatz et al.: Chapter 4