Multi Processing

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Review

Review

- Process
- Scheduling
- IO Redirection

Process

- What is process?
- Process vs program?

Process

- Process is a program in execution state

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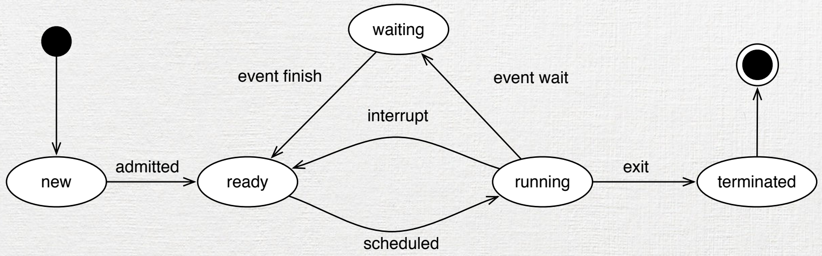
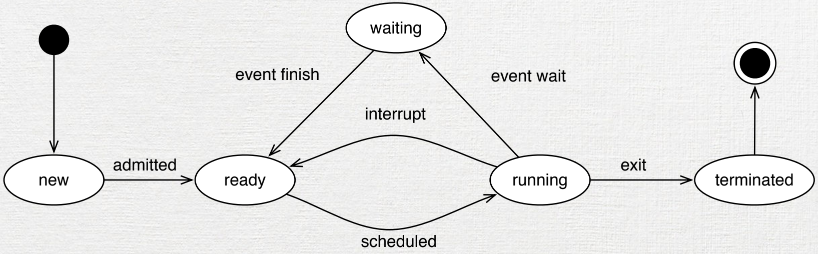
    - Process stack
    - Data section
    - Heap

Process States



Process States



- **new**: process has just been created
- **ready**: waiting to be assigned (scheduled) to a processor
- **running**: it's executing instructions
- **waiting**: waiting for some events to occur
- **terminated**: finished execution

Process Creation

- Start a new process == Create a new process
    - Create new child process
        - Can create child process → grand child process
    - Dependent on OS, parent and child can share
        - **All** resources: opened files, devices, etc. . .
        - **Some** resources: opened files only
        - **No** resource
- A fully loaded system will have a process tree

Process Creation

```
$ pstree -A
init-+-acpid
     |-cron
     |-daemon---mpt-statusd---sleep
     |-dbus-daemon
     |-dovecot-+-anvil
     |         |-config
     |         `-log
     |-master-+-pickup
     |        |-qmgr
     |        `-tlsmgr
     |-mysqld_safe---mysqld---23*[{mysqld}]
     |-php5-fpm---2*[php5-fpm]
     |-proftpd
     |-screen---bash---python2---{python2}
     |-sshd-+-sshd---sshd---bash---pstree
     |      `-sshd---sshd
     |-udevd---2*[udevd]
     `-znc---{znc}
```

Process Creation on Windows

```
BOOL WINAPI CreateProcess(
  _In_opt_    LPCTSTR               lpApplicationName,
  _Inout_opt_ LPTSTR                lpCommandLine,
  _In_opt_    LPSECURITY_ATTRIBUTES lpProcessAttributes,
  _In_opt_    LPSECURITY_ATTRIBUTES lpThreadAttributes,
  _In_        BOOL                  bInheritHandles,
  _In_        DWORD                 dwCreationFlags,
  _In_opt_    LPVOID                lpEnvironment,
  _In_opt_    LPCTSTR               lpCurrentDirectory,
  _In_        LPSTARTUPINFO         lpStartupInfo,
  _Out_       LPPROCESS_INFORMATION lpProcessInformation
);
```

Source: MSDN

Process Creation on Windows

- A simplified WinAPI function:

```
UINT WINAPI WinExec(
  _In_ LPCSTR lpCmdLine,
  _In_ UINT   uCmdShow
);
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Process Creation on Windows

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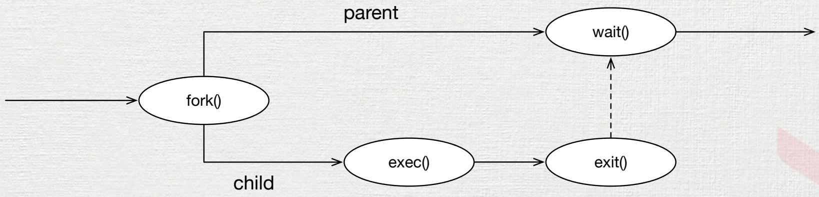

Process Creation on UNIX/Linux

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Process Creation on UNIX/Linux

- `fork()`
  - Perfectly «clone» current process to a new process
    - Open files
    - Register states
    - Memory allocations
    - **Except** process id
  - Who’s who?
    - Parent?
    - Child?

Process Creation on UNIX/Linux

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  - Who's who?
    - Parent?
    - Child?

```
pid_t fork(void);
```

Process Creation on UNIX/Linux

- Parent: `fork()` returns process id of child
- Child: `fork()` returns 0
- Example

```
#include <unistd.h>
#include <stdio.h>
int main() {
    printf("Main before fork()\n");
    int pid = fork();
    if (pid == 0) printf("I am child after fork()\n");
    else printf("I am parent after fork(), child is %d\n", pid);
    return 0;
}
```

```
$ ./dofork
Main before fork()
I am parent after fork(), child is 2378
I am child after fork()
```

Process Creation on UNIX/Linux

- `exec()`
  - Load an executable binary to replace current process image
  - A family of functions.
  - Ask `man`

```
int execl(...);
int execle(...);
int execlp(...);
int execv(...);
int execvp(const char *file, char *const argv[]);
int execvP(...);
```

Process Creation on UNIX/Linux

- exec() example

```c
#include <stdio.h>
#include <unistd.h>
int main() {
    printf("Going to launch ps -ef\n");
    char *args[]= { "/bin/ps", "-ef" , NULL};
    execvp("/bin/ps", args);
    return 0;
}
```

Scheduling

- Multiple processes running at the same time
- Process scheduler is a part that decides which processes to be executed at a certain time.

Scheduling

- Maximize CPU usage
- Responsiveness for User interface
- Provide computational power for heavy-workload processes
- «Multitasking»
- Different characteristics of processes
  - CPU bound: spends more time on computation
  - I/O bound: spends more time on I/O devices (reading/writing disk, printing...)

Scheduling

- By the ability to pause running processes
  - Preemption: OS forcely pauses running processes
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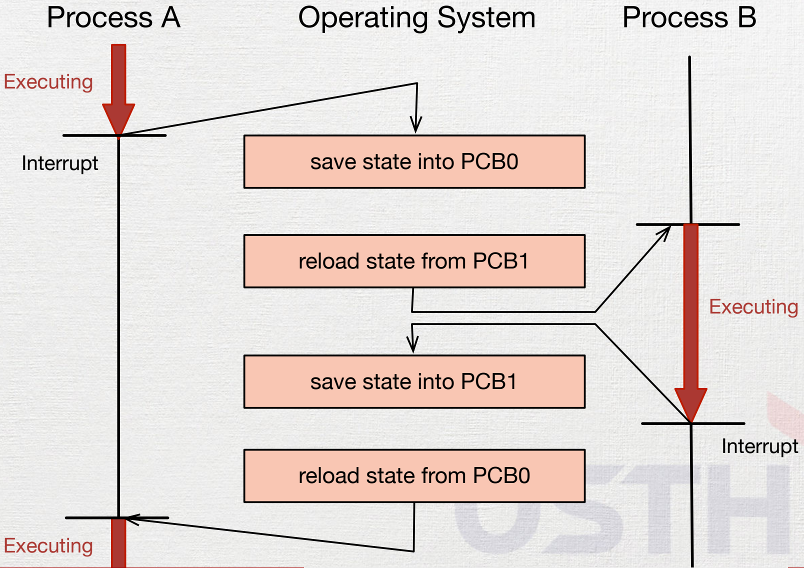
- By duration between each «switch»
  - Short term scheduler: milliseconds (fast, responsive)
  - Long term scheduler: seconds/minutes (batch jobs)

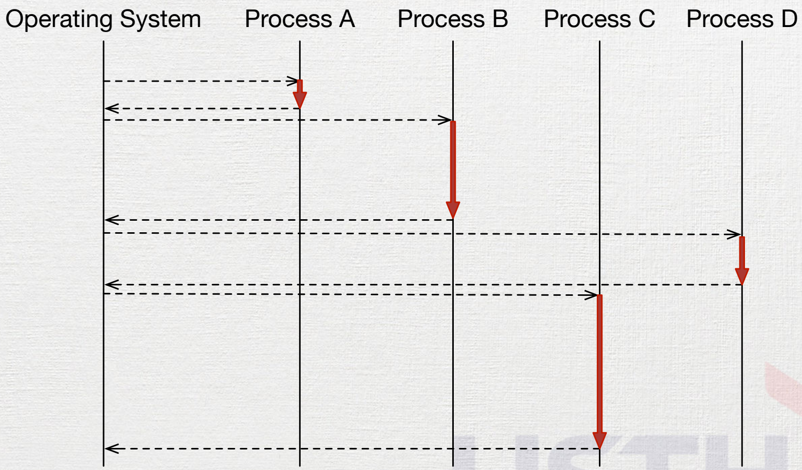
Scheduling with Context Switch



Scheduling with Context Switch

- Switch between processes
  - Save data of old process
  - Load previously saved data of new process
- Context switch is overhead
  - No work done for processes during context switch
  - Time slice (time between each switch) is hardware-limited

Scheduling with Context Switch



Scheduler

- Knowns
  - List of processes
  - Process states
  - Accounting information

Scheduler

- Knowns
    - List of processes
    - Process states
    - Accounting information
- Constraints
    - Process priority (if any)
        - Processes have scheduling **priority**
        - Indicates the importance of each process
        - Higher priority: more likely to be scheduled

Scheduler

- Problems
  - P1: What processes to run next?

Scheduler

- Problems
  - P1: What processes to run next?
  - P2: How long should it run?

Scheduler

- Problem 1: What processes to run next?
    - Job queue - set of all processes **entering** the system, stored on disk
    - Ready queue - set of all processes residing in **main memory**, ready and waiting to execute
    - Device queues - set of processes waiting for **an I/O device**
    - Lists of PCBs
    - Processes change state $\rightarrow$ they migrate among the various queues

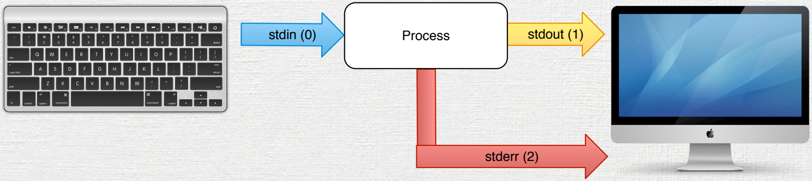
Scheduler

- Problem 2: How long should it run?
  - First In First Served
  - Earliest Deadline First
  - Shortest Remaining Time
  - Round Robin
  - ...

Scheduler

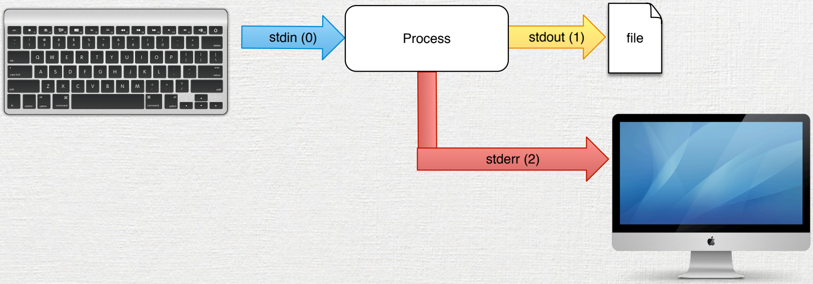
Algorithm	Preempt?	Priority?	Note
First Come, First Served	No	No	Depends on arrival time
Shortest-Job-First	No	Yes	Low waiting time ω
Shortest-Remaining-Time-First	Yes	Yes	Preemptive SJF, low ω
Round Robin	Yes	No	Low response time ρ
Multilevel Queue	Depends	Depends	Several subqueues, permanent
Multilevel Feedback Queue	Depends	Depends	Several subqueues, migrate

IO Redirection



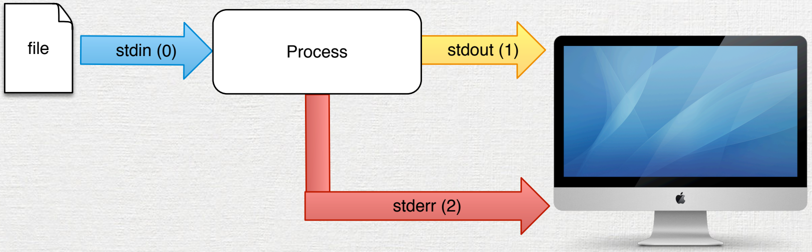
Default: input from keyboard and output to terminal

IO Redirection



Input from keyboard and output to file

IO Redirection



Input from file and output to terminal

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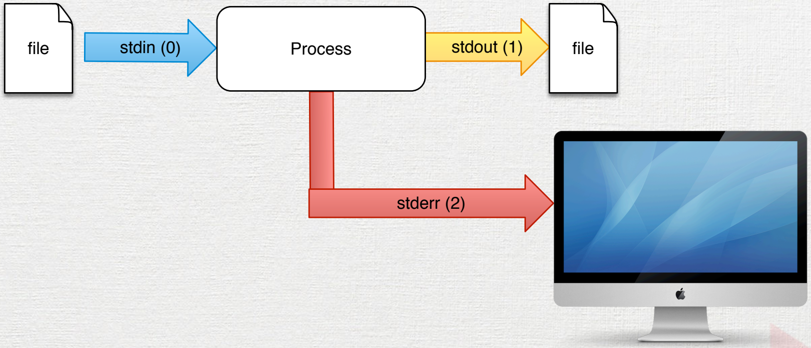
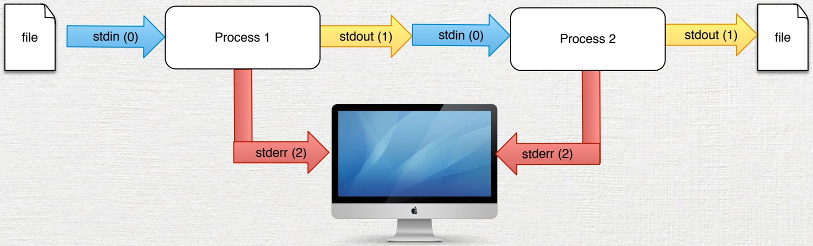


Input from file and output to another file

IO Redirection



Input from file, pipe output of Process 1 to Process 2, output to another file

Processes

Modules

- `os`
- `subprocess`

Task

- Create a process
    - Run and wait for finish
    - Run in background
    - Run with timeout
- IO redirection
    - Redirect input
    - Redirect output
    - Redirect with pipe
- Terminate
- Get return code

os module

- os module is deprecated in Python 3
- This is for references only.

Task	How
Run and wait	`os.system("ps aux")`
Run in background	`os.system("long_command.sh &")`
Timeout	N/A
Redirect input	`os.popen("bc", "w").write("1+2")`
Redirect output	`print(os.popen("ps aux", "r").readlines())`
Redirect with pipe	`os.pipe(), os.fork()`
Terminate	`os.kill(pid, signal.SIGTERM)`
Get return code	return value of `os.system()`

`subprocess` module

Task	How
Run and wait	`subprocess.run(["ps", "aux"])`
Run in background	`subprocess.Popen("long_command.sh")`
Timeout	`subprocess.run("long_command.sh", timeout = 10)`
Redirect input	`subprocess.Popen("bc", stdin=subprocess.PIPE).communicate(b"3+4\n")`
Redirect output	`subprocess.Popen(["ps", "aux"], stdout=subprocess.PIPE).communicate()`
Redirect with pipe	`subprocess.Popen("bc", stdin=anotherProcess.stdout)`
Terminate	`anotherProcess.terminate()`, `anotherProcess.kill()`
Get return code	`subprocess.check_output()`, catch `CalledProcessError`

Practice!

Practical work 7: Python shell

- Create a new python program, name it «7.shell.py»
- Make a shell
  - User inputs command
  - Shell executes the command, print output
  - Support IO redirection
    - input from file to process
    - output from process to file
    - e.g. input from one process being output of another

Practical work 7: Python shell

- Run it and test some commands
  - `ls -la`
  - `ls -la > out.txt`
  - `bc < input.txt`
  - `ps aux | grep term`
- Push your work to corresponding forked Github repository