Operating Systems

Lecture 7: MLFQ + Limited Direct Execution

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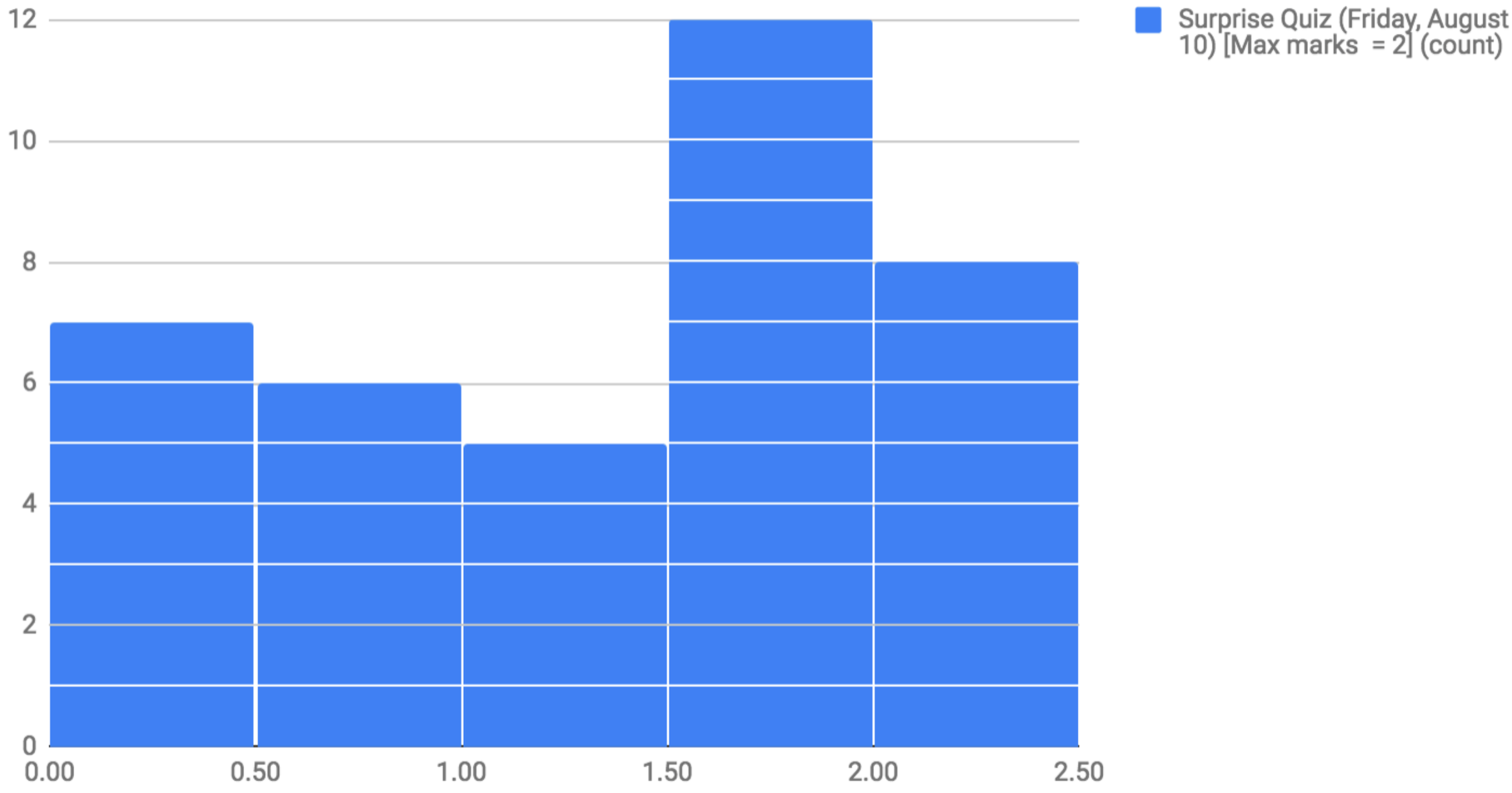
Aug 16, 2018

Histogram of Surprise Quiz (Friday, August 10) [Max marks = 2]



Administrative

1. Homework due tomorrow noon - form automatically closes
2. Quiz (worth 10%) on Tuesday. Syllabus - from start till MLFQ (including MLFQ)
3. Process API (Chapter 5) - lab questions:
    1. Do on own?
    2. Have a lab on weekend?
4. Linux extra lab

MLFQ - Revision

MLFQ - Revision

- Rule 1: If Priority(A) > Priority(B), A runs (B doesn't).
- Rule 2: If Priority(A) = Priority(B), A & B run in RR.
- Rule 3: When a job enters the system, it is placed at the highest priority (the topmost queue).
- Rule 4: Once a job uses up its time allotment at a given level (regardless of how many times it has given up the CPU), its priority is reduced (i.e., it moves down one queue).
- Rule 5: After some time period S, move all the jobs in the system to the topmost queue.

Practice Session

```
./mlfq.py -s 5 -Q 2,10,15 -n 3 -j 3 -M 0 -m 30 -c
```

```
OPTIONS jobs 3
OPTIONS queues 3
OPTIONS quantum length for queue  2 is   2
OPTIONS quantum length for queue  1 is  10
OPTIONS quantum length for queue  0 is  15
OPTIONS boost 0
OPTIONS ioTime 5
OPTIONS stayAfterIO False
OPTIONS iobump False


For each job, three defining characteristics are given:
  startTime : at what time does the job enter the system
  runTime   : the total CPU time needed by the job to finish
  ioFreq    : every ioFreq time units, the job issues an I/O
              (the I/O takes ioTime units to complete)

Job List:
  Job  0: startTime   0 - runTime  19 - ioFreq   0
  Job  1: startTime   0 - runTime  24 - ioFreq   0
  Job  2: startTime   0 - runTime  22 - ioFreq   0
```

Practice Session

```
./mlfq.py --jlist 0,40,0:20,20,0 -Q 5,10,10 -c
```

```
OPTIONS jobs 2
OPTIONS queues 3
OPTIONS quantum length for queue  2 is   5
OPTIONS quantum length for queue  1 is  10
OPTIONS quantum length for queue  0 is  10
OPTIONS boost 0
OPTIONS ioTime 5
OPTIONS stayAfterIO False
OPTIONS iobump False


For each job, three defining characteristics are given:
  startTime : at what time does the job enter the system
  runTime   : the total CPU time needed by the job to finish
  ioFreq    : every ioFreq time units, the job issues an I/O
              (the I/O takes ioTime units to complete)

Job List:
  Job  0: startTime   0 - runTime  40 - ioFreq   0
  Job  1: startTime  20 - runTime  20 - ioFreq   0
```

Practice Session

```
./mlfq.py --jlist 0,40,0:10,20,0:20,30,0 -Q 5,10,10 -c -B 50
```

```
OPTIONS jobs 3
OPTIONS queues 3
OPTIONS quantum length for queue  2 is   5
OPTIONS quantum length for queue  1 is  10
OPTIONS quantum length for queue  0 is  10
OPTIONS boost 50
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Job List:
  Job  0: startTime   0 - runTime  40 - ioFreq   0
  Job  1: startTime  10 - runTime  20 - ioFreq   0
  Job  2: startTime  20 - runTime  30 - ioFreq   0
```

Practice Session

```
./mlfq.py -c
```

```
Here is the list of inputs:
OPTIONS jobs 3
OPTIONS queues 3
OPTIONS quantum length for queue  2 is  10
OPTIONS quantum length for queue  1 is  10
OPTIONS quantum length for queue  0 is  10
OPTIONS boost 0
OPTIONS ioTime 0
OPTIONS stayAfterIO False


For each job, three defining characteristics are given:
  startTime : at what time does the job enter the system
  runTime   : the total CPU time needed by the job to finish
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              (the I/O takes ioTime units to complete)

Job List:
  Job  0: startTime   0 - runTime  84 - ioFreq   7
  Job  1: startTime   0 - runTime  42 - ioFreq   2
  Job  2: startTime   0 - runTime  51 - ioFreq   4
```

Practice Session

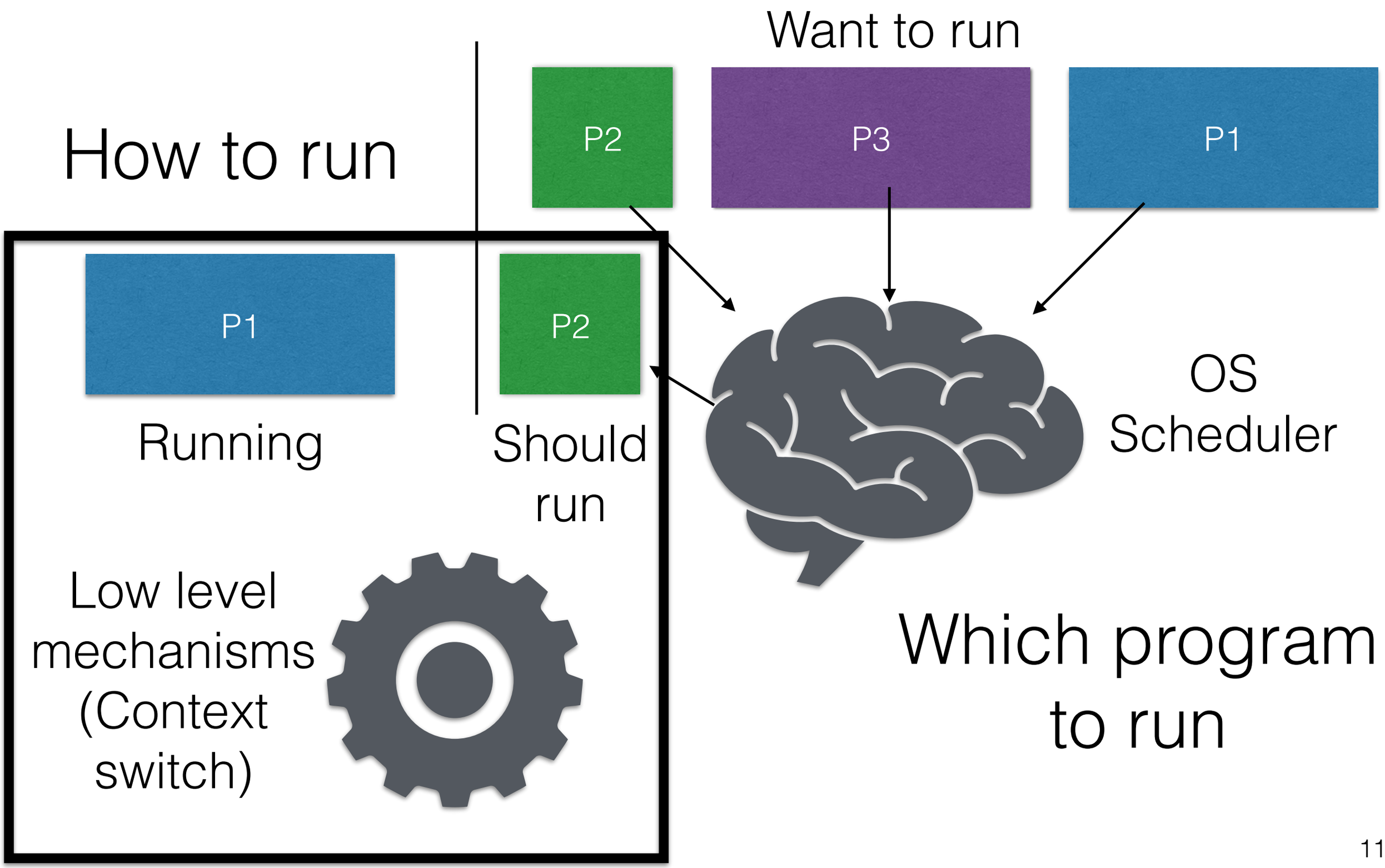
2. How would you run the scheduler to reproduce each of the examples in the chapter?
3. How would you configure the scheduler parameters to behave just like a round-robin scheduler?
4. Craft a workload with two jobs and scheduler parameters so that one job takes advantage of the older Rules 4a and 4b (turned on with the `-S` flag) to game the scheduler and obtain 99% of the CPU over a particular time interval.
5. Given a system with a quantum length of 10 ms in its highest queue, how often would you have to boost jobs back to the highest priority level (with the `-B` flag) in order to guarantee that a single long-running (and potentially-starving) job gets at least 5% of the CPU?
6. One question that arises in scheduling is which end of a queue to add a job that just finished I/O; the `-I` flag changes this behavior for this scheduling simulator. Play around with some workloads and see if you can see the effect of this flag.

More Topics

Will cover after remaining topics are finished:

1. Lottery scheduling
2. Multi-CPU scheduling (needs concurrency background)
3. Inter-process communication (IPC)

CPU Virtualisation Revisited



Core Challenges in CPU Virtualisation Mechanisms

1. Performance - Minimise OS overhead
2. Control - OS should maintain control
    1. Imagine OS schedules a process with infinite loop
    2. We saw priority reduces over time in MLFQ

Direct Execution

OS	Program

Direct Execution

OS	Program
1. Create entry for process	

Direct Execution

OS	Program
1. Create entry for process	
2. Allocate memory for process	

Direct Execution

OS	Program
1. Create entry for process 2. Allocate memory for process 3. Load program into memory	

Direct Execution

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Direct Execution

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Direct Execution

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	1. Run main()

Direct Execution

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1. Create entry for process 2. Allocate memory for process 3. Load program into memory 4. Set up stack 5. Execute call main()	
	1. Run main() 2. Execute return from main

Direct Execution

OS	Program
1. Create entry for process 2. Allocate memory for process 3. Load program into memory 4. Set up stack 5. Execute call main()	
	1. Run main() 2. Execute return from main
1. Free memory	

Direct Execution

OS	Program
1. Create entry for process 2. Allocate memory for process 3. Load program into memory 4. Set up stack 5. Execute call main()	
	1. Run main() 2. Execute return from main
1. Free memory 2. Remove process from process list	

Direct Execution Challenges

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2. How does OS ensure that the program doesn't make illegal access (issuing I/O)

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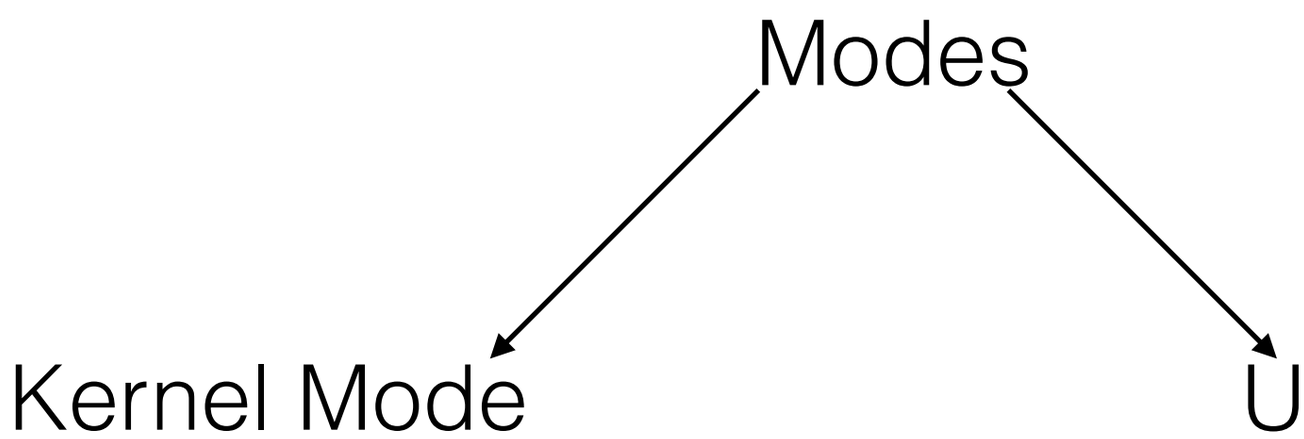
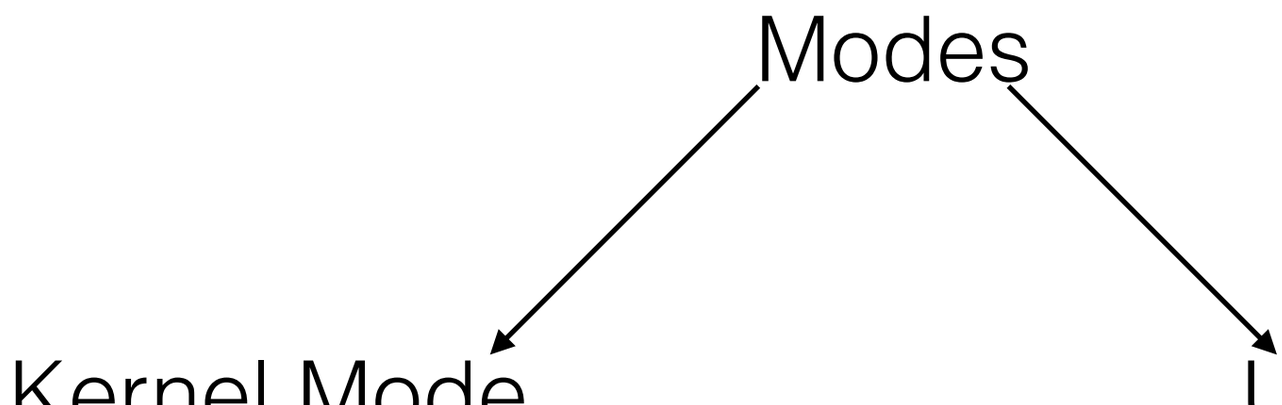
- Do we stop accessing I/O and network?

- Goal: A process must be able to perform I/O and some other restricted operations, but without giving the process complete control over the system.

Restricted Operations



Restricted Operations

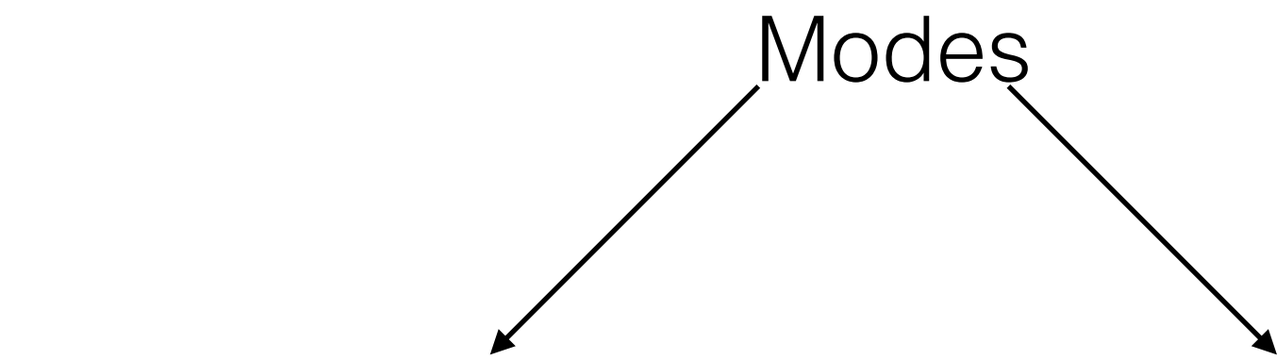


Kernel Mode

User Mode

1. Restricted mode - can not issue IO

Restricted Operations



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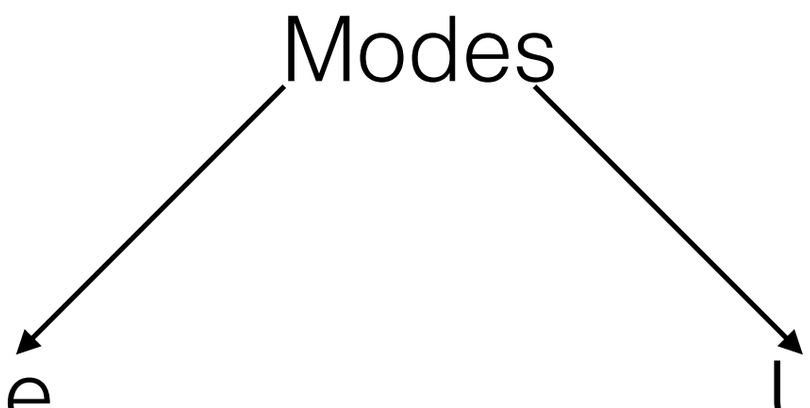
Restricted Operations



Kernel Mode

Code can issue IO.
Mode that OS runs in.

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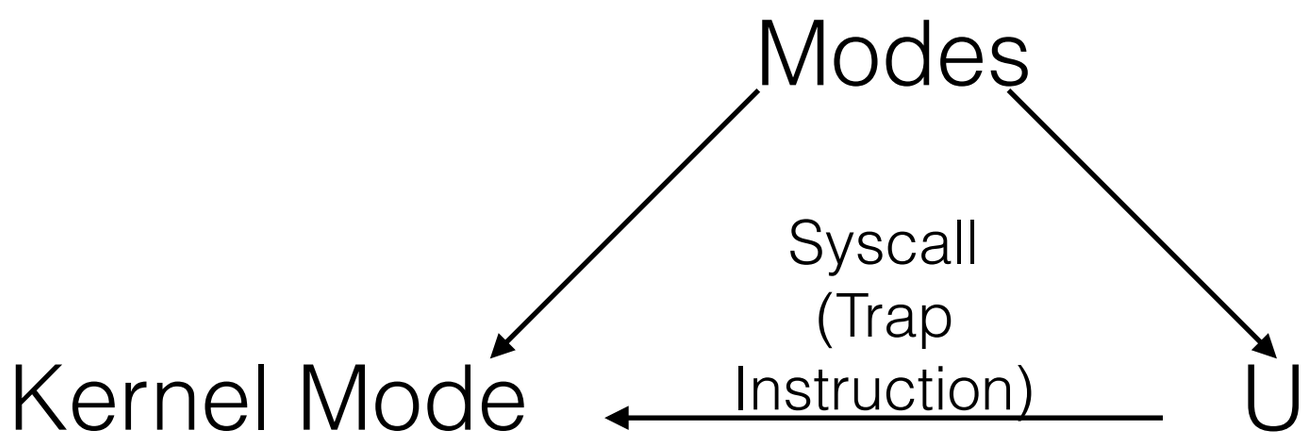
Restricted Operations



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Pop Quiz

Interrupt v/s Polling?