COP6611 Spring 2015
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1. Assume you are given a uniprocessor system with one gigabyte of memory and a 300 gigabyte disk. The OS on the machine has a demand paged virtual memory system with a local page replacement policy and a multi-level feedback queue (MLFQ) CPU scheduler. On the system there are two compute-intensive jobs running: Job-A and Job-B. Job-A has a working set* of 50 gigabytes while Job-B has a working set of 100 megabytes. Assume you left the system to run for a while until it reached a steady state with both jobs running.
    a. Which job would you expect to have a higher CPU scheduling priority from the MLFQ scheduler?
    b. Assume you add a second CPU to system, how would this affect the priorities of the jobs?
    c. Assume you switch from a local to a global page replacement policy, how does this change affect the priorities of the jobs?

    Justify your answer and state any assumptions you make.

    *Think of the working set as the memory footprint. That is, how much memory is seen as consumed by the process when, for example, you run the top command in a Unix terminal or use the Task Manager on a Windows machine.

2. You are given a bunch of scientific code that contains loops of the form:

```
for (i = 0; i < n; i++)
     for(j = 0; j < n; j++)
          a[j][i] += b[j][i];
```

The matrices `a` and `b` are allocated using code such as:

```
a = malloc (n* sizeof(*a));
for (i = 0; i < n; i++)
     a[i] = malloc(n* sizeof(a[i]));
```

While running the program, you notice that the addition loop trashes the TLB much more than it should. Say why, and give a simple fix. In general, what do you expect to happen to paging performance?

3. A process has four page frames allocated to it. (All the following numbers are decimal, and everything is numbered starting from zero.) The time of the last loading of a page into each page frame, the last access to the page in each page frame, the virtual page number in each page frame, and the referenced (R) and modified (M) bits for each page frame are as shown (the times are in clock ticks from the process start at time 0 to the event).

Virtual Page Number	Frame	Time Loaded	Time Referenced
20	0	60	161
22	1	130	160
24	2	10	162
31	3	20	163

A page fault to virtual page 23 has occurred at time 164. Which **frame** will have its contents replaced for each of the following memory management policies?

- LRU (least recently used)
- Optimal. Use the reference string generated by the following program, considering the following parameters: the system has 256-byte pages. The program is located at address 1020, and its stack pointer is at 8190 (the stack grows toward 0). Each instruction occupies 4 bytes (1 word), and both instruction and data references count in the reference string.

```
Load word from address 6144 into register 0
Push register 0 onto the stack
Call procedure from address 5120, stack the return address
Subtract the immediate constant 16 from the stack pointer
and place it in register RC
Compare the value in RC to the immediate constant 4
Jump if equal to 5152
```

Reference String:

Frame replaced by Optimal: