CS202 (003): Operating Systems Scheduling

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Most of the materials covered in this slide come from the lecture notes of Mike Walfish's CS202

Last Time

Scheduling disciplines (without I/O)

FCFS/FIFO

SJF and STCF

Round-robin (RR)

FCFS/FIFO

Run each job until it's done

Job	Time Needed (s)
P1	24
P2	3
P3	3

Throughput = $\frac{3 \text{ jobs}}{30 \text{ seconds}} = 0.1 \text{ jobs/second}$ **Avg Turnaround Time** = $\frac{24 + 27 + 30}{3} = 27$

How can we lower avg turnaround time?

Advantages

- simple
- no starvation
- few context switches

Disadvantages

- short jobs get stuck behind long ones!

SJF and STCF

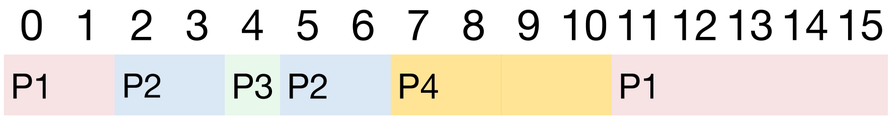
SJF

Schedule the job whose next CPU burst is the shortest

STCF

Preemptive version of SJF: if the new job arrived has a shorter time to completion than the remaining time on the current job, immediately preempt CPU to give to new job

Job	Arrival Time (s)	Burst Time (s)
P1	0	7
P2	2	4
P3	4	1
P4	5	4



Advantages

- Discuss later!

Disadvantages

- Discuss later!

Round Robin

Let's start considering response time
(i.e., we are adding a timer our scheduler)

Preempt CPU from long-running jobs (per time slice/quantum)
=> if a job hasn't finished by the end of a time slice,
put it to the back of the ready queue

Advantages

- Fair allocation of CPU across jobs
- Low average **response time** when job length vary
- Good for output time if small number of jobs

Disadvantages

- RR does not care about turnaround time!

Job	Time Needed (in time unit)
P1	50
P2	50

What is the average turnaround time if we have quantum of 1?

100.5

What happens if we use FIFO?

75

Round Robin

Let's start considering response time
(i.e., we are adding a timer our scheduler)

Preempt CPU from long-running jobs (per time slice/quantum)
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Advantages

- Fair allocation of CPU across jobs
- Low average **response time** when job length vary
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Disadvantages

- RR does not care about turnaround time!

How do we choose quantum size?

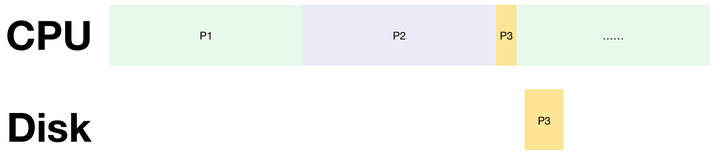
- Want much larger than context switch cost (amortization)
- Majority of bursts should be less than quantum
- If too small -> spend too much time context switching
- If too large -> response time suffers (and reverts to FIFO)

Scheduling disciplines (**with** I/O)

Job	Time Needed
P1	CPU-bound, 1 week
P2	CPU-bound, 1 week
P3	I/O bound, loop: 1ms CPU, 10ms Disk I/O

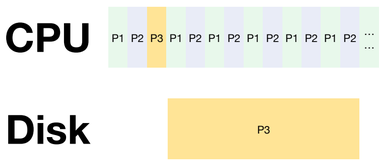
FCFS/FIFO

P1+P2 will take 2 weeks



Disk Utilization = $\frac{10\text{ms}}{201\text{ms}} \approx 5\,\%$

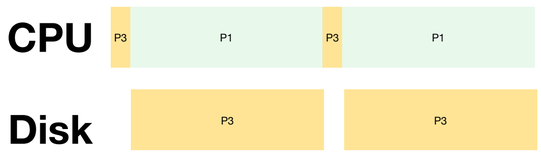
RR (100ms quantum)



Disk Utilization = $\frac{10\text{ms}}{11\text{ms}} \approx 91\,\%$

RR (1ms quantum)

STCF



Good disk utilization

Optimal average turnaround time

Low overhead

SJF and STCF

SJF

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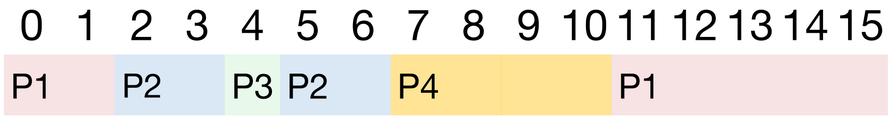

Advantages

- Good disk utilization
- Optimal (minimum) average turnaround time
- Low overhead (no needless preemption)

Disadvantages

- Long-running jobs get starved
- Does not optimize response time
- Requires predicting the future

Predicting CPU burst: EWMA

(exponentially weighted average)

Attempt to estimate future based on the past

t_n :**(time) length of proc's n^{th} burst**

τ_{n+1}: **estimate for $n+1$ burst**

$\tau_{n+1} = \alpha * t_n + (1-\alpha) * \tau_n$ **where** $0 < \alpha \leq 1$

Favor jobs that have been using CPU the least amount of time

Key idea in scheduling: Priority

Give every process a number, and give the CPU to the process with highest priority (which is either the highest/lowest numbers)

We don’t want to use strict priority (that leads to starvation on low priority tasks)

To reduce starvation, we can increase a process’s priority as it waits

Optimizing turnaround + response time: MLFQ

(multi-level feedback queue)

Multiple queues, each with different priority

RR within each queue

Processes priority changes overtime

Advantages

- Approximate SRTCF (shortest remaining time first)
- It overall gives higher priority that use less CPU time
- Helps reduce average turnaround time and response time for short jobs

Disadvantages

- Cannot donate priority
- Not very flexible
- Not good for real-time and multimedia
- Can be gameable

Another way of optimization: fair-share scheduler

Try to guarantee that each job obtain a certain percentage of CPU time

Lottery scheduling

Tickets: the share of a resource that a process should receive
The percent of tickles that a process has represents its share of the system resources

Hold a lottery to determine which process should get to run next, every now and then

Let p_i has t_i tickets

Let T be total # of tickets, $T = \sum_i t_i$

Chance of winning the next quantum $= \frac{t_i}{T}$

Control long-term average proportion of CPU for each process!

Lottery scheduling

Hold a lottery to determine which process should get to run next, every now and then

Advantages

- Deals with starvation (if you have ticket, you will make progress)
- Don’t worry that adding one high priority job will starve all others
- Adding/deleting jobs affects all jobs proportionally
- Can transfer tickets between processes
- Flexible by using ticket as a currency

Disadvantages

- Latency is unpredictable
- Expected error somewhat high

Follow-up work to reduce randomness -> Stride Scheduling (see textbook for details)