



Operating System

Process Scheduling
(Ch 2.5)

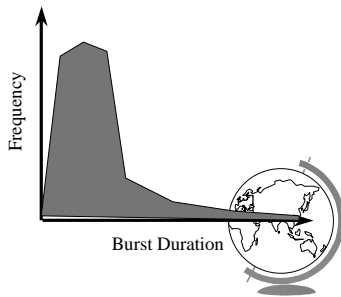
Schedulers

- Short-Term
 - “Which process gets the CPU?”
 - Fast, since once per 100 ms
- Long-Term (batch)
 - “Which process gets the Ready Queue?”
- Medium-Term (Unix)
 - “Which Ready Queue process to memory?”
 - Swapping



CPU-IO Burst Cycle

add
read
(I/O Wait)
store
increment
write
(I/O Wait)



Preemptive Scheduling

- Four times to re-schedule
 - 1 Running to Waiting (I/O wait)
 - 2 Running to Ready (time slice)
 - 3 Waiting to Ready (I/O completion)
 - 4 Termination
- #2 optional ==> “Preemptive”
- Timing may cause unexpected results
 - updating shared variable
 - kernel saving state



Question

- What Criteria Should the Scheduler Use?
 - Ex: favor processes that are small
 - Others?



Scheduling Criteria

- Internal
 - open files
 - memory requirements
 - CPU time used - time slice expired (RR)
 - process age - I/O wait completed
- External
 - \$
 - department sponsoring work
 - process importance
 - super-user (root) - nice



Scheduling Measures of Performance

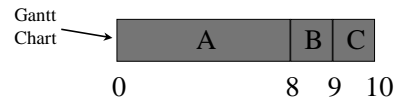
- 1 CPU utilization (40 to 90)
- 2 Throughput (processes / hour)
- 3 Turn-around time
- 4 Waiting time (in queue)

- Maximize #1, #2 Minimize #3, #4
- Response time
 - Self-regulated by users (go home)
 - Bounded ==> Variance!



First-Come, First-Served

| <u>Process</u> | <u>Burst Time</u> |
|----------------|-------------------|
| A | 8 |
| B | 1 |
| C | 1 |

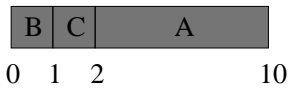


- Avg Wait Time $(0 + 8 + 9) / 3 = 5.7$



Shortest Job First

| <u>Process</u> | <u>Burst Time</u> |
|----------------|-------------------|
| A | 8 |
| B | 1 |
| C | 1 |



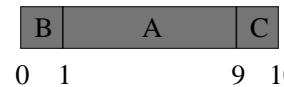
- Avg Wait Time $(0 + 1 + 2) / 3 = 1$
- Optimal Avg Wait
- Prediction tough ... Ideas?



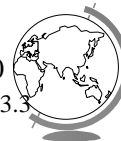
Priority Scheduling

- SJF is a special case

| <u>Process</u> | <u>Burst Time</u> | <u>Priority</u> |
|----------------|-------------------|-----------------|
| A | 8 | 2 |
| B | 1 | 1 |
| C | 1 | 3 |



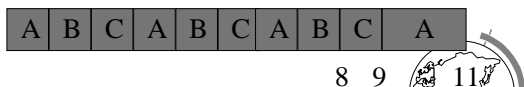
- Avg Wait Time $(0 + 1 + 9) / 3 = 3.3$



Round Robin

- Fixed time-slice and Preemption

| <u>Process</u> | <u>Burst Time</u> |
|----------------|-------------------|
| A | 5 |
| B | 3 |
| C | 3 |



- Avg Turnaround = $(8 + 9 + 11) / 3 = 9.3$
- FCFS? SJF?



SOS: Dispatcher

- What kind of scheduling algorithm is it?
- There is no "return" from the Dispatcher()
 - ... why?
 - OS system stack
- Why is there a `while(1);`?
 - Is this infinite loop ok? Why?



Round Robin Fun

| Process | Burst Time |
|---------|------------|
| A | 10 |
| B | 10 |
| C | 10 |

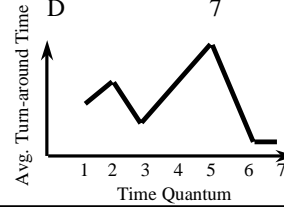
- Turn-around time?
 - q = 10
 - q = 1
 - q --> 0



More Round Robin Fun

| Process | Burst Time |
|---------|------------|
| A | 6 |
| B | 3 |
| C | 1 |
| D | 7 |

Rule:
80% within
one quantum



Fun with Scheduling

| Process | Burst Time | Priority |
|---------|------------|----------|
| A | 10 | 2 |
| B | 1 | 1 |
| C | 2 | 3 |

- Gantt Charts:
 - FCFS
 - SJF
 - Priority
 - RR (q=1)
- Performance:
 - Throughput
 - Waiting time
 - Turnaround time



More Fun with Scheduling

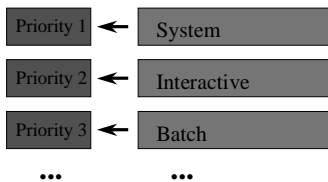
| Process | Arrival Time | Burst Time |
|---------|--------------|------------|
| A | 0.0 | 8 |
| B | 0.4 | 4 |
| C | 1.0 | 1 |

- Turn around time:
 - FCFS
 - SJF
 - q=1 CPU idle
 - q=0.5 CPU idle



Multi-Level Queues

- Categories of processes

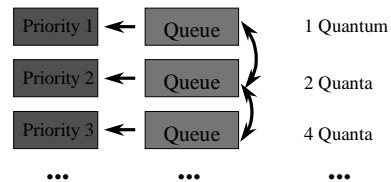


- Run all in 1 first, then 2 ...
- Starvation!
- Divide between queues: 70% 1, 20% 2 ...



Multi-Level Feedback Queues

- Time slice expensive but want interactive



- Consider process needing 100 quanta
 - 1, 4, 8, 16, 32, 64 = 7 swaps!
- Favor interactive users



Outline

- Processes **X**
 - PCB **X**
 - Interrupt Handlers **X**
- Scheduling **X**
 - Algorithms **X**
 - Linux ←
 - WinNT



Linux Process Scheduling

- Two classes of processes:
 - Real-Time
 - Normal
- Real-Time:
 - Always run Real-Time above Normal
 - Round-Robin or FIFO
 - “Soft” not “Hard”



Linux Process Scheduling

- Normal: *Credit-Based* (counter variable)
 - process with most credits is selected
 - + `goodness()` function
 - Timer goes off (jiffy, 1 per 10 ms)
 - + then lose a credit (0, then suspend)
 - no runnable process (all suspended), add to *every* process:
 - recalculate:
 - `credits = credits/2 + priority`
- Automatically favors I/O bound processes



Windows Scheduling

- Basic scheduling unit is a thread
 - (Can think of threads as processes for now)
- Priority based scheduling per thread
- Preemptive operating system
- No shortest job first, no quotas



Priority Assignment

- Windows kernel uses 31 priority levels
 - 31 is the highest; 0 is system idle thread
 - Realtime priorities: 16 - 31
 - Dynamic priorities: 1 - 15
- Users specify a *priority class*:
 - + realtime (24), high (13), normal (8) and idle (4)
 - and a relative priority:
 - + highest (+2), above normal (+1), normal (0), below normal (-1), and lowest (-2)
 - to establish the *starting priority*
- Threads also have a *current priority*

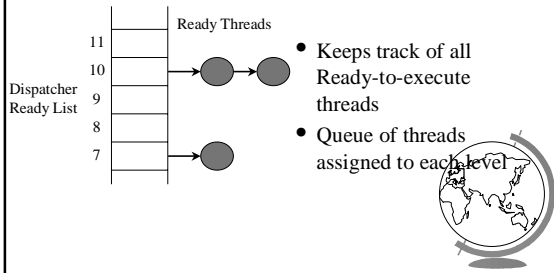


Quantum

- Determines how long a Thread runs once selected
- Varies based on:
 - NT Workstation or NT Server
 - Intel or Alpha hardware
 - Foreground/Background application threads (3x)
- *How do you think it varies with each*



Dispatcher Ready List



FindReadyThread

- Locates the highest priority thread that is ready to execute
- Scans dispatcher ready list
- Picks front thread in highest priority nonempty queue
- *When is this like round robin?*



Boosting and Decay

- Boost priority
 - Event that “wakes” blocked thread
 - + Amount of boost depends upon what blocked for
 - Ex: keyboard larger boost than disk
 - Boosts never exceed priority 15 for *dynamic*
 - *Realtime* priorities are not boosted
- Decay priority
 - by one for each quantum
 - decays only to starting priority (no lower)



Starvation Prevention

- Low priority threads may never execute
- “Anti-CPU starvation policy”
 - thread that has not executed for 3 seconds
 - boost priority to 15
 - double quantum
- Decay is swift not gradual after this boost

