**Kennesaw State University**

**College of Computing and Software Engineering**

**DEPARTMENT OF COMPUTER SCIENCE**

**CS 3502 / Operating Systems / Section 01**

**Assignment 2a**

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**September 18th, 2017**

**Summary and Purpose of the Assignment**

The purpose of the assignment is to study the behavior of a batch system with multi-programming. In this instance we compare the performance of one simulation, run with the default settings having degree of multi-programming set to 15, to another simulation, with its degree of multi-programming set to 1.

**Results**

Simulation run with Multi-Programming set to 15.

Batch Multiprogramming System with I/O

System Parameters

Simulation period: 1750

Close arrivals time: 800

Total memory: 255, queue sizes: 100

Degree of mult.: 15

Workload Parameters

Mean arrival: 7.3, mean CPU per: 11.5, mean I/O per: 11

Upper memory demand: 60 lower mem demand: 10

Starting Simulation Run

Psim3 project: Batch Multiprogramming System

Simulation date: Mon Sep 18 11:28:46 2017

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Memory % usage: 0.856225 avg num items used: 231.245

% of time spent in res usage: 0.944181

% of time spent waiting: 0.881108

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Service factor: 0.0205564

Total number of jobs that arrived: 115

Total number of rejected jobs: 0

Total number of completed jobs: 115

Average number of jobs in input queue: 26.7041

Maximum number of jobs in memory: 15

Average sojourn time: 501.089

Average total wait time: 481.18

CPU utilization: 0.73189

DISK utilization: 0.686433

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End of simulation Batch Multiprogramming System Mon Sep 18 11:28:46 2017

Simulation run with Multi-Programming set to 1.

Batch Multiprogramming System with I/O

System Parameters

Simulation period: 1750

Close arrivals time: 800

Total memory: 255, queue sizes: 100

Degree of mult.: 1

Workload Parameters

Mean arrival: 7.3, mean CPU per: 11.5, mean I/O per: 11

Upper memory demand: 60 lower mem demand: 10

Starting Simulation Run

Psim3 project: Batch Multiprogramming System

Simulation date: Mon Sep 18 11:33:02 2017

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Memory % usage: 0.136735 avg num items used: 35.6114

% of time spent in res usage: 0.979106

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Service factor: 0.0128776

Total number of jobs that arrived: 158

Total number of rejected jobs: 24

Total number of completed jobs: 78

Average number of jobs in input queue: 69.3529

Maximum number of jobs in memory: 1

Average sojourn time: 720.839

Average total wait time: 698.872

CPU utilization: 0.417375

DISK utilization: 0.580039

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End of simulation Batch Multiprogramming System Mon Sep 18 11:33:02 2017

**Solution Detail**

The model shows that through multiprogramming the processor obtains the ability to manage jobs. This improves performance which can be measured with the output results given by the model: Number of Jobs Completed, Number of Jobs Rejected, Average Sojourn Time, Average Total Wait Time, CPU Utilization, and Disk Utilization. With the results from the model we can see that multiprogramming improves overall performance of a processer.

**Conclusion**

In conclusion, multiprogramming enables better usage of the hardware, showing an overall increase to performance when it is implemented.

**Assignment Questions**

1. What are the main differences between this model and the previous model of OS (assignment #1 batch.cpp)?
   * The first model was a simple batch system. It completed each job one at a time and would not start a new job until the previous one was fully completed. This model using multiprogramming. This allows it to work on a job until it reaches a point where it has to wait for one or more tasks to be completed(ie: use of any IO devices) while it waits the OS pulls another job from the memory and starts work on it.
2. Explain how multiprogramming is made possible for these models. How is this implemented?
   * These models simulate how a normal multiprogramming system functions. Each job is given varying degrees of tasks that need to be waited on to be completed. This allows the model to simulate an actual operating system.
3. With no multiprogramming, why is the input queue needed? Why is the Ready queue needed?
   * Without multiprogramming, multiple jobs cannot be brought into memory at the same time. Thus the input queue is needed to hold all jobs that are not being completed. The ready queue, without multiprogramming, functions similarly to how it does with multiprogramming if there is more than one CPU to execute programs.
4. What aspect of an operating system is the model representing?
   * Scheduler and dispatcher
5. What performance measures does the model compute?
   * Memory Utilization, Number of Jobs Processed, Number of Jobs Rejected, Average Number of Jobs in Input Queue, Average Sojourn Time, Average Total Wait Time, CPU Utilization, Disk Utilization
6. After changing some of the parameters in the model (the workload) and executing again the model, what changes in the results do you notice?
   * The higher the degree of multiprogramming, the overall utilization of resources increases.

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**Assignment 2b**

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**September 18th, 2017**

**Summary and Purpose of the Assignment**

The purpose of this assignment is to study the behavior of three operating system scheduling policies: First Come First Serve, Shortest Job First, and Round Robin.

**Results**

First come first serve simulation run with default memory.

Batch Multiprogramming System with FCFS Scheduling

System Parameters

Simulation period: 1800.65

Close arrivals time: 800.5

Total memory: 1200, queue sizes: 300

Degree of mult.: 30

Workload Parameters

Mean arrival: 0, mean CPU per: 0

Upper memory demand: 40 lower mem demand: 5

Psim3 project: Batch Multiprogramming FCFS Scheduling

Simulation date: Mon Sep 18 15:13:34 2017

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Memory % usage: 0.540035 avg num items used: 650.83

% of time spent in res usage: 0.995715

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Service factor: 0.0418629

Total number of jobs that arrived: 212

Total number of rejected jobs: 0

Total number of completed jobs: 69

Maximum number of jobs in memory: 30

The proportion of rejected jobs is: 0

Average sojourn time: 626.251

Average total wait time: 600.266

CPU utilization: 0.998907

Number of completed jobs of type 0: 15

Average sojourn time for type 0: 666.322

Average waiting time for type 0: 658.598

Number of completed jobs of type 1: 18

Average sojourn time for type 1: 673.173

Average waiting time for type 1: 653.65

Number of completed jobs of type 2: 14

Average sojourn time for type 2: 593.262

Average waiting time for type 2: 562.829

Number of completed jobs of type 3: 15

Average sojourn time for type 3: 599.229

Average waiting time for type 3: 566.517

Number of completed jobs of type 4: 7

Average sojourn time for type 4: 543.612

Average waiting time for type 4: 485.193

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End of simulation Batch Multiprogramming FCFS Scheduling Mon Sep 18 15:13:34 2017

First come first serve simulation run with double the default memory.

Batch Multiprogramming System with FCFS Scheduling

System Parameters

Simulation period: 1800.65

Close arrivals time: 800.5

Total memory: 2400, queue sizes: 300

Degree of mult.: 30

Workload Parameters

Mean arrival: 0, mean CPU per: 0

Upper memory demand: 40 lower mem demand: 5

Psim3 project: Batch Multiprogramming FCFS Scheduling

Simulation date: Mon Sep 18 15:14:31 2017

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Memory % usage: 0.274831 avg num items used: 679.897

% of time spent in res usage: 0.970139

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Service factor: 0.0483335

Total number of jobs that arrived: 199

Total number of rejected jobs: 0

Total number of completed jobs: 64

Maximum number of jobs in memory: 30

The proportion of rejected jobs is: 0

Average sojourn time: 584.469

Average total wait time: 557.174

CPU utilization: 0.991998

Number of completed jobs of type 0: 14

Average sojourn time for type 0: 568.017

Average waiting time for type 0: 564.369

Number of completed jobs of type 1: 12

Average sojourn time for type 1: 544.292

Average waiting time for type 1: 524.642

Number of completed jobs of type 2: 15

Average sojourn time for type 2: 579.882

Average waiting time for type 2: 549.102

Number of completed jobs of type 3: 11

Average sojourn time for type 3: 609.053

Average waiting time for type 3: 573.334

Number of completed jobs of type 4: 12

Average sojourn time for type 4: 627.038

Average waiting time for type 4: 576.587

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End of simulation Batch Multiprogramming FCFS Scheduling Mon Sep 18 15:14:31 2017

Shortest Job First simulation run with default memory.

Batch System with SJF Scheduling

System Parameters

Simulation period: 2750

Close arrivals time: 400

Total memory: 255, queue sizes: 100

Degree of mult.: 15

Workload Parameters

Mean arrival: 0, mean CPU per: 0

Upper memory demand: 60 lower mem demand: 10

Mean inter-arrival for type 0: 18.5

Mean CPU service demand for type 0: 26

Mean inter-arrival for type 1: 18.5

Mean CPU service demand for type 1: 48.5

Mean inter-arrival for type 2: 18.5

Mean CPU service demand for type 2: 67.5

Mean inter-arrival for type 3: 18.5

Mean CPU service demand for type 3: 89.75

Mean inter-arrival for type 4: 18.5

Mean CPU service demand for type 4: 128.45

Psim3 project: Batch Multiprogramming System with SPN (or SJF) Scheduling

Simulation date: Mon Sep 18 15:16:34 2017

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Memory % usage: 0.763199 avg num items used: 228.935

% of time spent in res usage: 0.850092

% of time spent waiting: 0.845584

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Service factor: 0.218474

Total number of jobs that arrived: 100

Total number of rejected jobs: 0

Total number of completed jobs: 32

Average number of jobs in input queue: 59.0945

Maximum number of jobs in memory: 15

The proportion of rejected jobs is: 0

Average sojourn time: 409.462

Average total wait time: 336.84

CPU utilization: 0.994971

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Number of completed jobs of type 0: 7

Average sojourn time for type 0: 149.248

Average waiting time for type 0: 108.383

Number of completed jobs of type 1: 9

Average sojourn time for type 1: 126.539

Average waiting time for type 1: 85.3319

Number of completed jobs of type 2: 9

Average sojourn time for type 2: 384.792

Average waiting time for type 2: 274.23

Number of completed jobs of type 3: 6

Average sojourn time for type 3: 853.054

Average waiting time for type 3: 741.062

Number of completed jobs of type 4: 1

Average sojourn time for type 4: 2337.75

Average waiting time for type 4: 2337.75

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End of simulation Batch Multiprogramming System with SPN (or SJF) Scheduling Mon Sep 18 15:16:34 2017

Shortest Job First simulation run with double the default memory.

Batch System with SJF Scheduling

System Parameters

Simulation period: 2750

Close arrivals time: 400

Total memory: 510, queue sizes: 100

Degree of mult.: 15

Workload Parameters

Mean arrival: 0, mean CPU per: 0

Upper memory demand: 60 lower mem demand: 10

Mean inter-arrival for type 0: 18.5

Mean CPU service demand for type 0: 26

Mean inter-arrival for type 1: 18.5

Mean CPU service demand for type 1: 48.5

Mean inter-arrival for type 2: 18.5

Mean CPU service demand for type 2: 67.5

Mean inter-arrival for type 3: 18.5

Mean CPU service demand for type 3: 89.75

Mean inter-arrival for type 4: 18.5

Mean CPU service demand for type 4: 128.45

Psim3 project: Batch Multiprogramming System with SPN (or SJF) Scheduling

Simulation date: Mon Sep 18 15:18:36 2017

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Memory % usage: 0.89611 avg num items used: 483.596

% of time spent in res usage: 0.945038

% of time spent waiting: 0.936531

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Service factor: 0.163209

Total number of jobs that arrived: 110

Total number of rejected jobs: 0

Total number of completed jobs: 45

Average number of jobs in input queue: 62.5073

Maximum number of jobs in memory: 15

The proportion of rejected jobs is: 0

Average sojourn time: 383.712

Average total wait time: 325.999

CPU utilization: 0.999357

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Number of completed jobs of type 0: 12

Average sojourn time for type 0: 64.5119

Average waiting time for type 0: 37.9666

Number of completed jobs of type 1: 8

Average sojourn time for type 1: 147.074

Average waiting time for type 1: 110.426

Number of completed jobs of type 2: 14

Average sojourn time for type 2: 279.02

Average waiting time for type 2: 227.681

Number of completed jobs of type 3: 8

Average sojourn time for type 3: 543.335

Average waiting time for type 3: 421.374

Number of completed jobs of type 4: 3

Average sojourn time for type 4: 2354.45

Average waiting time for type 4: 2257.48

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End of simulation Batch Multiprogramming System with SPN (or SJF) Scheduling Mon Sep 18 15:18:36 2017

Round Robin simulation run with default memory.

Psim3 project: System with RR Scheduling

Simulation date: Mon Sep 18 15:19:59 2017

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Memory % usage: 0.504877 avg num items used: 606.679

% of time spent in res usage: 0.998638

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Number of completed processes of type 0: 11

Average turnaround time for type 0: 219.388

Average waiting time for type 0: 211.007

Number of completed processes of type 1: 11

Average turnaround time for type 1: 357.656

Average waiting time for type 1: 340.904

Number of completed processes of type 2: 8

Average turnaround time for type 2: 865.162

Average waiting time for type 2: 830.77

Number of completed processes of type 3: 7

Average turnaround time for type 3: 517.201

Average waiting time for type 3: 490.601

Number of completed processes of type 4: 4

Average turnaround time for type 4: 1357.5

Average waiting time for type 4: 1304.18

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End of simulation System with RR Scheduling Mon Sep 18 15:19:59 2017

Round Robin simulation run with double the default memory.

Psim3 project: System with RR Scheduling

Simulation date: Mon Sep 18 15:20:34 2017

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Memory % usage: 0.182022 avg num items used: 447.01

% of time spent in res usage: 0.977277

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Number of completed processes of type 0: 11

Average turnaround time for type 0: 125.399

Average waiting time for type 0: 117.928

Number of completed processes of type 1: 3

Average turnaround time for type 1: 461.383

Average waiting time for type 1: 444.465

Number of completed processes of type 2: 11

Average turnaround time for type 2: 690.813

Average waiting time for type 2: 655.531

Number of completed processes of type 3: 10

Average turnaround time for type 3: 807.875

Average waiting time for type 3: 771.776

Number of completed processes of type 4: 5

Average turnaround time for type 4: 575.19

Average waiting time for type 4: 550.579

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End of simulation System with RR Scheduling Mon Sep 18 15:20:34 2017

**Solution Detail**

No solution. This assignment is an analysis of various types of scheduling policies.

**Conclusion**

In conclusion, we can see some of the advantages and disadvantages of the three scheduling policies the models simulate and grasp a better understanding of the utilization.

**Assignment Questions**

1. What would observable in the model with RR scheduling for single-class system?
   * A single class system needs to complete one job before starting another. A scheduler like Round Robin is only needed with multi class systems.
2. Explain how multiprogramming is made possible for these models. How is this implemented?
   * Scheduling makes multiprogramming possible for these models. It is implemented with job management policies.
3. Explain the changes for the parameters of the FCFS model so that there are no jobs reject.
   * The model did not reject jobs with default settings however doubling the system memory did cause an increase in performance due to a decrease in both average sojourn time and average total wait time.
4. Identify the performance measures that conflict with each other. Give your reasons for this. Which ones are more important?
   * Average Wait Time and Number of Jobs Completed conflict with each other. If the Average Wait Time is lower that means the CPU has fewer Number of Jobs Completed. However with more Number of Jobs Completed increases the Average Wait Time. The more important of these two metrics is the Average Wait Time.
5. Change the time slice of the RR model (tsmul.cpp). What are your conclusions after reading the trace and performance measures?
   * Increasing the Time Slice causes the overall performance to suffer. Decreasing the Time Slice causes the performance to increase.
6. Analyze the simulation run of the RR model. RR does not have the best performance, why? What advantages does RR have compared to the other scheduling polices?
   * The main advantage of Round Robin is higher CPU Utilization and low Average Wait Time. It does not have the best performance due to the constant interruptions and context switches.