CISC 361 Programming Project Due: May 24th, 2018
Collin Clark and Colby Banbury

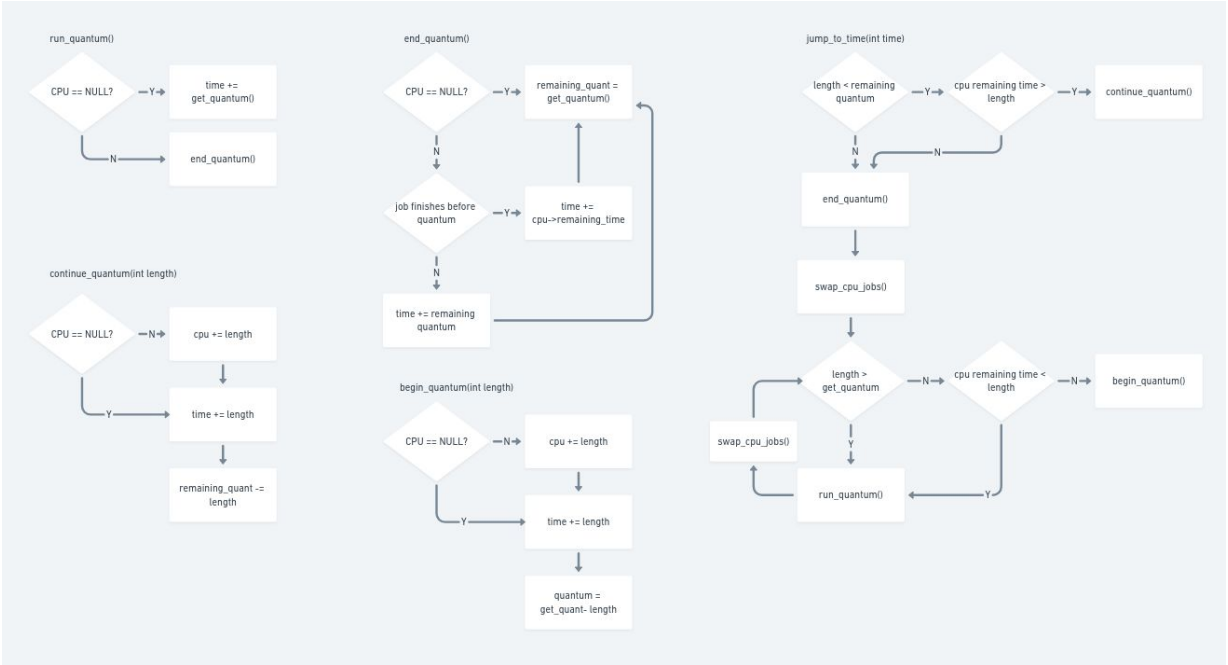
Design Process:

Our design process centered around an object oriented approach. Instructions are read line by line by our intake.cc file which creates an instance of a system when the first line is read. Jobs are created by the intake file and passed to the system which then points to them in various lists. When a job gets moved onto the ready queue from a hold queue a process is created, which has a job pointer along with other attributes to track what has been allocated to it. This approach minimizes job and process creation and allows us to conduct the simulation in place. When intake.cc reads a new line it calls system::jump_to_time which calculates run time on each process along with what process is on the cpu and when things should be swapped. The control flow for this function is shown below.

We used validate.py to automatically compare our json files to the expected values given. This allowed us to quickly determine when and how our program failed. We were unable to utilized gdb for most of the project due to an unresolvable error with the tool so instead we tested our program by checking the data dumps at key times. We compared the data dump results against whiteboard simulation results to determine at what time our virtual simulation failed. In this testing we discovered a number of edge cases that needed to be accounted for in the jump_to_time control flow.

The main design challenge of this project was determining unspecified behavior and identifying problematic edge cases

jump_to_time control flow:



Output:

Display Dumps:

```
make test
g++    -c -o system_test.o system_test.cc
g++ -std=c++98 -g -c system.cc
g++ -std=c++98 -g -c job.cc
g++ -std=c++98 -g -c process.cc
g++ -std=c++98 -g system_test.o system.o job.o process.o -o
system_test
./system_test
g++    -c -o intake.o intake.cc
g++ -std=c++98 -g intake.o system.o job.o process.o -o intake_test
./intake_test test.txt


---------- System Information ----------
Time | Tot Mem | Avail Mem | Tot Dev | Avail Dev | Quantum | CPU Job
#
 9999|      200|        200|       12|         12|        4|
0

         avg turnaround time: 29.5
avg weighted turnaround time: 3.0154

------------ CPU ----------------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev

------------ Hold Queue 1 -------------
Job # | Arr | Mem | Dev | Run | Pri

------------ Hold Queue 2 -------------
Job # | Arr | Mem | Dev | Run | Pri

------------ Ready Queue --------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev

------------ Wait Queue ---------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev

------------ Complete Queue -----------
Job # | Arr | Mem | MDev | Runtime | Pri | Compl Time | TAT | WTAT
     3|    9|   10|     8|        4|    1|          19|   10|   2.5
     1|    3|   20|     5|       10|    1|          29|   26|   2.6
```

```
     2|    4|   30|     2|       12|    2|          33|   29|2.41667
     4|   13|   20|     4|       11|    2|          56|   43|3.90909
     5|   24|   20|    10|        9|    1|          57|   33|3.66667
     6|   25|   20|     4|       12|    2|          61|   36|     3

g++    -c -o banker_test.o banker_test.cc
g++ -std=c++98 -g banker_test.o system.o job.o process.o -o
banker_test
./banker_test
first test
second test


---------- System Information ----------
Time | Tot Mem | Avail Mem | Tot Dev | Avail Dev | Quantum | CPU Job
#
   14|      200|          0|       12|         12|        4|
1

         avg turnaround time: -1
avg weighted turnaround time: -1

------------ CPU ----------------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev
     1|    3|   20|         7|     5|       10|    1|     0

------------ Hold Queue 1 -------------
Job # | Arr | Mem | Dev | Run | Pri

------------ Hold Queue 2 -------------
Job # | Arr | Mem | Dev | Run | Pri

------------ Ready Queue --------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev
     3|    9|   10|         0|     8|        4|    1|     0
     4|   10|   20|         0|     5|       10|    1|     0
     2|    4|   30|         4|     2|       12|    2|     0
     5|   11|   30|         0|     2|       12|    2|     0
     6|   12|   10|         0|     8|        4|    1|     0
     7|   13|   40|         0|     8|        4|    1|     0
     8|   14|   40|         0|     8|        4|    1|     0

------------ Wait Queue ---------------
```

```
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev

------------- Complete Queue -----------
Job # | Arr | Mem | MDev | Runtime | Pri | Compl Time | TAT | WTAT



---------- System Information ----------
Time | Tot Mem | Avail Mem | Tot Dev | Avail Dev | Quantum | CPU Job
#
    1|      100|         80|        4|          2|        2|
0

         avg turnaround time: -1
avg weighted turnaround time: -1

------------- CPU ----------------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev

------------- Hold Queue 1 -------------
Job # | Arr | Mem | Dev | Run | Pri

------------- Hold Queue 2 -------------
Job # | Arr | Mem | Dev | Run | Pri

------------- Ready Queue --------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev
     2|    0|   10|         0|     4|        5|    1|     0
     1|    0|   10|         1|     4|        5|    1|     2

------------- Wait Queue ---------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev

------------- Complete Queue -----------
Job # | Arr | Mem | MDev | Runtime | Pri | Compl Time | TAT | WTAT



---------- System Information ----------
Time | Tot Mem | Avail Mem | Tot Dev | Avail Dev | Quantum | CPU Job
#
    2|      100|         80|        4|          2|        2|
0
```

```
         avg turnaround time: -1
avg weighted turnaround time: -1

------------ CPU ----------------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev

------------ Hold Queue 1 -------------
Job # | Arr | Mem | Dev | Run | Pri

------------ Hold Queue 2 -------------
Job # | Arr | Mem | Dev | Run | Pri

------------ Ready Queue --------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev
     1|    0|   10|         1|     4|        5|    1|     2

------------ Wait Queue ---------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev
     2|    0|   10|         1|     4|        5|    1|     0

------------ Complete Queue -----------
Job # | Arr | Mem | MDev | Runtime | Pri | Compl Time | TAT | WTAT

g++ -std=c++98 -g intake.o system.o job.o process.o -o intake
./intake test1.in


---------- System Information ----------
Time | Tot Mem | Avail Mem | Tot Dev | Avail Dev | Quantum | CPU Job
#
   10|      200|          0|       12|         12|        4|
2

         avg turnaround time: -1
avg weighted turnaround time: -1

------------ CPU ----------------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev
     2|    4|   70|         3|     2|       12|    2|     0

------------ Hold Queue 1 -------------
Job # | Arr | Mem | Dev | Run | Pri
```

```
     3|    5|  100|    8|    4|    1

------------- Hold Queue 2 -------------
Job # | Arr | Mem | Dev | Run | Pri

------------- Ready Queue --------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev
     1|    3|  120|         4|     5|       10|    1|     0
     5|    8|   10|         0|     8|        4|    1|     0

------------- Wait Queue ---------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev

------------- Complete Queue -----------
Job # | Arr | Mem | MDev | Runtime | Pri | Compl Time | TAT | WTAT



---------- System Information ----------
Time | Tot Mem | Avail Mem | Tot Dev | Avail Dev | Quantum | CPU Job
#
   26|      200|         30|       12|         12|        4|
2

         avg turnaround time: 16.5
avg weighted turnaround time: 2.475

------------- CPU ----------------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev
     2|    4|   70|         9|     2|       12|    2|     0

------------- Hold Queue 1 -------------
Job # | Arr | Mem | Dev | Run | Pri

------------- Hold Queue 2 -------------
Job # | Arr | Mem | Dev | Run | Pri

------------- Ready Queue --------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev
     3|    5|  100|         0|     8|        4|    1|     0

------------- Wait Queue ---------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev
```

```
------------ Complete Queue -----------
Job # | Arr | Mem | MDev | Runtime | Pri | Compl Time | TAT | WTAT
     5|    8|   10|     8|        4|    1|          19|   11|  2.75
     1|    3|  120|     5|       10|    1|          25|   22|   2.2

./intake test2.in


---------- System Information ----------
Time | Tot Mem | Avail Mem | Tot Dev | Avail Dev | Quantum | CPU Job
#
    8|      200|         10|       12|          2|        4|
1

         avg turnaround time: -1
avg weighted turnaround time: -1

------------ CPU ----------------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev
     1|    3|  120|         4|    10|       10|    1|    10

------------ Hold Queue 1 ------------
Job # | Arr | Mem | Dev | Run | Pri

------------ Hold Queue 2 ------------
Job # | Arr | Mem | Dev | Run | Pri

------------ Ready Queue -------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev

------------ Wait Queue --------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev
     2|    4|   70|         1|     3|       12|    2|     0

------------ Complete Queue -----------
Job # | Arr | Mem | MDev | Runtime | Pri | Compl Time | TAT | WTAT



---------- System Information ----------
Time | Tot Mem | Avail Mem | Tot Dev | Avail Dev | Quantum | CPU Job
#
```

```
   11|      200|          0|       12|          3|        4|
1

         avg turnaround time: -1
avg weighted turnaround time: -1

------------ CPU ----------------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev
     1|    3|  120|         7|    10|       10|    1|     6

------------ Hold Queue 1 -------------
Job # | Arr | Mem | Dev | Run | Pri

------------ Hold Queue 2 -------------
Job # | Arr | Mem | Dev | Run | Pri

------------ Ready Queue --------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev
     2|    4|   70|         1|     3|       12|    2|     3
     3|   10|   10|         0|     8|        4|    1|     0

------------ Wait Queue ---------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev

------------ Complete Queue -----------
Job # | Arr | Mem | MDev | Runtime | Pri | Compl Time | TAT | WTAT



---------- System Information ----------
Time | Tot Mem | Avail Mem | Tot Dev | Avail Dev | Quantum | CPU Job
#
   20|      200|          0|       12|          3|        4|
3

         avg turnaround time: -1
avg weighted turnaround time: -1

------------ CPU ----------------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev
     3|   10|   10|         3|     8|        4|    1|     0

------------ Hold Queue 1 -------------
```

```
Job # | Arr | Mem | Dev | Run | Pri

------------ Hold Queue 2 ------------
Job # | Arr | Mem | Dev | Run | Pri

------------ Ready Queue -------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev
     1|    3|  120|         9|    10|       10|    1|     6
     2|    4|   70|         5|     3|       12|    2|     3

------------ Wait Queue --------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev

------------ Complete Queue -----------
Job # | Arr | Mem | MDev | Runtime | Pri | Compl Time | TAT | WTAT

./intake sample.in


---------- System Information ----------
Time | Tot Mem | Avail Mem | Tot Dev | Avail Dev | Quantum | CPU Job
#
 9999|      200|        200|       12|         12|        4|
0

         avg turnaround time: 29.5
avg weighted turnaround time: 3.0154

------------ CPU ---------------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev

------------ Hold Queue 1 ------------
Job # | Arr | Mem | Dev | Run | Pri

------------ Hold Queue 2 ------------
Job # | Arr | Mem | Dev | Run | Pri

------------ Ready Queue -------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev

------------ Wait Queue --------------
Job # | Arr | Mem | Exectime | MDev | Runtime | Pri | ADev
```

```
------------- Complete Queue -----------
Job # | Arr | Mem | MDev | Runtime | Pri | Compl Time | TAT | WTAT
     3|    9|   10|     8|        4|    1|          19|   10|   2.5
     1|    3|   20|     5|       10|    1|          29|   26|   2.6
     2|    4|   30|     2|       12|    2|          33|   29|2.41667
     4|   13|   20|     4|       11|    2|          56|   43|3.90909
     5|   24|   20|    10|        9|    1|          57|   33|3.66667
     6|   25|   20|     4|       12|    2|          61|   36|     3

./validate.py

checking D10.json against test1_D10.json


checking D26.json against test1_D26.json


checking D11.json against test2_D11.json


checking D20.json against test2_D20.json


checking D9999.json against sample_input.json
```

Json files:

D10.json


```
{
  "current_time": 2,
  "total_memory": 100,
  "available_memory": 80,
  "total_devices": 4,
  "available_devices": 2,
  "quantum": 2,
  "avg_turnaround": -1,
  "avg_weighted_turnaround": -1,
  "submitq": [],
  "readyq": [
  1
  ],
```

```
  "running": 0,
  "holdq2": [
  ],
  "holdq1": [
  ],
  "completeq": [
  ],
  "waitq": [
  2
  ],
  "job": [
  {
    "arrival_time": 0,
    "id": 1,
    "memory_required": 10,
    "max_devices": 4,
    "run_time": 5,
    "priority": 1,
    "devices_allocated": 2,
    "remaining_time": 4,
    "elapsed_time": 1
  },
  {
    "arrival_time": 0,
    "id": 2,
    "memory_required": 10,
    "max_devices": 4,
    "run_time": 5,
    "priority": 1,
    "devices_allocated": 0,
    "remaining_time": 4,
    "elapsed_time": 1
  }
  ]
}
```


D26.json


```
{
  "current_time": 26,
  "total_memory": 200,
  "available_memory": 30,
  "total_devices": 12,
  "available_devices": 12,
```

```
"quantum": 4,
"avg_turnaround": 16.5,
"avg_weighted_turnaround": 2.475,
"submitq": [],
"readyq": [
3
],
"running": 2,
"holdq2": [
],
"holdq1": [
],
"completeq": [
5,
1
],
"waitq": [
],
"job": [
{
  "arrival_time": 5,
  "id": 3,
  "memory_required": 100,
  "max_devices": 8,
  "run_time": 4,
  "priority": 1,
  "devices_allocated": 0,
  "remaining_time": 4,
  "elapsed_time": 0
},
  {
    "arrival_time": 8,
    "id": 5,
    "memory_required": 10,
    "max_devices": 8,
    "run_time": 4,
    "priority": 1,
    "devices_allocated": 0,
    "elapsed_time": 4,
    "turnaround_time": 11,
    "remaining_time": 0,
    "completion_time": 19,
    "weighted_turnaround_time": 2.75
```

```
    },
    {
      "arrival_time": 3,
      "id": 1,
      "memory_required": 120,
      "max_devices": 5,
      "run_time": 10,
      "priority": 1,
      "devices_allocated": 0,
      "elapsed_time": 10,
      "turnaround_time": 22,
      "remaining_time": 0,
      "completion_time": 25,
      "weighted_turnaround_time": 2.2
    },
  {
    "arrival_time": 4,
    "id": 2,
    "memory_required": 70,
    "max_devices": 2,
    "run_time": 12,
    "priority": 2,
    "devices_allocated": 0,
    "remaining_time": 3,
    "elapsed_time": 9
  }
  ]
}
```


D11.json


```
{
  "current_time": 11,
  "total_memory": 200,
  "available_memory": 0,
  "total_devices": 12,
  "available_devices": 3,
  "quantum": 4,
  "avg_turnaround": -1,
  "avg_weighted_turnaround": -1,
  "submitq": [],
  "readyq": [
  2,
  3
```

```
],
"running": 1,
"holdq2": [
],
"holdq1": [
],
"completeq": [
],
"waitq": [
],
"job": [
{
  "arrival_time": 4,
  "id": 2,
  "memory_required": 70,
  "max_devices": 3,
  "run_time": 12,
  "priority": 2,
  "devices_allocated": 3,
  "remaining_time": 11,
  "elapsed_time": 1
},
{
  "arrival_time": 10,
  "id": 3,
  "memory_required": 10,
  "max_devices": 8,
  "run_time": 4,
  "priority": 1,
  "devices_allocated": 0,
  "remaining_time": 4,
  "elapsed_time": 0
},
{
  "arrival_time": 3,
  "id": 1,
  "memory_required": 120,
  "max_devices": 10,
  "run_time": 10,
  "priority": 1,
  "devices_allocated": 6,
  "remaining_time": 3,
  "elapsed_time": 7
```

```
  }
  ]
}
```

D20.json


```
{
  "current_time": 20,
  "total_memory": 200,
  "available_memory": 0,
  "total_devices": 12,
  "available_devices": 3,
  "quantum": 4,
  "avg_turnaround": -1,
  "avg_weighted_turnaround": -1,
  "submitq": [],
  "readyq": [
  1,
  2
  ],
  "running": 3,
  "holdq2": [
  ],
  "holdq1": [
  ],
  "completeq": [
  ],
  "waitq": [
  ],
  "job": [
  {
    "arrival_time": 3,
    "id": 1,
    "memory_required": 120,
    "max_devices": 10,
    "run_time": 10,
    "priority": 1,
    "devices_allocated": 6,
    "remaining_time": 1,
    "elapsed_time": 9
  },
  {
    "arrival_time": 4,
    "id": 2,
```

```
    "memory_required": 70,
    "max_devices": 3,
    "run_time": 12,
    "priority": 2,
    "devices_allocated": 3,
    "remaining_time": 7,
    "elapsed_time": 5
  },
  {
    "arrival_time": 10,
    "id": 3,
    "memory_required": 10,
    "max_devices": 8,
    "run_time": 4,
    "priority": 1,
    "devices_allocated": 0,
    "remaining_time": 1,
    "elapsed_time": 3
  }
  ]
}
```


D9999.json


```
{
  "current_time": 9999,
  "total_memory": 200,
  "available_memory": 200,
  "total_devices": 12,
  "available_devices": 12,
  "quantum": 4,
  "avg_turnaround": 29.5,
  "avg_weighted_turnaround": 3.0154,
  "submitq": [],
  "readyq": [
  ],
  "running": 0,
  "holdq2": [
  ],
  "holdq1": [
  ],
  "completeq": [
  3,
  1,
```

```
2,
4,
5,
6
],
"waitq": [
],
"job": [
  {
    "arrival_time": 9,
    "id": 3,
    "memory_required": 10,
    "max_devices": 8,
    "run_time": 4,
    "priority": 1,
    "devices_allocated": 0,
    "elapsed_time": 4,
    "turnaround_time": 10,
    "remaining_time": 0,
    "completion_time": 19,
    "weighted_turnaround_time": 2.5
  },
  {
    "arrival_time": 3,
    "id": 1,
    "memory_required": 20,
    "max_devices": 5,
    "run_time": 10,
    "priority": 1,
    "devices_allocated": 0,
    "elapsed_time": 10,
    "turnaround_time": 26,
    "remaining_time": 0,
    "completion_time": 29,
    "weighted_turnaround_time": 2.6
  },
  {
    "arrival_time": 4,
    "id": 2,
    "memory_required": 30,
    "max_devices": 2,
    "run_time": 12,
    "priority": 2,
```

```
  "devices_allocated": 0,
  "elapsed_time": 12,
  "turnaround_time": 29,
  "remaining_time": 0,
  "completion_time": 33,
  "weighted_turnaround_time": 2.41667
},
{
  "arrival_time": 13,
  "id": 4,
  "memory_required": 20,
  "max_devices": 4,
  "run_time": 11,
  "priority": 2,
  "devices_allocated": 0,
  "elapsed_time": 11,
  "turnaround_time": 43,
  "remaining_time": 0,
  "completion_time": 56,
  "weighted_turnaround_time": 3.90909
},
{
  "arrival_time": 24,
  "id": 5,
  "memory_required": 20,
  "max_devices": 10,
  "run_time": 9,
  "priority": 1,
  "devices_allocated": 0,
  "elapsed_time": 9,
  "turnaround_time": 33,
  "remaining_time": 0,
  "completion_time": 57,
  "weighted_turnaround_time": 3.66667
},
{
  "arrival_time": 25,
  "id": 6,
  "memory_required": 20,
  "max_devices": 4,
  "run_time": 12,
  "priority": 2,
  "devices_allocated": 0,
```

```
      "elapsed_time": 12,
      "turnaround_time": 36,
      "remaining_time": 0,
      "completion_time": 61,
      "weighted_turnaround_time": 3
    }
  ]
}
```