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Present:

CS440 Project 3: Don’t Come Into the Potty With Me

a) Data Structures

Our project has three primary data structures: People, Restrooms, and the Restroom Scheduler. People, which are threads, contain the majority of the information that is utilized by the higher data structures, such as IDs, the amount of time they’ll be present in the restroom, and some other data, as well as taking a mutex lock (Semaphore key) from the semaphore set up in the restroom. The restroom has a number of stalls and a clock time, as well as two different arraylists - one to keep track of the people who have been finished, and one to keep track of the people who are currently present in the restroom. Each of those people’s start times, and their end times, are compared against the global time that the restroom pulls from the restroom scheduler. The restroom scheduler, while being an important structure, is where everything actually takes place, maintaining a single global time that is passed into the restroom to make sure that everyone is leaving at their proper time, and controlling everything through a while loop that ensures that each thread is incremented properly.

More importantly, the data structures we used to control our population of peasants pedantically petering about piteously outside of the bathroom were queues - or more accurately, linked lists. First come, first served… provided that they were the gender of the people who initially entered the bathroom. If they were, they got into the bathroom first, and only once all of that gender vacated the bathroom was the other allowed in. These were two separate linked lists, one for men, one for females, and were compared to each other so that not only was gender taken into account, but IDs too. As a result, a sequential order is established for each gender, which can lead to starvation (or at the very least, incredibly long waits), if there are enough of one gender vs the other.

b) Pseudocode:

```
while there are still people arriving to the bathroom:
    Give each person an id.
    Identify their gender.
    Separate them into a male queue and female queue.
    Give a key to person ID 0. Check their gender. Check their queue. Give key 2
    and/or key 3 to other people in that gender queue - else, hold onto them.
    Increment time: Wait for them to finish going to the bathroom.
    Take the key from them when they leave the bathroom, shame them for not
    washing their hands. Add them to Departed list.
        If PeopleWaitingOfGenderInBathroom are > 0
            Wave the next person in, giving them a key.
    Repeat until that line is empty.
        Switch restroom from gender A to gender neutral.
```

```
            Determine if anyone is waiting: if yes, check user ID and switch to that user’s gender.
        Hand keys for up to first three people waiting in line.
            Increment time/wait.
        When people leave restroom, collect keys, redistribute them.
        If PeopleWaitingOfGender2InBathroom are > 0
            Wave the next person in, giving them a key.
    Repeat until that line is empty.
        Switch restroom from gender A to gender-neutral. Check if anyone is waiting in either line.
    Increment time until next batch of customers arrive.
        Repeat previous steps.

While loop ends: Drink a Moscow Mule for success.
```

c) A Brief Outro

Our most basic take-away was that threads must be carefully controlled or executed carefully to ensure that information is not corrupted while they are utilizing it. As a result, we had to make use of atomic integers, and ensure that there was a global variable of time that was being incremented, to ensure that our threads did not decide to try to cut in line for leaving the bathroom.

Honestly, we found that semaphores were not not that difficult to actually implement. While it took a little while to ensure that we understood the code regarding the implementation and usage of them, and after a few tries the threads were acting properly in regards to taking the permits and returning them under the direction of their overseers.

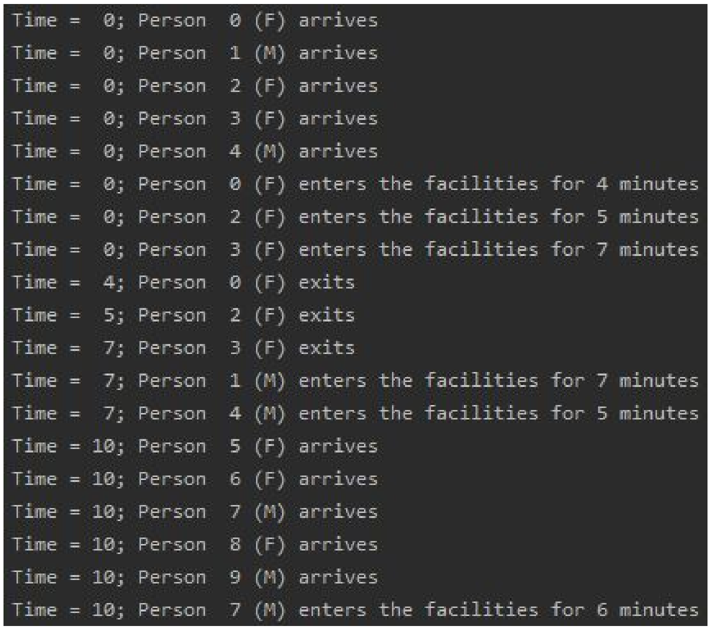
In regards to the program itself, we found that using seed 17 always resulted in females being the first person into the line, and thus, into the bathroom, and that the only time that men actually seemed to get into the bathroom first was if we ensured that was a 100% chance for the people arriving to be male.

And lastly, we found that starvation seemed fairly likely if the time-stamps were to be taken as actual minutes (or even seconds, or tenths of a second), as in a scenario where we implemented 5000 people with 10 stalls coming in groups of 100 every 60 minutes, we found that there were periods of time that went into ‘hours’ of waiting time for the people of opposite genders, if each time stamp was actually a minute. That seems to indicate starvation! This does mean that even something as simple as adding a binary discriminator like A or B as a means of choosing which processes get access to resources first can lead to severe time gaps.

And on the subject of extra stalls, just because you have extra stalls does not necessarily mean that things will get done much faster, due to the fact that if there’s a group of a single woman who arrived first, and a group of 9 men, they still need to wait for that one person who has the entire bathroom of six stalls to themselves, to finish up first before they are able to get done in roughly 1.5x the normal speed. In the end, there really was not that significant of a difference, although naturally less resources does mean it can take more time.

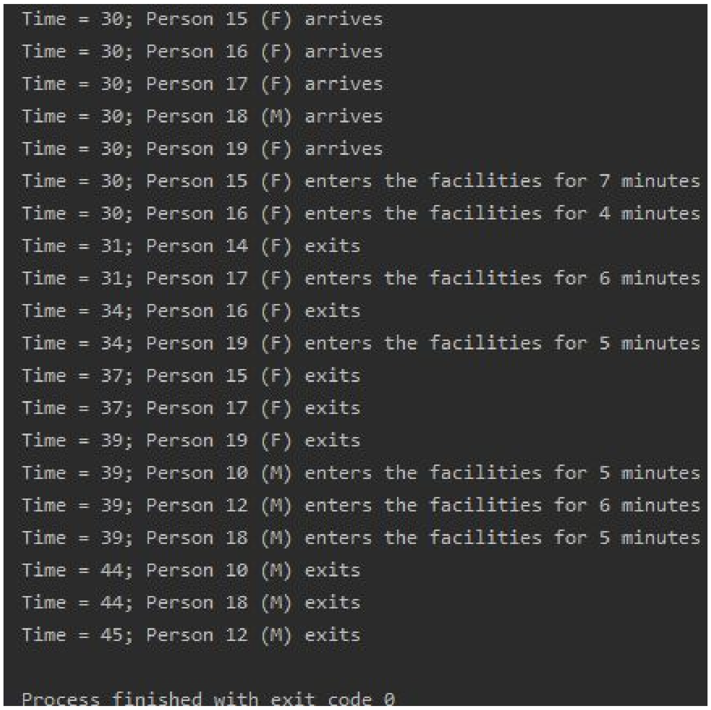
d) Output of Runs/Appendix

Option A First Arrivals



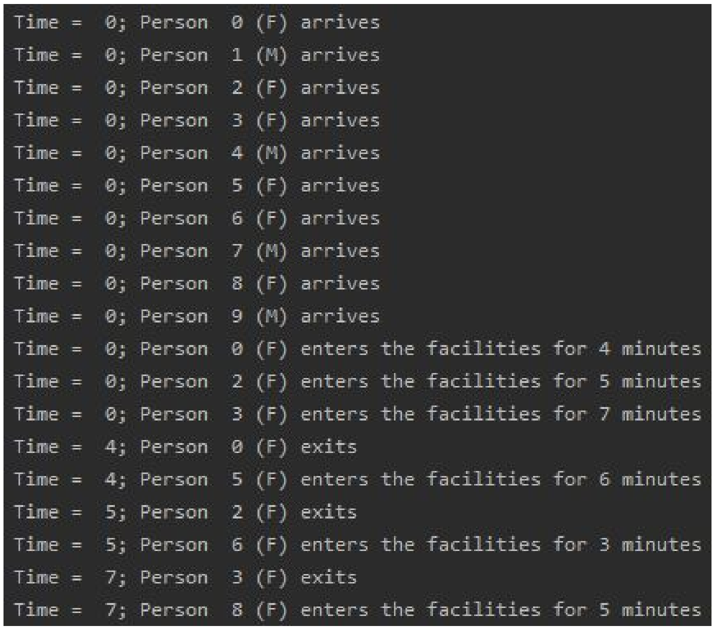
```
Time =  0; Person  0 (F) arrives
Time =  0; Person  1 (M) arrives
Time =  0; Person  2 (F) arrives
Time =  0; Person  3 (F) arrives
Time =  0; Person  4 (M) arrives
Time =  0; Person  0 (F) enters the facilities for 4 minutes
Time =  0; Person  2 (F) enters the facilities for 5 minutes
Time =  0; Person  3 (F) enters the facilities for 7 minutes
Time =  4; Person  0 (F) exits
Time =  5; Person  2 (F) exits
Time =  7; Person  3 (F) exits
Time =  7; Person  1 (M) enters the facilities for 7 minutes
Time =  7; Person  4 (M) enters the facilities for 5 minutes
Time = 10; Person  5 (F) arrives
Time = 10; Person  6 (F) arrives
Time = 10; Person  7 (M) arrives
Time = 10; Person  8 (F) arrives
Time = 10; Person  9 (M) arrives
Time = 10; Person  7 (M) enters the facilities for 6 minutes
```

Option A Last Exits



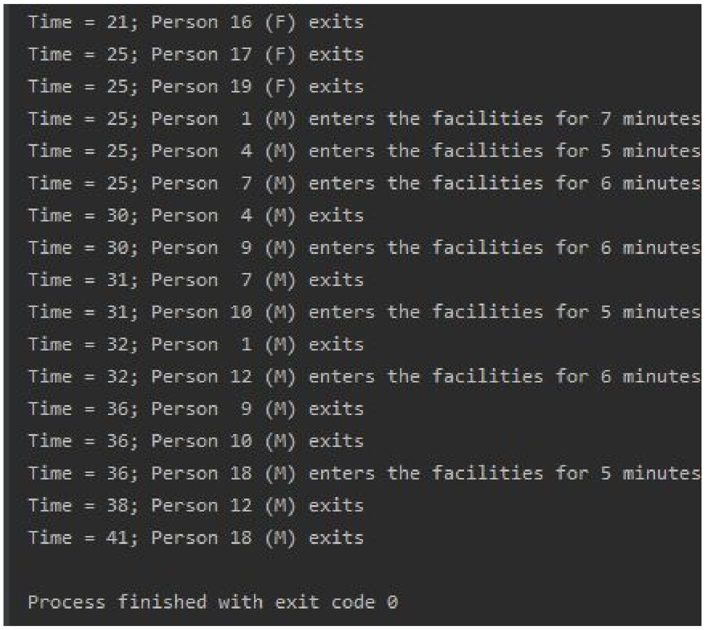
```
 Time = 30; Person 15 (F) arrives
 Time = 30; Person 16 (F) arrives
 Time = 30; Person 17 (F) arrives
 Time = 30; Person 18 (M) arrives
 Time = 30; Person 19 (F) arrives
 Time = 30; Person 15 (F) enters the facilities for 7 minutes
 Time = 30; Person 16 (F) enters the facilities for 4 minutes
 Time = 31; Person 14 (F) exits
 Time = 31; Person 17 (F) enters the facilities for 6 minutes
 Time = 34; Person 16 (F) exits
 Time = 34; Person 19 (F) enters the facilities for 5 minutes
 Time = 37; Person 15 (F) exits
 Time = 37; Person 17 (F) exits
 Time = 39; Person 19 (F) exits
 Time = 39; Person 10 (M) enters the facilities for 5 minutes
 Time = 39; Person 12 (M) enters the facilities for 6 minutes
 Time = 39; Person 18 (M) enters the facilities for 5 minutes
 Time = 44; Person 10 (M) exits
 Time = 44; Person 18 (M) exits
 Time = 45; Person 12 (M) exits

 Process finished with exit code 0
```

Option B First Arrivals



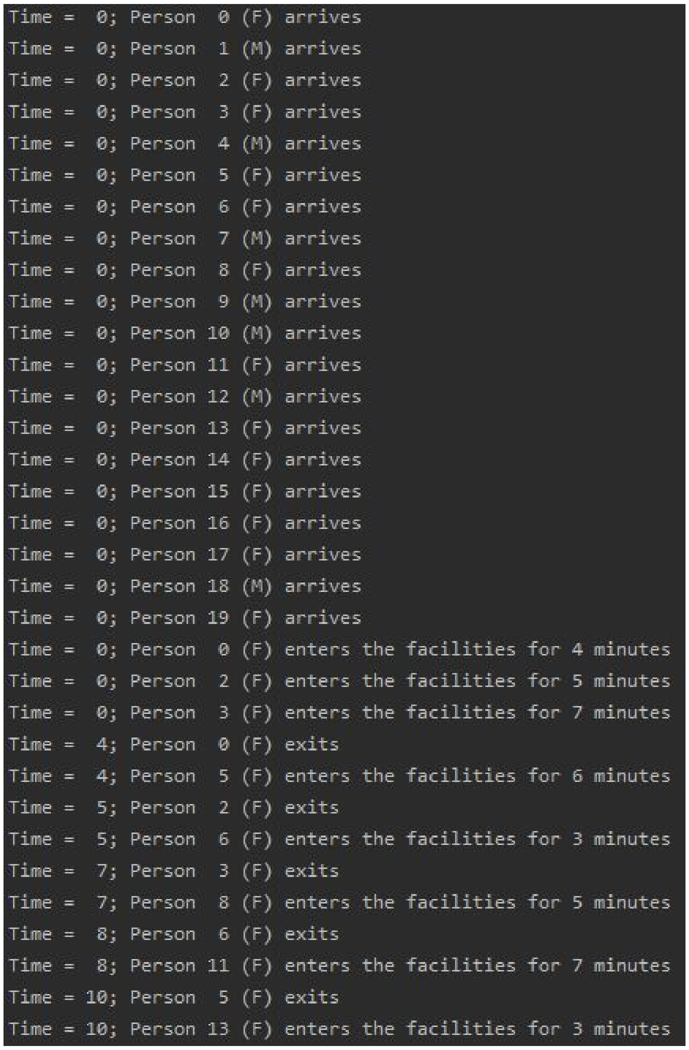
```
Time =  0; Person  0 (F) arrives
Time =  0; Person  1 (M) arrives
Time =  0; Person  2 (F) arrives
Time =  0; Person  3 (F) arrives
Time =  0; Person  4 (M) arrives
Time =  0; Person  5 (F) arrives
Time =  0; Person  6 (F) arrives
Time =  0; Person  7 (M) arrives
Time =  0; Person  8 (F) arrives
Time =  0; Person  9 (M) arrives
Time =  0; Person  0 (F) enters the facilities for 4 minutes
Time =  0; Person  2 (F) enters the facilities for 5 minutes
Time =  0; Person  3 (F) enters the facilities for 7 minutes
Time =  4; Person  0 (F) exits
Time =  4; Person  5 (F) enters the facilities for 6 minutes
Time =  5; Person  2 (F) exits
Time =  5; Person  6 (F) enters the facilities for 3 minutes
Time =  7; Person  3 (F) exits
Time =  7; Person  8 (F) enters the facilities for 5 minutes
```

Option B Last Exits



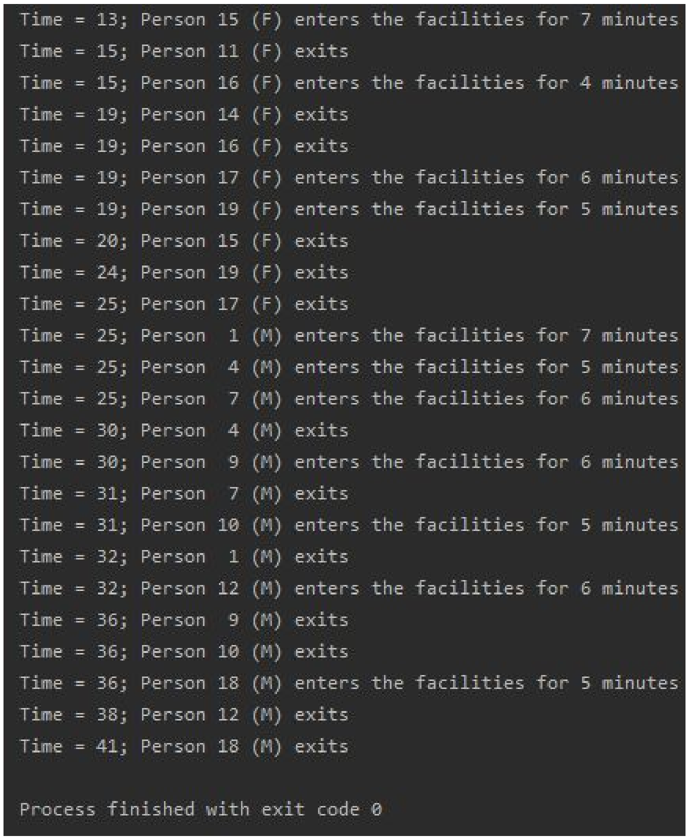
```
Time = 21; Person 16 (F) exits
Time = 25; Person 17 (F) exits
Time = 25; Person 19 (F) exits
Time = 25; Person  1 (M) enters the facilities for 7 minutes
Time = 25; Person  4 (M) enters the facilities for 5 minutes
Time = 25; Person  7 (M) enters the facilities for 6 minutes
Time = 30; Person  4 (M) exits
Time = 30; Person  9 (M) enters the facilities for 6 minutes
Time = 31; Person  7 (M) exits
Time = 31; Person 10 (M) enters the facilities for 5 minutes
Time = 32; Person  1 (M) exits
Time = 32; Person 12 (M) enters the facilities for 6 minutes
Time = 36; Person  9 (M) exits
Time = 36; Person 10 (M) exits
Time = 36; Person 18 (M) enters the facilities for 5 minutes
Time = 38; Person 12 (M) exits
Time = 41; Person 18 (M) exits

Process finished with exit code 0
```

Option C First Arrivals



```
Time =  0; Person  0 (F) arrives
Time =  0; Person  1 (M) arrives
Time =  0; Person  2 (F) arrives
Time =  0; Person  3 (F) arrives
Time =  0; Person  4 (M) arrives
Time =  0; Person  5 (F) arrives
Time =  0; Person  6 (F) arrives
Time =  0; Person  7 (M) arrives
Time =  0; Person  8 (F) arrives
Time =  0; Person  9 (M) arrives
Time =  0; Person 10 (M) arrives
Time =  0; Person 11 (F) arrives
Time =  0; Person 12 (M) arrives
Time =  0; Person 13 (F) arrives
Time =  0; Person 14 (F) arrives
Time =  0; Person 15 (F) arrives
Time =  0; Person 16 (F) arrives
Time =  0; Person 17 (F) arrives
Time =  0; Person 18 (M) arrives
Time =  0; Person 19 (F) arrives
Time =  0; Person  0 (F) enters the facilities for 4 minutes
Time =  0; Person  2 (F) enters the facilities for 5 minutes
Time =  0; Person  3 (F) enters the facilities for 7 minutes
Time =  4; Person  0 (F) exits
Time =  4; Person  5 (F) enters the facilities for 6 minutes
Time =  5; Person  2 (F) exits
Time =  5; Person  6 (F) enters the facilities for 3 minutes
Time =  7; Person  3 (F) exits
Time =  7; Person  8 (F) enters the facilities for 5 minutes
Time =  8; Person  6 (F) exits
Time =  8; Person 11 (F) enters the facilities for 7 minutes
Time = 10; Person  5 (F) exits
Time = 10; Person 13 (F) enters the facilities for 3 minutes
```

Option C Last Exits



```
Time = 13; Person 15 (F) enters the facilities for 7 minutes
Time = 15; Person 11 (F) exits
Time = 15; Person 16 (F) enters the facilities for 4 minutes
Time = 19; Person 14 (F) exits
Time = 19; Person 16 (F) exits
Time = 19; Person 17 (F) enters the facilities for 6 minutes
Time = 19; Person 19 (F) enters the facilities for 5 minutes
Time = 20; Person 15 (F) exits
Time = 24; Person 19 (F) exits
Time = 25; Person 17 (F) exits
Time = 25; Person  1 (M) enters the facilities for 7 minutes
Time = 25; Person  4 (M) enters the facilities for 5 minutes
Time = 25; Person  7 (M) enters the facilities for 6 minutes
Time = 30; Person  4 (M) exits
Time = 30; Person  9 (M) enters the facilities for 6 minutes
Time = 31; Person  7 (M) exits
Time = 31; Person 10 (M) enters the facilities for 5 minutes
Time = 32; Person  1 (M) exits
Time = 32; Person 12 (M) enters the facilities for 6 minutes
Time = 36; Person  9 (M) exits
Time = 36; Person 10 (M) exits
Time = 36; Person 18 (M) enters the facilities for 5 minutes
Time = 38; Person 12 (M) exits
Time = 41; Person 18 (M) exits

Process finished with exit code 0
```