# Summary

The project was to simulate a postal office situation where there are 3 postal workers and 50 customers for the day. At a time 10 customers were allowed to enter the office. The customers will assign some random tasks to the workers. If the customer has to mail a package, the worker will have to use a scale. Only one scale is available at the office. So if two customers have to mail a package, one has to wait until the other finishes.

## Simulation of the program

I’ve simulated the post office situation with the help of semaphores and threads. I used JAVA as the programming language and Net Beans as the client. The java SDK which was used is 1.8. First I created a main class “PostOffice” and main method where the execution first starts. I created two classes Customer and PostalWorker within the PostOffice class because everything interaction happens within the post office. All the classes use the Threads interface so whenever I start an instance of a class, the compiler executes the run method of that class. I created customers and postal workers inside the PostOffice class and I start them once they were created. I also assign the tasks for each customer when they were created.

In the run method of customer Class, I make the customer wait if there are already 10 customers inside the post office. If not, the customer can enter the office and is queued. Then the customer waits for a postal worker to get free. Once a postal worker is freed, the customer is assigned to the worker. The customer then asks for a task to be done and transfers the control to the worker. Once the task is completed, the control is transferred again to the customer and he finishes his work and exits the post office.

In the run method of PostalWorker class, I wait for a customer to be ready. Once a customer is ready, he is assigned to the worker and also a task. The worker does the task and each task takes different amount of time as given in the task time table. The worker uses a scale while mailing a package and there’s only one scale in the post office. So I’ve used a semaphore to let only one worker to use the scale at a time.

## Difficulties Faced

When I first wrote the program, I found that only the customer thread was running. Later, I found out that I did not write any code to start the PostalWorker threads.

The second and the biggest difficulty I faced was when I had to print the tasks done by the customer and postal worker in their respective threads. The difficulty is due to the fact that a customer is assigned to any free postal worker. So in every run it changes. So I created more array of semaphores for each customer to find out when the worker is assigned to the customer and save it in an array. I still feel that the code is complicated because of using too many arrays of semaphores but I couldn’t find any other way to print the tasks done by customer and the worker in their respective threads.

Another difficulty I faced was while using the mutex semaphore. Before doing the project, I did not have an idea about what a mutex will do. Once I searched for its function in the internet, it was fairly easy to understand it. I’ve used two mutex semaphores in the program, mutex and scales.

The final difficulty I faced was when the postal worker class failed to get joined. This happened because the worker has an infinite loop. I solved it by forcing the thread to close by adding a parameter to the join method. When there is no parameter, the thread waits for infinite time to exit before it is joined. I interrupted the worker when all the work is done and forced him to join.

## What I learnt

From this project, I learnt a great deal about semaphores. This project has helped understand how semaphores are implemented and how block, ready and running states work. I also learnt how to prevent mutual exclusion and the use of mutex semaphores.

## Results

The results followed the same structure as given in the output sample. I followed every naming pattern that the sample has used. One of the runs of the program in UNIX environment gave the following output:

Simulating Post Office with 50 customers and 3 postal workers

Customer 0 created

Customer 1 created

Customer 2 created

Customer 0 enters post office

Customer 3 created

Customer 1 enters post office

Customer 4 created

Customer 2 enters post office

Customer 5 created

Customer 3 enters post office

Customer 4 enters post office

Customer 6 created

Customer 7 created

Customer 5 enters post office

Customer 8 created

Customer 6 enters post office

Customer 9 created

Customer 7 enters post office

Customer 10 created

Customer 8 enters post office

Customer 11 created

Customer 9 enters post office

Customer 12 created

Customer 13 created

Customer 14 created

Customer 15 created

Customer 16 created

Customer 17 created

Customer 18 created

Customer 19 created

Customer 20 created

Customer 21 created

Customer 22 created

Customer 23 created

Customer 24 created

Customer 25 created

Customer 26 created

Customer 27 created

Customer 28 created

Customer 29 created

Customer 30 created

Customer 31 created

Customer 32 created

Customer 33 created

Customer 34 created

Customer 35 created

Customer 36 created

Customer 37 created

Customer 38 created

Customer 39 created

Customer 40 created

Customer 41 created

Customer 42 created

Customer 43 created

Customer 44 created

Customer 45 created

Customer 46 created

Customer 47 created

Customer 48 created

Customer 49 created

Postal Worker 0 created

Postal Worker 1 created

Postal Worker 0 serving customer 0

Postal Worker 2 created

Customer 0 asks postal worker 0 to mail a letter

Postal Worker 1 serving customer 2

Customer 2 asks postal worker 1 to buy stamps

Postal Worker 2 serving customer 1

Customer 1 asks postal worker 2 to mail a package

Scales in use by postal worker 2

Postal Worker 1 finished serving customer 2

Customer 2 finished buying stamps

Postal Worker 1 serving customer 3

Customer 2 leaves post office

Customer 3 asks postal worker 1 to buy stamps

Customer 10 enters post office

Postal Worker 0 finished serving customer 0

Customer 0 finished mailing a letter

Customer 0 leaves post office

Postal Worker 0 serving customer 4

Joined customer 0

Customer 4 asks postal worker 0 to mail a letter

Customer 11 enters post office

Scales released by postal worker 2

Postal Worker 1 finished serving customer 3

Postal Worker 2 finished serving customer 1

Customer 3 finished buying stamps

Customer 3 leaves post office

Customer 1 finished mailing a package

Postal Worker 2 serving customer 5

Customer 5 asks postal worker 2 to mail a package

Customer 1 leaves post office

Postal Worker 1 serving customer 6

Scales in use by postal worker 2

Customer 6 asks postal worker 1 to buy stamps

Joined customer 1

Joined customer 2

Customer 12 enters post office

Joined customer 3

Customer 13 enters post office

Postal Worker 0 finished serving customer 4

Customer 4 finished mailing a letter

Postal Worker 0 serving customer 7

Customer 4 leaves post office

Customer 7 asks postal worker 0 to mail a package

Joined customer 4

Customer 14 enters post office

Postal Worker 1 finished serving customer 6

Customer 6 finished buying stamps

Postal Worker 1 serving customer 8

Customer 6 leaves post office

Customer 8 asks postal worker 1 to buy stamps

Customer 15 enters post office

Scales released by postal worker 2

Postal Worker 2 finished serving customer 5

Scales in use by postal worker 0

Customer 5 finished mailing a package

Customer 5 leaves post office

Postal Worker 2 serving customer 9

Joined customer 5

Customer 9 asks postal worker 2 to mail a letter

Postal Worker 1 finished serving customer 8

Customer 8 finished buying stamps

Joined customer 6

Postal Worker 1 serving customer 10

Customer 8 leaves post office

Customer 16 enters post office

Customer 10 asks postal worker 1 to buy stamps

Customer 17 enters post office

Postal Worker 1 finished serving customer 10

Customer 10 finished buying stamps

Postal Worker 1 serving customer 11

Customer 10 leaves post office

Customer 11 asks postal worker 1 to mail a letter

Customer 18 enters post office

Postal Worker 2 finished serving customer 9

Customer 9 finished mailing a letter

Postal Worker 2 serving customer 12

Customer 9 leaves post office

Customer 12 asks postal worker 2 to mail a package

Customer 19 enters post office

Scales released by postal worker 0

Postal Worker 0 finished serving customer 7

Scales in use by postal worker 2

Customer 7 finished mailing a package

Postal Worker 0 serving customer 13

Customer 7 leaves post office

Customer 13 asks postal worker 0 to mail a letter

Joined customer 7

Joined customer 8

Joined customer 9

Joined customer 10

Customer 20 enters post office

Postal Worker 1 finished serving customer 11

Customer 11 finished mailing a letter

Postal Worker 1 serving customer 14

Customer 11 leaves post office

Customer 14 asks postal worker 1 to mail a package

Joined customer 11

Customer 21 enters post office

Postal Worker 0 finished serving customer 13

Customer 13 finished mailing a letter

Postal Worker 0 serving customer 15

Customer 13 leaves post office

Customer 22 enters post office

Customer 15 asks postal worker 0 to mail a package

Scales released by postal worker 2

Postal Worker 2 finished serving customer 12

Scales in use by postal worker 1

Customer 12 finished mailing a package

Postal Worker 2 serving customer 16

Customer 12 leaves post office

Customer 16 asks postal worker 2 to mail a package

Joined customer 12

Joined customer 13

Customer 23 enters post office

Scales released by postal worker 1

Postal Worker 1 finished serving customer 14

Scales in use by postal worker 0

Customer 14 finished mailing a package

Customer 14 leaves post office

Postal Worker 1 serving customer 17

Joined customer 14

Customer 17 asks postal worker 1 to mail a letter

Customer 24 enters post office

Postal Worker 1 finished serving customer 17

Customer 17 finished mailing a letter

Postal Worker 1 serving customer 18

Customer 17 leaves post office

Customer 18 asks postal worker 1 to mail a package

Customer 25 enters post office

Scales released by postal worker 0

Postal Worker 0 finished serving customer 15

Scales in use by postal worker 2

Customer 15 finished mailing a package

Postal Worker 0 serving customer 19

Customer 15 leaves post office

Customer 19 asks postal worker 0 to mail a package

Joined customer 15

Customer 26 enters post office

Scales released by postal worker 2

Postal Worker 2 finished serving customer 16

Scales in use by postal worker 1

Postal Worker 2 serving customer 20

Customer 16 finished mailing a package

Customer 16 leaves post office

Joined customer 16

Customer 20 asks postal worker 2 to mail a package

Joined customer 17

Customer 27 enters post office

Scales released by postal worker 1

Postal Worker 1 finished serving customer 18

Scales in use by postal worker 0

Customer 18 finished mailing a package

Customer 18 leaves post office

Postal Worker 1 serving customer 21

Joined customer 18

Customer 21 asks postal worker 1 to buy stamps

Customer 28 enters post office

Postal Worker 1 finished serving customer 21

Customer 21 finished buying stamps

Customer 21 leaves post office

Postal Worker 1 serving customer 22

Customer 22 asks postal worker 1 to mail a letter

Customer 29 enters post office

Scales released by postal worker 0

Postal Worker 0 finished serving customer 19

Scales in use by postal worker 2

Customer 19 finished mailing a package

Postal Worker 0 serving customer 23

Customer 19 leaves post office

Customer 23 asks postal worker 0 to mail a package

Joined customer 19

Customer 30 enters post office

Postal Worker 1 finished serving customer 22

Customer 22 finished mailing a letter

Postal Worker 1 serving customer 24

Customer 22 leaves post office

Customer 24 asks postal worker 1 to mail a letter

Customer 31 enters post office

Scales released by postal worker 2

Postal Worker 2 finished serving customer 20

Scales in use by postal worker 0

Customer 20 finished mailing a package

Postal Worker 2 serving customer 25

Customer 20 leaves post office

Customer 25 asks postal worker 2 to mail a letter

Joined customer 20

Joined customer 21

Joined customer 22

Customer 32 enters post office

Postal Worker 1 finished serving customer 24

Customer 24 finished mailing a letter

Customer 24 leaves post office

Postal Worker 1 serving customer 26

Customer 26 asks postal worker 1 to mail a package

Customer 33 enters post office

Postal Worker 2 finished serving customer 25

Customer 25 finished mailing a letter

Postal Worker 2 serving customer 27

Customer 25 leaves post office

Customer 27 asks postal worker 2 to mail a letter

Customer 34 enters post office

Scales released by postal worker 0

Postal Worker 0 finished serving customer 23

Scales in use by postal worker 1

Customer 23 finished mailing a package

Customer 23 leaves post office

Postal Worker 0 serving customer 28

Joined customer 23

Customer 28 asks postal worker 0 to buy stamps

Joined customer 24

Joined customer 25

Customer 35 enters post office

Postal Worker 0 finished serving customer 28

Customer 28 finished buying stamps

Customer 28 leaves post office

Postal Worker 2 finished serving customer 27

Postal Worker 0 serving customer 29

Customer 27 finished mailing a letter

Customer 29 asks postal worker 0 to buy stamps

Postal Worker 2 serving customer 30

Customer 27 leaves post office

Customer 36 enters post office

Customer 30 asks postal worker 2 to mail a package

Customer 37 enters post office

Scales released by postal worker 1

Postal Worker 1 finished serving customer 26

Scales in use by postal worker 2

Customer 26 finished mailing a package

Customer 26 leaves post office

Postal Worker 1 serving customer 31

Joined customer 26

Customer 31 asks postal worker 1 to buy stamps

Joined customer 27

Joined customer 28

Customer 38 enters post office

Postal Worker 0 finished serving customer 29

Customer 29 finished buying stamps

Customer 29 leaves post office

Postal Worker 0 serving customer 32

Joined customer 29

Customer 32 asks postal worker 0 to mail a package

Customer 39 enters post office

Postal Worker 1 finished serving customer 31

Customer 31 finished buying stamps

Customer 31 leaves post office

Postal Worker 1 serving customer 33

Customer 33 asks postal worker 1 to mail a package

Customer 40 enters post office

Scales released by postal worker 2

Postal Worker 2 finished serving customer 30

Scales in use by postal worker 0

Customer 30 finished mailing a package

Customer 30 leaves post office

Postal Worker 2 serving customer 34

Joined customer 30

Customer 34 asks postal worker 2 to mail a package

Joined customer 31

Customer 41 enters post office

Scales released by postal worker 0

Postal Worker 0 finished serving customer 32

Scales in use by postal worker 1

Customer 32 finished mailing a package

Postal Worker 0 serving customer 35

Customer 32 leaves post office

Customer 35 asks postal worker 0 to buy stamps

Joined customer 32

Customer 42 enters post office

Postal Worker 0 finished serving customer 35

Customer 35 finished buying stamps

Customer 35 leaves post office

Postal Worker 0 serving customer 36

Customer 36 asks postal worker 0 to mail a letter

Customer 43 enters post office

Scales released by postal worker 1

Postal Worker 1 finished serving customer 33

Scales in use by postal worker 2

Customer 33 finished mailing a package

Customer 33 leaves post office

Postal Worker 1 serving customer 37

Joined customer 33

Customer 37 asks postal worker 1 to mail a package

Customer 44 enters post office

Postal Worker 0 finished serving customer 36

Customer 36 finished mailing a letter

Postal Worker 0 serving customer 38

Customer 36 leaves post office

Customer 38 asks postal worker 0 to mail a letter

Customer 45 enters post office

Scales released by postal worker 2

Postal Worker 2 finished serving customer 34

Scales in use by postal worker 1

Customer 34 finished mailing a package

Customer 34 leaves post office

Postal Worker 2 serving customer 39

Customer 46 enters post office

Joined customer 34

Joined customer 35

Joined customer 36

Customer 39 asks postal worker 2 to mail a letter

Postal Worker 0 finished serving customer 38

Customer 38 finished mailing a letter

Customer 38 leaves post office

Postal Worker 0 serving customer 40

Customer 47 enters post office

Customer 40 asks postal worker 0 to mail a letter

Postal Worker 2 finished serving customer 39

Customer 39 finished mailing a letter

Postal Worker 2 serving customer 41

Customer 39 leaves post office

Customer 41 asks postal worker 2 to mail a letter

Postal Worker 0 finished serving customer 40

Customer 40 finished mailing a letter

Customer 40 leaves post office

Customer 48 enters post office

Postal Worker 0 serving customer 42

Customer 49 enters post office

Customer 42 asks postal worker 0 to mail a package

Scales released by postal worker 1

Postal Worker 1 finished serving customer 37

Scales in use by postal worker 0

Customer 37 finished mailing a package

Postal Worker 1 serving customer 43

Customer 37 leaves post office

Joined customer 37

Customer 43 asks postal worker 1 to mail a letter

Joined customer 38

Joined customer 39

Joined customer 40

Postal Worker 2 finished serving customer 41

Customer 41 finished mailing a letter

Customer 41 leaves post office

Postal Worker 2 serving customer 44

Joined customer 41

Customer 44 asks postal worker 2 to mail a package

Postal Worker 1 finished serving customer 43

Customer 43 finished mailing a letter

Customer 43 leaves post office

Postal Worker 1 serving customer 45

Customer 45 asks postal worker 1 to buy stamps

Scales released by postal worker 0

Postal Worker 0 finished serving customer 42

Customer 42 finished mailing a package

Customer 42 leaves post office

Postal Worker 0 serving customer 46

Scales in use by postal worker 2

Joined customer 42

Joined customer 43

Customer 46 asks postal worker 0 to buy stamps

Postal Worker 1 finished serving customer 45

Customer 45 finished buying stamps

Postal Worker 1 serving customer 47

Customer 45 leaves post office

Customer 47 asks postal worker 1 to mail a package

Postal Worker 0 finished serving customer 46

Customer 46 finished buying stamps

Customer 46 leaves post office

Postal Worker 0 serving customer 48

Customer 48 asks postal worker 0 to mail a letter

Scales released by postal worker 2

Postal Worker 2 finished serving customer 44

Scales in use by postal worker 1

Customer 44 finished mailing a package

Postal Worker 2 serving customer 49

Customer 44 leaves post office

Customer 49 asks postal worker 2 to buy stamps

Joined customer 44

Joined customer 45

Joined customer 46

Postal Worker 0 finished serving customer 48

Customer 48 finished mailing a letter

Customer 48 leaves post office

Postal Worker 2 finished serving customer 49

Customer 49 finished buying stamps

Customer 49 leaves post office

Scales released by postal worker 1

Postal Worker 1 finished serving customer 47

Customer 47 finished mailing a package

Customer 47 leaves post office

Joined customer 47

Joined customer 48

Joined customer 49

Joined Postal Worker 0

Joined Postal Worker 1

Joined Postal Worker 2