Kyle Carney

CSC 1051-1

Project 5

I did not have as much success with the project that I would like to have had. I was not able to spend as much time as I wanted because I work night shift and had to work overtime last weekend, but I did learn a lot. I came across a lot of errors and learned many things while trying to troubleshoot them. Some problems I had were when I was trying to randomly generate a character letter sometimes I got symbols like ), ;, :, etc.

I had some problems trying to come up with the algorithm for idle time and avg wait time. I know the idle time is when the queue is empty, so I must figure out the logic of how to update the idle time every time the queue equals 0. Also, the wait time average I must determine all of the wait times and then take the total number of customers and divide by it. I tried many things, but the program would break, and I decided to keep the outputs empty to get the code to run. I would like to go back and have the project completed and working efficiently.

There are a lot of problems with my code that I am aware of but need to fix such as the output for idle time, max wait time, and average wait time. After I am done writing the report I am going to start working to code those problems. Also, I currently do not have code in my program to stop the output of the same letter for consecutive customers. I tried a few ways to stop that from happening, but I need to figure out how to prevent that.

Experimenting with the program I could see how useful queueing theory can be. Coming into the project I was not very comfortable with how it works and how to read the data. I think the project gave me a lot of input to how to understand queueing theory. Something I thought was interesting is how the outputs for the data could be drastically different each time you run the program. There were times where the queue stayed small and manageable, but other times where the queue grew large and out of control.

\*\*\*\*UPDATE\*\*\*\*

I went back and finished the project. I was able add an output for total number of customers. Some problems I had was setting the variable to 1, and then updating total customers after the variable changes letters. Also, I was able to make sure that the personLetter was not the same by utilizing a do loop that generates a new letter when the old letter is the same as the new one. I felt like initially I was all over the place, but after I organized myself and wrote out the algorithm on paper I was able to tackle the project.

**Source Code**

1 //\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
 2 // QueueingTheory\_Start.java Author: Kyle Carney  
 3 //  
 4 // CSC 1051 Project 5: Customer Service Simulation  
 5 //\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
 6 import java.util.\*;  
 7 import java.util.Scanner;  
 8   
 9 public class QueueingTheory\_Start {  
 10   
 11 public static void main(String[] args) {  
 12 //-----------------------------------------------------------------  
 13 // Simulates a customer service queue using a Java String.  
 14 //-----------------------------------------------------------------  
 15 Scanner scan = new Scanner(System.in);  
 16 Random rand = new Random(); // randomized arrivals (and more?)  
 17 String queue = ""; // queue starts out empty  
 18 int minute = 1; // unit of time is minutes  
 19 //declare int variables  
 20 int minutesInput, minimumMinutes, maximumMinutes, idleTime, maxQueue;   
 21 int totalCustomers;  
 22 double avgQueue, totalQueue; //declare double variables  
 23 double customersInput; // input customers per minute  
 24 char lastLetter; //declare lastLetter  
 25 minutesInput = 0; // initalize minutesInput  
 26 customersInput = 0; //initialize customerInput  
 27 minimumMinutes = 0; //initialize minimumMinutes  
 28 maximumMinutes = 0; //initialize maximumMinutes  
 29 maxQueue = 0; //initialize maxQueue  
 30 idleTime = 0; //initialize idleTime  
 31 totalQueue = 0; //initialize totalQueue  
 32 avgQueue = 0; //initialize avgQueue  
 33 totalCustomers = 0; //initialize totalCustomers  
 34 double arrivalProbability = .25; // prob of customer arrival  
 35 // on any given minute (try different values!)  
 36 char personLetter = (char) (rand.nextInt(26) + 'A'); // symbolizes each customer  
 37 // print call center simulation title  
 38 System.out.println("Call center simulation.");  
 39 // print enter number of minutes for simulation  
 40 System.out.print("\nPlease enter the number of minutes for the simulation: ");  
 41 // input number of min for simulation  
 42 minutesInput = scan.nextInt();  
 43 // print enter number of customers per minute  
 44 System.out.print("\nPlease enter the number of customers per minute: ");  
 45 // input number of customers per minute  
 46 arrivalProbability = scan.nextDouble();  
 47 // print enter min number of min for customer service  
 48 System.out.print("\nWhat is the minimum number of minutes " +  
 49 " needed for customer service: ");  
 50 // input min number of min for customer service  
 51 minimumMinutes = scan.nextInt();  
 52 // print enter max number of min needed for customer service  
 53 System.out.print("\nWhat is the maximum number of minutes " +  
 54 "needed for customer service: ");  
 55 // input min number of minutes for customer service  
 56 maximumMinutes = scan.nextInt();  
 57 System.out.print("\n");  
 58 //generate random processing time  
 59 int processingTime = rand.nextInt(maximumMinutes) + minimumMinutes;   
 60 // main loop of simulation - minutes input  
 61 while (minute <= minutesInput) {  
 62   
 63 // randomly decide if a customer has arrived and add to queue  
 64 if (rand.nextFloat() < arrivalProbability) {  
 65   
 66 // add as many symbols as processingTime (minutes) required  
 67 int n = 0;  
 68 while (n < processingTime){  
 69 queue += personLetter;  
 70 n++;  
 71 }  
 72   
 73 // keep track of total number of customers  
 74 lastLetter = 0;  
 75 if (personLetter != lastLetter)  
 76 totalCustomers ++;  
 77   
 78 // lastLetter = personLetter  
 79 lastLetter = personLetter;  
 80 // change symbol for next customer A=Z  
 81 personLetter = (char) (rand.nextInt(26) + 'A');   
 82   
 83 do { // generate new randomLetter when personLetter is same as last letter  
 84 personLetter = (char) (rand.nextInt(26) + 'A');   
 85 } while (personLetter == lastLetter);   
 86 }  
 87 // display the current state of the queue  
 88 System.out.println(minute + " >>> \t" + queue);  
 89   
 90 //if queue length > 0 totalQueue = totalqueue + queue length  
 91 if (queue.length() > 0)  
 92 totalQueue = totalQueue + queue.length();  
 93   
 94 //average queue = total queue / total minutes  
 95 avgQueue = totalQueue / minutesInput;  
 96   
 97 // if queue length is > max queue increase maxqueue set maxQueue = queue.length  
 98 if (queue.length() > maxQueue)  
 99 maxQueue = queue.length();  
100   
101 // if queue is empty increase total minutes of idle time  
102 if (queue.length() < 1)  
103 idleTime ++;  
104   
105 // serve customer at front of queue (if any) for 1 minute  
106 if (queue.length() > 0)  
107 queue = queue.substring(1);  
108   
109 minute++; // tick tock... as time goes by  
110 }  
111 System.out.println("\n\n\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*");  
112 //print call center simulation  
113 System.out.println("Call center simulation.");  
114 // print calls placed with probability per minute  
115 System.out.println("Calls placed with probability per minute: "  
116 + arrivalProbability);  
117 //print call duration minimum to maximum  
118 System.out.println("Call duration: " + minimumMinutes + " to " + maximumMinutes);  
119 //print idle time  
120 System.out.println("Idle time: " + idleTime );  
121 //print maximum queue length  
122 System.out.println("Max queue length: " + maxQueue);  
123 //print average queue length  
124 System.out.println("Avg queue length: " + avgQueue);  
125 //print total number of customers  
126 System.out.println("Total number of customers during session: " + totalCustomers);  
127 }  
128 }

**Test Runs**

**Inputs .25, 50, 2, 10 (same as sample)**  
  
Please enter the number of minutes for the simulation: 50  
  
Please enter the number of customers per minute: .25  
  
What is the minimum number of minutes needed for customer service: 2  
  
What is the maximum number of minutes needed for customer service: 10  
  
1 >>>   
2 >>>   
3 >>>   
4 >>> ZZZZZZZZ  
5 >>> ZZZZZZZ  
6 >>> ZZZZZZ  
7 >>> ZZZZZVVVVVVVV  
8 >>> ZZZZVVVVVVVV  
9 >>> ZZZVVVVVVVV  
10 >>> ZZVVVVVVVVMMMMMMMM  
11 >>> ZVVVVVVVVMMMMMMMM  
12 >>> VVVVVVVVMMMMMMMM  
13 >>> VVVVVVVMMMMMMMM  
14 >>> VVVVVVMMMMMMMM  
15 >>> VVVVVMMMMMMMM  
16 >>> VVVVMMMMMMMM  
17 >>> VVVMMMMMMMM  
18 >>> VVMMMMMMMMWWWWWWWW  
19 >>> VMMMMMMMMWWWWWWWW  
20 >>> MMMMMMMMWWWWWWWWBBBBBBBB  
21 >>> MMMMMMMWWWWWWWWBBBBBBBB  
22 >>> MMMMMMWWWWWWWWBBBBBBBB  
23 >>> MMMMMWWWWWWWWBBBBBBBB  
24 >>> MMMMWWWWWWWWBBBBBBBB  
25 >>> MMMWWWWWWWWBBBBBBBB  
26 >>> MMWWWWWWWWBBBBBBBB  
27 >>> MWWWWWWWWBBBBBBBBIIIIIIII  
28 >>> WWWWWWWWBBBBBBBBIIIIIIII  
29 >>> WWWWWWWBBBBBBBBIIIIIIII  
30 >>> WWWWWWBBBBBBBBIIIIIIII  
31 >>> WWWWWBBBBBBBBIIIIIIII  
32 >>> WWWWBBBBBBBBIIIIIIIIEEEEEEEE  
33 >>> WWWBBBBBBBBIIIIIIIIEEEEEEEE  
34 >>> WWBBBBBBBBIIIIIIIIEEEEEEEE  
35 >>> WBBBBBBBBIIIIIIIIEEEEEEEE  
36 >>> BBBBBBBBIIIIIIIIEEEEEEEE  
37 >>> BBBBBBBIIIIIIIIEEEEEEEE  
38 >>> BBBBBBIIIIIIIIEEEEEEEE  
39 >>> BBBBBIIIIIIIIEEEEEEEE  
40 >>> BBBBIIIIIIIIEEEEEEEE  
41 >>> BBBIIIIIIIIEEEEEEEE  
42 >>> BBIIIIIIIIEEEEEEEEJJJJJJJJ  
43 >>> BIIIIIIIIEEEEEEEEJJJJJJJJ  
44 >>> IIIIIIIIEEEEEEEEJJJJJJJJ  
45 >>> IIIIIIIEEEEEEEEJJJJJJJJ  
46 >>> IIIIIIEEEEEEEEJJJJJJJJCCCCCCCC  
47 >>> IIIIIEEEEEEEEJJJJJJJJCCCCCCCC  
48 >>> IIIIEEEEEEEEJJJJJJJJCCCCCCCCYYYYYYYY  
49 >>> IIIEEEEEEEEJJJJJJJJCCCCCCCCYYYYYYYY  
50 >>> IIEEEEEEEEJJJJJJJJCCCCCCCCYYYYYYYYRRRRRRRR  
  
  
\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
Call center simulation.  
Calls placed with probability per minute: 0.25  
Call duration: 2 to 10  
Idle time: 3  
Max queue length: 42  
Avg queue length: 19.5  
Total number of customers during session: 11  


**2 cases queue growing out of control**

 ----jGRASP exec: java QueueingTheory\_Start  
Call center simulation.  
  
Please enter the number of minutes for the simulation: 50  
  
Please enter the number of customers per minute: .25  
  
What is the minimum number of minutes needed for customer service: 2  
  
What is the maximum number of minutes needed for customer service: 10  
  
1 >>>   
2 >>>   
3 >>>   
4 >>> LLLLLLLLL  
5 >>> LLLLLLLLYYYYYYYYY  
6 >>> LLLLLLLYYYYYYYYY  
7 >>> LLLLLLYYYYYYYYY  
8 >>> LLLLLYYYYYYYYYKKKKKKKKK  
9 >>> LLLLYYYYYYYYYKKKKKKKKK  
10 >>> LLLYYYYYYYYYKKKKKKKKK  
11 >>> LLYYYYYYYYYKKKKKKKKK  
12 >>> LYYYYYYYYYKKKKKKKKKNNNNNNNNN  
13 >>> YYYYYYYYYKKKKKKKKKNNNNNNNNN  
14 >>> YYYYYYYYKKKKKKKKKNNNNNNNNN  
15 >>> YYYYYYYKKKKKKKKKNNNNNNNNN  
16 >>> YYYYYYKKKKKKKKKNNNNNNNNN  
17 >>> YYYYYKKKKKKKKKNNNNNNNNN  
18 >>> YYYYKKKKKKKKKNNNNNNNNN  
19 >>> YYYKKKKKKKKKNNNNNNNNN  
20 >>> YYKKKKKKKKKNNNNNNNNN  
21 >>> YKKKKKKKKKNNNNNNNNN  
22 >>> KKKKKKKKKNNNNNNNNN  
23 >>> KKKKKKKKNNNNNNNNNJJJJJJJJJ  
24 >>> KKKKKKKNNNNNNNNNJJJJJJJJJUUUUUUUUU  
25 >>> KKKKKKNNNNNNNNNJJJJJJJJJUUUUUUUUU  
26 >>> KKKKKNNNNNNNNNJJJJJJJJJUUUUUUUUU  
27 >>> KKKKNNNNNNNNNJJJJJJJJJUUUUUUUUU  
28 >>> KKKNNNNNNNNNJJJJJJJJJUUUUUUUUU  
29 >>> KKNNNNNNNNNJJJJJJJJJUUUUUUUUU  
30 >>> KNNNNNNNNNJJJJJJJJJUUUUUUUUUWWWWWWWWW  
31 >>> NNNNNNNNNJJJJJJJJJUUUUUUUUUWWWWWWWWW  
32 >>> NNNNNNNNJJJJJJJJJUUUUUUUUUWWWWWWWWW  
33 >>> NNNNNNNJJJJJJJJJUUUUUUUUUWWWWWWWWW  
34 >>> NNNNNNJJJJJJJJJUUUUUUUUUWWWWWWWWWDDDDDDDDD  
35 >>> NNNNNJJJJJJJJJUUUUUUUUUWWWWWWWWWDDDDDDDDD  
36 >>> NNNNJJJJJJJJJUUUUUUUUUWWWWWWWWWDDDDDDDDD  
37 >>> NNNJJJJJJJJJUUUUUUUUUWWWWWWWWWDDDDDDDDDFFFFFFFFF  
38 >>> NNJJJJJJJJJUUUUUUUUUWWWWWWWWWDDDDDDDDDFFFFFFFFF  
39 >>> NJJJJJJJJJUUUUUUUUUWWWWWWWWWDDDDDDDDDFFFFFFFFFWWWWWWWWW  
40 >>> JJJJJJJJJUUUUUUUUUWWWWWWWWWDDDDDDDDDFFFFFFFFFWWWWWWWWW  
41 >>> JJJJJJJJUUUUUUUUUWWWWWWWWWDDDDDDDDDFFFFFFFFFWWWWWWWWWNNNNNNNNN  
42 >>> JJJJJJJUUUUUUUUUWWWWWWWWWDDDDDDDDDFFFFFFFFFWWWWWWWWWNNNNNNNNN  
43 >>> JJJJJJUUUUUUUUUWWWWWWWWWDDDDDDDDDFFFFFFFFFWWWWWWWWWNNNNNNNNNIIIIIIIII  
44 >>> JJJJJUUUUUUUUUWWWWWWWWWDDDDDDDDDFFFFFFFFFWWWWWWWWWNNNNNNNNNIIIIIIIII  
45 >>> JJJJUUUUUUUUUWWWWWWWWWDDDDDDDDDFFFFFFFFFWWWWWWWWWNNNNNNNNNIIIIIIIIIHHHHHHHHH  
46 >>> JJJUUUUUUUUUWWWWWWWWWDDDDDDDDDFFFFFFFFFWWWWWWWWWNNNNNNNNNIIIIIIIIIHHHHHHHHH  
47 >>> JJUUUUUUUUUWWWWWWWWWDDDDDDDDDFFFFFFFFFWWWWWWWWWNNNNNNNNNIIIIIIIIIHHHHHHHHH  
48 >>> JUUUUUUUUUWWWWWWWWWDDDDDDDDDFFFFFFFFFWWWWWWWWWNNNNNNNNNIIIIIIIIIHHHHHHHHH  
49 >>> UUUUUUUUUWWWWWWWWWDDDDDDDDDFFFFFFFFFWWWWWWWWWNNNNNNNNNIIIIIIIIIHHHHHHHHHYYYYYYYYY  
50 >>> UUUUUUUUWWWWWWWWWDDDDDDDDDFFFFFFFFFWWWWWWWWWNNNNNNNNNIIIIIIIIIHHHHHHHHHYYYYYYYYY  
  
  
\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
Call center simulation.  
Calls placed with probability per minute: 0.25  
Call duration: 2 to 10  
Idle time: 3  
Max queue length: 81  
Avg queue length: 35.98  
Total number of customers during session: 14  


 ----jGRASP exec: java QueueingTheory\_Start  
Call center simulation.  
  
Please enter the number of minutes for the simulation: 50  
  
Please enter the number of customers per minute: .25  
  
What is the minimum number of minutes needed for customer service: 2  
  
What is the maximum number of minutes needed for customer service: 10  
  
1 >>>   
2 >>>   
3 >>>   
4 >>>   
5 >>>   
6 >>>   
7 >>>   
8 >>>   
9 >>>   
10 >>>   
11 >>>   
12 >>> KKKKKKKKKKK  
13 >>> KKKKKKKKKK  
14 >>> KKKKKKKKKSSSSSSSSSSS  
15 >>> KKKKKKKKSSSSSSSSSSSRRRRRRRRRRR  
16 >>> KKKKKKKSSSSSSSSSSSRRRRRRRRRRR  
17 >>> KKKKKKSSSSSSSSSSSRRRRRRRRRRR  
18 >>> KKKKKSSSSSSSSSSSRRRRRRRRRRR  
19 >>> KKKKSSSSSSSSSSSRRRRRRRRRRR  
20 >>> KKKSSSSSSSSSSSRRRRRRRRRRR  
21 >>> KKSSSSSSSSSSSRRRRRRRRRRR  
22 >>> KSSSSSSSSSSSRRRRRRRRRRR  
23 >>> SSSSSSSSSSSRRRRRRRRRRR  
24 >>> SSSSSSSSSSRRRRRRRRRRR  
25 >>> SSSSSSSSSRRRRRRRRRRR  
26 >>> SSSSSSSSRRRRRRRRRRRZZZZZZZZZZZ  
27 >>> SSSSSSSRRRRRRRRRRRZZZZZZZZZZZ  
28 >>> SSSSSSRRRRRRRRRRRZZZZZZZZZZZ  
29 >>> SSSSSRRRRRRRRRRRZZZZZZZZZZZ  
30 >>> SSSSRRRRRRRRRRRZZZZZZZZZZZ  
31 >>> SSSRRRRRRRRRRRZZZZZZZZZZZ  
32 >>> SSRRRRRRRRRRRZZZZZZZZZZZ  
33 >>> SRRRRRRRRRRRZZZZZZZZZZZ  
34 >>> RRRRRRRRRRRZZZZZZZZZZZDDDDDDDDDDD  
35 >>> RRRRRRRRRRZZZZZZZZZZZDDDDDDDDDDD  
36 >>> RRRRRRRRRZZZZZZZZZZZDDDDDDDDDDDKKKKKKKKKKK  
37 >>> RRRRRRRRZZZZZZZZZZZDDDDDDDDDDDKKKKKKKKKKKZZZZZZZZZZZ  
38 >>> RRRRRRRZZZZZZZZZZZDDDDDDDDDDDKKKKKKKKKKKZZZZZZZZZZZ  
39 >>> RRRRRRZZZZZZZZZZZDDDDDDDDDDDKKKKKKKKKKKZZZZZZZZZZZ  
40 >>> RRRRRZZZZZZZZZZZDDDDDDDDDDDKKKKKKKKKKKZZZZZZZZZZZ  
41 >>> RRRRZZZZZZZZZZZDDDDDDDDDDDKKKKKKKKKKKZZZZZZZZZZZ  
42 >>> RRRZZZZZZZZZZZDDDDDDDDDDDKKKKKKKKKKKZZZZZZZZZZZ  
43 >>> RRZZZZZZZZZZZDDDDDDDDDDDKKKKKKKKKKKZZZZZZZZZZZ  
44 >>> RZZZZZZZZZZZDDDDDDDDDDDKKKKKKKKKKKZZZZZZZZZZZ  
45 >>> ZZZZZZZZZZZDDDDDDDDDDDKKKKKKKKKKKZZZZZZZZZZZVVVVVVVVVVV  
46 >>> ZZZZZZZZZZDDDDDDDDDDDKKKKKKKKKKKZZZZZZZZZZZVVVVVVVVVVV  
47 >>> ZZZZZZZZZDDDDDDDDDDDKKKKKKKKKKKZZZZZZZZZZZVVVVVVVVVVV  
48 >>> ZZZZZZZZDDDDDDDDDDDKKKKKKKKKKKZZZZZZZZZZZVVVVVVVVVVV  
49 >>> ZZZZZZZDDDDDDDDDDDKKKKKKKKKKKZZZZZZZZZZZVVVVVVVVVVVQQQQQQQQQQQ  
50 >>> ZZZZZZDDDDDDDDDDDKKKKKKKKKKKZZZZZZZZZZZVVVVVVVVVVVQQQQQQQQQQQ  
  
  
\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
Call center simulation.  
Calls placed with probability per minute: 0.25  
Call duration: 2 to 10  
Idle time: 11  
Max queue length: 62  
Avg queue length: 27.2  
Total number of customers during session: 9  
  
 ----jGRASP: operation complete.  


**Frequent arrival with short processing**

 ----jGRASP exec: java QueueingTheory\_Start  
Call center simulation.  
  
Please enter the number of minutes for the simulation: 50  
  
Please enter the number of customers per minute: .5  
  
What is the minimum number of minutes needed for customer service: 1  
  
What is the maximum number of minutes needed for customer service: 3  
  
1 >>> VV  
2 >>> VII  
3 >>> II  
4 >>> INN  
5 >>> NNFF  
6 >>> NFFII  
7 >>> FFII  
8 >>> FII  
9 >>> II  
10 >>> I  
11 >>> HH  
12 >>> H  
13 >>> XX  
14 >>> XBB  
15 >>> BBEE  
16 >>> BEE  
17 >>> EE  
18 >>> ERR  
19 >>> RR  
20 >>> RTT  
21 >>> TT  
22 >>> TJJ  
23 >>> JJ  
24 >>> JGG  
25 >>> GG  
26 >>> GSS  
27 >>> SS  
28 >>> SPP  
29 >>> PP  
30 >>> P  
31 >>> WW  
32 >>> WNN  
33 >>> NNVV  
34 >>> NVV  
35 >>> VVYY  
36 >>> VYY  
37 >>> YYQQ  
38 >>> YQQVV  
39 >>> QQVVOO  
40 >>> QVVOO  
41 >>> VVOO  
42 >>> VOO  
43 >>> OOUU  
44 >>> OUURR  
45 >>> UURR  
46 >>> URR  
47 >>> RRFF  
48 >>> RFF  
49 >>> FF  
50 >>> F  
  
  
\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
Call center simulation.  
Calls placed with probability per minute: 0.5  
Call duration: 1 to 3  
Idle time: 0  
Max queue length: 6  
Avg queue length: 2.98  
Total number of customers during session: 25  
  
 ----jGRASP: operation complete.  


Please enter the number of minutes for the simulation: 50  
  
Please enter the number of customers per minute: .5  
  
What is the minimum number of minutes needed for customer service: 1  
  
What is the maximum number of minutes needed for customer service: 3  
  
1 >>>   
2 >>>   
3 >>>   
4 >>>   
5 >>>   
6 >>>   
7 >>> RR  
8 >>> RQQ  
9 >>> QQSS  
10 >>> QSS  
11 >>> SSCC  
12 >>> SCC  
13 >>> CCSS  
14 >>> CSSOO  
15 >>> SSOO  
16 >>> SOO  
17 >>> OO  
18 >>> O  
19 >>> DD  
20 >>> D  
21 >>>   
22 >>> VV  
23 >>> V  
24 >>>   
25 >>> HH  
26 >>> HLL  
27 >>> LLMM  
28 >>> LMM  
29 >>> MMDD  
30 >>> MDDLL  
31 >>> DDLL  
32 >>> DLL  
33 >>> LL  
34 >>> L  
35 >>> FF  
36 >>> FVV  
37 >>> VVPP  
38 >>> VPPBB  
39 >>> PPBB  
40 >>> PBB  
41 >>> BBOO  
42 >>> BOO  
43 >>> OO  
44 >>> OFF  
45 >>> FFMM  
46 >>> FMM  
47 >>> MM  
48 >>> M  
49 >>>   
50 >>>   
  
  
\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
Call center simulation.  
Calls placed with probability per minute: 0.5  
Call duration: 1 to 3  
Idle time: 10  
Max queue length: 5  
Avg queue length: 2.36  
Total number of customers during session: 20

**Infrequent arrival with longer processing**

 ----jGRASP exec: java QueueingTheory\_Start  
Call center simulation.  
  
Please enter the number of minutes for the simulation: 50  
  
Please enter the number of customers per minute: .2  
  
What is the minimum number of minutes needed for customer service: 1  
  
What is the maximum number of minutes needed for customer service: 15  
  
1 >>>   
2 >>>   
3 >>>   
4 >>>   
5 >>>   
6 >>>   
7 >>>   
8 >>> LLLLL  
9 >>> LLLL  
10 >>> LLL  
11 >>> LL  
12 >>> LCCCCC  
13 >>> CCCCC  
14 >>> CCCC  
15 >>> CCC  
16 >>> CC  
17 >>> C  
18 >>> RRRRR  
19 >>> RRRRBBBBB  
20 >>> RRRBBBBB  
21 >>> RRBBBBB  
22 >>> RBBBBB  
23 >>> BBBBBFFFFF  
24 >>> BBBBFFFFF  
25 >>> BBBFFFFF  
26 >>> BBFFFFF  
27 >>> BFFFFF  
28 >>> FFFFF  
29 >>> FFFF  
30 >>> FFF  
31 >>> FF  
32 >>> F  
33 >>>   
34 >>>   
35 >>> HHHHH  
36 >>> HHHH  
37 >>> HHH  
38 >>> HH  
39 >>> H  
40 >>>   
41 >>>   
42 >>>   
43 >>> OOOOO  
44 >>> OOOONNNNN  
45 >>> OOONNNNNXXXXX  
46 >>> OONNNNNXXXXXHHHHH  
47 >>> ONNNNNXXXXXHHHHH  
48 >>> NNNNNXXXXXHHHHH  
49 >>> NNNNXXXXXHHHHH  
50 >>> NNNXXXXXHHHHH  
  
  
\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
Call center simulation.  
Calls placed with probability per minute: 0.2  
Call duration: 1 to 15  
Idle time: 12  
Max queue length: 17  
Avg queue length: 4.84  
Total number of customers during session: 10

 ----jGRASP exec: java QueueingTheory\_Start  
Call center simulation.  
  
Please enter the number of minutes for the simulation: 50  
  
Please enter the number of customers per minute: .2  
  
What is the minimum number of minutes needed for customer service: 3  
  
What is the maximum number of minutes needed for customer service: 7  
  
1 >>>   
2 >>>   
3 >>>   
4 >>>   
5 >>>   
6 >>>   
7 >>>   
8 >>>   
9 >>> TTTTTTT  
10 >>> TTTTTT  
11 >>> TTTTT  
12 >>> TTTT  
13 >>> TTT  
14 >>> TTIIIIIII  
15 >>> TIIIIIII  
16 >>> IIIIIII  
17 >>> IIIIII  
18 >>> IIIII  
19 >>> IIII  
20 >>> III  
21 >>> II  
22 >>> I  
23 >>> RRRRRRR  
24 >>> RRRRRR  
25 >>> RRRRRGGGGGGG  
26 >>> RRRRGGGGGGG  
27 >>> RRRGGGGGGG  
28 >>> RRGGGGGGG  
29 >>> RGGGGGGG  
30 >>> GGGGGGG  
31 >>> GGGGGG  
32 >>> GGGGGLLLLLLL  
33 >>> GGGGLLLLLLL  
34 >>> GGGLLLLLLL  
35 >>> GGLLLLLLL  
36 >>> GLLLLLLL  
37 >>> LLLLLLL  
38 >>> LLLLLL  
39 >>> LLLLLQQQQQQQ  
40 >>> LLLLQQQQQQQ  
41 >>> LLLQQQQQQQ  
42 >>> LLQQQQQQQKKKKKKK  
43 >>> LQQQQQQQKKKKKKK  
44 >>> QQQQQQQKKKKKKK  
45 >>> QQQQQQKKKKKKK  
46 >>> QQQQQKKKKKKKGGGGGGG  
47 >>> QQQQKKKKKKKGGGGGGG  
48 >>> QQQKKKKKKKGGGGGGG  
49 >>> QQKKKKKKKGGGGGGGFFFFFFF  
50 >>> QKKKKKKKGGGGGGGFFFFFFFDDDDDDD  
  
  
\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
Call center simulation.  
Calls placed with probability per minute: 0.2  
Call duration: 3 to 7  
Idle time: 8  
Max queue length: 29  
Avg queue length: 8.12  
Total number of customers during session: 10  
  
 ----jGRASP: operation complete.  


**Weird inputs to test program limitations**

 ----jGRASP exec: java QueueingTheory\_Start  
Call center simulation.  
  
Please enter the number of minutes for the simulation: 20  
  
Please enter the number of customers per minute: 0  
  
What is the minimum number of minutes needed for customer service: 1  
  
What is the maximum number of minutes needed for customer service: 5  
  
1 >>>   
2 >>>   
3 >>>   
4 >>>   
5 >>>   
6 >>>   
7 >>>   
8 >>>   
9 >>>   
10 >>>   
11 >>>   
12 >>>   
13 >>>   
14 >>>   
15 >>>   
16 >>>   
17 >>>   
18 >>>   
19 >>>   
20 >>>   
  
  
\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
Call center simulation.  
Calls placed with probability per minute: 0.0  
Call duration: 1 to 5  
Idle time: 20  
Max queue length: 0  
Avg queue length: 0.0  
Total number of customers during session: 0  
  
 ----jGRASP: operation complete.

 ----jGRASP exec: java QueueingTheory\_Start  
Call center simulation.  
  
Please enter the number of minutes for the simulation: 20  
  
Please enter the number of customers per minute: 1  
  
What is the minimum number of minutes needed for customer service: 4  
  
What is the maximum number of minutes needed for customer service: 4  
  
1 >>> KKKK  
2 >>> KKKRRRR  
3 >>> KKRRRRKKKK  
4 >>> KRRRRKKKKDDDD  
5 >>> RRRRKKKKDDDDOOOO  
6 >>> RRRKKKKDDDDOOOOVVVV  
7 >>> RRKKKKDDDDOOOOVVVVWWWW  
8 >>> RKKKKDDDDOOOOVVVVWWWWKKKK  
9 >>> KKKKDDDDOOOOVVVVWWWWKKKKRRRR  
10 >>> KKKDDDDOOOOVVVVWWWWKKKKRRRRUUUU  
11 >>> KKDDDDOOOOVVVVWWWWKKKKRRRRUUUUYYYY  
12 >>> KDDDDOOOOVVVVWWWWKKKKRRRRUUUUYYYYAAAA  
13 >>> DDDDOOOOVVVVWWWWKKKKRRRRUUUUYYYYAAAAVVVV  
14 >>> DDDOOOOVVVVWWWWKKKKRRRRUUUUYYYYAAAAVVVVKKKK  
15 >>> DDOOOOVVVVWWWWKKKKRRRRUUUUYYYYAAAAVVVVKKKKVVVV  
16 >>> DOOOOVVVVWWWWKKKKRRRRUUUUYYYYAAAAVVVVKKKKVVVVGGGG  
17 >>> OOOOVVVVWWWWKKKKRRRRUUUUYYYYAAAAVVVVKKKKVVVVGGGGBBBB  
18 >>> OOOVVVVWWWWKKKKRRRRUUUUYYYYAAAAVVVVKKKKVVVVGGGGBBBBKKKK  
19 >>> OOVVVVWWWWKKKKRRRRUUUUYYYYAAAAVVVVKKKKVVVVGGGGBBBBKKKKTTTT  
20 >>> OVVVVWWWWKKKKRRRRUUUUYYYYAAAAVVVVKKKKVVVVGGGGBBBBKKKKTTTTEEEE  
  
  
\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
Call center simulation.  
Calls placed with probability per minute: 1.0  
Call duration: 4 to 4  
Idle time: 0  
Max queue length: 61  
Avg queue length: 32.5  
Total number of customers during session: 20  
  
 ----jGRASP: operation complete.  


 ----jGRASP exec: java QueueingTheory\_Start  
Call center simulation.  
  
Please enter the number of minutes for the simulation: 30  
  
Please enter the number of customers per minute: 1  
  
What is the minimum number of minutes needed for customer service: 3  
  
What is the maximum number of minutes needed for customer service: 3  
  
1 >>> KKKKK  
2 >>> KKKKNNNNN  
3 >>> KKKNNNNNHHHHH  
4 >>> KKNNNNNHHHHHNNNNN  
5 >>> KNNNNNHHHHHNNNNNRRRRR  
6 >>> NNNNNHHHHHNNNNNRRRRRJJJJJ  
7 >>> NNNNHHHHHNNNNNRRRRRJJJJJFFFFF  
8 >>> NNNHHHHHNNNNNRRRRRJJJJJFFFFFPPPPP  
9 >>> NNHHHHHNNNNNRRRRRJJJJJFFFFFPPPPPKKKKK  
10 >>> NHHHHHNNNNNRRRRRJJJJJFFFFFPPPPPKKKKKTTTTT  
11 >>> HHHHHNNNNNRRRRRJJJJJFFFFFPPPPPKKKKKTTTTTAAAAA  
12 >>> HHHHNNNNNRRRRRJJJJJFFFFFPPPPPKKKKKTTTTTAAAAAHHHHH  
13 >>> HHHNNNNNRRRRRJJJJJFFFFFPPPPPKKKKKTTTTTAAAAAHHHHHOOOOO  
14 >>> HHNNNNNRRRRRJJJJJFFFFFPPPPPKKKKKTTTTTAAAAAHHHHHOOOOOUUUUU  
15 >>> HNNNNNRRRRRJJJJJFFFFFPPPPPKKKKKTTTTTAAAAAHHHHHOOOOOUUUUUHHHHH  
16 >>> NNNNNRRRRRJJJJJFFFFFPPPPPKKKKKTTTTTAAAAAHHHHHOOOOOUUUUUHHHHHJJJJJ  
17 >>> NNNNRRRRRJJJJJFFFFFPPPPPKKKKKTTTTTAAAAAHHHHHOOOOOUUUUUHHHHHJJJJJNNNNN  
18 >>> NNNRRRRRJJJJJFFFFFPPPPPKKKKKTTTTTAAAAAHHHHHOOOOOUUUUUHHHHHJJJJJNNNNNIIIII  
19 >>> NNRRRRRJJJJJFFFFFPPPPPKKKKKTTTTTAAAAAHHHHHOOOOOUUUUUHHHHHJJJJJNNNNNIIIIITTTTT  
20 >>> NRRRRRJJJJJFFFFFPPPPPKKKKKTTTTTAAAAAHHHHHOOOOOUUUUUHHHHHJJJJJNNNNNIIIIITTTTTHHHHH  
21 >>> RRRRRJJJJJFFFFFPPPPPKKKKKTTTTTAAAAAHHHHHOOOOOUUUUUHHHHHJJJJJNNNNNIIIIITTTTTHHHHHGGGGG  
22 >>> RRRRJJJJJFFFFFPPPPPKKKKKTTTTTAAAAAHHHHHOOOOOUUUUUHHHHHJJJJJNNNNNIIIIITTTTTHHHHHGGGGGDDDDD  
23 >>> RRRJJJJJFFFFFPPPPPKKKKKTTTTTAAAAAHHHHHOOOOOUUUUUHHHHHJJJJJNNNNNIIIIITTTTTHHHHHGGGGGDDDDDTTTTT  
24 >>> RRJJJJJFFFFFPPPPPKKKKKTTTTTAAAAAHHHHHOOOOOUUUUUHHHHHJJJJJNNNNNIIIIITTTTTHHHHHGGGGGDDDDDTTTTTHHHHH  
25 >>> RJJJJJFFFFFPPPPPKKKKKTTTTTAAAAAHHHHHOOOOOUUUUUHHHHHJJJJJNNNNNIIIIITTTTTHHHHHGGGGGDDDDDTTTTTHHHHHTTTTT  
26 >>> JJJJJFFFFFPPPPPKKKKKTTTTTAAAAAHHHHHOOOOOUUUUUHHHHHJJJJJNNNNNIIIIITTTTTHHHHHGGGGGDDDDDTTTTTHHHHHTTTTTKKKKK  
27 >>> JJJJFFFFFPPPPPKKKKKTTTTTAAAAAHHHHHOOOOOUUUUUHHHHHJJJJJNNNNNIIIIITTTTTHHHHHGGGGGDDDDDTTTTTHHHHHTTTTTKKKKKSSSSS  
28 >>> JJJFFFFFPPPPPKKKKKTTTTTAAAAAHHHHHOOOOOUUUUUHHHHHJJJJJNNNNNIIIIITTTTTHHHHHGGGGGDDDDDTTTTTHHHHHTTTTTKKKKKSSSSSHHHHH  
29 >>> JJFFFFFPPPPPKKKKKTTTTTAAAAAHHHHHOOOOOUUUUUHHHHHJJJJJNNNNNIIIIITTTTTHHHHHGGGGGDDDDDTTTTTHHHHHTTTTTKKKKKSSSSSHHHHHTTTTT  
30 >>> JFFFFFPPPPPKKKKKTTTTTAAAAAHHHHHOOOOOUUUUUHHHHHJJJJJNNNNNIIIIITTTTTHHHHHGGGGGDDDDDTTTTTHHHHHTTTTTKKKKKSSSSSHHHHHTTTTTNNNNN  
  
  
\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*  
Call center simulation.  
Calls placed with probability per minute: 1.0  
Call duration: 3 to 3  
Idle time: 0  
Max queue length: 121  
Avg queue length: 63.0  
Total number of customers during session: 30  
  
 ----jGRASP