Trent University

COIS4470H

Winter 2018

Assignment 3: GPSS

due: March 20, 2018

By Jake Tully

Question 1:

a)

```
                SIMULATE
                INTEGER     &LIMIT
                LET         &LIMIT=5000
                GENERATE    RVEXPO(1,5)
                QUEUE       LINE
                SEIZE       CHECKOUT
                ADVANCE     RVEXPO(1,3)
                RELEASE     CHECKOUT
                DEPART      LINE
                TABULATE    RES
                TERMINATE   1
RES TABLE                   M1,0,5,14
                START       &LIMIT
                END
```

```
          --Avg-Util-During--
Facility  Total  Avail  Unavl     Entries    Average   Current  Percent  Seizing  Preempting
           Time   Time   Time              Time/Xact   Status   Avail     Xact      Xact
CHECKOUT  0.607                      5000       3.038    AVAIL
```

```
   Queue     Maximum      Average       Total        Zero     Percent      Average     $Average     Qtable     Current
             Contents     Contents      Entries      Entries  Zeros        Time/Unit   Time/Unit    Number     Contents
    LINE          14        1.542         5006            0                  7.705       7.705                     6
```

```
TABLE      RES

ENTRIES IN TABLE   MEAN ARGUMENT   STANDARD DEVIATION   SUM OF ARGUMENTS
       5000.0000          7.7022               7.2187         38510.9315   NON-WEIGHTED

       UPPER    OBSERVED     PERCENT  CUMULATIVE  CUMULATIVE    MULTIPLE   DEVIATION
       LIMIT   FREQUENCY    OF TOTAL  PERCENTAGE   REMAINDER     OF MEAN   FROM MEAN
         ...
      5.0000   2356.0000     47.1200       47.12       52.88      0.6492     -0.3743
     10.0000   1204.0000     24.0800       71.20       28.80      1.2983      0.3183
     15.0000    685.0000     13.7000       84.90       15.10      1.9475      1.0110
     20.0000    423.0000      8.4600       93.36        6.64      2.5967      1.7036
     25.0000    185.0000      3.7000       97.06        2.94      3.2458      2.3963
     30.0000     83.0000      1.6600       98.72        1.28      3.8950      3.0889
     35.0000     43.0000      0.8600       99.58        0.42      4.5442      3.7816
     40.0000      9.0000      0.1800       99.76        0.24      5.1933      4.4742
     45.0000      3.0000      0.0600       99.82        0.18      5.8425      5.1669
     50.0000      3.0000      0.0600       99.88        0.12      6.4917      5.8595
     55.0000      3.0000      0.0600       99.94        0.06      7.1408      6.5522
     60.0000      3.0000      0.0600      100.00        0.00      7.7900      7.2448
```

b)

```
|           SIMULATE
            INTEGER     &LIMIT
            LET         &LIMIT=5000
            GENERATE    RVEXPO(1,4)
            QUEUE       LINE
            SEIZE       CHECKOUT
            ADVANCE     RVEXPO(1,3)
            RELEASE     CHECKOUT
            DEPART      LINE
            TABULATE    RES
            TERMINATE   1
RES TABLE               M1,0,5,14
            START       &LIMIT
            END
```

```
          --Avg-Util-During--
Facility  Total  Avail  Unavl     Entries    Average   Current  Percent  Seizing  Preempting
           Time   Time   Time               Time/Xact   Status   Avail     Xact      Xact
CHECKOUT  0.736                     5000       2.990    AVAIL
```

```
   Queue     Maximum      Average       Total        Zero     Percent      Average     $Average     Qtable     Current
            Contents     Contents     Entries     Entries     Zeros     Time/Unit    Time/Unit     Number    Contents
    LINE          18        2.741        5002           0                 11.125       11.125                    2
```

```
TABLE      RES

ENTRIES IN TABLE   MEAN ARGUMENT   STANDARD DEVIATION   SUM OF ARGUMENTS
       5000.0000         11.1280              10.4706         55639.9389   NON-WEIGHTED

       UPPER    OBSERVED     PERCENT  CUMULATIVE  CUMULATIVE    MULTIPLE   DEVIATION
       LIMIT   FREQUENCY    OF TOTAL  PERCENTAGE   REMAINDER     OF MEAN   FROM MEAN
         ...
      5.0000   1774.0000     35.4800       35.48       64.52      0.4493     -0.5853
     10.0000   1142.0000     22.8400       58.32       41.68      0.8986     -0.1077
     15.0000    747.0000     14.9400       73.26       26.74      1.3480      0.3698
     20.0000    476.0000      9.5200       82.78       17.22      1.7973      0.8473
     25.0000    329.0000      6.5800       89.36       10.64      2.2466      1.3249
     30.0000    188.0000      3.7600       93.12        6.88      2.6959      1.8024
     35.0000    130.0000      2.6000       95.72        4.28      3.1452      2.2799
     40.0000    110.0000      2.2000       97.92        2.08      3.5945      2.7574
     45.0000     46.0000      0.9200       98.84        1.16      4.0439      3.2350
     50.0000     23.0000      0.4600       99.30        0.70      4.4932      3.7125
     55.0000     21.0000      0.4200       99.72        0.28      4.9425      4.1900
     60.0000      8.0000      0.1600       99.88        0.12      5.3918      4.6676
    OVERFLOW      6.0000        0.12      100.00        0.00

AVERAGE VALUE OF OVERFLOW IS      63.2864
```

```
            SIMULATE
            INTEGER     &LIMIT
            LET         &LIMIT=5000
            GENERATE    RVEXPO(1,3.3333)
            QUEUE       LINE
            SEIZE       CHECKOUT
            ADVANCE     RVEXPO(1,3)
            RELEASE     CHECKOUT
            DEPART      LINE
            TABULATE    RES
            TERMINATE   1
RES TABLE               M1,0,5,14
            START       &LIMIT
            END
```

```
          --Avg-Util-During--
Facility  Total  Avail  Unavl     Entries    Average   Current  Percent  Seizing  Preempting
           Time   Time   Time              Time/Xact   Status   Avail     Xact      Xact
CHECKOUT  0.893                      5000       3.009    AVAIL
```

```
   Queue     Maximum      Average       Total        Zero     Percent      Average      $Average     Qtable     Current
            Contents     Contents     Entries     Entries     Zeros      Time/Unit    Time/Unit     Number    Contents
    LINE          39        7.861        5008           0                  26.447       26.447                    8
```

```
TABLE      RES

ENTRIES IN TABLE   MEAN ARGUMENT   STANDARD DEVIATION   SUM OF ARGUMENTS
       5000.0000         26.4720              23.1582         1.3236E+05   NON-WEIGHTED

       UPPER    OBSERVED     PERCENT  CUMULATIVE  CUMULATIVE    MULTIPLE   DEVIATION
       LIMIT   FREQUENCY    OF TOTAL  PERCENTAGE   REMAINDER     OF MEAN   FROM MEAN
         ...
      5.0000    831.0000     16.6200       16.62       83.38      0.1889     -0.9272
     10.0000    640.0000     12.8000       29.42       70.58      0.3778     -0.7113
     15.0000    507.0000     10.1400       39.56       60.44      0.5666     -0.4954
     20.0000    425.0000      8.5000       48.06       51.94      0.7555     -0.2795
     25.0000    434.0000      8.6800       56.74       43.26      0.9444     -0.0636
     30.0000    425.0000      8.5000       65.24       34.76      1.1333      0.1523
     35.0000    350.0000      7.0000       72.24       27.76      1.3222      0.3682
     40.0000    261.0000      5.2200       77.46       22.54      1.5110      0.5842
     45.0000    216.0000      4.3200       81.78       18.22      1.6999      0.8001
     50.0000    195.0000      3.9000       85.68       14.32      1.8888      1.0160
     55.0000    132.0000      2.6400       88.32       11.68      2.0777      1.2319
     60.0000    135.0000      2.7000       91.02        8.98      2.2665      1.4478
    OVERFLOW    449.0000        8.98      100.00        0.00

AVERAGE VALUE OF OVERFLOW IS      80.6350
```

c)

```
            SIMULATE
            INTEGER     &LIMIT
            LET         &LIMIT=5000
            GENERATE    RVEXPO(1,6.6667)
            QUEUE       LINE
            SEIZE       CHECKOUT
            ADVANCE     RVEXPO(1,3)
            RELEASE     CHECKOUT
            DEPART      LINE
            TABULATE    RES
            TERMINATE   1
RES TABLE               M1,0,5,14
            START       &LIMIT
            END
```

```
          --Avg-Util-During--
Facility  Total  Avail  Unavl     Entries    Average   Current  Percent  Seizing  Preempting
           Time   Time   Time              Time/Xact   Status   Avail     Xact      Xact
CHECKOUT  0.443                      5000       2.995    AVAIL
```

```
   Queue     Maximum      Average       Total        Zero     Percent      Average      $Average     Qtable     Current
              Contents     Contents     Entries     Entries     Zeros     Time/Unit    Time/Unit     Number    Contents
    LINE           9        0.798        5000           0                   5.389        5.389                        0
```

```
TABLE      RES

ENTRIES IN TABLE   MEAN ARGUMENT   STANDARD DEVIATION   SUM OF ARGUMENTS
       5000.0000          5.3890               5.3388         26945.0559   NON-WEIGHTED

       UPPER    OBSERVED     PERCENT  CUMULATIVE  CUMULATIVE    MULTIPLE   DEVIATION
       LIMIT   FREQUENCY    OF TOTAL  PERCENTAGE   REMAINDER     OF MEAN   FROM MEAN
         ...
      5.0000   3035.0000     60.7000       60.70       39.30      0.9278     -0.0729
     10.0000   1148.0000     22.9600       83.66       16.34      1.8556      0.8637
     15.0000    493.0000      9.8600       93.52        6.48      2.7834      1.8002
     20.0000    215.0000      4.3000       97.82        2.18      3.7113      2.7367
     25.0000     74.0000      1.4800       99.30        0.70      4.6391      3.6733
     30.0000     19.0000      0.3800       99.68        0.32      5.5669      4.6098
     35.0000     10.0000      0.2000       99.88        0.12      6.4947      5.5464
     40.0000      2.0000      0.0400       99.92        0.08      7.4225      6.4829
     45.0000      2.0000      0.0400       99.96        0.04      8.3503      7.4194
     50.0000      1.0000      0.0200       99.98        0.02      9.2781      8.3560
     55.0000      1.0000      0.0200      100.00       -0.00     10.2060      9.2925
```

In the one scenario customers are arriving almost as fast as they can be processed which results in a log jam or build up of customers waiting to be serviced and this defect in the system causes a breakdown resulting in the large waiting time observed. When arrival time increases the processing, time must be decreased or more servers must be added to handle the increase.

```
            SIMULATE
            INTEGER     &LIMIT
            LET         &LIMIT=5000
            GENERATE    RVEXPO(1,10)
            QUEUE       LINE
            SEIZE       CHECKOUT
            ADVANCE     RVEXPO(1,3)
            RELEASE     CHECKOUT
            DEPART      LINE
            TABULATE    RES
            TERMINATE   1
RES TABLE               M1,0,5,14
            START       &LIMIT
            END
```

```
         --Avg-Util-During--
Facility  Total  Avail  Unavl     Entries    Average   Current  Percent  Seizing  Preempting
           Time   Time   Time              Time/Xact   Status   Avail     Xact      Xact
CHECKOUT  0.301                      5000       3.021    AVAIL
```

```
   Queue     Maximum      Average       Total        Zero     Percent      Average     $Average     Qtable     Current
            Contents     Contents     Entries     Entries      Zeros    Time/Unit    Time/Unit     Number    Contents
    LINE           7        0.437        5000           0                   4.390        4.390                       0
```

```
TABLE      RES

ENTRIES IN TABLE   MEAN ARGUMENT   STANDARD DEVIATION   SUM OF ARGUMENTS
       5000.0000          4.3896               4.3378         21948.1764   NON-WEIGHTED

       UPPER    OBSERVED     PERCENT  CUMULATIVE  CUMULATIVE    MULTIPLE   DEVIATION
       LIMIT   FREQUENCY    OF TOTAL  PERCENTAGE   REMAINDER     OF MEAN   FROM MEAN
         ...
      5.0000   3409.0000     68.1800       68.18       31.82      1.1390      0.1407
     10.0000   1060.0000     21.2000       89.38       10.62      2.2781      1.2934
     15.0000    374.0000      7.4800       96.86        3.14      3.4171      2.4460
     20.0000    113.0000      2.2600       99.12        0.88      4.5562      3.5987
     25.0000     31.0000      0.6200       99.74        0.26      5.6952      4.7514
     30.0000     10.0000      0.2000       99.94        0.06      6.8343      5.9040
     35.0000      2.0000      0.0400       99.98        0.02      7.9733      7.0567
     40.0000      1.0000      0.0200      100.00       -0.00      9.1124      8.2093
```

When the arrival rate decreases the rate at which the line builds decreases because the server can handle more transactions before the next arrival this results in a overall shorter time in the system and a shorter server utilization time.

d)

```
            SIMULATE
            INTEGER     &LIMIT
            LET         &LIMIT=5000
            GENERATE    RVEXPO(1,5)
            QUEUE       LINE
            ENTER       1,1
            ADVANCE     RVEXPO(1,4)
            DEPART      LINE
            LEAVE       1,1
            TABULATE    RES
            TERMINATE
*
            STORAGE     S1,2
*
  RES TABLE             M1,0,3,14
            GENERATE    &LIMIT
            TERMINATE   1
            START       1
            END
```

Storage	--Avg-Util-During-- Total Time	Avail Time	Unavl Time	Entries	Average Time/Unit	Current Status	Percent Avail	Capacity	Average Contents	Current Contents	Maximum Contents
1	0.403			970	4.153	AVAIL	100.0	2	0.806	2	2

Queue	Maximum Contents	Average Contents	Total Entries	Zero Entries	Percent Zeros	Average Time/Unit	$Average Time/Unit	Qtable Number	Current Contents
LINE	8	0.959	971	0		4.940	4.940		3

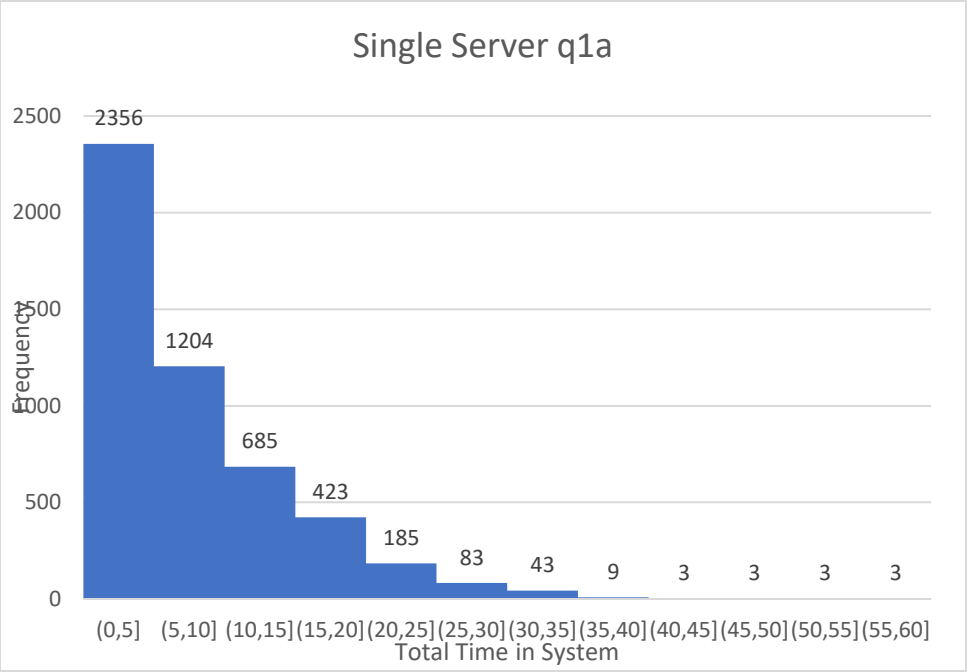
TABLE RES

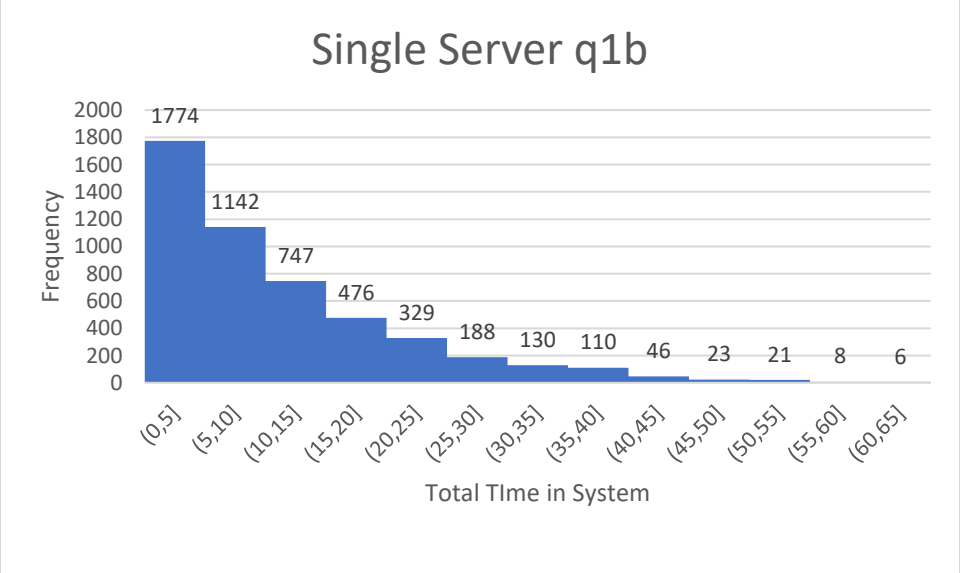
ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	SUM OF ARGUMENTS	
968.0000	4.9325	4.5868	4774.6300	NON-WEIGHTED

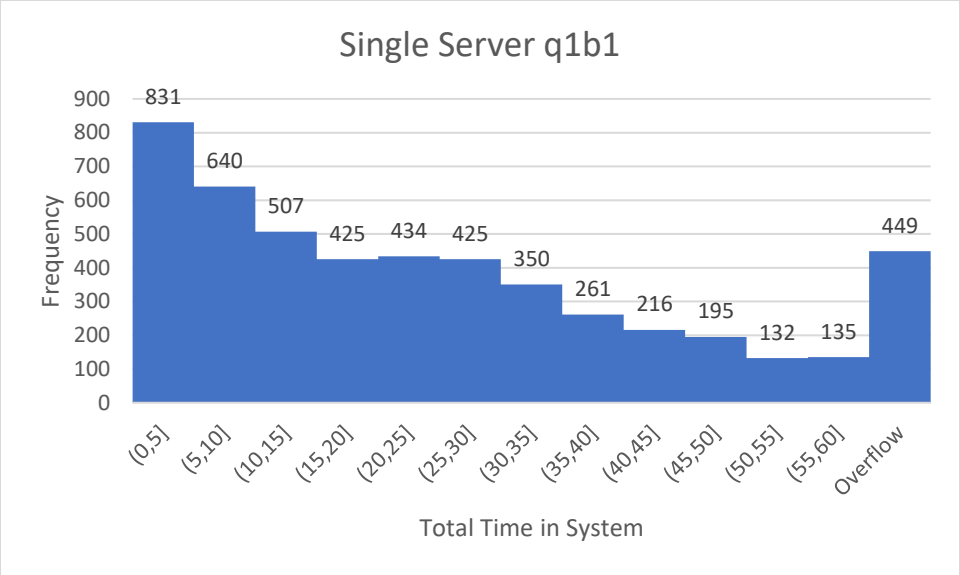
UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
...						
3.0000	418.0000	43.1818	43.18	56.82	0.6082	-0.4213
6.0000	261.0000	26.9628	70.14	29.86	1.2164	0.2327
9.0000	135.0000	13.9463	84.09	15.91	1.8246	0.8868
12.0000	66.0000	6.8182	90.91	9.09	2.4329	1.5408
15.0000	44.0000	4.5455	95.45	4.55	3.0411	2.1949
18.0000	22.0000	2.2727	97.73	2.27	3.6493	2.8489
21.0000	15.0000	1.5496	99.28	0.72	4.2575	3.5030
24.0000	5.0000	0.5165	99.79	0.21	4.8657	4.1570
27.0000	1.0000	0.1033	99.90	0.10	5.4739	4.8111
...						
33.0000	1.0000	0.1033	100.00	0.00	6.6904	6.1191

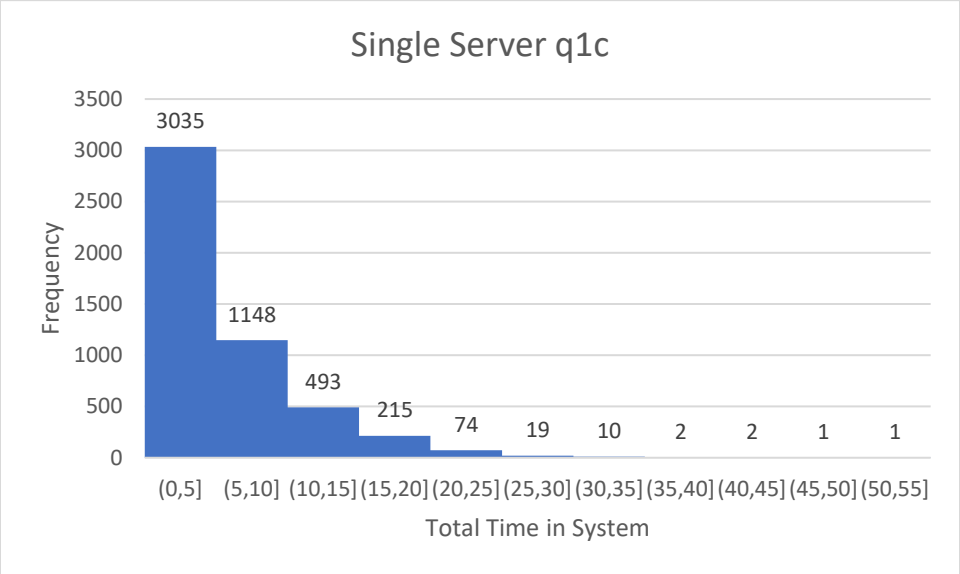
Increasing the number of tellers reduces the chance of a log jam scenario but because of the increase to process time we find that the overall system does not work as well as when the arrival rates are higher but the system handle a lower arrival rate better than it would with one server. But we find that the utilization of each server is decreased.

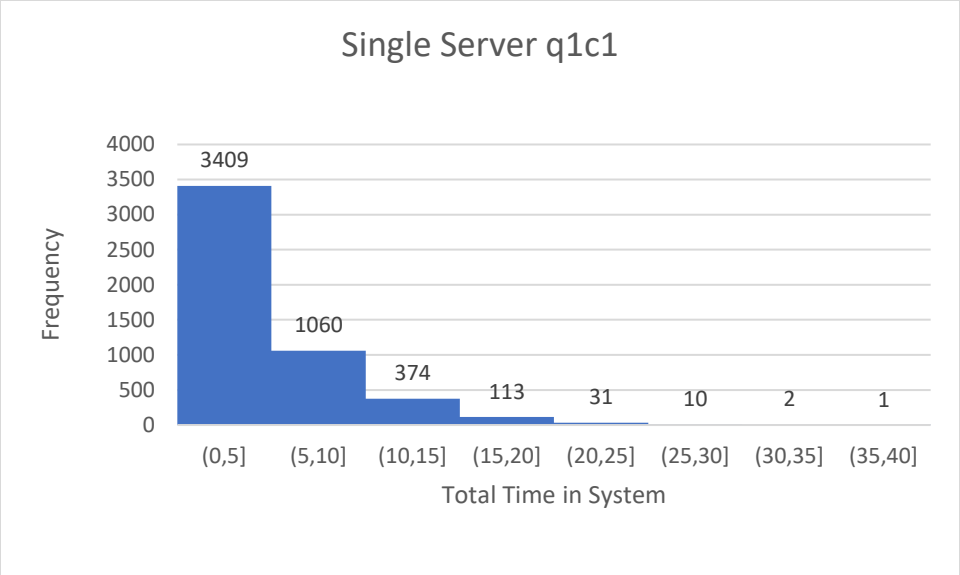
Output Histograms:

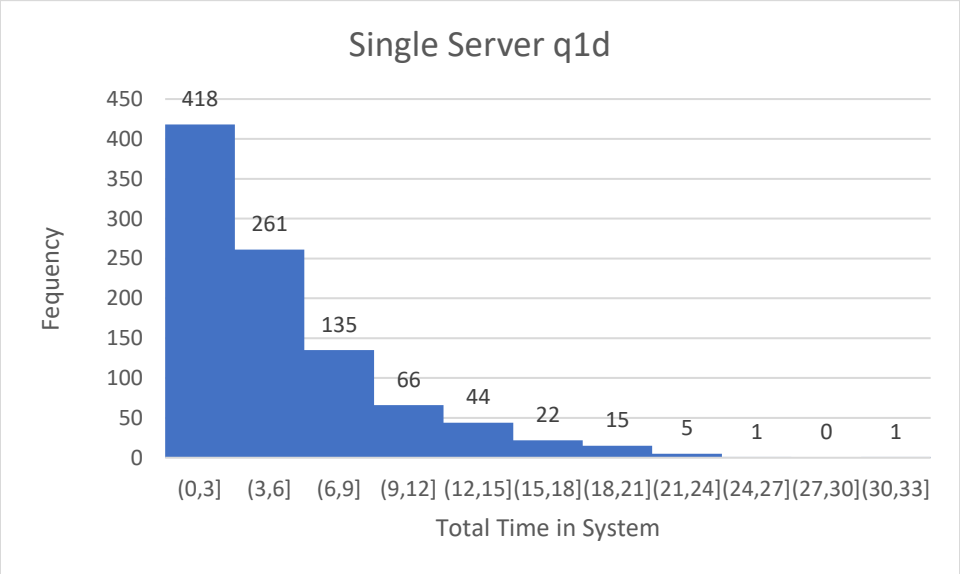





Single Server q1b1
Frequency
900
800
700
600
500
400
300
200
100
0
831
640
507
425
434
425
350
261
216
195
132
135
449
(0,5]
(5,10]
(10,15]
(15,20]
(20,25]
(25,30]
(30,35]
(35,40]
(40,45]
(45,50]
(50,55]
(55,60]
Overflow
Total Time in System


Single Server q1c
Frequency
3500
3000
2500
2000
1500
1000
500
0
3035
1148
493
215
74
19
10
2
2
1
1
(0,5]
(5,10]
(10,15]
(15,20]
(20,25]
(25,30]
(30,35]
(35,40]
(40,45]
(45,50]
(50,55]
Total Time in System


Single Server q1c1
Frequency
4000
3500
3000
2500
2000
1500
1000
500
0
3409
1060
374
113
31
10
2
1
(0,5]
(5,10]
(10,15]
(15,20]
(20,25]
(25,30]
(30,35]
(35,40]
Total Time in System


Single Server q1d
Fequency
450
400
350
300
250
200
150
100
50
0
418
261
135
66
44
22
15
5
1
0
1
(0,3]
(3,6]
(6,9]
(9,12]
(12,15]
(15,18]
(18,21]
(21,24]
(24,27]
(27,30]
(30,33]
Total Time in System

Question 2:

```
            SIMULATE
            INTEGER     &LIMIT
            LET         &LIMIT=5000
*
            GENERATE    RVEXPO(1,8)
            TRANSFER    .25,FEMALE,MALE
*
  FEMALE    QUEUE       FEMLINE
            ENTER       1,1
            ADVANCE     12,3
            DEPART      FEMLINE
            LEAVE       1,1
*
  MALE      QUEUE       MALELINE
            ENTER       2,1
            ADVANCE     7,2
            DEPART      MALELINE
            LEAVE       2,1
            TERMINATE
*
            STORAGE     S1,1/S2,2
*
            GENERATE    &LIMIT
            TERMINATE   1
            START       1
            END
```

Queue	Maximum Contents	Average Contents	Total Entries	Zero Entries	Percent Zeros	Average Time/Unit	$Average Time/Unit	Qtable Number	Current Contents
FEMLINE	49	21.323	463	0		230.266	230.266		48
MALELINE	3	0.200	139	0		7.190	7.190		0

TABLE RES

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	SUM OF ARGUMENTS	
554.0000	172.9023	149.0437	95787.8907	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
...						
6.0000	30.0000	5.4152	5.42	94.58	0.0347	-1.1198
7.0000	32.0000	5.7762	11.19	88.81	0.0405	-1.1131
8.0000	38.0000	6.8592	18.05	81.95	0.0463	-1.1064
9.0000	36.0000	6.4982	24.55	75.45	0.0521	-1.0997
10.0000	5.0000	0.9025	25.45	74.55	0.0578	-1.0930
11.0000	2.0000	0.3610	25.81	74.19	0.0636	-1.0863
12.0000	1.0000	0.1805	25.99	74.01	0.0694	-1.0796
13.0000	1.0000	0.1805	26.17	73.83	0.0752	-1.0729
OVERFLOW	409.0000	73.83	100.00	0.00		

AVERAGE VALUE OF OVERFLOW IS 231.6206

Question 3:

a)

```
          REALLOCATE COM,32720
          SIMULATE
          INTEGER    &LIMIT
          LET        &LIMIT=10000
*
          GENERATE   RVEXPO(1,5)
          QUEUE      LINE
          TRANSFER   .6,SERVICEA,SERVICEB
*
SERVICEA  GATE SNF   2
          ENTER      2,1
          ENTER      1,1
          GATE SNF   2
          ENTER      2,1
          ADVANCE    RVEXPO(1,9)
          ADVANCE    2,0
          DEPART     LINE
          LEAVE      1,1
          LEAVE      2,2
          TABULATE   RES
          TERMINATE
*
SERVICEB  GATE SNF   2
          ENTER      2,1
          ENTER      2,1
          ENTER      1,1
          ADVANCE    RVEXPO(1,9)
          ADVANCE    2,0
          DEPART     LINE
          LEAVE      1,1
          LEAVE      2,1
          TABULATE   RES
          TERMINATE
*
RES TABLE           M1,0,3,15
*
          STORAGE    S1,4/S2,4
*
          GENERATE   &LIMIT
          TERMINATE  1
          START      1
          END
```

Storage	Total Time	Avail Time	Unavl Time	Entries	Average Time/Unit	Current Status	Percent Avail	Capacity	Average Contents	Current Contents	Maximum Contents
1	0.595			1932	12.327	AVAIL	100.0	4	2.382	2	4
2	0.815			2705	12.054	AVAIL	100.0	4	3.261	4	4

Queue	Maximum Contents	Average Contents	Total Entries	Zero Entries	Percent Zeros	Average Time/Unit	$Average Time/Unit	Qtable Number	Current Contents
LINE	24	5.288	1939	0		27.273	27.273		9

TABLE RES

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	SUM OF ARGUMENTS	
1930.0000	27.3415	23.1068	52769.1745	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
...						
3.0000	54.0000	2.7979	2.80	97.20	0.1097	-1.0534
6.0000	163.0000	8.4456	11.24	88.76	0.2194	-0.9236
9.0000	158.0000	8.1865	19.43	80.57	0.3292	-0.7938
12.0000	149.0000	7.7202	27.15	72.85	0.4389	-0.6639
15.0000	162.0000	8.3938	35.54	64.46	0.5486	-0.5341
18.0000	141.0000	7.3057	42.85	57.15	0.6583	-0.4043
21.0000	144.0000	7.4611	50.31	49.69	0.7681	-0.2744
24.0000	117.0000	6.0622	56.37	43.63	0.8778	-0.1446
27.0000	107.0000	5.5440	61.92	38.08	0.9875	-0.0148
30.0000	89.0000	4.6114	66.53	33.47	1.0972	0.1151
33.0000	80.0000	4.1451	70.67	29.33	1.2070	0.2449
36.0000	81.0000	4.1969	74.87	25.13	1.3167	0.3747
39.0000	62.0000	3.2124	78.08	21.92	1.4264	0.5045
OVERFLOW	423.0000	21.92	100.00	0.00		

AVERAGE VALUE OF OVERFLOW IS 62.3047

B) The best result I obtained will be shown below explanation will be found below results

```
|           REALLOCATE COM,32720
            SIMULATE
            INTEGER    &LIMIT
            LET        &LIMIT=10000
*
            GENERATE   RVEXPO(1,5)
            QUEUE      LINE
            GATE SNF   1
            TRANSFER   .6,SERVICEA,SERVICEB
*
 SERVICEA   GATE SNF   2
            ENTER      2,1
            ENTER      1,1
            GATE SNF   2
            ENTER      2,1
            ADVANCE    RVEXPO(1,9)
            ADVANCE    2,0
            DEPART     LINE
            LEAVE      1,1
            LEAVE      2,2
            TABULATE   RES
            TERMINATE
*
 SERVICEB   GATE SNF   2
            ENTER      2,1
            ENTER      1,1
            ADVANCE    RVEXPO(1,9)
            ADVANCE    2,0
            DEPART     LINE
            LEAVE      1,1
            LEAVE      2,1
            TABULATE   RES
            TERMINATE
*
  RES TABLE            M1,0,3,15
*
            STORAGE    S1,5/S2,8

*
            GENERATE   &LIMIT
            TERMINATE  1
            START      1
            END
```

Storage	Total Time	Avail Time	Unavl Time	Entries	Average Time/Unit	Current Status	Percent Avail	Capacity	Average Contents	Current Contents	Maximum Contents
1	0.452			2002	11.287	AVAIL	100.0	5	2.260	2	5
2	0.394			2817	11.192	AVAIL	100.0	8	3.153	3	8

Queue	Maximum Contents	Average Contents	Total Entries	Zero Entries	Percent Zeros	Average Time/Unit	$Average Time/Unit	Qtable Number	Current Contents
LINE	10	2.326	2002	0		11.618	11.618		2

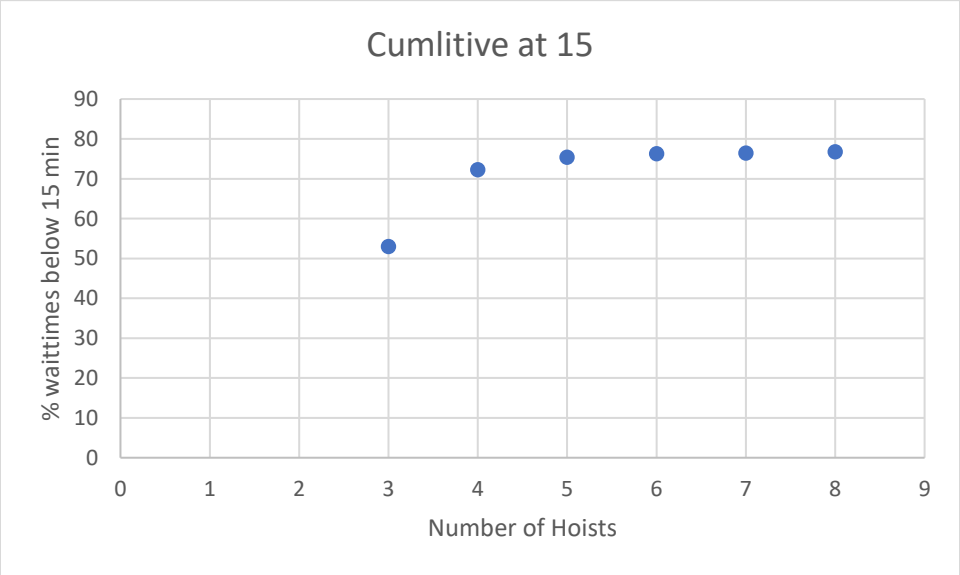
TABLE RES

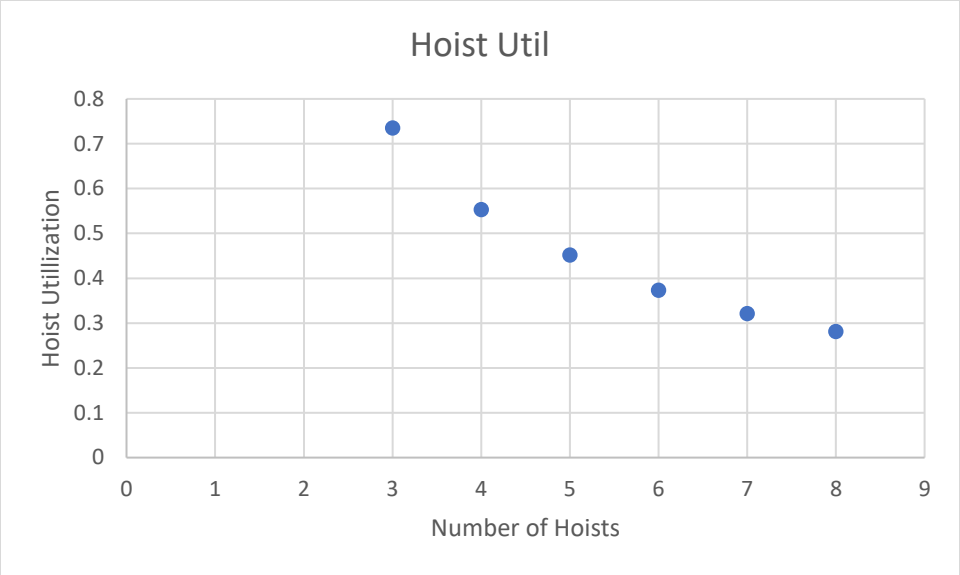
ENTRIES IN TABLE MEAN ARGUMENT STANDARD DEVIATION SUM OF ARGUMENTS
2000.0000 11.6248 9.4667 23249.5958 NON-WEIGHTED

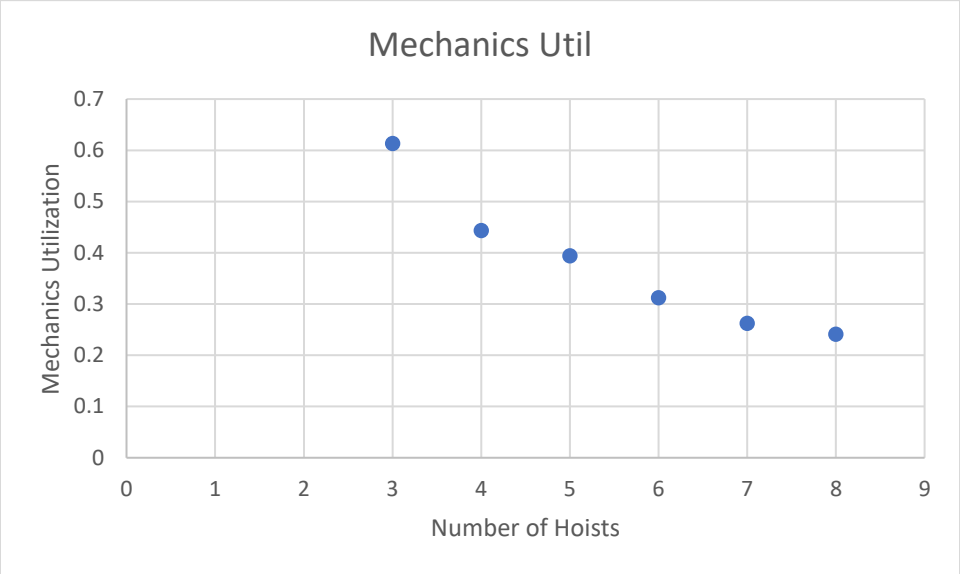
UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
...						
3.0000	184.0000	9.2000	9.20	90.80	0.2581	-0.9111
6.0000	488.0000	24.4000	33.60	66.40	0.5161	-0.5942
9.0000	350.0000	17.5000	51.10	48.90	0.7742	-0.2773
12.0000	271.0000	13.5500	64.65	35.35	1.0323	0.0396
15.0000	215.0000	10.7500	75.40	24.60	1.2903	0.3565
18.0000	114.0000	5.7000	81.10	18.90	1.5484	0.6734
21.0000	103.0000	5.1500	86.25	13.75	1.8065	0.9903
24.0000	74.0000	3.7000	89.95	10.05	2.0646	1.3072
27.0000	45.0000	2.2500	92.20	7.80	2.3226	1.6241
30.0000	43.0000	2.1500	94.35	5.65	2.5807	1.9410
33.0000	36.0000	1.8000	96.15	3.85	2.8388	2.2579
36.0000	20.0000	1.0000	97.15	2.85	3.0968	2.5748
39.0000	14.0000	0.7000	97.85	2.15	3.3549	2.8917
OVERFLOW	43.0000	2.15	100.00	0.00		

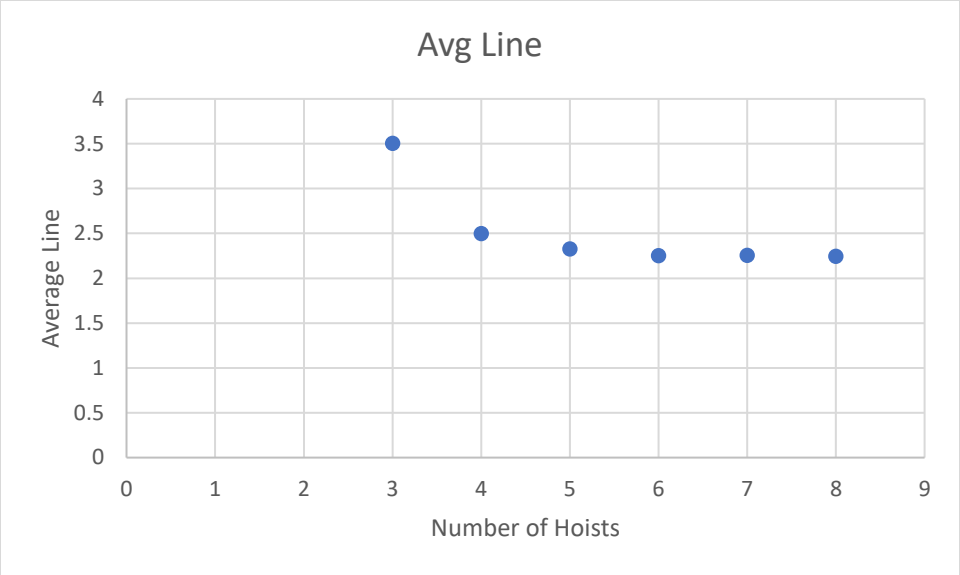
AVERAGE VALUE OF OVERFLOW IS 47.4221

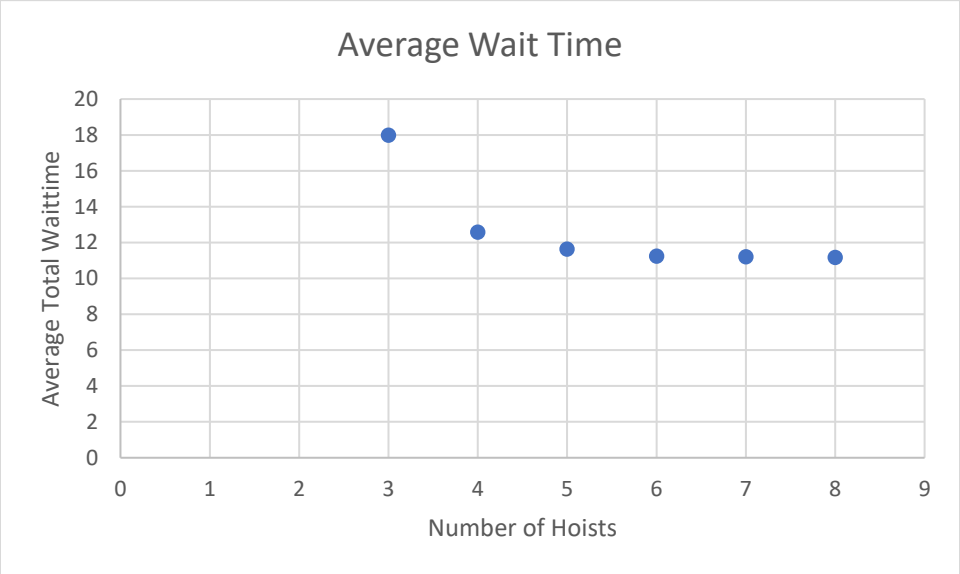
Results:




Hoist Util
Hoist Utillization
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0 1 2 3 4 5 6 7 8 9
Number of Hoists


Mechanics Util
Mechanics Utilization
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0 1 2 3 4 5 6 7 8 9
Number of Hoists





hoists	cumulative at 15	hoist util	mechanics util	Avg Line	average wait time
3	53.06	0.735	0.613	3.503	17.972
4	72.3	0.553	0.443	2.497	12.575
5	75.4	0.452	0.394	2.326	11.618
6	76.34	0.373	0.312	2.25	11.241
7	76.48	0.321	0.262	2.254	11.199
8	76.77	0.281	0.241	2.246	11.166

The simulation was ran with (hoist,mechanics) (3,5),(4,7),(5,8),(6,10),(7,12),(8,13)

The simulation does not clear at the end of each day because after talks with people familiar with mechanic shops they stated that there is normally an influx of people at the beginning of the day, because of this I decided that whatever amount was in the queue at the end of the day could just be immediately in the queue at the beginning of the next day. I found that because there is a percentage of jobs that require two mechanics if you have (1+percentage)*hoist = mechanics, you will have the optimal system.

Approach 2:

```
          REALLOCATE COM,32720
          SIMULATE
          INTEGER    &LIMIT
          LET        &LIMIT=2240
*
          GENERATE   RVEXPO(1,5)
          QUEUE      LINE
          GATE SNF   1
          GATE SNF   3
          ENTER      3,1
          ENTER      1,1
          ADVANCE    1,0
          LEAVE      3,1
          TRANSFER   .6,SERVICEA,SERVICEB
*
 SERVICEA GATE SNF   2
          ENTER      2,1
          GATE SNF   2
          ENTER      2,1
          ADVANCE    RVEXPO(1,9)
          LEAVE      2,2
          GATE SNF   3
          ENTER      3,1
          ADVANCE    1,0
          LEAVE      3,1
          LEAVE      1,1
          DEPART     LINE

          TABULATE   RES
          TERMINATE
*
 SERVICEB GATE SNF   2
          ENTER      2,1
          ADVANCE    RVEXPO(1,9)
          LEAVE      2,1
          GATE SNF   3
          ENTER      3,1
          GATE SNF   3
          ENTER      3,1
          ADVANCE    1,0
          LEAVE      3,1
          LEAVE      1,1
          DEPART     LINE
          TABULATE   RES
          TERMINATE
*
  RES TABLE           M1,0,3,15
*
          STORAGE    S1,5/S2,6/S3,2
*
          GENERATE   &LIMIT
          TERMINATE  1
          START      1
          END
```

Storage	--Avg-Util-During-- Total Time	Avail Time	Unavl Time	Entries	Average Time/Unit	Current Status	Percent Avail	Capacity	Average Contents	Current Contents	Maximum Contents
1	0.432			412	11.743	AVAIL	100.0	5	2.160	2	5
2	0.401			572	9.420	AVAIL	100.0	6	2.405	3	6
3	0.183			822	1.000	AVAIL	100.0	2	0.367	0	2

Queue	Maximum Contents	Average Contents	Total Entries	Zero Entries	Percent Zeros	Average Time/Unit	$Average Time/Unit	Qtable Number	Current Contents
LINE	11	2.383	412	0		12.955	12.955		2

TABLE RES

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	SUM OF ARGUMENTS	
410.0000	12.9963	11.3775	5328.4824	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
...						
3.0000	45.0000	10.9756	10.98	89.02	0.2308	-0.8786
6.0000	94.0000	22.9268	33.90	66.10	0.4617	-0.6149
9.0000	63.0000	15.3659	49.27	50.73	0.6925	-0.3512
12.0000	40.0000	9.7561	59.02	40.98	0.9233	-0.0876
15.0000	36.0000	8.7805	67.80	32.20	1.1542	0.1761
18.0000	36.0000	8.7805	76.59	23.41	1.3850	0.4398
21.0000	24.0000	5.8537	82.44	17.56	1.6158	0.7035
24.0000	14.0000	3.4146	85.85	14.15	1.8467	0.9671
27.0000	15.0000	3.6585	89.51	10.49	2.0775	1.2308
30.0000	11.0000	2.6829	92.20	7.80	2.3083	1.4945
33.0000	9.0000	2.1951	94.39	5.61	2.5392	1.7582
36.0000	5.0000	1.2195	95.61	4.39	2.7700	2.0219
39.0000	2.0000	0.4878	96.10	3.90	3.0009	2.2855
OVERFLOW	16.0000	3.90	100.00	0.00		

With approach two I ran out of memory much faster we also can observe that the utilization of mechanics serving cars stays about the same but the number of mechanics in that facility has gone down by two meaning that the efficiency of the mechanics job has increased but the overall performance of the system has gone down

(I have over 1tb of memory available why can’t I use it lol?)

Approach 3: someone other than mechanic raises and lowers hoist

```
Student GPSS/H Release 3.60 (CT114)     22 Mar 2018   19:44:16     File: Jiffy_Lube_BTYPE2_3.gps

Line# Stmt#  If Do  Block#  *Loc    Operation       A,B,C,D,E,F,G   Comments

    1     1                          REALLOCATE COM,32720
    2     2                          SIMULATE
    3     3                          INTEGER    &LIMIT
    4     4                          LET        &LIMIT=18000
    5     5                 *
    6     6               1          GENERATE   RVEXPO(1,5)
    7     7               2          QUEUE      LINE
    8     8               3          GATE SNF   1
    9     9               4          ENTER      1,1
   10    10               5          ADVANCE    1,0
   11    11               6          TRANSFER   .6,SERVICEA,SERVICEB
   12    12                  *
   13    13               7   SERVICEA  ENTER      2,1
   14    14               8          GATE SNF   2
   15    15               9          ENTER      2,1
   16    16              10          ADVANCE    RVEXPO(1,9)
   17    17              11          LEAVE      2,2
   18    18              12          ADVANCE    1,0
   19    19              13          LEAVE      1,1
   20    20              14          DEPART     LINE
   21    21              15          TABULATE   RES
   22    22              16          TERMINATE
   23    23                  *
   24    24              17   SERVICEB  ENTER      2,1
   25    25              18          ADVANCE    RVEXPO(1,9)
   26    26              19          LEAVE      2,1
   27    27              20          ADVANCE    1,0
   28    28              21          LEAVE      1,1
   29    29              22          DEPART     LINE
   30    30              23          TABULATE   RES
   31    31              24          TERMINATE
   32    32                  *
   33    33                    RES TABLE           M1,0,3,15
   34    34                  *
   35    35                          STORAGE    S1,4/S2,5
   36    36                  *
   37    37              25          GENERATE   &LIMIT
   38    38              26          TERMINATE  1
   39    39                          START      1
   40    40                          END
```

Storage	--Avg-Util-During-- Total Time	Avail Time	Unavl Time	Entries	Average Time/Unit	Current Status	Percent Avail	Capacity	Average Contents	Current Contents	Maximum Contents
1	0.583			3594	11.687	AVAIL	100.0	4	2.334	4	4
2	0.518			5013	9.298	AVAIL	100.0	5	2.590	5	5

Queue	Maximum Contents	Average Contents	Total Entries	Zero Entries	Percent Zeros	Average Time/Unit	$Average Time/Unit	Qtable Number	Current Contents
LINE	15	2.721	3594	0		13.626	13.626		4

TABLE RES

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	SUM OF ARGUMENTS	
3590.0000	13.6337	10.3824	48944.9228	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
...						
3.0000	254.0000	7.0752	7.08	92.92	0.2200	-1.0242
6.0000	670.0000	18.6630	25.74	74.26	0.4401	-0.7353
9.0000	578.0000	16.1003	41.84	58.16	0.6601	-0.4463
12.0000	489.0000	13.6212	55.46	44.54	0.8802	-0.1574
15.0000	382.0000	10.6407	66.10	33.90	1.1002	0.1316
18.0000	260.0000	7.2423	73.34	26.66	1.3203	0.4206
21.0000	244.0000	6.7967	80.14	19.86	1.5403	0.7095
24.0000	180.0000	5.0139	85.15	14.85	1.7603	0.9985
27.0000	137.0000	3.8162	88.97	11.03	1.9804	1.2874
30.0000	117.0000	3.2591	92.23	7.77	2.2004	1.5764
33.0000	81.0000	2.2563	94.48	5.52	2.4205	1.8653
36.0000	55.0000	1.5320	96.02	3.98	2.6405	2.1543
39.0000	35.0000	0.9749	96.99	3.01	2.8606	2.4432
OVERFLOW	108.0000	3.01	100.00	0.00		

AVERAGE VALUE OF OVERFLOW IS 47.5113

Best results explained: Clearing queue At end of each day

```
Student GPSS/H Release 3.60 (CT114)     22 Mar 2018   21:20:22     File: Jiffy_Lube4.gps

Line# Stmt#  If Do  Block#  *Loc    Operation       A,B,C,D,E,F,G   Comments

    1     1                          REALLOCATE COM,32720
    2     2                          SIMULATE
    3     3                          INTEGER    &LIMIT
    4     4                          LET        &LIMIT=600
    5     5                          INTEGER    &I
    6     6                  *
    7     7              1           GENERATE   RVEXPO(1,5)
    8     8              2           QUEUE      LINE
    9     9              3           GATE SNF   1
   10    10              4           TRANSFER   .6,SERVICEA,SERVICEB
   11    11                  *
   12    12              5   SERVICEA  GATE SNF   2
   13    13              6           ENTER      2,1
   14    14              7           ENTER      1,1
   15    15              8           GATE SNF   2
   16    16              9           ENTER      2,1
   17    17             10           ADVANCE    RVEXPO(1,9)
   18    18             11           ADVANCE    2,0
   19    19             12           DEPART     LINE
   20    20             13           LEAVE      1,1
   21    21             14           LEAVE      2,2
   22    22             15           TABULATE   RES
   23    23             16           TERMINATE
   24    24                  *
   25    25             17   SERVICEB  GATE SNF   2
   26    26             18           ENTER      2,1
   27    27             19           ENTER      1,1
   28    28             20           ADVANCE    RVEXPO(1,9)
   29    29             21           ADVANCE    2,0
   30    30             22           DEPART     LINE
   31    31             23           LEAVE      1,1
   32    32             24           LEAVE      2,1
   33    33             25           TABULATE   RES
   34    34             26           TERMINATE
   35    35                  *
   36    36                    RES TABLE           M1,0,3,15
   37    37                  *
   38    38                          STORAGE    S1,5/S2,8
   39    39
   40    40                  *
   41    41      1                   DO &I=1,30,1
   42    42      1      27           GENERATE   &LIMIT
   43    43      1      28           TERMINATE  1
   44    44      1                   START      1
   45    45      1                   CLEAR
   46    46                          ENDDO
   47    47                          END
```

Storage	--Avg-Util-During-- Total Time	Avail Time	Unavl Time	Entries	Average Time/Unit	Current Status	Percent Avail	Capacity	Average Contents	Current Contents	Maximum Contents
1	0.376			107	10.528	AVAIL	100.0	5	1.878	0	5
2	0.343			157	10.501	AVAIL	100.0	8	2.748	0	8

Queue	Maximum Contents	Average Contents	Total Entries	Zero Entries	Percent Zeros	Average Time/Unit	$Average Time/Unit	Qtable Number	Current Contents
LINE	7	1.910	107	0		10.708	10.708		0

TABLE RES

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	SUM OF ARGUMENTS	
107.0000	10.7075	9.2933	1145.7025	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
...						
3.0000	13.0000	12.1495	12.15	87.85	0.2802	-0.8294
6.0000	27.0000	25.2336	37.38	62.62	0.5604	-0.5065
9.0000	22.0000	20.5607	57.94	42.06	0.8405	-0.1837
12.0000	14.0000	13.0841	71.03	28.97	1.1207	0.1391
15.0000	9.0000	8.4112	79.44	20.56	1.4009	0.4619
18.0000	5.0000	4.6729	84.11	15.89	1.6811	0.7847
21.0000	5.0000	4.6729	88.79	11.21	1.9612	1.1075
24.0000	3.0000	2.8037	91.59	8.41	2.2414	1.4303
27.0000	2.0000	1.8692	93.46	6.54	2.5216	1.7531
30.0000	1.0000	0.9346	94.39	5.61	2.8018	2.0760
33.0000	4.0000	3.7383	98.13	1.87	3.0820	2.3988
...						
OVERFLOW	2.0000	1.87	100.00	0.00		

AVERAGE VALUE OF OVERFLOW IS 50.3037

Clearing the queue at the end of the day decreased both servers utilization and decreased the average length of the line and increased the cumulative percentage of jobs under 15 min. this would correspond to a policy that 15 min before the end of each day new customers are rejected and not given priority on the following business day

1) Use maximum memory
2) Start simulation
3) Declare variable
4) Assign variable (time limit one day in minutes)
5) Declare loop counter
6) *
7) Generate arrival
8) Place in lane
9) Wait for available hoist
10) Transfer to service block to process for job type
11) *
12) SERVICE A wait for available mechanic
13) Select a mechanic
14) Select a hoist
15) Wait for a second available mechanic (first one could have already started work)
16) Select second mechanic
17) Advance job time length

18) Advance hoist raises and lower time (can be done at once here)
19) Leave line
20) Leave hoist
21) Leave both mechanics
22) Jump to RES and store results (checkout)
23) End transaction
24) *
25) SERVICEB wait for a mechanic
26) Select a mechanic
27) Select a hoist
28) Advance job time
29) Advance hoist raise lower time
30) Leave line
31) Leave hoist
32) Leave mechanic
33) Jump to RES and store results (checkout)
34) End transaction
35) *
36) RES make a table (histogram with SNA M1,start,bin width, number of bins)
37) *
38) Define queuing facilities
39)
40) *
41) Start do loop (30 days)
42) Get limit
43) Decrement limit
44) Start a new round
45) Clear all variables
46) End do loop
47) End sim