Problem 1

Write a CSIM program for the first version of the priority queuing system you simulated earlier (where arriving high priority customers preempt low priority customersin service). Again, use the same old generator, compare your results and also report your experience with run times (C versus CSIM). In principle you should get exactly the same results. Very few lines of code required. Submit your code and a very brief writeup.

1. Parameters and Values

Parameters	Meanings	Values
NTYPE0	The number of low-priority customer per run	200
NTYPE1	The number of high-priority customer per run	200
ITAM0	The inter-arrival time of low-priority customer	10~20 (fix ITAM1=10 while vary ITAM0 from 11~20)
ITAM1	The inter-arrival time of high-priority customer	10~20 (fix ITAM0=10 while vary ITAM1 from 11~20)
ITAM	The expected inter-arrival time of two types	(11/21)*10~(20/30)*10
P	Probability that customer is type0	When fixing ITAM0=10 while vary ITAM1 from 11~20: vary in range of 11/21, 12/22, 13/23, … , 20/30 When fixing ITAM1=10 while vary ITAM0 from 11~20: vary in range of 10/21, 10/22, 10/23, … , 10/30
NARS	Number of arrivals to be simulated	4000
SVTM	The expected service time	5

2. From C to CSIM

This time I used a different mechanism to generate two different types of customers. In the previous C program, I generated two different queues with respective EXPARRIV values. In this CSIM program, I used a single queue instead of two queues and for each customer in the queue I randomly assigned the type. In order to compare C and CSIM, I need to specify the how to use a single queue to achieve the same effect from two queues.

Let **a** be the inter-arrival time of the two types of customers, then **1/a** is the inter-arrival rate. Since we generate the types randomly, assume there is a probability of **p** that the customer is type0 and **(1-p)** type1. Therefore, the inter-arrival rate of type0 and type1 customers are **p/a** and **(1-p)/a** respectively. That is to say, the inter-arrival rate of these two types of customers are **a/p** and **a/(1-p)** respectively. Therefore, when we fix type0 inter-arrival time to be 10, and vary type1's from 10 to 20, that is to vary **p** in the range of 11/21, 12/22, 13/23, … , 20/30, and let **a** equal to **10p**. When we fix type1 inter-arrival time to be 10, and vary type0's from 10 to 20, that is to vary **p** in the range of 10/21, 10/22, 10/23, … , 10/30, and let **a** equal to **10(1-p)** which is the same as the previous case.

3. Simulation results

(1) fix ITAM0=10 while vary ITAM1 from 11~20

The pictures on the left side are the results from homework #3 generated by C code, the pictures on the right side are the results generated by CSIM.

```
ITAM0 vs. average # of type0 jobs in the system (one '*' = 0.25)
 11     |******************************************************
 12     |*****************************************
 13     |****************************
 14     |********************
 15     |*******************
 16     |**************
 17     |************
 18     |***********
 19     |********
 20     |********
ITAM0 vs. average # of type0 jobs in the system (one '*' = 0.2)
 11 |************************************************
 12 |********************************************
 13 |**************************************
 14 |**********************************
 15 |*******************************
 16 |****************************
 17 |**************************
 18 |************************
 19 |**********************
 20 |*********************
```

When the inter-arrival time of type1 jobs increases, that is, the arrival rate of type1 jobs decrease, the average number of type1 jobs in the system decreases as well. That makes sense since if the customer arrives less frequently, the server can finish service for the current customer before next customer arrives, then there can be less customers in the queue waiting.

```
ITAM0 vs. average # of type1 jobs in the system (one '*' = 0.02)
 11    |***********************************
 12    |***********************************
 13    |*************************************
 14    |********************************
 15    |***********************************
 16    |**********************************
 17    |********************************
 18    |***********************************
 19    |**********************************
 20    |*******************************
ITAM0 vs. average # of type1 jobs in the system (one '*' = 0.02)
 11 |*************************************************
 12 |**************************************************
 13 |**************************************************
 14 |**************************************************
 15 |***************************************************
 16 |**************************************************
 17 |**************************************************
 18 |**************************************************
 19 |**************************************************
 20 |**************************************************
```

As the arrival rate of type1 jobs decrease, the average number of type0 jobs in the system decreases. That makes sense because type1 jobs always preempts type0 jobs, therefore, the more frequently type1 jobs come, they longer length the type0 queue will be.

```
ITAM0 vs. average time spent in system by type0 jobs (one '*' = 2)
 11    |*********************************************
 12    |***********************************
 13    |*************************
 14    |*******************
 15    |*****************
 16    |*************
 17    |************
 18    |***********
 19    |********
 20    |********
ITAM0 vs. average time spent in system by type0 jobs (one '*' = 2)
 11 |**************************************
 12 |***********************************
 13 |*******************************
 14 |*****************************
 15 |***************************
 16 |*************************
 17 |************************
 18 |***********************
 19 |**********************
 20 |**********************
```

When the arrival rate of type1 jobs decreases, the average time they spent in the system decreases as well. This is for the same reason why the average number of type1 jobs decreases.

```
ITAM0 vs. average time spent in system by type1 jobs (one '*' = 0.2)
 11    |*************************************************
 12    |*************************************************
 13    |*************************************************
 14    |*********************************************
 15    |*************************************************
 16    |************************************************
 17    |***********************************************
 18    |*************************************************
 19    |*************************************************
 20    |**********************************************
ITAM0 vs. average time spent in system by type1 jobs (one '*' = 0.2)
 11 |**************************************************
 12 |**************************************************
 13 |**************************************************
 14 |***************************************************
 15 |***************************************************
 16 |***************************************************
 17 |**************************************************
 18 |***************************************************
 19 |**************************************************
 20 |***************************************************
```

As the arrival rate of type1 jobs decreases, the average time type0 jobs spent in the system decreases. This is for the same reason why the average number of type0 jobs decreases.

(2) fix ITAM1=10 while vary ITAM0 from 11~20

```
ITAM1 vs. average # of type0 jobs in the system (one '*' = 0.25)
 11     |*********************************************************
 12     |***************************************************
 13     |****************************************
 14     |**********************************
 15     |*****************************
 16     |***********************
 17     |*********************
 18     |*******************
 19     |**************
 20     |**************
ITAM1 vs. average # of type0 jobs in the system (one '*' = 0.2)
 11 |**************************************************
 12 |**********************************************
 13 |****************************************
 14 |************************************
 15 |*********************************
 16 |*******************************
 17 |*****************************
 18 |**************************
 19 |*************************
 20 |***********************
```

The average number of type1 customers does not change with the expected arrival rate of type0 customers. That is because type1 customers can get served immediately even if a type0 customer is being served, as if the type0 customer was not there.

```
ITAM1 vs. average # of type1 jobs in the system (one '*' = 0.01)
 11     |**********************************************************
 12     |**********************************************
 13     |*************************************
 14     |****************************
 15     |****************************
 16     |***********************
 17     |*******************
 18     |*****************
 19     |**************
 20     |************
ITAM1 vs. average # of type1 jobs in the system (one '*' = 0.02)
 11 |********************************************
 12 |******************************************
 13 |****************************************
 14 |************************************
 15 |**********************************
 16 |*********************************
 17 |*******************************
 18 |******************************
 19 |****************************
 20 |***************************
```

When inter-arrival time of type0 customers increases from 11 to 20, that is, when the arrival rate of type0 customers decreases, the average number in the system decreases as well. That makes sense since if the customer arrives less frequently, the server can finish service for the current customer before next customer arrives, then there can be less customers in the queue waiting.

```
ITAM1 vs. average time spent in system by type0 jobs (one '*' = 2)
 11     |************************************************
 12     |*********************************************
 13     |************************************
 14     |******************************
 15     |**************************
 16     |*********************
 17     |*******************
 18     |******************
 19     |**************
 20     |**************
ITAM1 vs. average time spent in system by type0 jobs (one '*' = 2
 11 |************************************
 12 |*********************************
 13 |*****************************
 14 |**************************
 15 |************************
 16 |**********************
 17 |*********************
 18 |********************
 19 |*******************
 20 |******************
```

Just like the average number of type1 jobs, the average time type1 jobs spent in the system does not change with the arrival rate of type0 jobs for the same reason.

```
ITAM1 vs. average time spent in system by type1 jobs (one '*' = 0.2)
 11    |*********************************************
 12    |***************************************
 13    |**********************************
 14    |****************************
 15    |****************************
 16    |**************************
 17    |***********************
 18    |**********************
 19    |*******************
 20    |******************
ITAM1 vs. average time spent in system by type1 jobs (one '*' = 0.2)
 11 |***********************************************
 12 |***********************************************
 13 |**********************************************
 14 |*********************************************
 15 |********************************************
 16 |*******************************************
 17 |******************************************
 18 |*****************************************
 19 |*****************************************
 20 |****************************************
```

When the arrival rate of type0 jobs decreases, the average time they spent in the system decreases as well. This is for the same reason why the average number of type0 jobs decreases.

(3) Conclusion

From the simulation results above, we can see that the results from C and CSIM show the same trend and are both reasonable. The minor differences between the values of the two set of results may due to the different priority generation mechanism.

4. C vs. CSIM in Run Time

From the report generated by CSIM, we get the CPU time used is 2.280 seconds. While the C program only used 0.034769 seconds.

Problem 2

A small company widget xyz, inc. has two departments: production (makes just one type of widget) and packing/delivery (packs and ships widgets). The packing/delivery dept. has one packing machine. Incoming orders are satisfied FIFO by taking widgets from stock (where production puts them) and sending on to packing machine. Production is small. So incoming order backlog is limited to 10 orders max. Further incoming orders are sent to another company wantmore, inc. to be fulfilled. When backlog is decreased incoming orders are accepted again (but 10 is still the limit). Widget production time is random: U(60,100) secs. Order interarrival time is random: Expo(300) secs; 300 is the mean. Each order requires integer n widgets, 4 _ n _ 7, distributed as P(4) = .10; P(5) = .40; P(6) = .30 and P(7) = .20. The packing time per order is 90 + 50 * n secs, with the n just defined.

OUTPUT:

For ORDERS=91

(a) How many orders are lost to wantmore, inc.? This is lost business: 57

(b) Utilization of packing machine: 0.777 sec

(c) Average number of orders (from customers) waiting to be satisfied: 4.93 sec

(d) Average number of orders waiting, and average waiting time at the packing machine: 3.48sec; 9.58sec

Problem 3

A two-lane road is being repaired and one lane is closed for 500 meters. Traffic lights must be installed to manage traffic. Traffic is described as follows: in the A to B direction it is Poisson (300) cars/hour, and in the B to A direction it is Poisson (400) cars/hour. In the 500 meters common section, all cars have a speed limit of 40 km/hour. When a light turns green, waiting (stopped) cars for that light start and pass the light every 2 seconds. A light cycle consists of green (greenab) in the A to B direction, both red, then green again (greenba) in the B to A direction, and then both red. In either case, when a light turns from green to red, it must stay red for 55 seconds to allow all cars in the common section to pass. (Hint: the 40kmph speed limit means 55 secs is ample, so no need to actually use the 40kmph).
The problem is to use CSIM to implement this model, with the goal of finding a way to \minimize" the average waiting time for all car, i.e., find \optimal" values of greenab and greenba.

If we put multiple values of GREENAB and GREENBA in our code then we find the minimum average waiting time for cars.

1. When GREENAB=60 and GREENBA=45 then avg waiting time for cars from A to B is 13.15 sec and B to A is 17.81 sec.

2. When GREENAB=30 and GREENBA=20 then avg waiting time for cars from A to B is 8.6sec and B to A is 11.7 sec.

3. When GREENAB=80 and GREENBA=60 then avg waiting time for cars from A to B is 15.94 sec and B to A is 21.90 sec.

Conclusion:

Out of all three values minimum value of GREENAB and GREEBA is 30 sec and 20sec respectively.