BLEKINGE INSTITUTE OF TECHNOLOGY

Written test in (subject): ET2596 Simulation

Date: 2021.01.05

Name: _____

Civic number: _____

Number of sheets handed in:_____

Mark the question(s) you have answered by putting a ring around the relevant number(s)

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Instructions
A student who cannot produce valid ID will not be permitted to take the examination.
No examination scripts will be accepted by the proctor during the first hour of the examination. (Students arriving late will thus be permitted to take part in the examination).
Write your name and civic number on each sheet of paper you hand in.
Examination results are posted by e-mail no later than 10 working days after the date of the examination. Exceptions to this rule can occur. In this case, students will be informed by the teacher responsible for the course/program or by the examiner.
All blank answer sheets are to be handed in to the proctor.

(To be filled in by the proctor)

ID presented: _____
Proctor's sign.

Student union fee paid: _____
Proctor's sign.

Student union fee not paid: _____
Proctor's sign.

(To be filled in by the teacher)

Number of credits gained:_____ Grade:_____ ECTS:_____Examiner´s sign:_____

(To be filled in and signed by the student, after the correction of the examination)

I hereby sign my examination script. I am aware that by signing for my script, after correction, I waive my right to contest the examiner's comments and the credits or grade awarded.

Date_____ Signature:_____

Re-Exam In

Simulation
(2020.01.05) ET2596

Tuesday: 9:00 to 15:00

Lecturer: Siamak Khatibi

Allowed items on exam: Open book

The exam includes 5 problems (100 credit points); where for grade in ECTS you should obtain as following:

F (0-32), FX (33-49),
E (50-57), D (58-64),
C (65-74), B (75-82),
A (83-100)

Each question can be answered by a mfile using Matlab (i.e. Q1sol_XXXX.m, Q2sol_XXXX.m, …) where XXXX is your personal ID number. In the header of each mfile you should write your name. In each mfile beside your code for solution of the respective problem you should write your comments/arguments (which is more important than the coding by itself). You can write/draw on the paper as complementary material to your respective mfile (please mention it in your respective mfile that you have such complementary). You can digitize your written work in any way it is possible for you (e.g. photo, scan…).

You should zip all your digital materials (e.g. your mfiles related to each question, other used functions which are not standard Matlab functions, mat file, your scanned material or photos …) and upload it to the Canvas under modul "exam", in "Upoad your answer to Re-exam 2020-01-05".

As far as the exam is open you can use any material you find anywhere (even the internet), however you should mention the used martial by its reference. As may you know from other exams it is not difficult to find the copies of codes between students, Thus. please avoid it because with detection of any copied material it does not become possible to grade your exam.

Good Luck

Q1

As you may recall that the warming up has great effect on the result of any simulation process. In this problem we try investigating the warming up problem for a M/M/1 system. Please use the file "Q1sim.m" and change it in a way that you can observe the warming up process for a system with 65% loading (i.e. in the steady state the ρ=0.65).

a)- Plot the warming up process by showing the actual load (i.e. the time-based load; called as offered load). (4p)

b)- What is the time amount we need to consider for the warming up in the system; from your observation. Here you need to argue about your finding. Do not forget to save your actual result as mat files (i.e. your results are based on random and I need to see your result in connection to your argumentation) (4p)

c)- What is the probability that the offered load in beginning of the simulation is unstable. You need to repeat the simulation (e.g. 200 times) to calculate the probability. (4p)

d)- Calculate the probability as in C when the system is 15%, 25%, 35%, 45%, 55%, 65%, 75%, 85% and 95%. Plot your result (use bar function in Matlab), why these probabilities do not have a linear relation, please argue your answer? (8p)

Q2

Let us continue our investigation about warming up. You can use the file "Q2sim.m" which simulates the system of M/M/1/11.

a)- In relation to simulation time, plot the number of customers in a system with 95% loading (i.e. in the steady state the ρ=0.95), spending time of customers in the system and loss ratio **with and without** considering the warming up duration. (5p)

b)- Calculate the 95% confidence interval (CI) and relative CI of the spending time of customers in the system **with and without** considering the warming up duration. (5p)

c)- Calculate the relative half size of 95% confidence interval (CI) as in b (i.e. two type of results considering **with and without** warming up**)** when you repeat the simulation (e.g. 200 times). (5p)

d)- Considering your results in c, find the relation between the two types of data in relation of their distribution probability and cross-correlation. From these relations what can you conclude about the warming up process? (5p)

Q3

In this problem we are interested to investigate the performance of two methods: Batch-Means and Replication-Deletion methods. Let us use the file "Q3sim.m" which is a M/M/1 system. Let us configure the system with 65% loading (i.e. in the steady state the ρ=0.65).

a)- Calculate the 50%, 60%, 75% confidence intervals of the number of customers in the system and the spending time of customers in the system with Batch-Means method. (8p)

b)- Calculate the 50%, 60%, 75% confidence intervals of the number of customers in the system and the spending time of customers in the system with Replication-Deletion method. (8p)

c)- Argue/comments your results from a) and b) to compare the performance of the two methods while you are obtaining different levels of confidence intervals. (4p)

Q4

In this problem please use the file "Q4sim.m" which simulates two different systems using sysType as one of its input parameters. The sysType can be 1 or 2 to simulate the systems of M/M/1 and M/U/1 respectively.

a)- Do the modification on "Q4sim.m" to achieve simulation of the two types of systems. The M/M/1 system should have 75% loading and M/U/1 should have 95% loading. (2p)

b)- Using the "Q4sim.m", make a new function as

```
[N,T, arrivals,services]=Q4sim2(sysType,endtime,p,rstate,antithetic)
```

where the new input parameters of the function in comparison to the "Q4sim.m" are `p`, `rstate` and `antithetic` which represent probability of using a system type, state of random number generator and antithetic flag (i.e. 1 turns on antithetic variates, 0 turn them off). (10p)

c)- There are 2 configurations of each of two systems with p being either 0.15 or 0.85. Make 10 replications of each system simulation with both values of p by first using independent random numbers. Then repeat the experiment using common random numbers (CRN) for both inter-arrival times and service times across the systems.

d)- Compare the estimated means and variances of the difference between the measured performance of customer time (i.e. T) as it is obtained in c. Comment your result. (4p)

Hint: Choose the "rstate" input parameter in Q4sim2.m in a way that be able to control the RNGs (i.e. to find common or independent generated random numbers).

b) For p=0.72, make five pairs of runs using both independent sampling and antithetic variates within each pair. Compare the estimated means and variances of the measured performance of customer time (i.e. T). Comment your result. (4p)

Q5

Two students of our course were trying to find a way to generate random values. To have also fun and find a way, they went to a swimming pool. Suddenly they came with a crazy idea to use swimmers as random generation source. They observed that each swimmer during his/her swimming should stick out the head to get air. They thought they could use the position of swimmers' head which can be quite randomly. To investigate their idea, they fetched two

lasers, and each one used one laser and measured x and y distance of swimmers' head from the corner of the pool which had a size of 7 and 10 meters in x and y directions respectively. You can find their measured data in file "q5.mat" file. The file includes a Matrix A of size of 5000 by 2. In the first column of A the swimmers' head in direction of x is measured. The second column of A represents the y distances. Then the students used the distance $Z = \sqrt{x^2 + y^2}$ as their random sampling source to generate Random Variate numbers according to its sampling pattern.

a)-To generate the RVN from the sampling pattern of the distances to the swimmers' heads we come up with the following solution to find the distance of Z. Argue (only according to the facts) why we need to calculate the distance Z according to the yellow marked solution. (4p)

```
lambdaX=7;
lambdaY=10;
load q5.mat
xxS=A(:,1);
yyS=A(:,2);
%%%%%%%%%%%%%%%%%
xx=xxS(xxS<=7);
yy=yyS(yyS<=10);

TH=min(length(xx),length(yy));
xx=xx(1:TH); yy=yy(1:TH);
z=sqrt(xx.^2+yy.^2);
```

b)- Using the solution in a, generate the RVN from the sampling pattern of the distances to the swimmers' heads. In this generation you can not model the pattern (e.g. it becomes best guess which is going to affect heavily the generated RVN). (4p)

c)-Generate randomly 5 numbers with 4 digits. (2p)

d)- Use the generated numbers in c as seeds to generate different sequences of RVN from the sampling pattern of the distances to the swimmers' heads. Then calculate the autocorrelation lag-1 and the pdf of each generated RVN sequences, Argue/comment your results. (6p)

d)- Calculate the cross correlation between each two generated RVN sequences from c); Argue/comment your results. (4p)