Boğaziçi University	**IE 306.02**	KORUGAN
Department of	System Simulation	Due Date:
Industrial Engineering	**Homework 1**	April 17^{th} 2022

Jobs arrive one by one at a queueing network where the first station is a GI/G/1 queueing system and the second station is a GI/G/c/c queueing system. Each arriving job enters the first station. If the server is idle the job is served. If the server is busy the job enters the queue. Each job in queue reneges after an independently distributed exponential time with rate ρ. After a job is served by the first station it enters the second station with c parallel servers if a server is idle. It picks randomly with equal probability among available servers. When all servers of the second station are busy a job that is completed at station one stays inside the first server, blocking the service of the first station until a server in the second station is available. When blocked, the first server cannot process any new jobs since there is no waiting area for processed jobs. As soon as one of the c servers in the second station becomes available the job that blocks the first station is sent to this server and the first station resumes its work. All queues operate under an FCFS discipline. The necessary parameters for this simulation are:

- Interarrival time distribution of job arrival process defined as Uniform $[a, b]$.
- The service time distribution of the first station defined as Erlang(k, μ_1).
- Reneging time distribution for the jobs waiting in the first station queue defined as Exponential(ρ)
- Service time distribution of each server at the second station defined as Exponential(μ_2)
- Number of parallel servers at the second station given as c.

The values for each parameter is different for each homework group and is given in the Excel file provided in this link. Make sure you are using the values assigned for your group.

Generate an **event scheduling** based discrete event simulation model for this queueing network.

- First perform a hand simulation. Start the system empty. Generate the arrival process. Prepare a simulation table where you report the simulation time, future event list, number in queue one, state of server 1, waiting times, number of reneging jobs, service times, number of busy servers of second station, service times and other necessary model outputs in a table until the first 15 arrivals leave the system by reneging or by being processed. Calculate average sojourn time of a job in the system, proportion of time the first server is blocked, average reneging rate, proportion of jobs that completed service.
- Generate a flowchart and pseudocode of your simulation model.

- Then code your model. For the first of the following experimental settings report the above table using your code. For all experimental settings calculate average sojourn time of a job in the system, proportion of time the first server is blocked, average reneging rate, proportion of jobs that completed service.
  - Run all your simulations with the following three starting conditions:
    - with an empty queueing network,
    - with 5 jobs in the first system and half of the c servers full (if not divisible by 2 round down) in the second system.
    - with 10 jobs in the first system and all of the c servers full in the second system.
  - For each condition run each simulation for 20, 200 and 1000 exiting jobs using the same random number seed.
  - Change the random number seed and repeat the previous runs.
- Compare all results with the approximate results of all service, interarrival and reneging times being independent and exponential for given average times. Comment on the statistical outcomes.

For each step of the simulation an understandable and proper reporting is required. You are also required to compare and discuss the results of your simulations thoroughly with the knowledge you have gathered in the course so far.

You should base your code on the SimPy pseudocode provided in the Jupyter notebook. Document your code in teh notebook properly. For coding use Python 3.7 or higher. Your report has to follow standard reporting lines and should be uploaded as a pdf file. One zipped file that contains the code and the report should be uploaded. The file should not be larger than 2 Mb, it must be submitted through the Moodle website (e-mails and other means will be disregarded) and it should be named as:
IE306- Asn-1-Group-yy-Lastname1-Lastname2-Lastname3.zip
with names in alphabetical order.