Project 7: Code Errors and the Butterfly Effect

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CST-305: Principles of Modeling and Simulation

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Part 1:

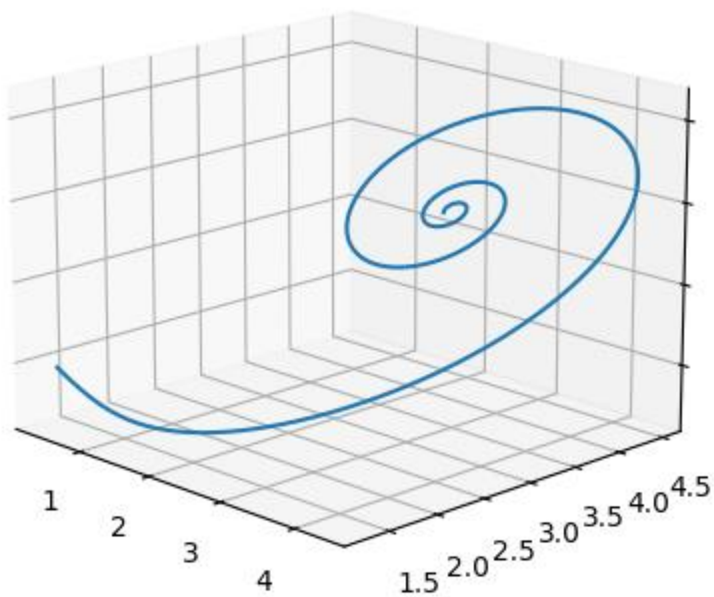
We needed to write a program that ran the following equations and executed them perfectly using Python:

$$\frac{\mathrm{d}x}{\mathrm{d}t} = \sigma(y - x),$$

$$\frac{\mathrm{d}y}{\mathrm{d}t} = x(\rho - z) - y,$$

$$\frac{\mathrm{d}z}{\mathrm{d}t} = xy - \beta z.$$

Users can enter a value for Rho in the Python program. Once the input is received, the 3D graph of the Lorenz system is displayed in an animated fashion. The program can be restarted and different values can be entered.

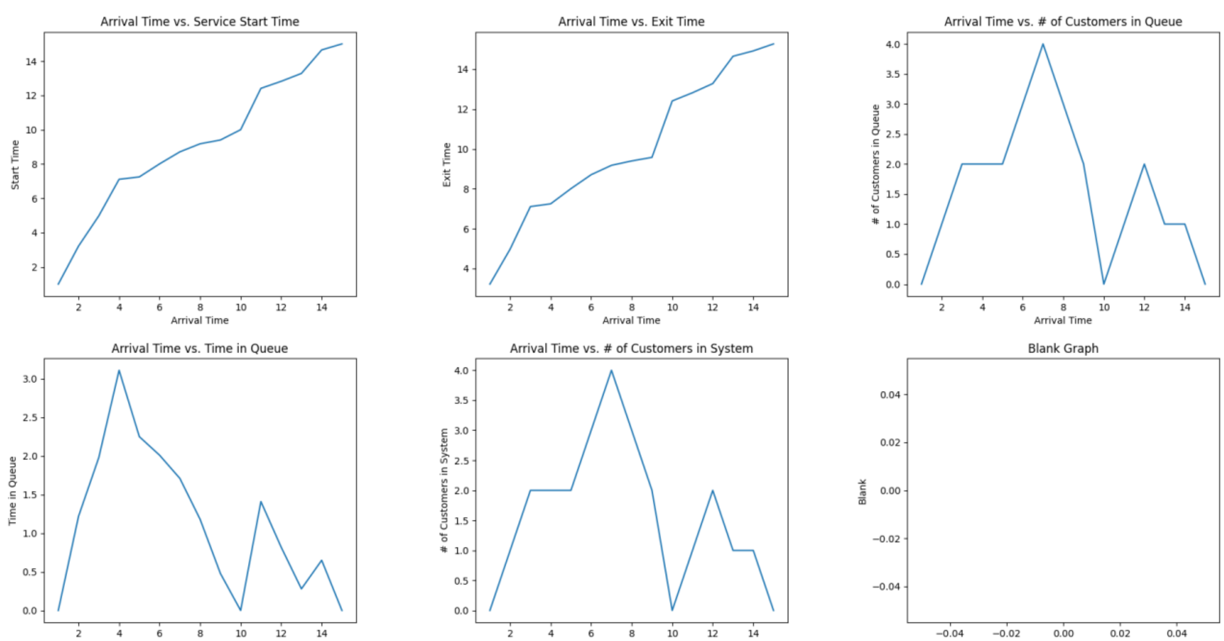


Animated result with Rho = 5

Part 2:

Q1:

Arrival Tim	Service Du	Service Sta	Exit Time	Time In Qu	# in Systen	# in Queue		Trial	
1	2.22	1	3.22	0	0	0			
2	1.76	3.22	4.98	1.22	1	0			
3	2.13	4.98	7.11	1.98	2	1			
4	0.14	7.11	7.25	3.11	2	1			
5	0.76	7.25	8.01	2.25	2	1			
6	0.7	8.01	8.71	2.01	3	2			
7	0.47	8.71	9.18	1.71	4	3			
8	0.22	9.18	9.4	1.18	3	2			
9	0.18	9.4	9.58	0.4	2	1			
10	2.41	10	12.41	0	0	0			
11	0.41	12.41	12.82	1.41	1	0			
12	0.46	12.82	13.28	0.82	2	1			
13	1.37	13.28	14.65	0.28	1	0			
14	0.27	14.65	14.92	0.65	1	0			
15	0.27	15	15.27	0	0	0			
				Time average Number in Queue					
				1.1346667					
				Average Number in queue as seen by arriving customers					
				0.6					



Using the arrival times and the service duration lists, one can obtain the service start and exit times, the length of the queue, the number of customers in the queue, and the number of customers in the system. These values are then calculated manually and put into an array and plotted using matplotlib in Python. It should be noted that despite a slight difference, the service start times and exit times follow a similar trend. In addition, the remaining three graphs also follow a similar pattern, with peaks when the arrival time falls between four and seven minutes.

Q2

2 ms throughput 12 buffers

125 pps

Arrival = 125 pps

Service = 1/0.002 = 500 pps

$10^{-1} = 0.1$

Gateway = 125/500 = 0.25

Probability of Buffer Overflow: $\rho^{12} = 0.25^{12} = 5.96 \cdot 10^{-8}$

around 60 per billion

$0.25^{x} \leq 1 \times 10^{-6}$

$x \geq 10$

Q3

if $\lambda + k$ [illegible] $\mu + k$ then

$\text{Util} = \frac{\lambda + k}{\mu + k}$ Overall decrease

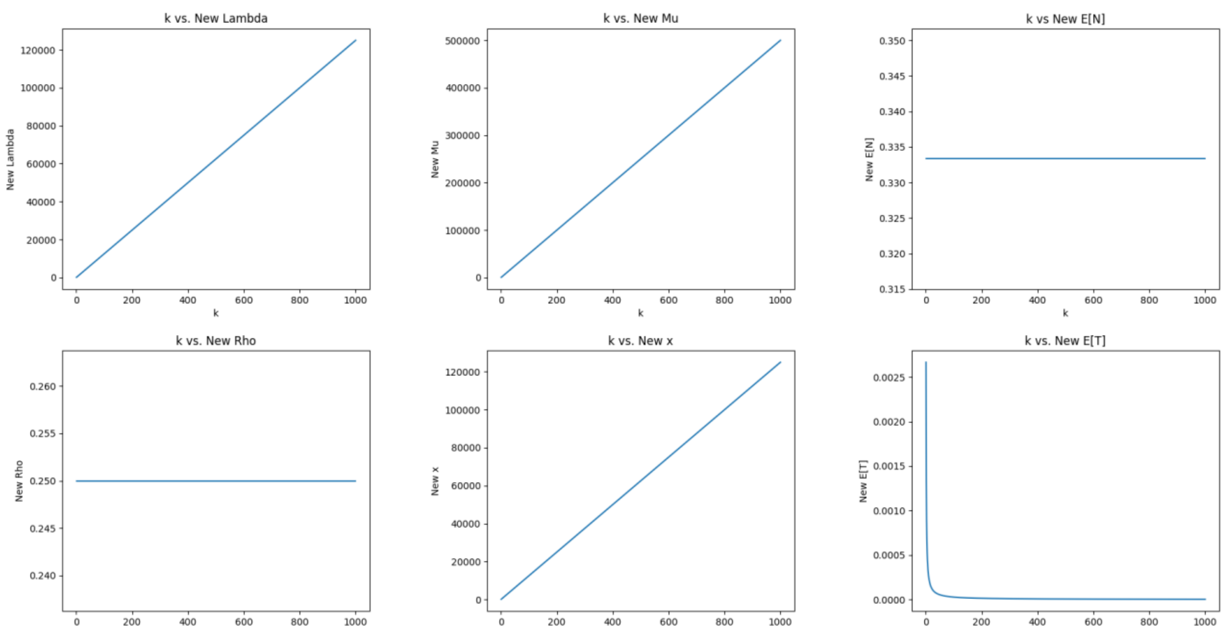
$$\text{Mean \# in Sys} = \frac{\lambda + k}{\mu + k} \Big/ 1 - \frac{\lambda + k}{\mu + k} = \frac{\lambda + k}{\mu + k} \Big/ \frac{\mu + k - (\lambda + k)}{\mu + k} = \frac{(\lambda + k)\cancel{(\mu + k)}}{\cancel{(\mu + k)}(\mu - \lambda)}$$

$$\boxed{\frac{\lambda + k}{\mu - \lambda}}$$ Overall increase

$$\text{mean \# time} : \frac{1}{\mu + k} \Big/ 1 - \frac{\lambda + k}{\mu + k} = \frac{1}{\mu + k} \Big/ \frac{\mu + k - (\lambda + k)}{\mu + k} = \frac{\cancel{(\mu + k)}}{\cancel{(\mu + k)}(\mu - \lambda)}$$

$\frac{1}{\mu - \lambda}$ no change

$\text{throughput} = \cancel{\frac{1}{\mu + k}}$ overall decrease



Q4

$$\lambda_{max} = 1/6 \times 3 = 0.5 \text{ jobs/min}$$

Q5