Stevens Institute of Technology

SYS-611 Homework #6

Due Apr. 7 2021

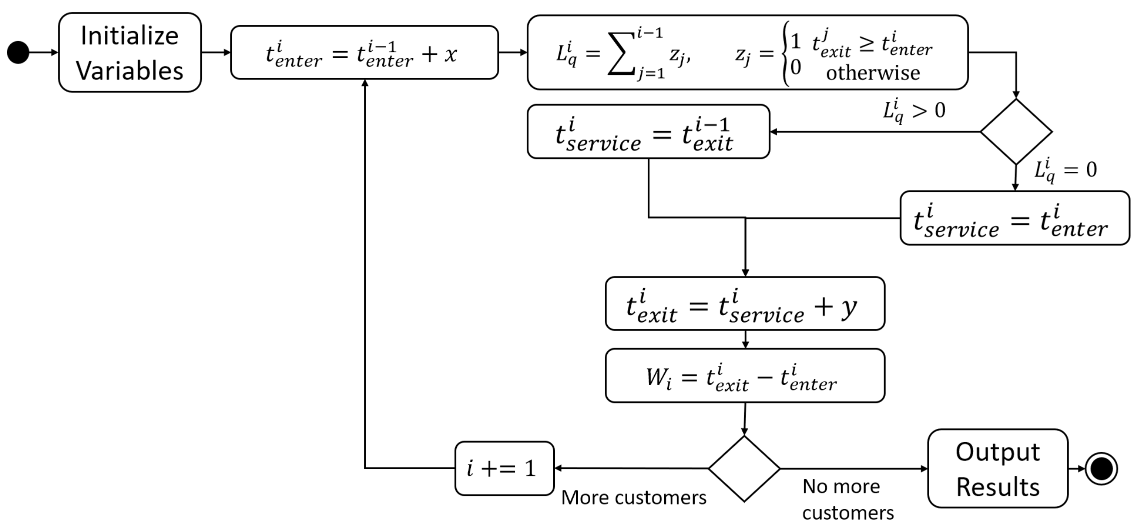
Submit the following using the online submission system: 1) Cover sheet with name, date, and collaborators, 2) Written responses in PDF format, 3) All work (e.g. .xlsx or .py files).

6.1 Café Java Operations Model [10 points]

Consider a discrete event simulation model for Café Java similar to the one developed in lecture. Use the following inter-arrival durations (x) and service times (y) in (a) and (b).

$$x = [0.41, 0.58, 5.37, 1.02, 0.82], \quad y = [1.12, 4.18, 4.53, 5.42, 0.26]$$

(a) 4 PTS Using a *customer-centric perspective*, consider the following state variables for customer i: time entering the café (t^i_{enter}), queue length on arrival (L^i_q), time receiving service (t^i_{service}), time service complete (t^i_{exit}), and waiting time (W_i).

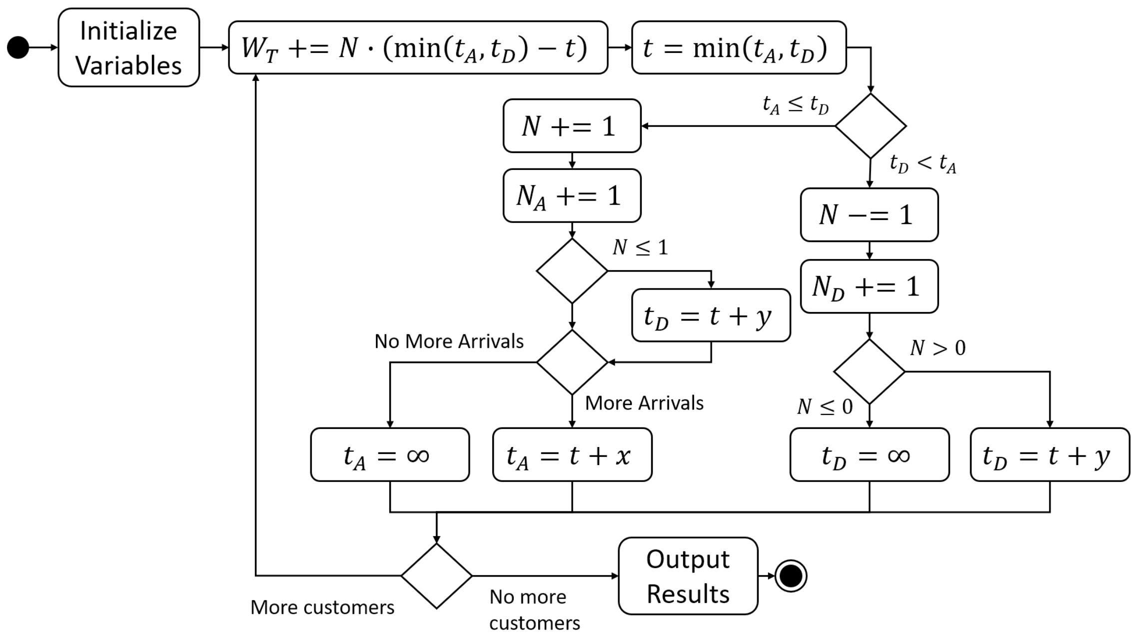


Using provided inter-arrival periods x and service times y when needed (pre-filled in table), follow the activity diagram to complete the following table to manually simulate the first five customers and find the average waiting time.

$$\overline{W} = \frac{1}{5} \sum_{i=1}^{5} W_i$$

Customer (i)	x	t^i_{enter}	L^i_q	t^i_{service}	y	t^i_{exit}	W_i
1	0.41				1.12		
2	0.58				4.18		
3	5.37				4.53		
4	1.02				5.42		
5	0.82				0.26		

(b) 4 PTS Using an *event-centric perspective*, consider the state variable: number of customers in the café (N); simulation variables: simulation time (t), time of next arrival (t_A), and time of next departure (t_D); and counter variables: number of arrivals (N_A), number of departures (N_D), and total wait time (W_T).



Using the generated inter-arrival periods x and service times y when needed, follow the activity diagram to complete the following table to manually simulate the first ten events and find the average waiting time at the end of the simulation.

$$\overline{W} = W_T / N_A$$

Hint: as this example uses the same model assumptions and identical samples of x and y as part (a), you should obtain the same results!

Event	t	t_A	t_D	N	N_A	N_D	W_T
0	0	0.41	∞	0	0	0	0
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

(c) 2 PTS Choose either the customer-centric or event-centric perspective and explain how a maximum queue capacity of 5 customers could be enforced. Modify an activity diagram to support your answer (OK to screen-capture and edit existing diagrams).

6.2 Logistics for Submarine Upgrades [15 points]

The Navy is upgrading its submarines to take advantage of commercial off-the-shelf (COTS) components. The sonar system analog-to-digital (A/D) converter is one of the key systems targeted for modernization. A random demand (D) for A/D converters required each day is modeled with the discrete PMF below based on records over the past 100 days.

d	$p(d)$
2	0.13
3	0.42
5	0.45

If there is insufficient inventory, the component is back-ordered (represented as a negative inventory) and the upgrade will be performed on the next day when available.

The A/D converter supplier orders from a subcontractor in California and hardens for reliability in the harsh submarine environment. The total lead-time (L) is a minimum of 5 days plus exponentially-distributed shipping delay S with average $1/\lambda = 4$ days.

$$L = 5 + S, \qquad S \sim \text{exponential}(\lambda = 0.25)$$

Currently, the Navy places an order for 40 A/D converters when its current inventory falls below 30. Assume that new orders are placed at the end of the day and the purchasing system only allows one pending order at a time. New A/D converters are available for use on the day after being delivered. Work only takes place on weekdays (Monday–Friday).

As the systems project manager for the prime contractor, you are asked to simulate inventory levels and anticipate any problems. You are primarily concerned about back-ordered A/D converters which can be measured by assigning a penalty of 1 unit for each back-ordered converter each day. For example, sequential days with 3 and 5 back-ordered converters contribute 8 total units to the cumulative penalty.

(a) 2 PTS Develop a discrete process generator for the daily A/D converter demand (D) using a uniform(0,1) sample r_d and a continuous process generator for the lead time L using a uniform(0,1) sample r_s.

(b) 4 PTS **By hand**, perform a manual simulation of the inventory system for three work-weeks. Use the provided random numbers r_d for daily demands and r_s for shipping delays when needed. Record results in the table below where N is the inventory of A/D converters at the start of the day, D is the daily demand, P is the *cumulative* penalty for back-ordered converters (i.e. P increases by $|N|$ if $N < 0$), and t_d is the time of the next delivery. The column $N(t+1)$ may be helpful to count the inventory at the end of the day (after subtracting demand and adding received shipments).

Explain any assumptions required to complete the simulation in your written response.

t	r_d	r_s	$N(t)$	D	P	t_d	$N(t+1)$
0	—	—	40	—	0	∞	40
1	0.05	0.88					
2	0.20	0.55					
3	0.70	0.56					
4	0.04	0.55					
5	0.84	0.27					
6	0.33	0.62					
7	0.26	0.16					
8	0.44	0.60					
9	0.43	0.22					
10	0.73	0.90					
11	0.05	0.84					
12	0.67	0.22					
13	0.43	0.84					
14	0.49	0.73					
15	0.17	0.22					

(c) 3 PTS Draw an activity diagram for the logistics system simulation to show how you update the simulation variables each day.

(d) 4 PTS **Using a computer**, implement a computational simulation model for the logistics problem. Using at least 10 simulation runs, report the 95% confidence interval for the total penalty P after a 52-week (260 day) simulation. Write a short analysis including plots to communicate any problems with the current logistics strategy.

(e) 2 PTS Suggest an alternative (does not have to be optimal) for how many A/D converters to order (change from 40) and/or at what inventory level to trigger the order (change from 30). Write a short analysis using results from the computational simulation model to demonstrate the potential benefit of the alternative strategy.

