SIE 431/531 Simulation Modeling and Analysis （Spring 2023）
Take home exam 2 (due on 05/02/2023, 12pm) Name:
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By signing here, Agustin Espinoza, I signify that I have completed the problems below independently and I have not shared my solutions with others.

For problems below involving the construction of ARENA models, please submit .doe files and all other files created to generate the result.

Problem 2 (25 pts):

At a hub airport, passengers arrive one at a time through the entrance with interarrival times distributed exponential with mean 0.5 minute (all times are in minutes unless otherwise noted). Of these passengers 35% go to the manual check-in counter, 50% go right to the kiosks, and the remaining 15% don't need to check in at all and proceed directly to the security (it takes these latter types of passengers between 3 and 5 minutes, uniformly distributed, to walk from the entrance to the security area. There are two-agents at the manual check-in station, fed by a single FIFO queue. Manual check-in times follow a triangular distribution between 1 and 5 minutes with a mode of 2 minutes. After manual check-in, passengers walk to the security area, which takes them about 2.0 and 5.8 minutes, uniformly distributed. There are two kiosks (two stations) fed by a single FIFO queue. Check-in times for using kiosks are triangularly distributed between 0.5 and 1.5 minutes with a mode of 1. After check-in, passengers walk to the security area, taking between 1 and 3 minutes, uniformly distributed. All passengers eventually get to the security area, where there are six stations fed by a single FIFO queue. Security-check times are triangularly distributed between 1 and 6 minutes with a mode of 2.

Simulate this system for one replication of an 8-hour period and show:

1) the average queue length, average times in queue, and average time in system of passengers for EACH passenger type.

EACH Passenger Type: *Kiosk Check-In Passengers, Manual Check-In Passengers, No Check-In Passengers*

Kiosk Check-In Passengers:

- Average Kiosk Check-In Queue Length = 0.2419
- Average Kiosk Check-In Times in Queue = 0.2444 min
- Average Time in System for Kiosk Check-In Passengers = 137.10 min

Manual Check-In Passengers:

- Average Manual Check-In Queue Length = 13.0769
- Average Manual Check-In Times in Queue = 17.30333 min
- Average Time in System for Manual Check-In Passengers = 165.68 min

No Check-In Passengers:

- Average No Check-In Queue Length = 16.8155
- Average No Check-In Times in Queue = 8.1805 min
- Average Time in System for No Check-In Passengers = 208.81 min

2) the average queue length, average times in queue, and average time in system of passengers for all passenger types COMBINED.

COMBINED Passenger Types:

- Average Combined Check-In Queue Length = 30.1343
- Average Combined Check-In Times in Queue = 14.7548 min
- Average Time in System for Combined Check-In Passengers = 22.1610 min

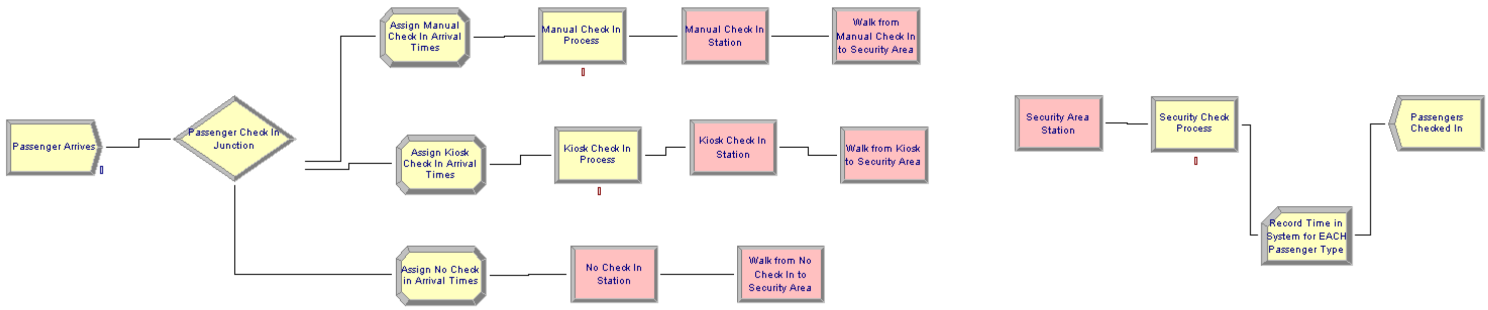

Figure 1. Airport Check-In Model

Problem 3 (25 pts):

(A state driver's license exam center would like to examine its operation for potential improvement. Arriving customers enter the building and take a number to determine their place in line for the written exam, which is self administered by one of five electronic testers. The testing times are distributed as EXPO(8); all times are in minutes. Thirteen percent of the customers fail the test. These customers are given a booklet on the state driving rules for further study and leave the system.

The customers who pass the test select one of two photo booths where their picture is taken and the new license is issued. The photo booth times are distributed TRIA(2.6, 3.6, 4.3). The photo booths have separate lines, and the customers enter the line with the fewest number of customers waiting in queue. If there is a tie in queue length, they enter Booth 1. If there is no queue, they also enter Booth 1, whether it is busy or not. Note that customers cannot see into the photo booths.

The center is open for arriving customers eight hours a day, although the services are continued for an additional hour to accommodate the remaining customers. The customer arrival pattern varies over the day and is summarized below:

Hour	Arrivals per Hour
1	21
2	28
3	40
4	31
5	43
6	35
7	29
8	22

Run your simulation for ten days, keeping statistics on 1) the average number of test failures per day; 2) utilization for electronic-tester, photo-booth1, and photo-booth2 utilization, respectively; 3) average number in electronic-tester queue, in photo-booth1 queue, and in photo-booth2, respectively; and 4) average customer system time for those customers passing the written exam.

1) Average Number of Failures per day = Total Run Test Failure Count / 10
   Average Number of Failures per day = 30.9 / 10 = 3.09 failures per day
2) Utilizations:
   Electronic-Tester = 0.8389
   Photo-Booth1 = 0.9549
   Photo-Booth2 = 0.00
3) Average Numbers in Queue:
   Electronic-Tester = 7.3085
   Photo-Booth1 = 36.9452
   Photo-Booth2 = 0.00
4) Average Customer System time for Passing Customers = 77.8873 min

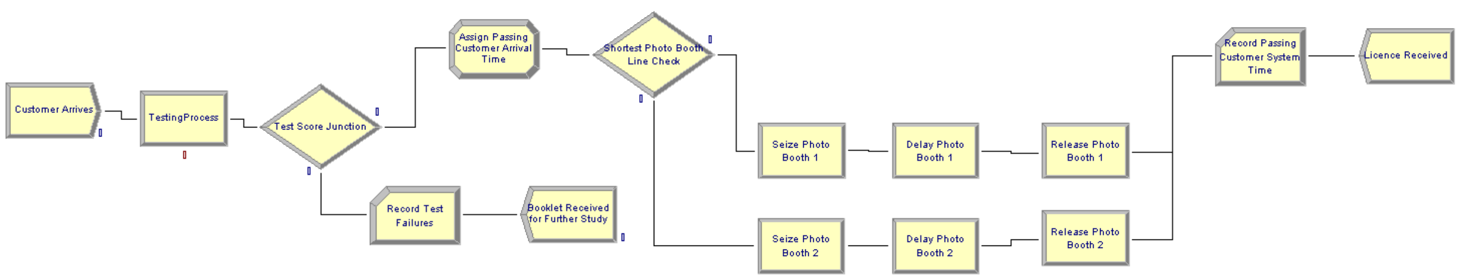

Figure 2. State Driver's License Exam Center Model

Problem 5 (25 pts):

A part arrives every 10 minutes to a system having three workstations (A, B, and C), where each workstation has a single machine; the first part arrives at time 0. There are four part types, each with equal probability of arriving. The process plans for the four part types are given here. The entries for the process times are the parameters for a triangular distribution (in minutes).

Part Type	**Workstation/ Process Time**	**Workstation/ Process Time**	**Workstation/ Process Time**
Part 1	A 5.5,9.5,13.5	C 8.5,14.1,19.7	
Part 2	A 8.9,13.5,18.1	B 9,15,21	C 4.3,8.5,12.7
Part 3	A 8.4,12,15.6	B 5.3,9.5,13.7	
Part 4	B 9.3,12.6,16.0	C 8.6,11.4,14.2	

Assume that the transfer time between arrival and the first station, between all stations, and between the last station and the system exit is 3 minutes. Use the Sequence feature to direct the parts through the system and to assign the processing times at each station. Use the Sets feature to collect cycle times (total times in system) for each of the part types separately. Run the simulation for a single replication of length 10,000 minutes, and collect statistics on the average part cycle time.

Average Part Cycle Times:

Part 1 = 3764.29 min

Part 2 = 3806.29 min

Part 3 = 3839.37 min

Part 4 = 3784.91 min

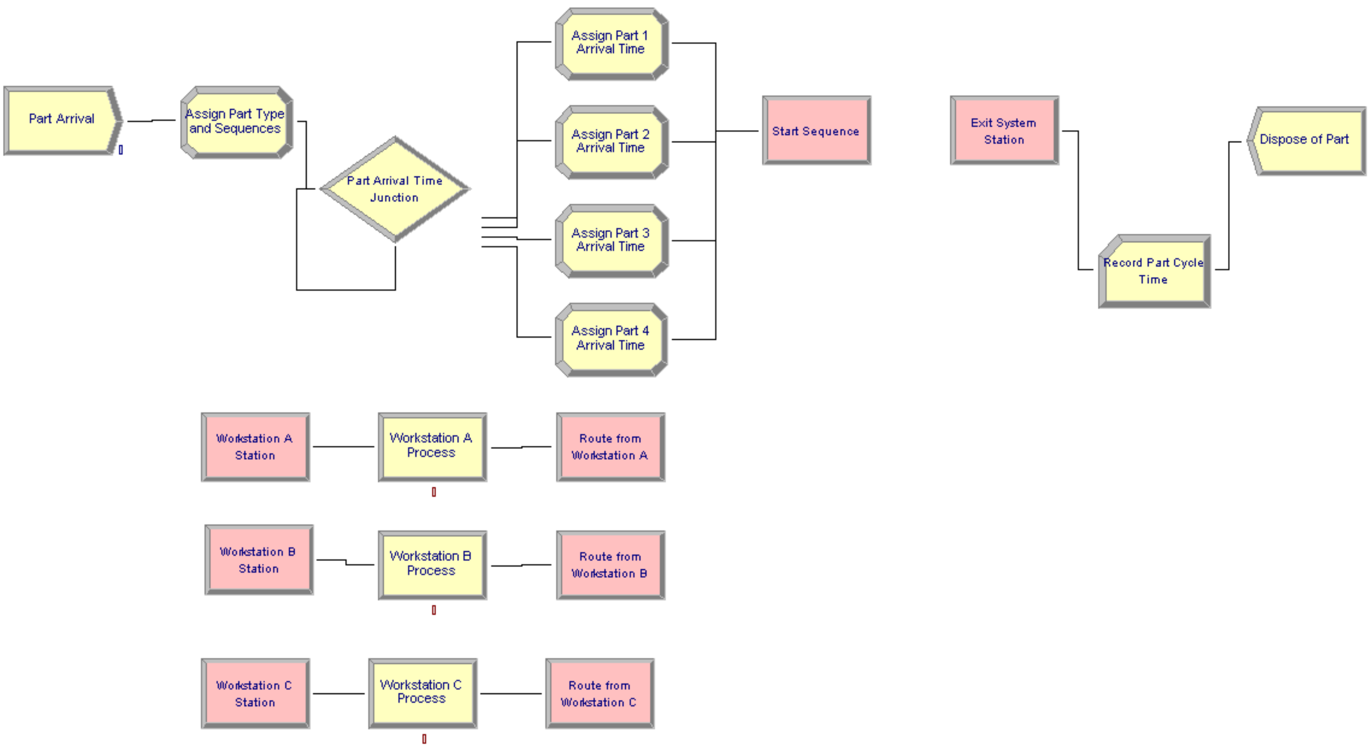

Figure 3. Part Processing Model

Problem 7 (25 pts):

Figure 1. A mystery sandwich (photo credit: http://fastfoodgeek.com/restaurants/dunkin-donuts/dunkin-donuts-bakery-sandwiches-review-ham-cheese-and-turkey-cheddar-bacon/).

In the "coach" (i.e., cheap) seats on airline flights there's no real food given out for "free" anymore, but most airlines will sell you something on board. Let's say the only choice is a mystery sandwich (See Fig. 1) selling for \$8.00, and that historically about 17% of passengers will opt to buy one (nobody buys more than one, and the other approximately 83% of passengers don't buy any). Operationally, this means that each passenger on a flight has an independent probability of 0.17 of buying a sandwich, as if each passenger flips a biased coin with P(heads) = 0.17 and if it comes up heads this passenger buys a sandwich, and if it comes up tails this passenger does not buy a sandwich. The wholesale cost to the airline per sandwich is \$4.75. If a passenger *wants* to buy a sandwich but they're sold out by the time he or she is asked, then the airline incurs a loss-of-goodwill cost of \$10.00 for that hungry and disgruntled passenger. Any unsold sandwiches left over have to be thrown out (so the airline gets no revenue, not even scrap/salvage, on any unsold sandwiches, and just loses the \$4.75 on each one). Throughout, assume that all seats on a flight are occupied (which is almost true these days anyway). We'll consider two types of airplanes, and composed completely of coach seats: the Embraer ERJ 135 (https://en.wikipedia.org/wiki/Embraer_ERJ_145_family), a small regional jet with 37 seats, and the Airbus A380 (https://en.wikipedia.org/wiki/Airbus_A380), currently the world's largest commercial passenger jet with an all-coach-configuration capacity of 853 seats.

1) Determine how many sandwiches to put on a given flight to maximize the profit for the Embraer ERJ 135 in order to maximize the profit;

   Sandwiches needed on a given flight for the ERJ 135 to maximize profit = 27

2) Determine how many sandwiches to put on a given flight to maximize the profit for the Airbus A380 in order to maximize the profit.

   Sandwiches needed on a given flight for the A380 to maximize profit = 532