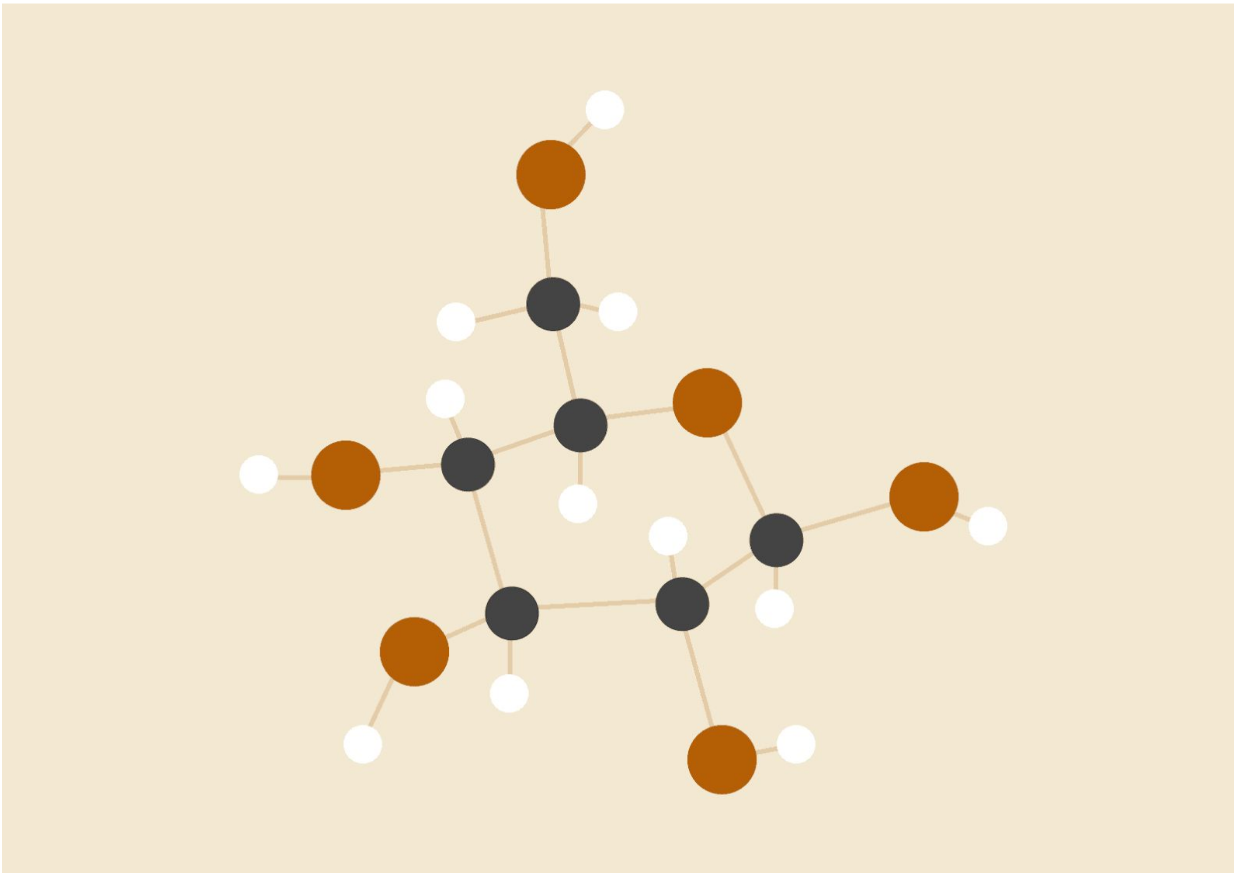
Bicycle-sharing System Design and Analysis



Wanyun Yang, Changnan Jing

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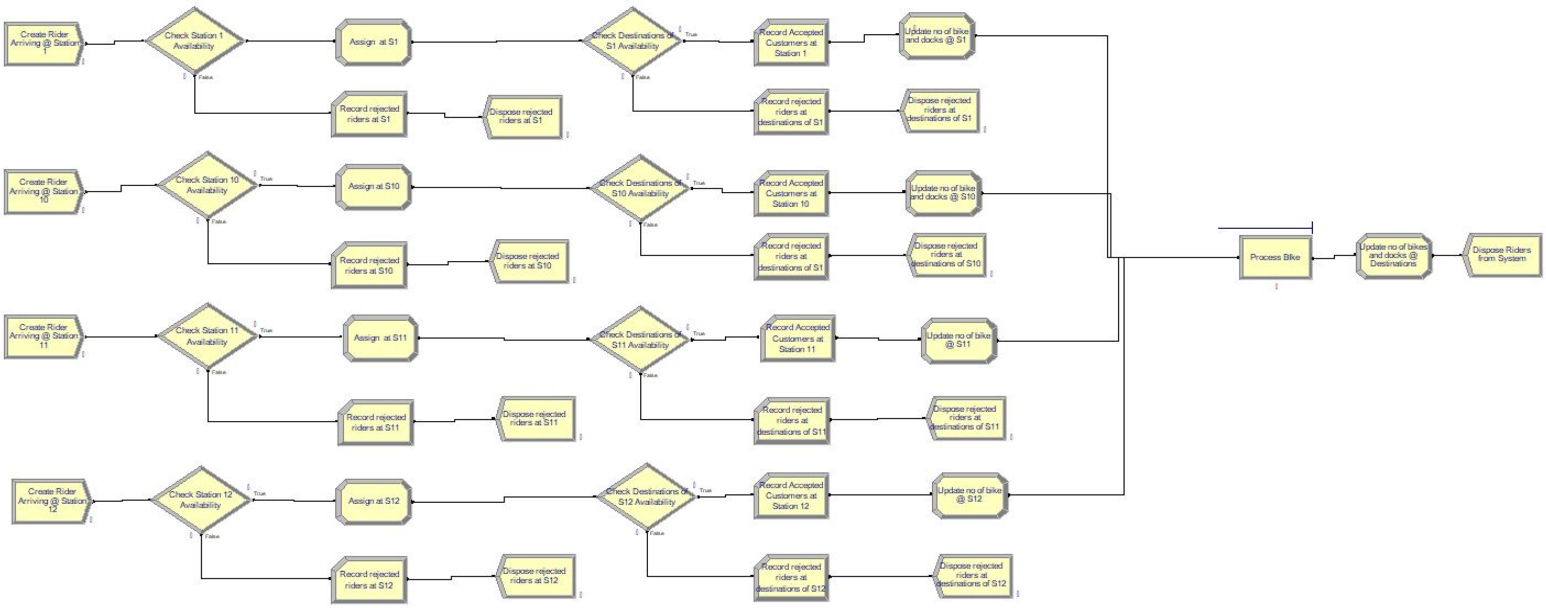
ARENA FLOWCHART



MODEL DESCRIPTION

1. **Input model for arrivals**

   Among the stations, we decided to include Station 1, Station 2, Station 3, and Station 4 in our model. In the input part, we first filtered out data by these stations. Then we calculated the arrival rate of every couple hours in Excel.

The counts of records were divided by 22, since the data covered 22 days total. We also followed instructions that use numbers that are ten times bigger as the final arrival rate of the system. The values were inputted in the schedule table, which is used in the Create Modules for arrivals to different stations separately.

We used the first Decide module to check the availability of bikes in the station. If there were no available bikes at the moment, the system would return false and the request would be recorded as a rejection. If bikes were available (bike number is equal or greater than one), the system would return true and move to the next Assign module.

Every input would be assigned a new attribute according to the destination they would like to go. In the following decision module, the system would check the availability of docks at the end stations. If there were no vacant docks in the destination, the system would return false and it would be recorded as a rejection. Only the customers whose request passes both decision modules would be recorded as an accepted customer. The ones who are rejected in either of the Decide modules would be recorded as a rejection and ended at the dispose module for each starting station.

2. **Input model for trip durations**

Following the instructions in the previous assignment, we checked the outliers first. All the trips' durations are less than 12 hours (43,200 seconds), so we considered them all as valid records. After dividing the whole data into four groups according to the four starting stations, all combinations in the groups have enough observations to fit a distribution. Some of them contain more than 250 samples, so we generated random numbers to help us resample it within the range. (@RISK limits the sample size down to 250 for students.) After using the fitting distribution feature in @RISK, we found the corresponding distributions for the trip duration of each combination.

3. **Output measures for output analysis**

We used the percentages of rejection to be our measures for output analysis. The number of rejected records refers to the efficiency of our system. We defined two types of rejection percentages here, percentage of customers rejected by the lack of bikes at the start station and percentage of customers rejected by the lack of docks at the end station. We used two record modules to record these two types of rejections. One is for counting the number of rejections brought by the unavailability of bikes at the starting station, the other is for the number of rejections by the lack of docks at destinations. Calculating them by the percentage formula, we can explain the specific results of output and determine corresponding operation to stations.

4. **Explanation for implementation of the bike dock operation**

We used two assign modules to achieve the bike dock operation. The first

Assign module is used for the update of the number of bikes and docks at the starting station after the bike service request is approved. The number of bikes in the starting station would decrease one unit and the number of vacant docks would increase one unit. The second assign module is used to update the number of docks and bikes at the destination. When a customer arrives, the number of bikes would increase one unit and the number of available docks would decrease one unit.

5. **Explanation for implementation of the rebalancing operation**

   We chose to use the logical cutoff entity to identify the rebalancing operation. It is composed of a create module, an assign model and a dispose module. We are able to check the current number of available docks and bikes at a fixed time every day and refill bikes to the station when the number of bikes is lower than the optimal capacity or remove bikes from the station when the number of bikes is more than the optimal capacity.

6. **Run setup**

   We chose to run ten replications to get a fair result. The system will run twenty four hours per day and the replication length is one day. The base time unit is set to hours.

OUTPUT ANALYSIS

	Scenario Properties				Controls							
	S	Name	Program File	Reps	Bike Number(1)	Bike Number(2)	Bike Number(3)	Bike Number(4)	Dock Number(1)	Dock Number(2)	Dock Number(3)	Dock Number(4)
1		Scenario 1	2 : BikeShare_TA2	1	20	20	20	20	5	5	5	5
2		Scenario 2	2 : BikeShare_TA2	1	40	20	40	20	5	5	5	5
3		Scenario 3	2 : BikeShare_TA2 T	1	40	15	15	15	5	5	5	5
4		Scenario 4	2 : BikeShare_TA2 T	1	45	10	10	10	5	5	5	5
5		Scenario 5	2 : BikeShare_TA2	1	42	5	5	5	10	10	10	10
6		Scenario 6	2 : BikeShare_TA2	1	42	3	4	3	9	9	9	9
7		Scenario 7	2 : BikeShare_TA2 T	1	42	4	4	4	8	8	8	8
8		Scenario 8	2 : BikeShare_TA2 T	1	42	4	4	4	8	11	16	16

Responses							
Percent Rejected Customers at Destinations of Station 1	Percent Rejected Customers at Destinations of Station 10	Percent Rejected Customers at Destinations of Station 11	Percent Rejected Customers at Destinations of Station 12	Percent Rejected Customers at Station 1	Percent Rejected Customers at Station 10	Percent Rejected Customers at Station 11	Percent Rejected Customers at Station 12
3.650	17.033	8.333	11.048	41.241	0.824	3.283	9.348
4.104	16.076	15.309	11.699	29.478	0.000	0.000	8.635
5.302	25.441	23.267	17.101	30.896	0.000	0.000	6.377
6.163	16.398	19.490	15.152	25.646	0.000	5.568	10.468
1.835	7.303	5.419	4.399	41.101	7.865	26.108	17.595
0.188	1.961	0.231	1.648	37.030	24.090	37.644	32.418
2.326	9.091	7.068	6.604	42.397	14.171	30.628	14.780
0.000	0.254	0.258	0.877	41.088	21.066	23.514	21.345

We did the sensitivity analysis via PAN. The control variables are the number of docks and the number of bikes at each station, and the response variables are rejection rates of each station. When there are more docks and bikes, the rejection rate will decrease for sure. However, we need to consider the cost. We think the bikes cost more than the docks, so we will control the rejection due to the lack of bikes under 30%. For the rejection due to the lack of docks at the destination, it is hard to control which station the customer will go and the cost is relatively low as well, so we were able to control the rejection rate by approximately 10%.

CONCLUSION

According to the result, among the four stations, station 1 had the highest rejection rate which was 41% due to the lack of bikes while the rejection rates of other three stations remained at a lower level. Our solution for the lack of bikes is increasing the number of bikes at the station. We found that station 1 had already 42 bikes in stock. The maintenance cost of bikes was extremely high, so it is not realistic to assign more bikes to one single station. Combined with practical considerations, we decided to keep rejection rates of other stations as low as possible while recommending citizens around station 1 to be prepared for the high possibility of rejection.