TITLE:

AMUSEMENT PARK SIMULATION USING ARENA

TEAM NUMBER 8

TEAM MEMBERS:

GOPI VARMA MANTHENA

SANDESH GEORGE OOMMEN

ANESH KRISHNA J N

KARTHIK SAJEEV

AMUSEMENT PARK SIMULATION USING ARENA

SUMMARY:

With the growth of the tourism industry, amusement parks worldwide have witnessed a marked surge in the number of visitors they attract per year. With a rising crowd comes the issue of long queues and diminishing satisfaction levels of the customers. In order to remain competitive and to ensure better customer satisfaction for their visitors, the management of the parks need to do their best to reduce waiting times and subsequently increase the number of rides that a visitor is able to cover on a typical day.

This study is an attempt to create a simulation model by considering various real-life aspects of a fully-functional amusement park- segregation of rides into land and water rides, availability of a restaurant, buses to shuttle visitors from one site to another within the park, varying preferences for queues based on the type of ticket purchased by the visitor and their age group, and different arrival rates of customers based on the day of the week. By varying various parameters like the number of buses, their capacity, the capacity of the rides and the speed of the buses, we try to zero in on the scenarios which give us the best values for the average waiting time in queues and the average number of rides covered per person, while ensuring that everyone leaves the park within a pre-determined closing time.

INTRODUCTION:

This project is about simulating an amusement park. The main objective of the project is to make the visitor's happy at the end of the day. After simulating our amusement park, using the Process Analyzer we control the input variables to try and get the best possible combination that will make the visitors joyful. From visitor's perspective, they would want to go to as many rides as possible and spend very less time waiting in the queues.

From management perspective of the amusement park, they would like to close the amusement park as early as possible at the end of the day as soon as the rides are closed. To accomplish this, they should plan on spending their resources and transport vehicles in a more efficient way to transport people from all locations in the amusement park to the entrance.

PROBLEM DESCRIPTION:

The main goal of the project is to simulate an amusement park by including a transport system for customers to travel from one destination to another, thus comprehending the complexities of an amusement park as well as that of a transport system into a single model. We try to find the best transport system for the given criterion. Our model also aims to help the management to employ the minimum number of buses required to close the amusement park by 7 PM after opening it at 9 AM in the morning.

AMUSEMENT PARK SIMULATION USING ARENA

POTENTIAL SOLUTION APPROACHES:

In this project, there are two different kind of customers, the fast track people and the normal people. The fast track customers get more preferences in all the ride queues and the old customers get more preference in bus queues over the young customers.

For simplicity, it is assumed that the ratio of average number of fast track people and normal people is 0.2 and that of young to old people is 4.

There are 20 rides in total, in which there are 10 land rides and 10 water rides. Both the models have a single restaurant in the entire park. In both the models, it is assumed that all the land rides are at one place and all the water rides at another place.

Different kind of routing rules and probabilities are used in the simulation model to route the customers between various rides among the land/water rides and also to route between different locations in the park. Queuing rules are also specified based on the fast track/ normal or old/ young customers. Every customer has the option to do any number of rides till the time becomes 5 PM. It is assumed that no customer leaves the park before 5 PM.

In total, there are 4 primary locations in the entire park. They are the main entrance (where the customers arrive and purchase their tickets), the land rides (which includes all the 10 land rides), the water rides (which includes all the 10 water rides) and lastly, the restaurant.

The timings for the amusement park opens at 9 AM and the entry of customers is restricted after 3 PM. All the rides are closed after 5 PM to ensure that the customers exit the park through same entrance by a maximum time of 7 PM (which is time when the amusement park is shut down completely).

Bus facility is available to travel between the four locations. But the two solution approaches follow different bus routing rules which are explained in detail below. All the buses are assumed to move with a constant speed of 2 mph for simplicity.

It is assumed that the normal customers arrive with expo (0.4) and fast track customers arrive with expo (2) during the week days. Similarly, the normal customers arrive with expo (0.2) and fast track customers arrive with expo (1) during the holidays or weekends. This shows that the customers are doubled on an average during the weekends and holidays compared to week days.

Simulation of these models are carried out with various ride times, ride capacities of each rides, bus capacities and number of buses to find out an optimal system during week days and weekends. Only the scenarios where all customers are able to exit before 7 PM are considered as optimal.

The differences in the two different solution approaches/models that are discussed in this project are explained below:

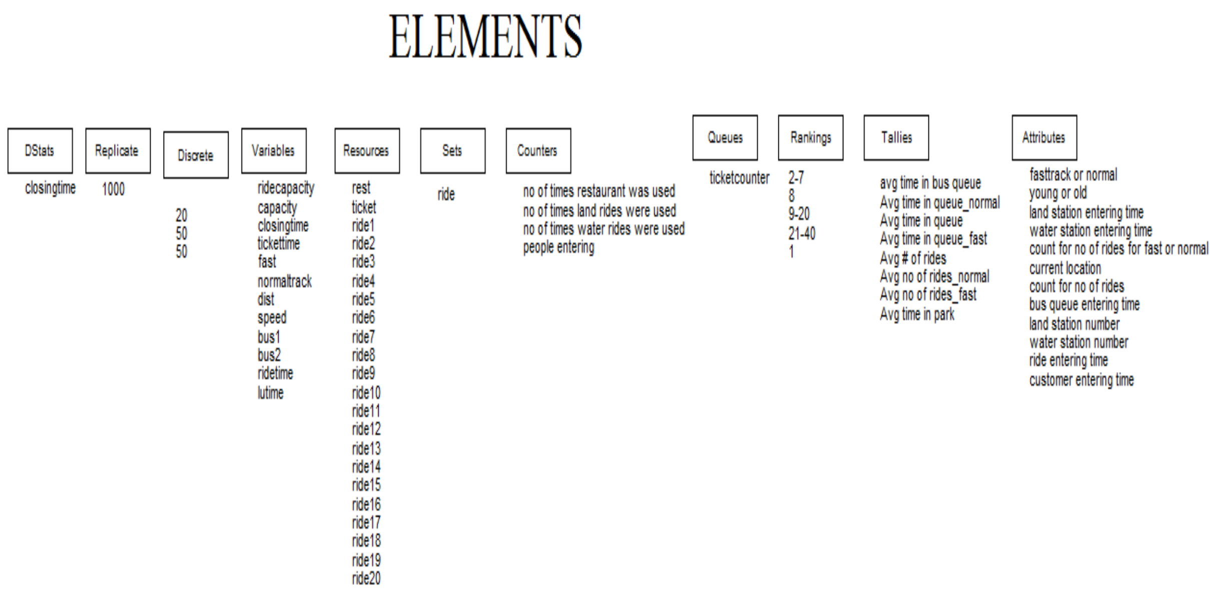
AMUSEMENT PARK SIMULATION USING ARENA

1. The first model has a set of buses which travel from the entrance to land or water rides depending on the maximum number of customers waiting for a particular destination. In this model, there is no transportation provided for the restaurant, but there are a different set of buses running in a loop between land and water rides. After 5PM, this model has a provision/option to double the number of buses available to go to the entrance to facilitate faster exiting of customers such that the condition of shutting down the amusement park by 7 PM is satisfied.
2. The second model has a set of buses stationed at each of four locations (entrance, land rides, water rides and restaurant) in the park. Every location has 3 queues for different destinations. The buses always choose from the maximum queue length among the 3 queues to serve. The buses that belong to a particular location will always travel to some destination and return back to the location it belongs to, with the customers from the destination that want to travel to the initial location of the bus. After 5 PM every customer is directed back to the queue which has the destination as the entrance and all the buses are routed to function as the buses that have the initial location as the entrance. This is done to transport the customers quickly to satisfy the condition of shutting down the amusement park by 7 PM.

<u>SIMULATION MODELING:</u>

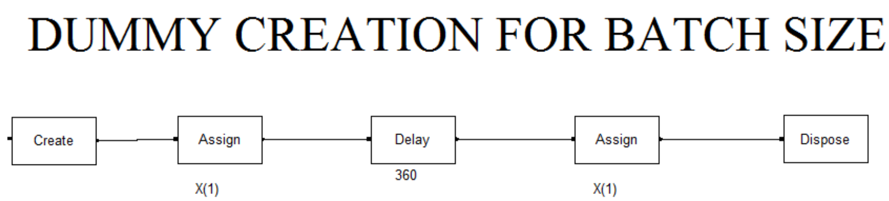
Model 1

Elements



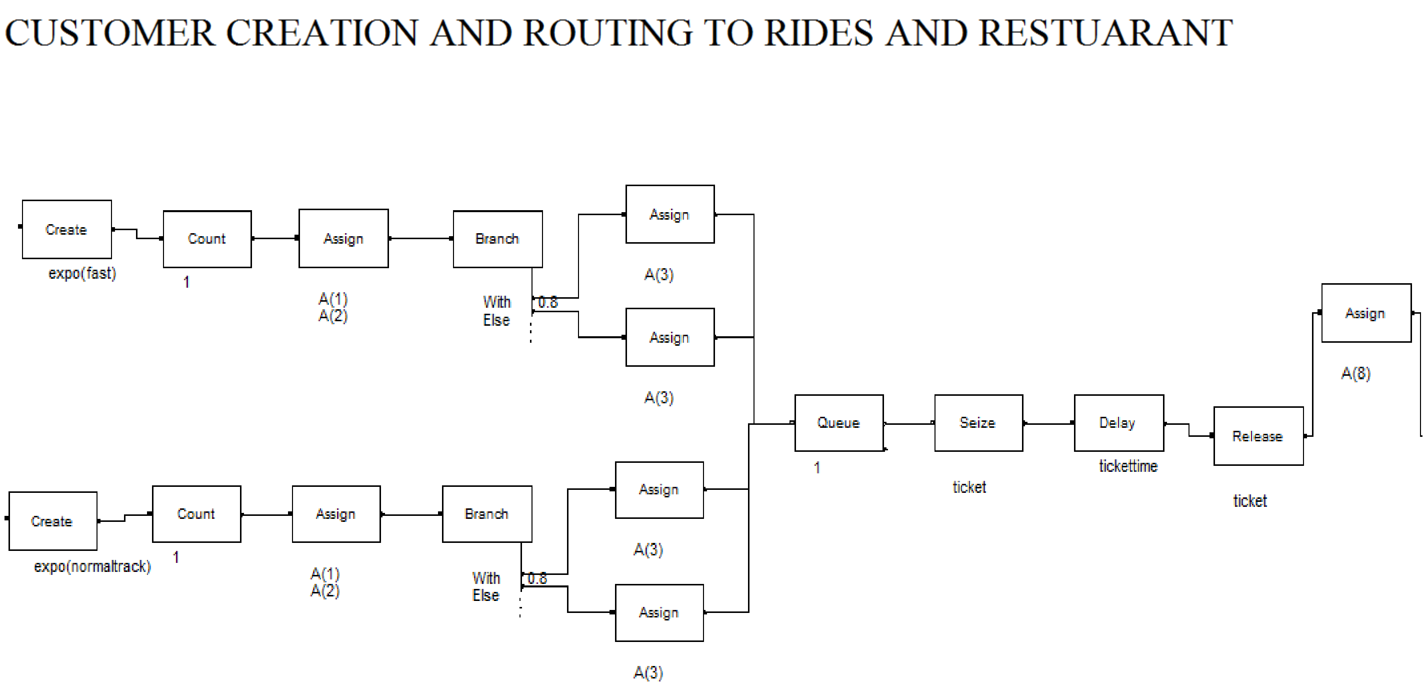
The above diagram shows all the elements used in the first model.

Dummy creation for batch size

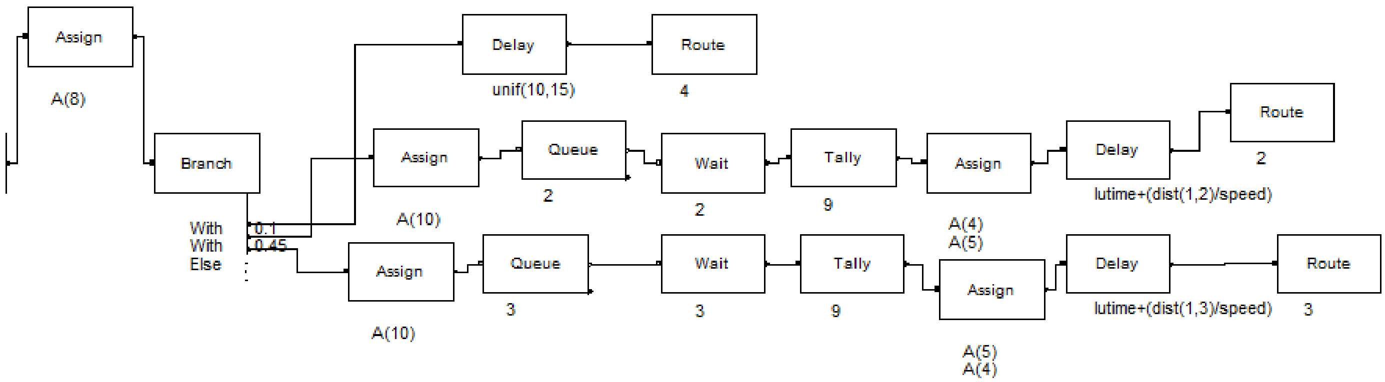


These blocks are used to stop the arrival of people after 360 minutes (3 pm) by changing batch size of entities from 1 to 0 after specified time.

Customer creation and routing to rides and restaurant

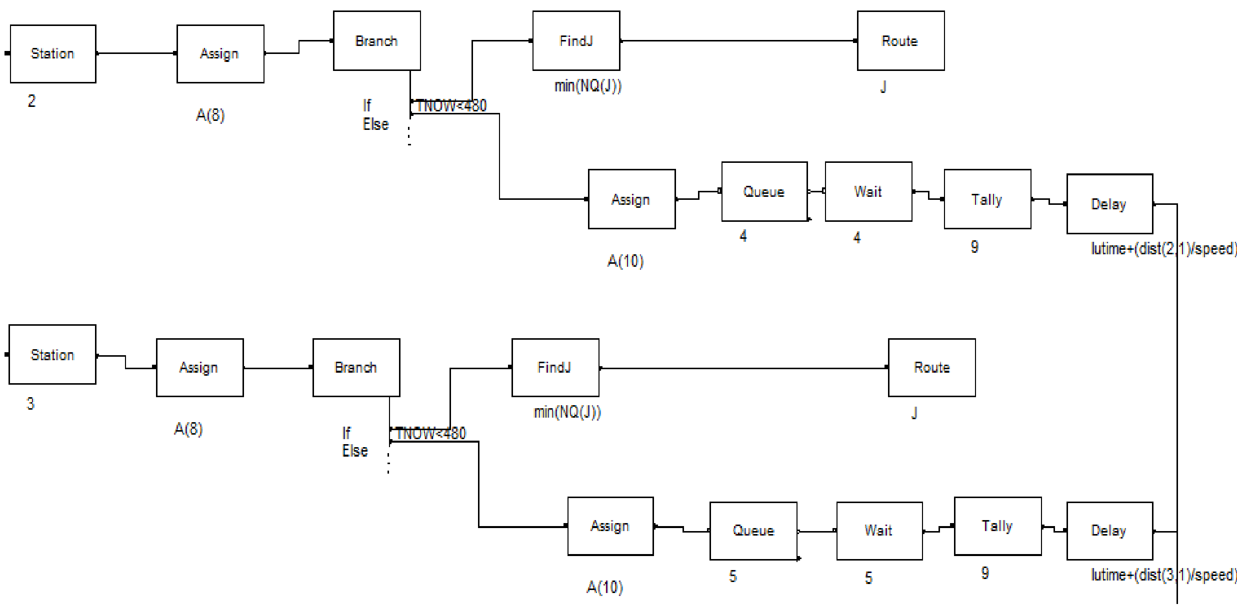


AMUSEMENT PARK SIMULATION USING ARENA

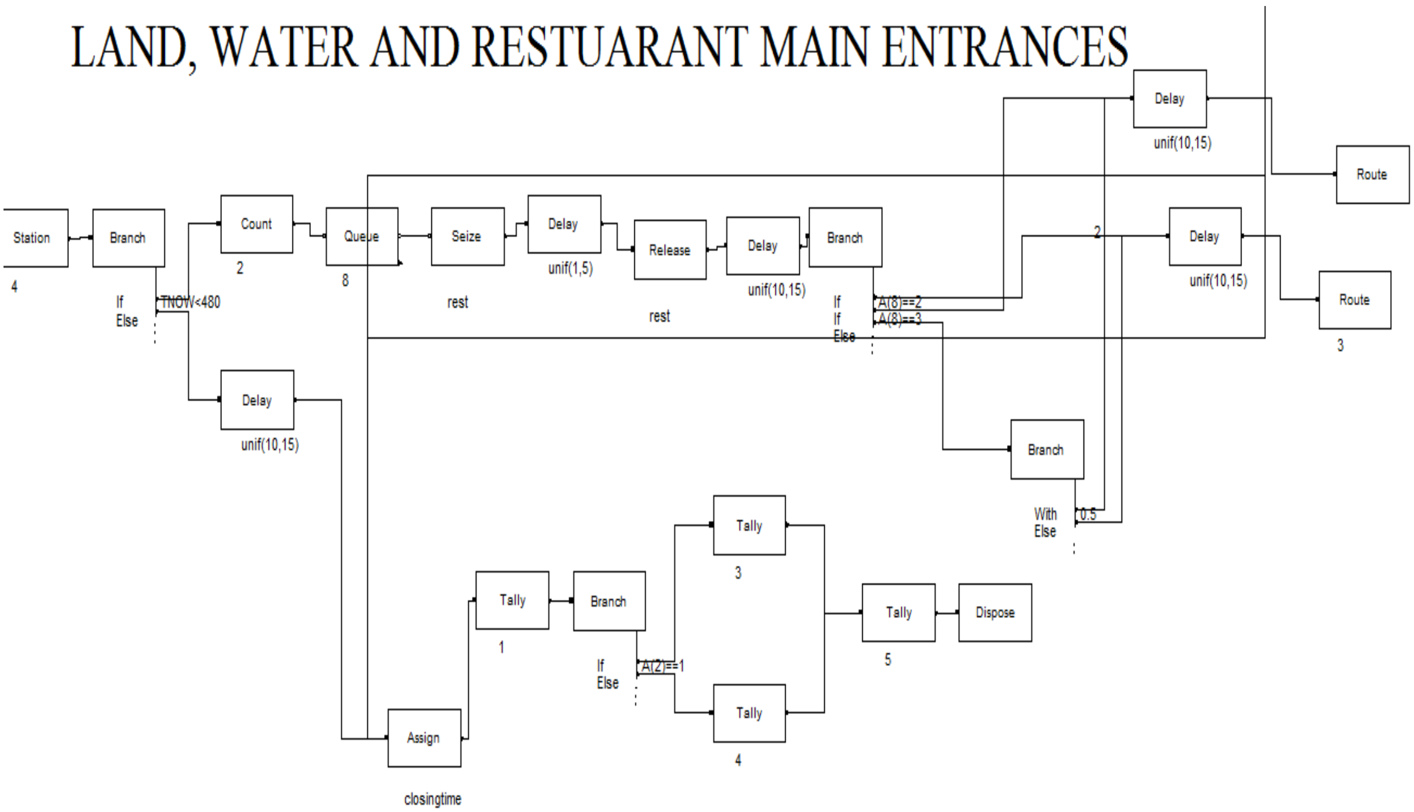


Customers opting fast track tickets and normal tickets arrive at different inter arrival times, out of which young people and old people arrive with probabilities 0.8 and 0.2. After getting the tickets from the ticket counter, they either walk to restaurant with probability 0.1, take bus to land rides with probability 0.45, or take bus to water rides with probability 0.45.

Land, water and restaurant main entrances

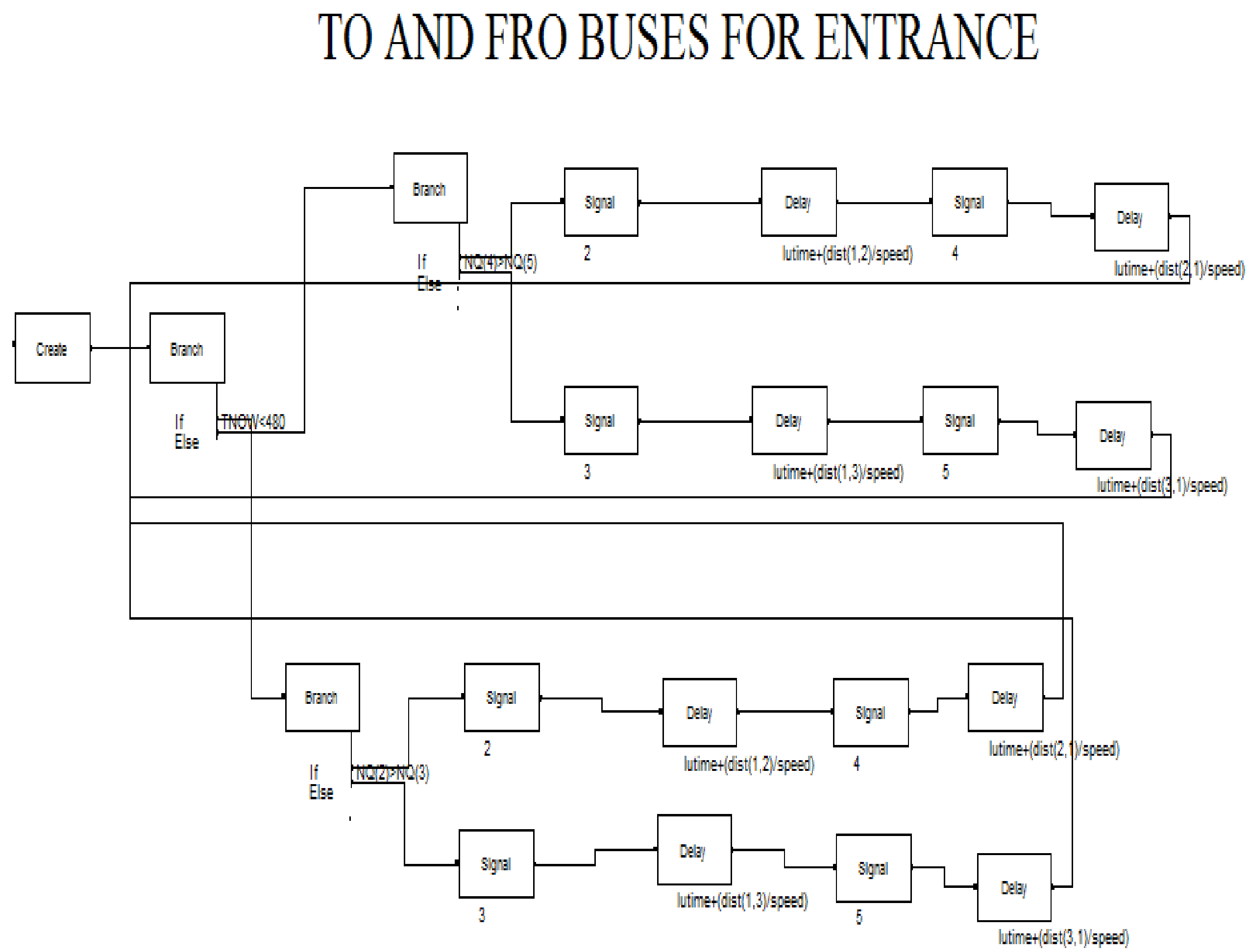


LAND, WATER AND RESTUARANT MAIN ENTRANCES



Customers coming from the ticket counter arrive at either restaurant entrance, land rides entrance or water rides entrance either by walk (for restaurant) or by bus (for land and water rides). For land rides and water rides, people will select the ride with minimum queue length and move to the designated queue using the route block. People arriving at restaurant move to either land rides or water rides depending on from where they have come from. If customers are arriving from main entrance, they move to water or land rides with equal probabilities. If they are arriving from water rides, they move to land rides and vice versa. Here attribute A(8) refers to the previous location. However, after 480 minutes (5 pm), customers move to the main entrance (by walk from restaurant and by bus from land and water rides).

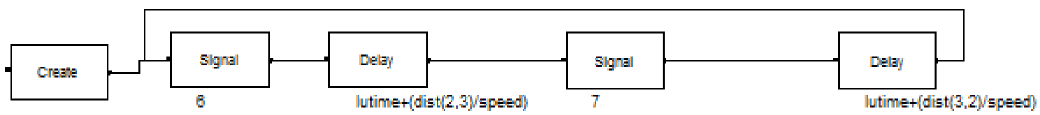
To and fro buses for entrance



Till 5pm, the buses in the main entrance go to either land rides or water rides depending on the maximum queue length rule and returns back to the main entrance. After 5 pm, the buses from the main entrance will take people waiting in the land rides entrance or water rides entrance depending on whichever queue is having more length and returns back to the entrance. The signal blocks give signals to wait blocks to release the customers waiting in the queue for bus after arriving at the destination.

Bus loop between land and water rides

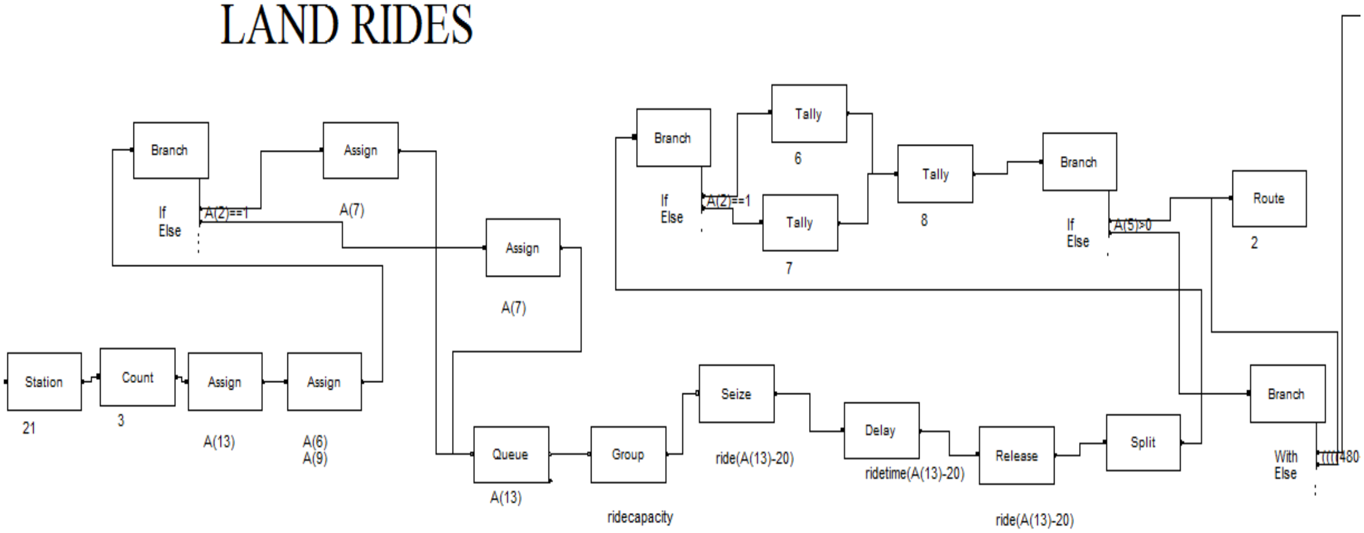
BUS LOOP BETWEEN LAND AND WATER



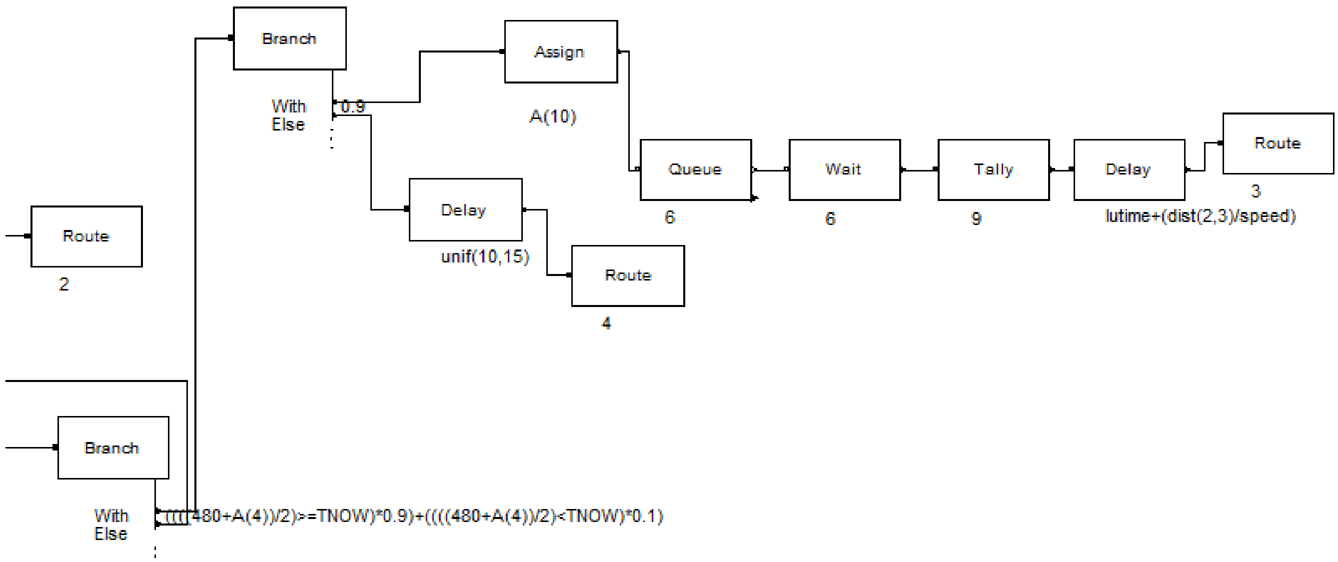
The buses in this loop will carry customers from the land rides to the water rides and vice versa.

Land rides and water rides

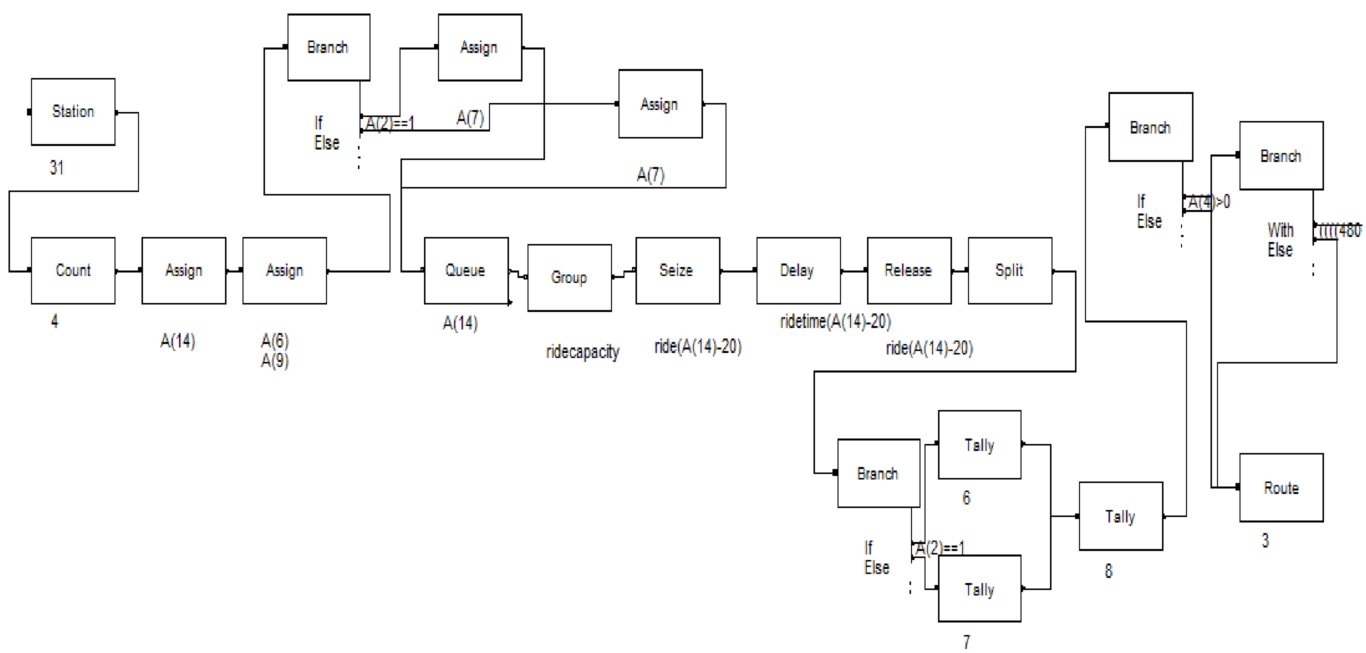
LAND RIDES



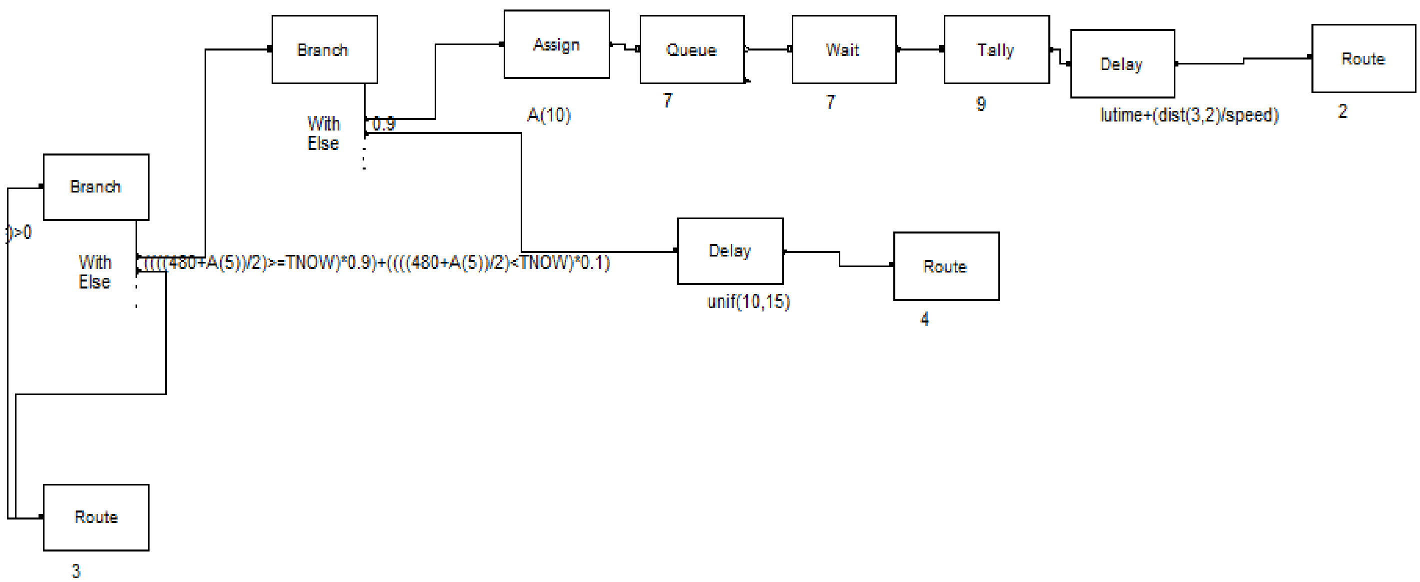
AMUSEMENT PARK SIMULATION USING ARENA



WATER RIDES



AMUSEMENT PARK SIMULATION USING ARENA

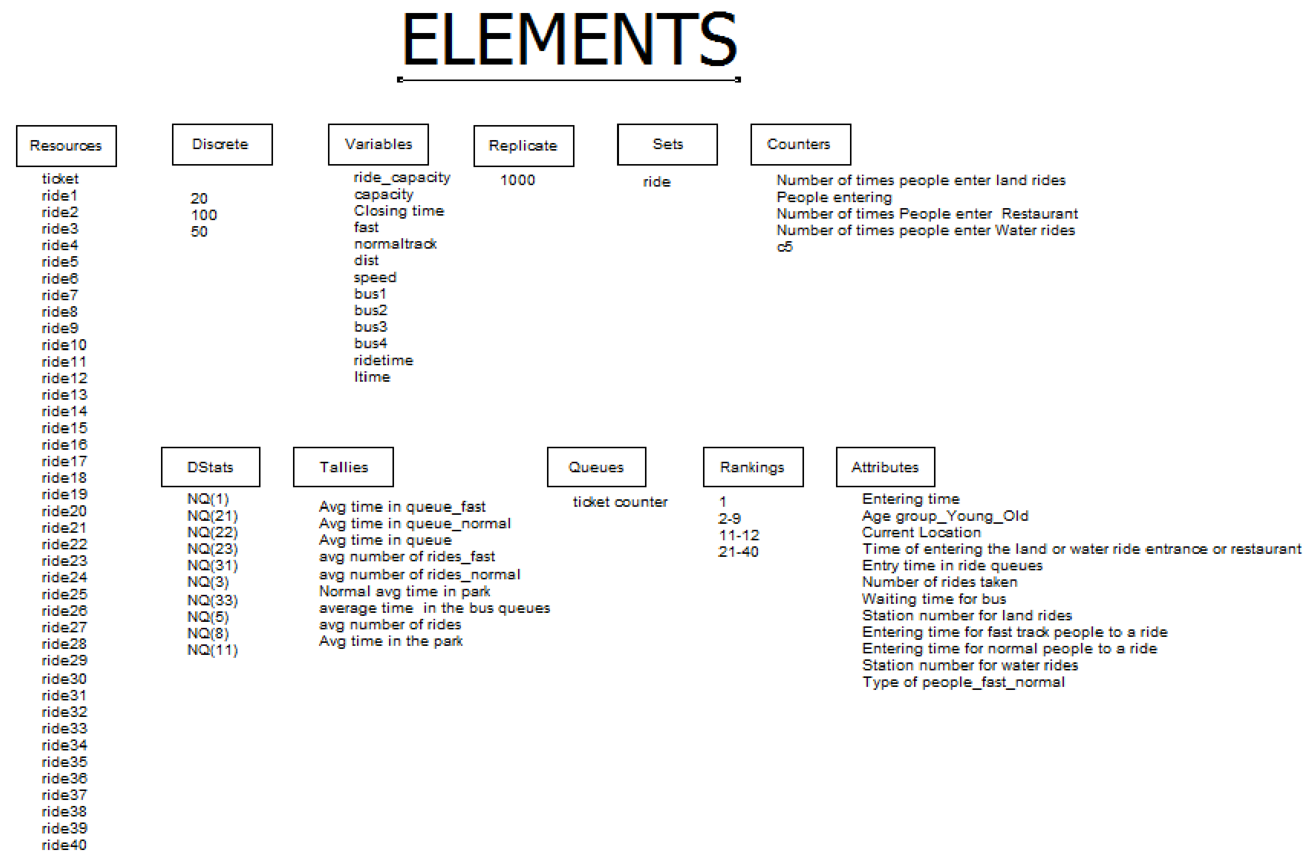


Customers arriving at the land rides will spend time completely in the land rides if they have already visited the water rides which is given by the condition A(5)>0. However, if they have not completed the water rides, customers will either move to the water rides, restaurant or carry on with the land rides. The customers move to either water rides or restaurant with probability 0.9 if they have already taken half their time in amusement park in land rides. However, if the time spent in land rides is less, they move with only 0.1 probability to either water rides or restaurant. Among the water rides and restaurant, customers move with 0.9 probability to water rides and with 0.1 probability to restaurant if they are choosing to leave the land rides.

The above cases apply equally to customers arriving at the water rides also. So the same blocks and conditions are used for both cases.

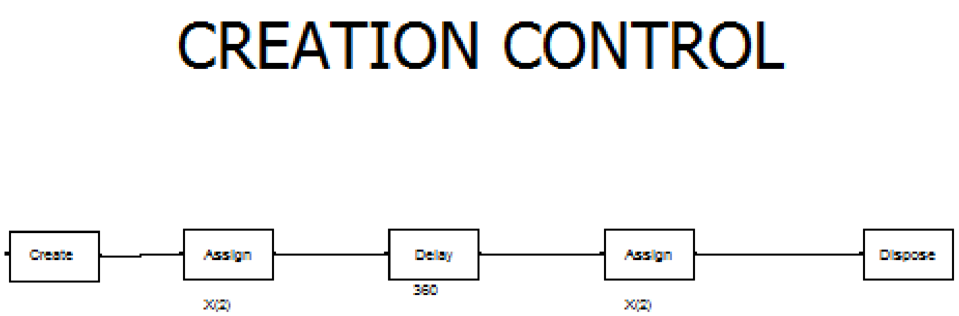
Model 2

Elements



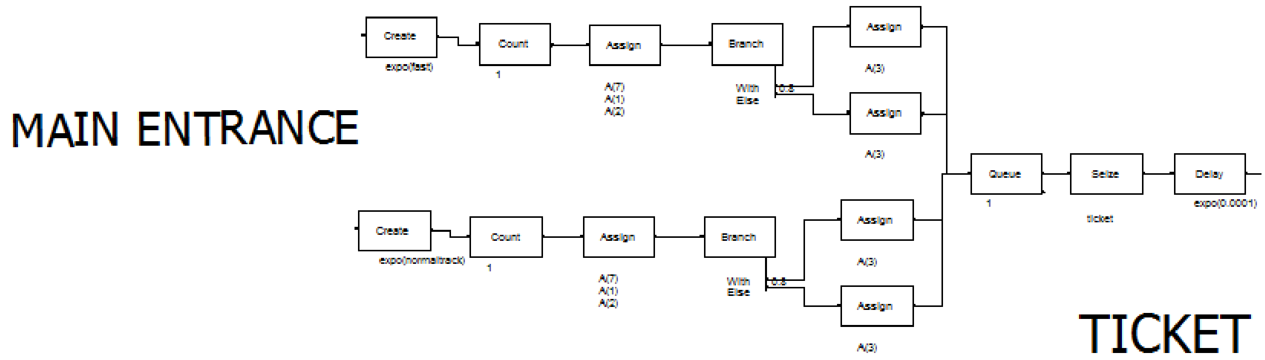
The above diagram shows all the elements used in the second model.

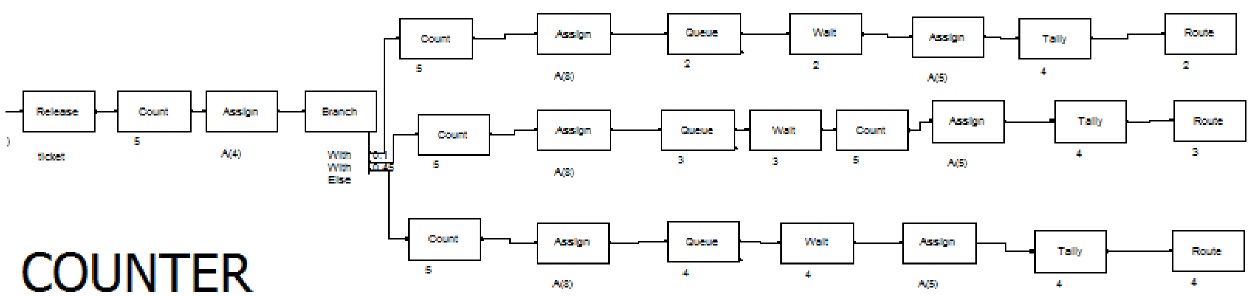
Creation control



This is used to stop the creation of entities at 3 PM by changing the batch size of entities from 1 to 0 after 360 minutes.

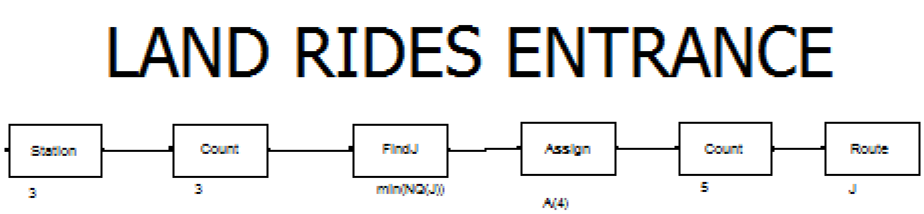
Customer creation and routing to rides and restaurant





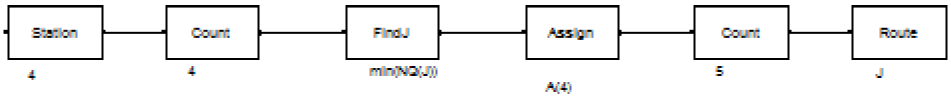
Customers arrive at the main entrance spaced out by inter-arrival times that are different for fast track and normal customers. In both cases, young and old people arrive with probabilities of 0.8 and 0.2. After receiving their tickets from the ticket counters, they line up in respective queues awaiting buses which would take them to either the restaurant or the entrances of the land or water rides. Routing to these destinations happen with a probability of 0.1 for the restaurant and 0.45 each for the entrances of the land and water rides.

Entrance of land and water rides

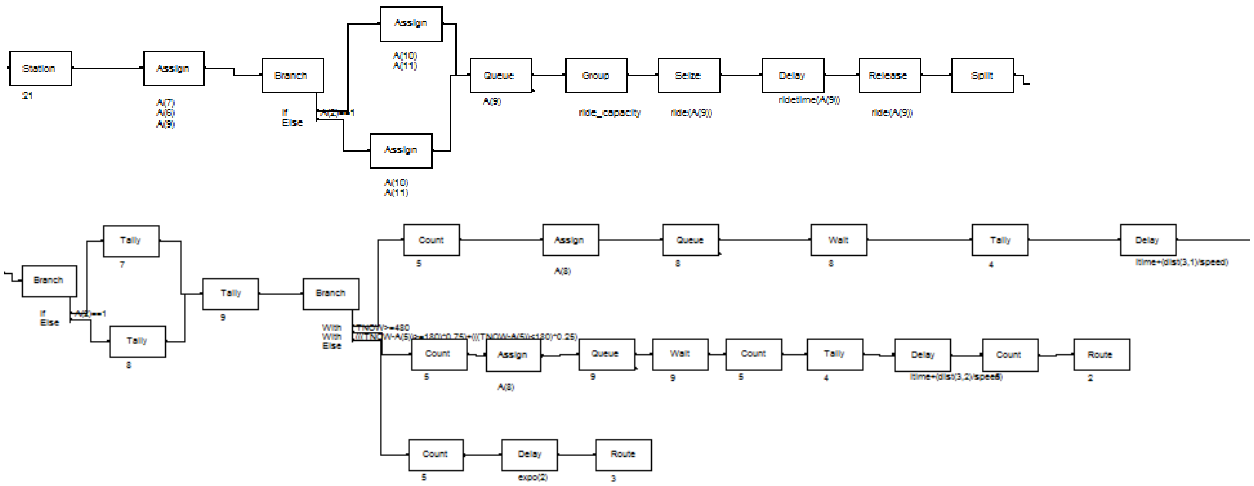


AMUSEMENT PARK SIMULATION USING ARENA

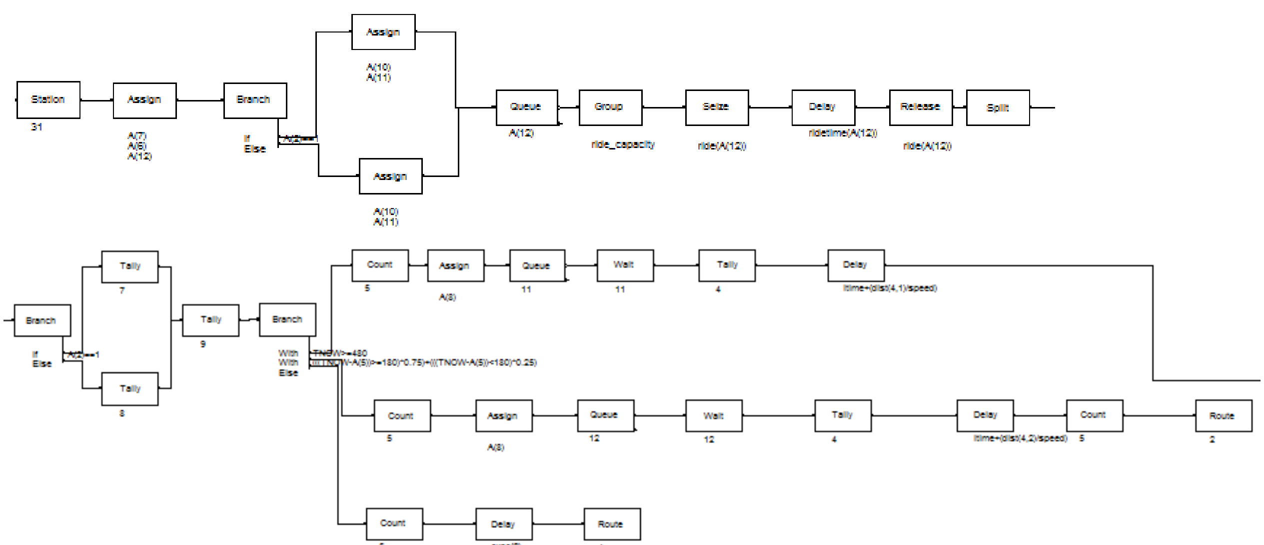
WATER RIDES ENTRANCE



LAND RIDES

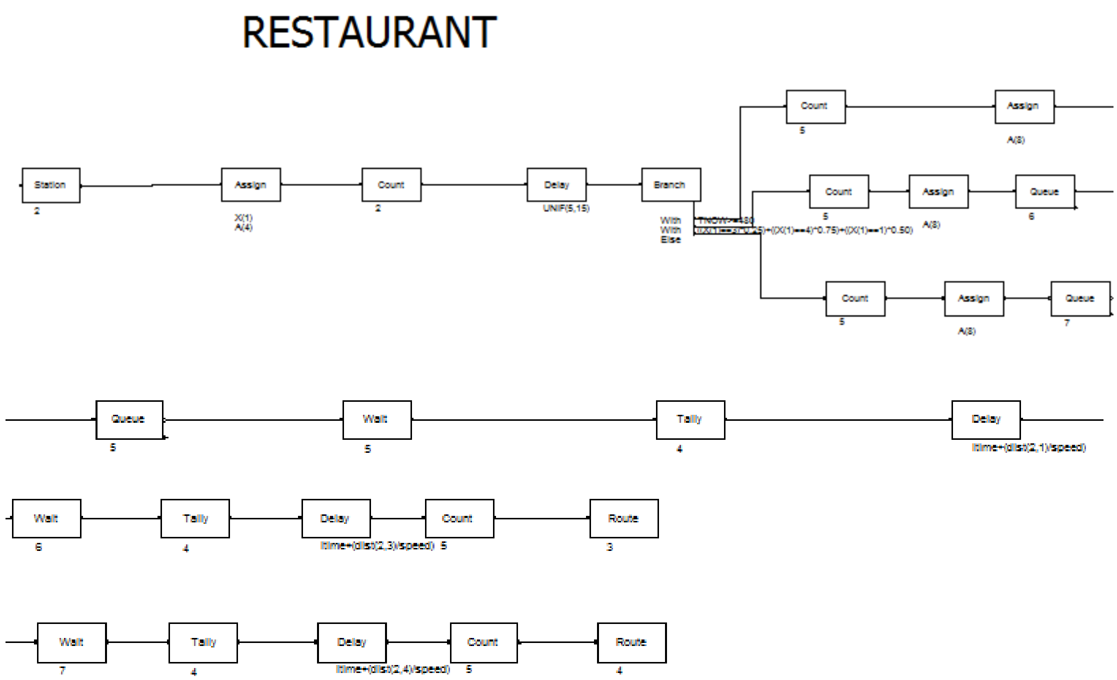


WATER RIDES



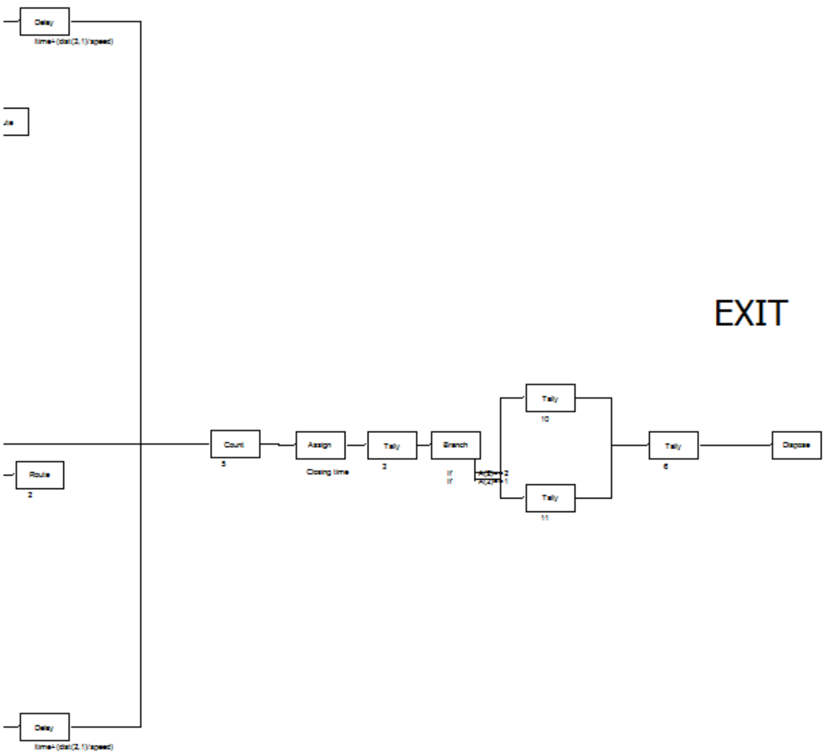
Once customers arrive at the entrances of land or water rides, they decide which individual land or water ride to visit based on which corresponding queue has the least number of people. After moving to their chosen ride, they queue up for the previous ride(s) to end. While doing so, customers with a fast track ticket are given precedence over those that have a normal ticket. They are also grouped in batches based on the capacity of the ride. After finishing the ride, customers decide their next destination based on the time of day and the amount of time they have been in that section of the park. If the time is past 5 PM, they are directly routed to the queue corresponding to the bus that would take them back to the entrance and subsequently disposed. Alternatively, if they have been in the same section of the park for more than three hours, they have a high probability of being routed to the restaurant. Otherwise, they have a high probability of staying in the same section by being routed to the entrance of that section and again choosing the individual ride based on the queue length of that ride.

Restaurant

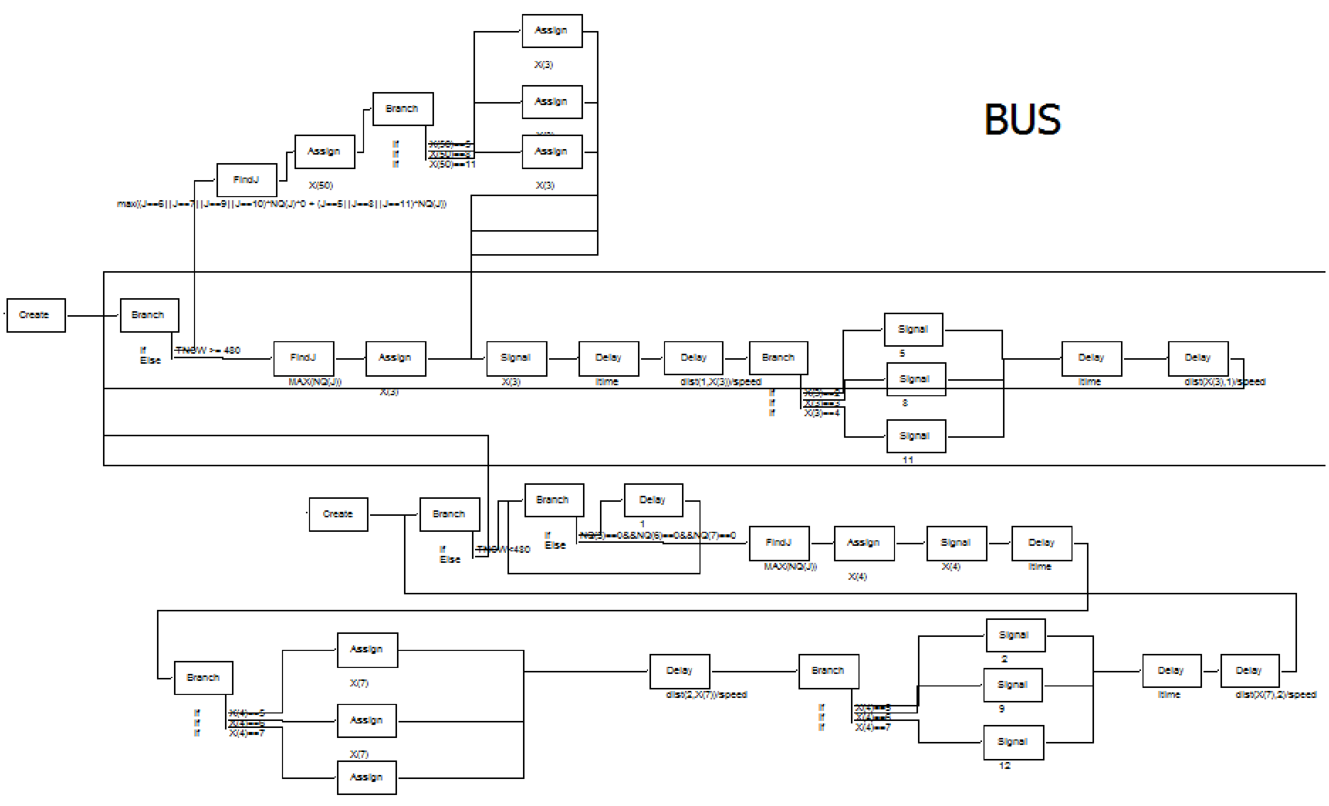


Customers arriving from either the main entrance or one of the rides spend between 5 and 15 minutes at the restaurant, after which they are sent to one of the bus queues based on the time of day and the location of the customers prior to arriving at the restaurant. If the time is past 5 PM, they are directly routed to the queue corresponding to the bus that would take them back to the entrance and subsequently disposed. Otherwise, if they had come to the restaurant from the land rides section, they are routed to the water rides section with a high probability and vice versa. If their previous location was the main entrance, then they are routed with an equal probability to either the land rides or the water rides section.

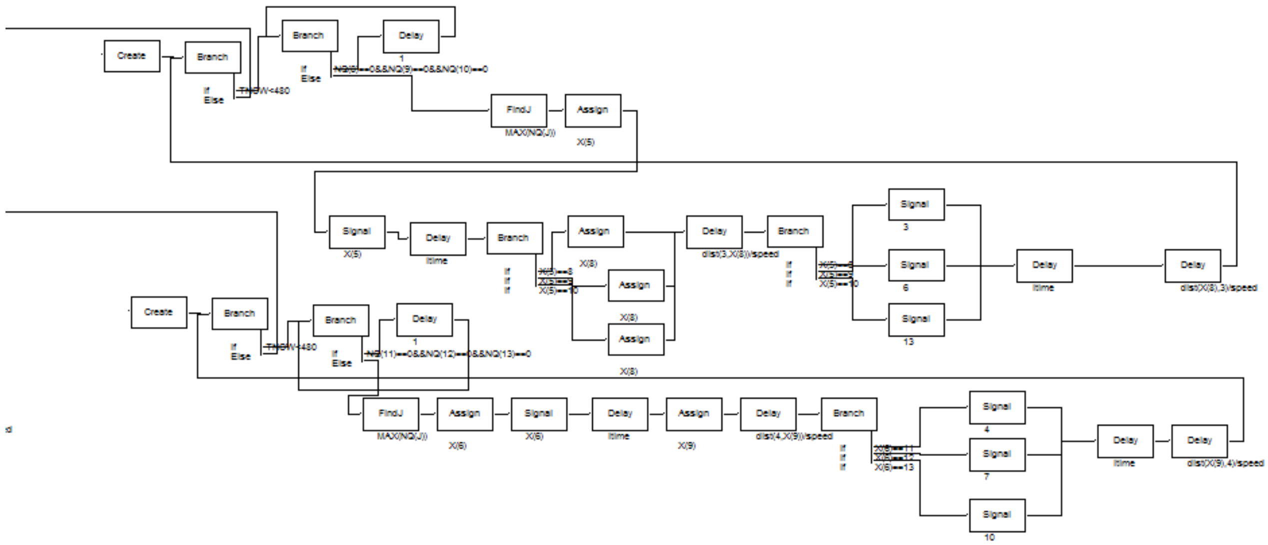
AMUSEMENT PARK SIMULATION USING ARENA



Bus routing



AMUSEMENT PARK SIMULATION USING ARENA



To start off, each of the four locations namely the main entrance, entrance of land rides, entrance of water rides, and the restaurant have a fixed number of buses. Each location has three queues where people line up in order to go to each of the other three locations. The buses choose a queue based on a check for the one having the maximum number of people in it, and carry them onward to their destinations. If all the queues are empty, they wait for another minute and check again. Once they arrive at their destination, they pick up people in the queue corresponding to the one that returns to the location from which the bus originated. Note that here, there is no check made on the number of people in the queues. This in effect, means that every bus shuttles between just two locations based on which route it had chosen for its first journey. However, after 5 PM, each bus is routed back to the main entrance. Once there, it drops the customers and checks for the presence of any non-empty queue at the other three locations and goes to the same to transport them back to the entrance. After a point, all queues would become empty indicating that all customers have left the amusement park.

DESIGN OF EXPERIMENT:

MODEL 1:

	Scenario Properties				Controls							Responses								
	S	Name	Program File	Reps	bus1	bus2	fast	normaltrack	capacity	ridecapacity	Num Reps	closingtime	Avg # of rides	Avg no of rides_fast	Avg no of rides_normal	avg time in bus queue	Avg time in park	Avg time in queue	Avg time in queue_fast	Avg time in queue_norm
1		R=2, NO B	9 : GOP6.p	20	5.0000	5.0000	1.0000	0.2000	30.0000	30.0000	20	762.000	6.958	7.170	6.917	41.616	399.627	30.637	29.838	30.799
2		Scenario 1	9 : GOP6.p	20	7.0000	7.0000	1.0000	0.2000	40.0000	40.0000	20	624.000	8.960	9.292	8.889	22.189	319.189	20.812	19.956	21.000
3		Scenario 2	9 : GOP6.p	20	8.0000	8.0000	1.0000	0.2000	40.0000	40.0000	20	620.400	8.931	9.303	8.854	20.632	313.717	20.850	19.938	21.048
4		Scenario 3	9 : GOP6.p	20	3.0000	3.0000	2.0000	0.4000	40.0000	40.0000	20	574.800	18.099	20.057	17.647	16.300	258.492	6.848	5.989	7.044
5		Scenario 4	9 : GOP6.p	20	2.0000	2.0000	2.0000	0.4000	40.0000	40.0000	20	613.200	18.151	20.087	17.711	19.535	272.972	6.818	6.010	7.000
6		R=2, B	10 : GOP6.p	20	2.0000	2.0000	2.0000	0.4000	40.0000	40.0000	20	561.600	17.799	19.850	17.327	14.941	249.027	6.866	6.095	7.044
7		Scenario 5	10 : GOP6.p	20	1.0000	1.0000	2.0000	0.4000	40.0000	40.0000	20	618.000	1.369	1.735	1.297	94.063	283.411	30.185	25.435	31.383
8		Scenario 6	10 : GOP6.p	20	3.0000	3.0000	2.0000	0.4000	40.0000	40.0000	20	548.400	17.784	19.960	17.297	13.514	243.317	6.914	6.131	7.087
9		Scenario 7	10 : GOP6.p	20	2.0000	2.0000	2.0000	0.4000	30.0000	30.0000	20	613.200	12.497	13.357	12.302	29.687	289.872	10.445	9.651	10.626
10		Scenario 8	10 : GOP6.p	20	5.0000	5.0000	1.0000	0.2000	40.0000	40.0000	20	596.400	8.916	9.396	8.818	17.513	302.950	20.775	19.782	20.989
11		Scenario 9	10 : GOP6.p	20	7.0000	7.0000	1.0000	0.2000	40.0000	40.0000	20	573.600	8.966	9.356	8.885	15.228	296.504	20.820	19.855	21.027
12		Scenario 10	10 : GOP6.p	20	5.0000	5.0000	1.0000	0.2000	30.0000	30.0000	20	642.000	6.974	7.108	6.946	22.562	340.419	30.738	30.173	30.859
13		R=1.5, B	12 : GOP6.p	20	5.0000	5.0000	1.0000	0.2000	30.0000	30.0000	20	628.800	9.001	9.241	8.953	23.384	336.841	23.019	22.350	23.159
14		Scenario 11	12 : GOP6.p	20	5.0000	5.0000	1.0000	0.2000	40.0000	40.0000	20	592.800	11.533	12.332	11.369	18.269	301.698	15.753	14.873	15.944
15		Scenario 12	12 : GOP6.p	20	7.0000	7.0000	1.0000	0.2000	40.0000	40.0000	20	572.400	11.603	12.277	11.465	15.407	292.795	15.766	14.896	15.955
16		Scenario 13	12 : GOP6.p	20	4.0000	4.0000	1.0000	0.2000	40.0000	40.0000	20	615.600	11.582	12.207	11.456	21.331	312.452	15.757	14.906	15.940
17		R=1, B	13 : GOP6.p	20	5.0000	5.0000	1.0000	0.2000	40.0000	40.0000	20	591.600	16.706	17.988	16.446	19.616	300.667	10.507	9.844	10.651
18		Scenario 14	13 : GOP6.p	20	4.0000	4.0000	1.0000	0.2000	40.0000	40.0000	20	620.400	16.749	17.639	16.566	22.552	311.414	10.535	9.917	10.670
19		Scenario 15	13 : GOP6.p	20	5.0000	5.0000	1.0000	0.2000	30.0000	30.0000	20	628.800	12.781	13.053	12.726	25.185	335.375	15.502	15.092	15.590
20		R=1, NO B	14 : GOP6.p	20	5.0000	5.0000	1.0000	0.2000	40.0000	40.0000	20	676.800	16.759	17.548	16.597	32.052	343.221	10.526	9.956	10.650
21		Scenario 16	14 : GOP6.p	20	7.0000	7.0000	1.0000	0.2000	40.0000	40.0000	20	624.000	16.759	17.784	16.548	24.817	318.503	10.513	9.902	10.646
22		Scenario 17	14 : GOP6.p	20	8.0000	8.0000	1.0000	0.2000	40.0000	40.0000	20	613.200	16.836	17.681	16.652	22.445	310.889	10.458	9.867	10.592
23		Scenario 19	14 : GOP6.p	20	3.0000	3.0000	2.0000	0.4000	40.0000	40.0000	20	573.600	33.367	37.762	32.381	16.915	256.642	3.573	3.139	3.671
24		Scenario 20	14 : GOP6.p	20	2.0000	2.0000	2.0000	0.4000	40.0000	40.0000	20	614.400	33.355	37.236	32.504	20.364	273.791	3.587	3.142	3.688

The above table is the process analyzer for model-1 of the project.

The input parameters that are changed in the various scenarios above are:

1. Number of buses for entrance (bus1)
2. Number of buses between the land and water loop (bus2)
3. Average inter arrival times of the normal and fast track customers (normaltrack and fast)
4. Ride capacities of each ride (ridecapacity)
5. Bus capacity (capacity)

The loading and unloading time of 2 min, replication length of simulation of 1000 minutes and number of replications of 20 are kept constant.

Other than these parameters,

1. Scenarios with S.no 1 – 5 have a ride time of 2 min with no extra buses after 5 PM
2. Scenarios with S.no 6 – 12 have a ride time of 2 min with double the number of buses from entrance after 5 PM
3. Scenarios with S.no 13 – 16 have a ride time of 1.5 min with double the number of buses from entrance after 5 PM

4. Scenarios with S.no 17 – 19 have a ride time of 1 min with double the number of buses from entrance after 5 PM
5. Scenarios with S.no 20 – 24 have a ride time of 1 min with no extra buses after 5 PM

The output parameters used for analysis and making decisions are:

1. Time of exiting of all the customers (closingtime)
2. Average number of rides made by the customers
3. Average number of rides made by fast track customers
4. Average number of rides made by normal customers
5. Average time in bus queues
6. Average time in the amusement park
7. Average time in ride queues
8. Average time in ride queues for fast track customers
9. Average time in ride queues for normal customers.

From these various scenarios/experiments above, the input parameters are increased/decreased based on the closing times. If the closing time crosses 600 min (7 PM) the parameter is not increased/decreased beyond that point as any closing time beyond 7 PM is not considered optimal.

Also, the average number of rides covered by the customers should be as high as possible with a minimum average waiting time in queues. These criteria are also taken into consideration while choosing the best possible parameters.

In this project, the optimum parameters are found for weekdays and weekend/holidays separately.

This analysis for selecting the best scenarios is discussed in the next section.

MODEL 2:

	Scenario Properties				Controls												
	S	Name	Program File	Reps	bus1	bus2	bus3	bus4	capacity	fast	normaltrack	ltime	ride_capacity	speed	Rep Length	Num Reps
1		Scenario 7	2 : KAR8.p	20	5.000	5.00	5.0000	5.0000	40.0000	1.0000	0.2000	2.0000	40.0000	0.2000	1000.00	20
2		Scenario 8	2 : KAR8.p	20	4.000	4.00	4.0000	4.0000	40.0000	1.0000	0.2000	2.0000	40.0000	0.2000	1000.00	20
3		Scenario 9	2 : KAR8.p	20	3.000	3.00	3.0000	3.0000	40.0000	1.0000	0.2000	2.0000	40.0000	0.2000	1000.00	20
4		Scenario 10	2 : KAR8.p	20	2.000	2.00	2.0000	2.0000	40.0000	1.0000	0.2000	2.0000	40.0000	0.2000	1000.00	20
5		Scenario 13	2 : KAR8.p	20	5.000	5.00	5.0000	5.0000	30.0000	1.0000	0.2000	2.0000	40.0000	0.2000	1000.00	20
6		Scenario 11	2 : KAR8.p	20	5.000	5.00	5.0000	5.0000	50.0000	1.0000	0.2000	2.0000	40.0000	0.2000	1000.00	20
7		Scenario 12	2 : KAR8.p	20	5.000	5.00	5.0000	5.0000	60.0000	1.0000	0.2000	2.0000	40.0000	0.2000	1000.00	20
8		Scenario 14	2 : KAR8.p	20	5.000	5.00	5.0000	5.0000	60.0000	1.0000	0.2000	2.0000	30.0000	0.2000	1000.00	20
9		Scenario 15	2 : KAR8.p	20	5.000	5.00	5.0000	5.0000	60.0000	1.0000	0.2000	2.0000	50.0000	0.2000	1000.00	20
10		Scenario 16	2 : KAR8.p	20	5.000	5.00	5.0000	5.0000	60.0000	1.0000	0.2000	2.0000	60.0000	0.2000	1000.00	20
11		Scenario 18	2 : KAR8.p	20	5.000	5.00	5.0000	5.0000	60.0000	1.0000	0.2000	2.0000	50.0000	0.4000	1000.00	20
12		Scenario 19	3 : KAR8.p	20	5.000	5.00	5.0000	5.0000	60.0000	1.0000	0.2000	2.0000	50.0000	0.4000	1000.00	20
13		Scenario 20	3 : KAR8.p	20	5.000	5.00	5.0000	5.0000	60.0000	1.0000	0.2000	2.0000	50.0000	0.2000	1000.00	20
14		Scenario 21	4 : KAR8.p	20	5.000	5.00	5.0000	5.0000	60.0000	1.0000	0.2000	2.0000	50.0000	0.4000	1000.00	20
15		Scenario 22	4 : KAR8.p	20	5.000	5.00	5.0000	5.0000	60.0000	1.0000	0.2000	2.0000	50.0000	0.2000	1000.00	20
16		Scenario 23	6 : KAR8.p	20	5.000	5.00	5.0000	5.0000	40.0000	2.0000	0.4000	2.0000	40.0000	0.2000	1000.00	20
17		Scenario 24	6 : KAR8.p	20	4.000	4.00	4.0000	4.0000	40.0000	2.0000	0.4000	2.0000	40.0000	0.2000	1000.00	20
18		Scenario 25	6 : KAR8.p	20	3.000	3.00	3.0000	3.0000	40.0000	2.0000	0.4000	2.0000	40.0000	0.2000	1000.00	20
19		Scenario 26	6 : KAR8.p	20	2.000	2.00	2.0000	2.0000	40.0000	2.0000	0.4000	2.0000	40.0000	0.2000	1000.00	20
20		Scenario 27	6 : KAR8.p	20	3.000	3.00	3.0000	3.0000	30.0000	2.0000	0.4000	2.0000	40.0000	0.2000	1000.00	20
21		Scenario 28	6 : KAR8.p	20	3.000	3.00	3.0000	3.0000	50.0000	2.0000	0.4000	2.0000	40.0000	0.2000	1000.00	20
22		Scenario 29	6 : KAR8.p	20	3.000	3.00	3.0000	3.0000	60.0000	2.0000	0.4000	2.0000	40.0000	0.2000	1000.00	20
23		Scenario 30	6 : KAR8.p	20	3.000	3.00	3.0000	3.0000	60.0000	2.0000	0.4000	2.0000	30.0000	0.2000	1000.00	20
24		Scenario 31	6 : KAR8.p	20	3.000	3.00	3.0000	3.0000	60.0000	2.0000	0.4000	2.0000	50.0000	0.2000	1000.00	20
25		Scenario 32	6 : KAR8.p	20	3.000	3.00	3.0000	3.0000	60.0000	2.0000	0.4000	2.0000	30.0000	0.4000	1000.00	20

The above table is the process analyzer for model-2 of the project.

The input parameters that are changed in the various scenarios/experiments above are:

1. Number of buses specific to each section (bus1, bus2, bus3, bus4)
2. Bus capacity (capacity)
3. Average inter arrival time for fast track and normal people (fast and normaltrack)
4. Loading and unloading time (ltime)
5. Ride Capacity (capacity)

The loading and unloading time of 2 min, replication length of simulation of 1000 minutes and number of replications of 20 are kept constant.

Other than these parameters,

1. Scenarios with S.no 1 – 4 are varied by number of buses
2. Scenarios with S.no 5 – 7 are varied by the bus capacity
3. Scenarios with S.no 7 – 10 are varied by the ride capacity
4. Scenarios with S.no 9 – 11 are varied by the speed of the bus
5. Scenarios with S.no 12 – 15 are varied by the ride times.
6. Scenarios with S.no 16 – 19 are varied by number of buses
7. Scenarios with S.no 20 – 22 are varied by the bus capacity
8. Scenarios with S.no 22 – 24 are varied by the ride capacity
9. Scenarios with S.no 23 – 25 are varied by the speed of the bus.

The first fifteen scenarios are carried out on weekends where the arrival rate is more compared to the normal rates. The last ten scenarios are corresponding to the weekdays where the inferences are slightly different from that of its counterpart.

Responses												
avg number of rides	avg number of rides_fast	avg number of rides_normal	average time in the bus queues	Avg time in the park	Avg time in queue	Avg time in queue_fast	Avg time in queue_normal	Closing time	People entering	Number of times people enter land rides	Number of times People enter Restaurant	Number of times people enter Water rides
13.227	13.411	13.193	8.484	278.141	2.914	2.887	2.919	534.550	2160	10125	5635	9782
12.225	12.082	12.254	11.890	283.980	2.902	2.880	2.907	548.700	2162	8974	4974	9405
9.951	9.929	9.957	22.321	288.716	2.760	2.765	2.759	561.000	2148	7309	3594	7289
4.331	4.343	4.330	59.354	313.509	4.233	4.244	4.230	593.500	2167	3955	1804	3855
12.367	12.394	12.362	11.866	283.280	2.718	2.692	2.723	546.650	2166	9232	4999	9364
13.328	13.260	13.342	7.732	277.289	3.239	3.223	3.243	532.200	2154	10395	5759	9605
13.599	13.482	13.622	6.582	276.741	3.450	3.436	3.452	529.550	2148	10277	5990	10133
11.538	11.543	11.537	7.454	289.459	6.968	6.930	6.976	536.500	2161	9781	5922	9728
14.197	14.264	14.182	5.912	262.875	2.670	2.629	2.679	530.000	2145	9526	5395	9385
13.684	13.811	13.659	5.622	250.815	3.089	3.019	3.104	523.800	2148	8051	4450	7966
18.773	18.632	18.802	2.422	254.091	2.871	2.884	2.868	514.150	2161	12513	7704	12440
11.545	11.484	11.556	2.617	254.108	10.829	10.874	10.822	514.050	2160	7823	4874	7851
10.614	10.647	10.609	5.309	262.923	8.799	8.763	8.807	528.900	2166	7230	4248	7337
21.410	21.489	21.394	2.362	253.880	1.416	1.423	1.415	513.700	2152	14116	8579	14014
14.904	14.923	14.903	5.985	262.162	1.870	1.821	1.880	529.100	2146	9714	5627	10127
11.638	11.446	11.680	5.430	235.340	5.638	5.844	5.599	518.600	1080	2535	1366	2573
11.168	11.002	11.202	6.265	234.610	5.849	5.971	5.821	519.600	1083	2502	1305	2482
10.525	10.667	10.494	7.599	237.884	6.306	6.322	6.302	524.850	1077	2245	1206	2411
8.903	8.654	8.950	14.603	250.565	7.415	7.580	7.388	559.050	1086	2027	999	2028
10.352	10.253	10.370	9.303	241.595	6.217	5.852	6.296	535.250	1086	2403	1189	2278
10.535	10.505	10.543	7.460	235.078	6.260	6.403	6.238	522.950	1081	2276	1216	2430
10.626	10.672	10.616	7.405	235.544	6.266	6.375	6.251	522.700	1081	2303	1215	2416
12.535	12.405	12.561	7.779	255.323	3.396	3.381	3.401	530.150	1083	3897	2071	3683
5.630	5.558	5.642	8.608	255.836	28.413	28.445	28.477	517.400	1082	1014	495	1030
18.063	18.129	18.054	3.091	244.694	2.661	2.607	2.671	514.750	1089	5152	3213	5659

The output parameters used for analysis and making decisions are:

1. Time of exiting of all the customers (closingtime)
2. Average number of rides made by the customers
3. Average number of rides made by fast track customers
4. Average number of rides made by normal customers
5. Average time in bus queues
6. Average time in the amusement park

7. Average time in ride queues
8. Average time in ride queues for fast track customers
9. Average time in ride queues for normal customers.
10. People entering
11. Number of times people enter the land rides
12. Number of times people enter the restaurant
13. Number of times people enter the water rides

From these various scenarios/experiments above, the input parameters are increased/decreased based on the closing times. If the closing time crosses 600 min (7 PM) the parameter is not increased/decreased beyond that point as any closing time beyond 7 PM is not considered optimal.

Also, the average number of rides covered by the customers should be as high as possible with a minimum average waiting time in queues. These criteria are also taken into consideration while choosing the best possible parameters.

In this project, the optimum parameters are found for weekdays and weekend/holidays separately.

This analysis for selecting the best scenarios is discussed in the next section.

ANALYSIS:

MODEL 1:

1. The initial conditions taken are ride time = 2min and with no extra buses after 5 PM for the first 5 S. no's in the process analyzer table.

	Scenario Properties				Controls							Responses				
	S	Name	Program File	Reps	bus1	bus2	fast	normaltrack	capacity	ridecapacity	Num Reps	closingtime	Avg # of rides	avg time in bus queue	Avg time in park	Avg time in queue
1	#B	R=2, NO B	9 : GO	20	5.0000	5.0000	1.0000	0.2000	30.0000	30.0000	20	762.000	6.958	41.616	399.627	30.637
2	#B	Scenario 1	9 : GO	20	7.0000	7.0000	1.0000	0.2000	40.0000	40.0000	20	624.000	8.960	22.189	319.189	20.812
3	#B	Scenario 2	9 : GO	20	8.0000	8.0000	1.0000	0.2000	40.0000	40.0000	20	620.400	8.931	20.632	313.717	20.850
4	#B	Scenario 3	9 : GO	20	3.0000	3.0000	2.0000	0.4000	40.0000	40.0000	20	574.800	18.099	16.300	258.492	6.848
5	#B	Scenario 4	9 : GO	20	2.0000	2.0000	2.0000	0.4000	40.0000	40.0000	20	613.200	18.151	19.535	272.972	6.818

Among these 5 scenarios, the only scenario that has a closing time of < 600 min (7 PM) is S.no: 4. Therefore, among the above scenarios, without even comparing the average number of rides or average time in queue, we can conclude that it the best one. In this scenario, we will be using 6 buses (3 + 3) to achieve a closing time of 574.8 min

2. The conditions of ride time = 2min with double the number of entrance buses after 5 PM is taken for the S.no: 6 – 12 in the process analyzer table.

6	#B	R=2, B	10 : G	20	2.0000	2.0000	2.0000	0.4000	40.0000	40.0000	20	561.600	17.799	14.941	249.027	6.866
7	#B	Scenario 5	10 : G	20	1.0000	1.0000	2.0000	0.4000	40.0000	40.0000	20	618.000	1.369	94.063	283.411	30.185
8	#B	Scenario 6	10 : G	20	3.0000	3.0000	2.0000	0.4000	40.0000	40.0000	20	548.400	17.784	13.514	243.317	6.914
9	#B	Scenario 7	10 : G	20	2.0000	2.0000	2.0000	0.4000	30.0000	30.0000	20	613.200	12.497	29.687	289.872	10.445
10	#B	Scenario 8	10 : G	20	5.0000	5.0000	1.0000	0.2000	40.0000	40.0000	20	596.400	8.916	17.513	302.950	20.775
11	#B	Scenario 9	10 : G	20	7.0000	7.0000	1.0000	0.2000	40.0000	40.0000	20	573.600	8.966	15.228	296.504	20.820
12	#B	Scenario 10	10 : G	20	5.0000	5.0000	1.0000	0.2000	30.0000	30.0000	20	642.000	6.974	22.562	340.419	30.738

Among these 7 scenarios, the best scenario for the week days is S.no: 6 where the number of buses used to achieve the closing criteria of < 600 min is only 6 buses (2 + 2 + 2) and the closing time is 561.6 min. Though, S.no: 8 has lesser closing time than S.no: 6, we have to spend more on providing 9 buses which is a waste to achieve the same criteria.
Among these 7 scenarios, the best scenario for the weekends is S.no: 10 where the number of buses used to achieve the closing criteria of < 600 min is only 15 buses which is less compared to the other two weekend/holiday scenarios.

3. The conditions of ride time = 1 min with no extra buses after 5 PM is taken for the S.no: 17 – 19 in the process analyzer table.

17	#B	R=1, B	13 : G	20	5.0000	5.0000	1.0000	0.2000	40.0000	40.0000	20	591.600	16.706	19.616	300.667	10.507
18	#B	Scenario 14	13 : G	20	4.0000	4.0000	1.0000	0.2000	40.0000	40.0000	20	620.400	16.749	22.552	311.414	10.535
19	#B	Scenario 15	13 : G	20	5.0000	5.0000	1.0000	0.2000	30.0000	30.0000	20	628.800	12.781	25.185	335.375	15.502

Among these 3 scenarios, the best scenario for the weekend is S.no: 17, where the number of buses used to achieve the closing criteria of < 600 min is only 15 buses.

Among the various scenarios, the best scenario for the week days is S.no: 6 which uses 6 buses, ride capacity =40 and bus capacity =40.

Among the various scenarios, the best scenario for the weekend/holiday has to be chosen between S.no: 10 and S.no: 17. Both these scenarios use 15 buses and both of them satisfy the criteria of closing before 7 PM. So, the choice is made by looking at the ride times, average time in queue and average number of rides. By analyzing these criteria, we can conclude that the S.no: 17 is better than 10 because it has less average time in queue and also more average number of rides.

MODEL 2:

Weekends:

Scenario-1:

Varying the number of buses used, keeping all other control variables constant and 5 buses in each section so 20 buses overall give us the best closing time and people would be more satisfied with more number of average rides and relatively less waiting time in the queues.

1		Scenario 7	2 : KAR8.p	20	5.000	5.00	5.0000	5.0000	40.0000	1.0000	0.2000	2.0000	40.0000	0.2000	1000.00	20
2		Scenario 8	2 : KAR8.p	20	4.000	4.00	4.0000	4.0000	40.0000	1.0000	0.2000	2.0000	40.0000	0.2000	1000.00	20
3		Scenario 9	2 : KAR8.p	20	3.000	3.00	3.0000	3.0000	40.0000	1.0000	0.2000	2.0000	40.0000	0.2000	1000.00	20
4		Scenario 10	2 : KAR8.p	20	2.000	2.00	2.0000	2.0000	40.0000	1.0000	0.2000	2.0000	40.0000	0.2000	1000.00	20

13.227	13.411	13.193	8.484	278.141	2.914	2.887	2.919	534.550	2160	10125	5635	9782
12.225	12.082	12.254	11.890	283.980	2.902	2.880	2.907	548.700	2162	8974	4974	9405
9.951	9.929	9.957	22.321	288.716	2.760	2.765	2.759	561.000	2148	7309	3594	7289
4.331	4.343	4.330	59.354	313.509	4.233	4.244	4.230	593.500	2167	3955	1804	3855

Scenario-2:

Fixing on 5 buses and varying the bus capacity now, gives the following results:

5		Scenario 13	2 : KAR8.p	20	5.000	5.00	5.0000	5.0000	30.0000	1.0000	0.2000	2.0000	40.0000	0.2000	1000.00	20
6		Scenario 11	2 : KAR8.p	20	5.000	5.00	5.0000	5.0000	50.0000	1.0000	0.2000	2.0000	40.0000	0.2000	1000.00	20
7		Scenario 12	2 : KAR8.p	20	5.000	5.00	5.0000	5.0000	60.0000	1.0000	0.2000	2.0000	40.0000	0.2000	1000.00	20

12.367	12.394	12.362	11.866	283.280	2.718	2.692	2.723	546.650	2166	9232	4999	9364
13.328	13.260	13.342	7.732	277.289	3.239	3.223	3.243	532.200	2154	10395	5759	9605
13.599	13.482	13.622	6.582	276.741	3.450	3.436	3.452	529.550	2148	10277	5990	10133

5 Buses and Bus capacity as 60 gives us the best closing time and the best number of average rides per person. The average time in the queues for rides is slightly higher than the other cases; but visitors would not complain spending more time in the queues as long as they get more rides to go around.

Scenario-3:

Fixing on 5 buses, 60 as bus capacity and varying ride capacity gives us following results:

7	Scenario 12	2 : KAR8.p	20	5.000	5.00	5.0000	5.0000	60.0000	1.0000	0.2000	2.0000	40.0000	0.2000	1000.00	20
8	Scenario 14	2 : KAR8.p	20	5.000	5.00	5.0000	5.0000	60.0000	1.0000	0.2000	2.0000	30.0000	0.2000	1000.00	20
9	Scenario 15	2 : KAR8.p	20	5.000	5.00	5.0000	5.0000	60.0000	1.0000	0.2000	2.0000	50.0000	0.2000	1000.00	20
10	Scenario 16	2 : KAR8.p	20	5.000	5.00	5.0000	5.0000	60.0000	1.0000	0.2000	2.0000	60.0000	0.2000	1000.00	20

13.599	13.482	13.622	6.582	276.741	3.450	3.436	3.452	529.550	2148	10277	5990	10133
11.538	11.543	11.537	7.454	289.459	6.968	6.930	6.976	536.500	2161	9781	5922	9728
14.197	14.264	14.182	5.912	262.875	2.670	2.629	2.679	530.000	2145	9526	5395	9385
13.684	13.811	13.659	5.622	250.815	3.089	3.019	3.104	523.800	2148	8051	4450	7966

5 Buses, Bus capacity as 60 and 50 as ride capacity gives us the best number of average rides per person and the lowest average time in the queues for rides. The closing time of Amusement Park is the not the best; but still, the customer satisfaction is more important when it comes to the Amusement park. Hence, we would advise the management to go ahead with this combination.

Scenario-4:

Fixing on 5 Buses, Bus capacity as 60, 50 as ride capacity varying the speed we have the following results:

10	Scenario 15	2 : KAR8.p	20	5.000	5.00	5.0000	5.0000	60.0000	1.0000	0.2000	2.0000	50.0000	0.2000	1000.00	20
11	Scenario 18	2 : KAR8.p	20	5.000	5.00	5.0000	5.0000	60.0000	1.0000	0.2000	2.0000	50.0000	0.4000	1000.00	20

14.197	14.264	14.182	5.912	262.875	2.670	2.629	2.679	530.000	2145	9526	5395	9385
18.773	18.632	18.802	2.422	254.091	2.871	2.884	2.868	514.150	2161	12513	7704	12440

5 Buses, Bus capacity as 60, 50 as ride capacity and 0.4 units/min as speed gives us the best closing time and best possible results in all aspects. With this combination, we could save 26 hours of working and overhead costs during the weekends throughout the entire year! But if there is any speed restriction in the amusement park, then the other alternative would be preferred.

Scenario-5:

The ride times were varied and it was observed that decrease in ride time provides the best possible results; but, it will not have pleasant reactions from the visitors, since they wouldn't be very happy with the reduction in ride times.

Also, increasing ride times wouldn't provide any better results. So, that option is not feasible at all.

Weekdays:

Scenario-6:

Varying the number of buses used, keeping all other control variables constant and 3 buses in each section so 12 buses overall give us the best closing time and people would be more satisfied with more number of average rides and relatively less waiting time in the queues.

16	Scenario 23	6 : KAR8.p	20	5.000	5.00	5.0000	5.0000	40.0000	2.0000	0.4000	2.0000	40.0000	0.2000	1000.00	20
17	Scenario 24	6 : KAR8.p	20	4.000	4.00	4.0000	4.0000	40.0000	2.0000	0.4000	2.0000	40.0000	0.2000	1000.00	20
18	Scenario 25	6 : KAR8.p	20	3.000	3.00	3.0000	3.0000	40.0000	2.0000	0.4000	2.0000	40.0000	0.2000	1000.00	20
19	Scenario 26	6 : KAR8.p	20	2.000	2.00	2.0000	2.0000	40.0000	2.0000	0.4000	2.0000	40.0000	0.2000	1000.00	20

11.638	11.446	11.680	5.430	235.340	5.638	5.844	5.599	518.600	1080	2535	1366	2573
11.168	11.002	11.202	6.265	234.610	5.849	5.971	5.821	519.600	1083	2502	1305	2482
10.525	10.667	10.494	7.599	237.884	6.306	6.322	6.302	524.850	1077	2245	1206	2411
8.903	8.654	8.950	14.603	250.565	7.415	7.580	7.388	559.050	1086	2027	999	2028

Scenario-7:

Fixing on 3 buses and varying the bus capacity now, gives the following results:

19	Scenario 26	6 : KAR8.p	20	2.000	2.00	2.0000	2.0000	40.0000	2.0000	0.4000	2.0000	40.0000	0.2000	1000.00	20
20	Scenario 27	6 : KAR8.p	20	3.000	3.00	3.0000	3.0000	30.0000	2.0000	0.4000	2.0000	40.0000	0.2000	1000.00	20
21	Scenario 28	6 : KAR8.p	20	3.000	3.00	3.0000	3.0000	50.0000	2.0000	0.4000	2.0000	40.0000	0.2000	1000.00	20
22	Scenario 29	6 : KAR8.p	20	3.000	3.00	3.0000	3.0000	60.0000	2.0000	0.4000	2.0000	40.0000	0.2000	1000.00	20

8.903	8.654	8.950	14.603	250.565	7.415	7.580	7.388	559.050	1086	2027	999	2028
10.352	10.253	10.370	9.303	241.595	6.217	5.852	6.296	535.250	1086	2403	1189	2278
10.535	10.505	10.543	7.460	235.078	6.260	6.403	6.238	522.950	1081	2276	1216	2430
10.626	10.672	10.616	7.405	235.544	6.266	6.375	6.251	522.700	1081	2303	1215	2416

3 Buses and Bus capacity as 60 gives us the best closing time and the best number of average rides per person. The average time in the queues for rides is slightly higher than the other cases; but visitors would not complain spending more time in the queues as long as they get more rides to go around.

Scenario-8:

Fixing on 3 buses, 60 as bus capacity and varying ride capacity gives us following results:

22	Scenario 29	6 : KAR8.p	20	3.000	3.00	3.0000	3.0000	60.0000	2.0000	0.4000	2.0000	40.0000	0.2000	1000.00	20
23	Scenario 30	6 : KAR8.p	20	3.000	3.00	3.0000	3.0000	60.0000	2.0000	0.4000	2.0000	30.0000	0.2000	1000.00	20
24	Scenario 31	6 : KAR8.p	20	3.000	3.00	3.0000	3.0000	60.0000	2.0000	0.4000	2.0000	50.0000	0.2000	1000.00	20

10.626	10.672	10.616	7.405	235.544	6.266	6.375	6.251	522.700	1081	2303	1215	2416
12.535	12.405	12.561	7.779	255.323	3.396	3.381	3.401	530.150	1083	3897	2071	3683
5.630	5.558	5.642	8.608	255.836	28.413	28.445	28.477	517.400	1082	1014	495	1030

3 Buses, Bus capacity as 60 and 30 as ride capacity gives us the best number of average rides per person and the lowest average time in the queues for rides. The closing time of Amusement Park is the not the best; but still, the customer satisfaction is more important when it comes to the Amusement park. Hence, we would advise the management to go ahead with this combination.

Scenario-9:

Fixing on 3 Buses, Bus capacity as 60, 30 as ride capacity varying the speed we have the following results:

24		Scenario 31	6 : KAR8.p	20	3.000	3.00	3.0000	3.0000	60.0000	2.0000	0.4000	2.0000	50.0000	0.2000	1000.00	20
25		Scenario 32	6 : KAR8.p	20	3.000	3.00	3.0000	3.0000	60.0000	2.0000	0.4000	2.0000	30.0000	0.4000	1000.00	20

5.630	5.558	5.642	8.608	255.836	28.413	28.445	28.477	517.400	1082	1014	495	1030
18.063	18.129	18.054	3.091	244.694	2.661	2.607	2.671	514.750	1089	5152	3213	5659

3 Buses, Bus capacity as 60, 30 as ride capacity and 0.4 units/min as speed gives us the best closing time and best possible results in all aspects. With this combination, we could save 65 hours of working and overhead costs during the weekends throughout the entire year! But if there is any speed restriction in the amusement park, then the other alternative would be preferred.

CONCLUSIONS AND DISCUSSIONS:

From the above analysis we have concluded upon the below input parameters

1. For model 1: (week days) (fast=2) (normal=0.4)

Ride capacity = 40, Buses = 6 (2 + 2+ 2), bus capacity = 40, ride time =2 min

2. For model 1: (weekend/holidays) (fast=1) (normal=0.2)

Ride capacity = 40, Buses = 15 (5 + 5 + 5), bus capacity = 40, ride time =1 min

3. For model 2: (week days) (fast=2) (normal=0.4)

Ride capacity = 30, Buses = 12, bus capacity = 60, ride time =1 min

4. For model 2: (weekend/holidays) (fast=1) (normal=0.2)

Ride capacity = 50, Buses = 20, bus capacity = 60, ride time =1 min

Though both the models are very different in the way they are modelled, they can still be compared broadly based on certain output parameters like:

1. Average number of rides per customer: Model 1 shows a higher average number of rides per customer on both weekdays and weekends.
2. Closing time: Model 2 shows a better closing time on both weekdays and weekends.

Both the models can still be relevant: one in case of a small scale amusement park which doesn't have transport facility to every location and the other has connectivity everywhere and is larger in scale.

REFERENCES:

1. Chu, Liou, Fu Yi Hung, and Yen Cheng Lu. "Analysis and Simulation of Theme Park Queuing System." Intelligent Information Hiding and Multimedia Signal Processing (IIH-MSP), 2014 Tenth International Conference on. IEEE, 2014.

2. Chu, Liou, Lin Hui, and Fu-Yi Hung. "Simulation of theme park queuing system by using arena." Intelligent Information Hiding and Multimedia Signal Processing, 2013 Ninth International Conference on. IEEE, 2013.

3. Handout1, Handout2, Handout3, Handout4 by Professor Seokcheon Lee under course IE 580 Systems Simulation.