IIE/RA Contest Problem 6

SM Theme Parks

Final presentation

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PROBLEMS & OBJECTIVES

Short summary of the problems and objectives in our case study.

Problems

- Car capacity of **approximately 25 people (+/-)**
- 2 different configurations for **loading and unloading** (one side/ both sides)
- Depart only **if full** (almost full) or **fixed period** of time?
- To look at the **proportion of time** that a people-mover leaves a station when people are unable to board.

Design a public transit system for a theme park.

→ **Objective**

Objective

Minimize 2 & 3, if possible, avoid state 4 with minimal cost !

States:

1. Train leaves a stop with no people waiting to board
2. Train leaves with 1 to 24 people still waiting
3. Train leaves with 25 to 49 people still waiting
4. Train leaves with 50 or more people still waiting

STATION DESIGNS

→ **4 different options:**

Assumption:
-Deviation: binomial distribution

A

Action	Value	Unit
to unload	30	[seconds]
to board	45	[seconds]
cost per car	20	[USD]
bounded possible positve deviation	10	[seconds]

B

Action	Value	Unit
to unload and load	120	[seconds]
bounded possible positve deviation	10	[seconds]

C

Action	Value	Unit
to unload and load	either A or B	[seconds]
bounded possible positve deviation	10	[seconds]
leave station	if next train arrives	
leave station	if close to full	

COSTS

- Cost for the first car of each train is $800 per day.
- The cost for additional cars is $500 per day per car
- The trains are computer-controlled and fully automatic → no labour costs

Other costs depent on which variation of station design we are looking at!

2

DATA

An overview of our input data

DATA 1

Table 1: Travel times

Route	Time	Unit
Frog Pond - Skunk Hollow	5	[minutes]
Skunk Hollow - Gator Island	8	[minutes]
Gator Island - Raccoon Corner	7	[minutes]
Raccoon Corner - Frog Pond	6	[minutes]
Sum:	26	[minutes]

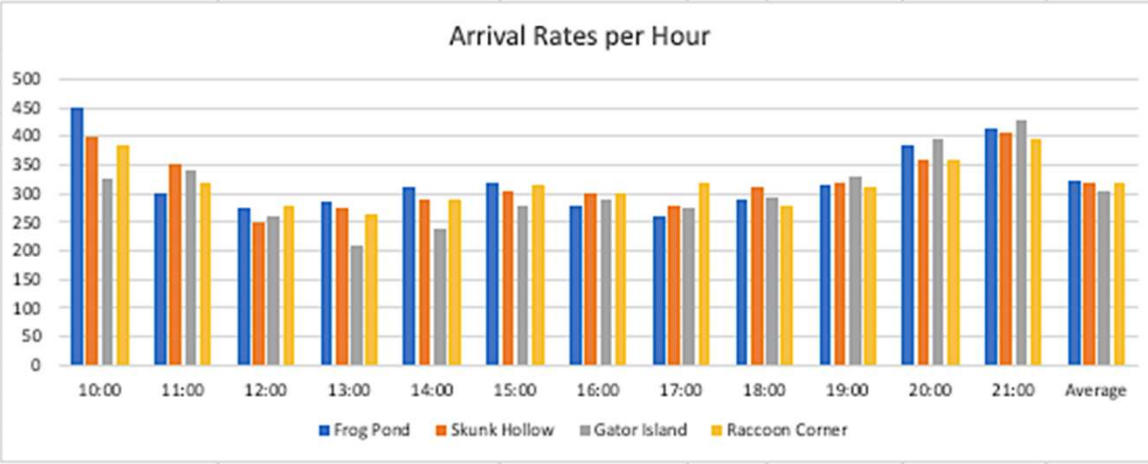
Assumption:
-Travel times are constant

DATA 2

Table 2: Expected customers per hour

Time	Frog Pond	Skunk Hollow	Gator Island	Raccoon Corner	Unit
10:00	450	400	325	385	[rate/hour]
11:00	300	350	340	320	[rate/hour]
12:00	275	250	260	280	[rate/hour]
13:00	285	275	210	265	[rate/hour]
14:00	310	290	240	290	[rate/hour]
15:00	320	305	280	315	[rate/hour]
16:00	280	300	290	300	[rate/hour]
17:00	260	280	275	320	[rate/hour]
18:00	290	310	295	280	[rate/hour]
19:00	315	320	330	310	[rate/hour]
20:00	385	360	395	360	[rate/hour]
21:00	415	405	430	395	[rate/hour]
Average:	323,75	320,42	305,83	318,33	[rate/hour]

Assumption:
- Arrival times follow an exponential distribution



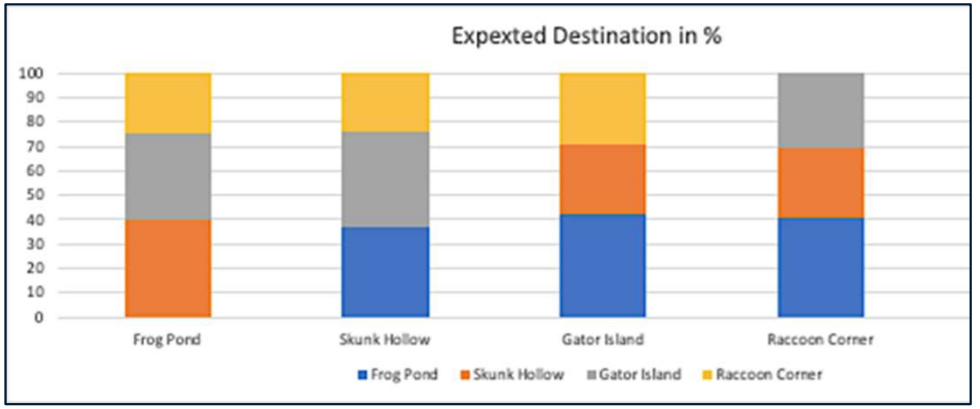
Observations:
- Peaks when opening and closing the park
- Average arrival rates are similar

DATA 3

Table 3: Expected Destination

From	Frog Pond	Skunk Hollow	Gator Island	Raccoon Corner	Unit
Frog Pond	-	40	35	25	[%]
Skunk Hollow	37	-	39	24	[%]
Gator Island	42	29	-	29	[%]
Raccoon Corner	41	28	31	-	[%]

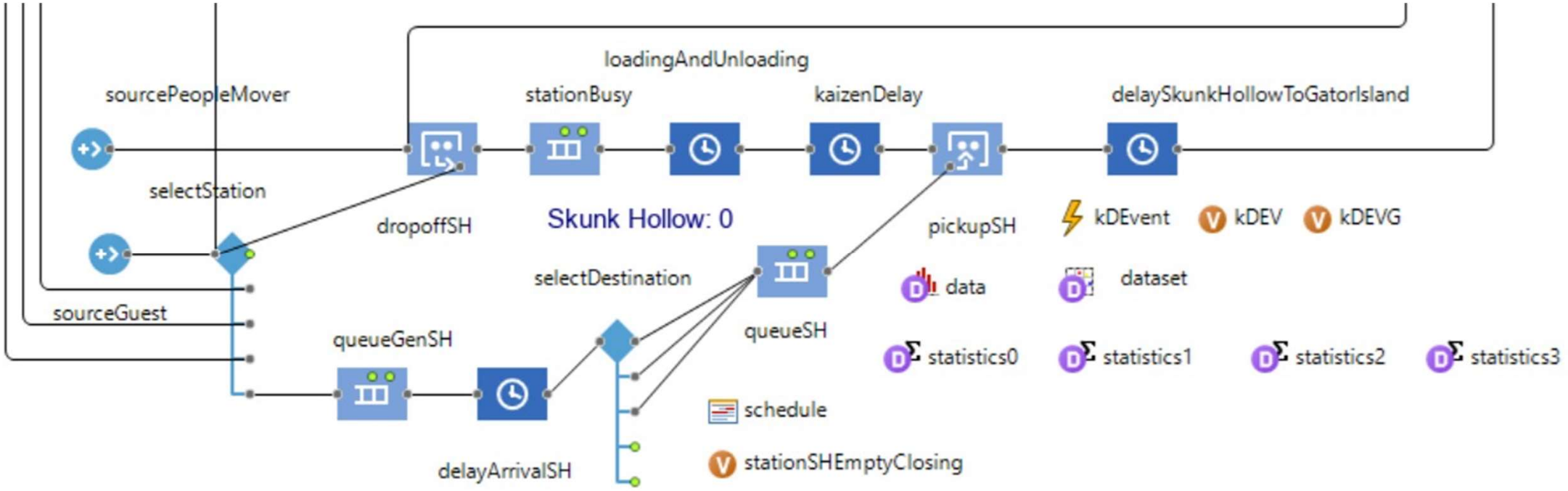
Observations:
- Used capacity of the cars, will be high, because customers tend to use the peoplemover 2 or 3 Stations long



3

MODEL & EXPERIMENTAL DESIGN

SINGLE STATION



AGENTS

sourcePeopleMover

The source “PeopleMover” is defined by two parameters:

- numberOfCars : integer type, with a default value of 1
- guestsLoaded : integer type, with a default value of 0

sourceGuest

The source “Guest” is also defined by two parameters:

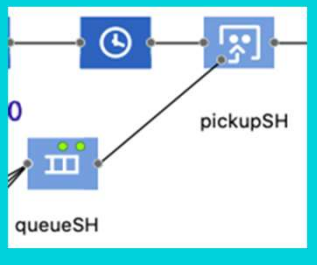
- guestsLoaded : integer type, with a default value of 0
- dummy : integer type, with a default value of 0

KAIZEN

kaizen → Activates Kaizen. If enabled the people movers are waiting for 80% for the cars to be full or leave if the next train enters the current station

→ The value type is boolean: true or false.

PICK UP



1. Train leaves a stop with no people waiting to board
2. Train leaves with 1 to 24 people still waiting
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```
}else if(queueSH.size()==0){
data.add(1);
statistics0.add(1);
dataset.add(1);
}
else if(queueSH.size()<25){
data.add(2);
statistics1.add(1);
dataset.add(2);
}
else if(queueSH.size()<50){
data.add(3);
statistics2.add(1);
dataset.add(3);
}
else {
data.add(4);
statistics3.add(1);
dataset.add(4);
}
```

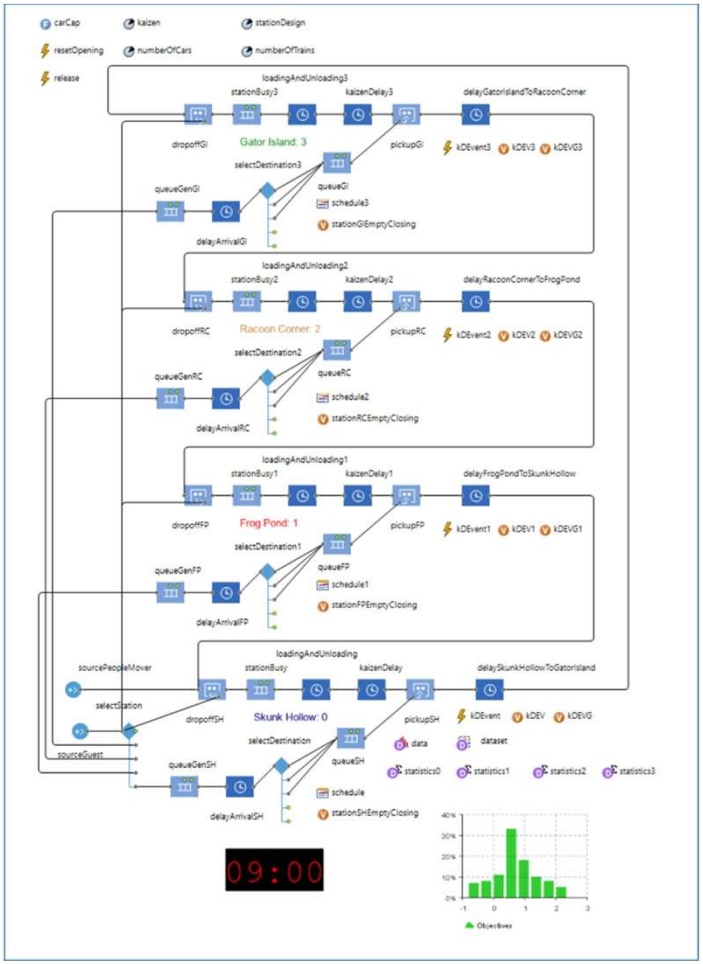
statistics0

statistics1

statistics2

statistics3

Any Logic Run



PARAMETER VARIATON

To compare and vary our Layouts A, B, Kaizen+A and Kaizen+B we used the “ParametersVariation” Experiment.
The parameters we defined were:

- kaizen (true/false)
- numberOfCars(1-10)
- numberOfTrains(1-8)
- stationDesign (75/120 minutes)

Parameter	Type	Value		
		Min	Max	Step
kaizen	Fixed	false		
numberOfCars	Range	1	10	1
numberOfTrains	Range	1	8	1
stationDesign	Range	75	120	45

→ 320 possible combinations of parameters

→ No singular variable to base confidence on → fixed amount of iterations

→ With 30 iterations each → 9600 runs total

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RESULTS & RECOMMENDATIONS

GOALS AND DELIVERABLES

Decision support: Not a single solution but a menu of choices

If requested by client: Neighborhood search near chosen combination

Presentation of each combination is not feasible:

Matrix of the KPIs for numbers of trains and cars in each run

Beyond the scope: differing number of cars per train in individual runs

DASHBOARD

trains/cars	1				2				3				4				5				6				7				8			
1	0,0	1,0	0,0	99,0	1,0	0,0	0,6	98,4	1,0	0,6	0,3	98,1	1,2	0,7	0,0	98,1	1,9	0,0	0,0	98,1	1,9	0,0	0,2	97,9	1,9	0,2	0,4	97,5	2,0	0,6	0,6	96,9
	DNF	Cost:	820,0		DNF	Cost:	1340,0		DNF	Cost:	1860,0		DNF	Cost:	2380,0		DNF	Cost:	2900,0		DNF	Cost:	3420,0		DNF	Cost:	3940,0		DNF	Cost:	4460,0	
	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,94	0,98	0,82	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,82	0,00	0,98	NA	0,77	0,00	0,97	NA	1,00	0,00	0,95
2	0,0	0,8	0,1	99,0	0,8	0,1	0,4	98,6	1,0	0,3	0,3	98,4	1,1	0,5	0,8	97,6	1,5	1,5	2,3	94,7	9,5	23,0	10,9	56,6	50,4	25,7	9,7	14,2	78,1	16,1	3,9	1,9
	DNF	Cost:	1640,0		DNF	Cost:	2680,0		DNF	Cost:	3720,0		DNF	Cost:	4760,0		DNF	Cost:	5800,0		DNF	Cost:	6840,0		FIN	Cost:	7880,0		FIN	Cost:	8920,0	
	0,98	0,00	0,09	NA	0,96	0,97	0,85	0,29	0,96	0,85	0,37	0,99	0,82	0,18	0,00	0,95	0,26	0,00	0,00	0,61	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,00
3	0,5	0,4	0,5	98,5	1,0	0,4	0,8	97,9	1,2	1,0	1,1	96,8	10,4	25,6	13,0	51,0	63,4	24,6	7,1	4,8	90,7	8,7	0,5	0,0	98,1	1,9	0,0	0,0	99,7	0,3	0,0	0,0
	DNF	Cost:	2460,0		DNF	Cost:	4020,0		DNF	Cost:	5580,0		FIN	Cost:	7140,0		FIN	Cost:	8700,0		FIN	Cost:	10260,0		FIN	Cost:	11820,0		FIN	Cost:	13380,0	
	0,79	0,93	0,84	NA	0,95	0,78	0,91	0,97	0,79	0,00	0,00	0,92	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,03	0,00	NA	NA	NA	NA	NA	NA	NA	NA
4	0,0	0,8	0,5	98,7	0,7	0,7	1,1	97,4	10,3	31,1	13,6	45,0	72,9	22,8	3,0	1,4	95,9	4,0	0,1	0,0	99,5	0,5	0,0	0,0	100,0	0,0	0,0	0,0	100,0	0,0	0,0	0,0
	DNF	Cost:	3280,0		DNF	Cost:	5360,0		FIN	Cost:	7440,0		FIN	Cost:	9520,0		FIN	Cost:	11600,0		FIN	Cost:	13680,0		FIN	Cost:	15760,0		FIN	Cost:	17840,0	
	0,00	0,00	0,13	NA	0,95	0,00	0,00	0,77	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	0,3	0,8	0,7	98,2	1,2	3,1	5,8	89,9	60,9	29,5	6,4	3,1	94,9	5,1	0,0	0,0	99,5	0,5	0,0	0,0	100,0	0,0	0,0	0,0	100,0	0,0	0,0	0,0	100,0	0,0	0,0	0,0
	DNF	Cost:	4100,0		DNF	Cost:	6700,0		FIN	Cost:	9300,0		FIN	Cost:	11900,0		FIN	Cost:	14500,0		FIN	Cost:	17100,0		FIN	Cost:	19700,0		FIN	Cost:	22300,0	
	0,95	0,00	1,00	NA	0,09	0,00	0,00	0,05	0,00	0,00	0,00	0,00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6	0,4	0,9	0,7	98,0	12,0	35,9	14,0	38,2	85,6	13,7	0,6	0,0	98,7	1,3	0,0	0,0	100,0	0,0	0,0	0,0	100,0	0,0	0,0	0,0	100,0	0,0	0,0	0,0	100,0	0,0	0,0	0,0
	DNF	Cost:	4920,0		FIN	Cost:	8040,0		FIN	Cost:	11160,0		FIN	Cost:	14280,0		FIN	Cost:	17400,0		FIN	Cost:	20520,0		FIN	Cost:	23640,0		FIN	Cost:	26760,0	
	1,00	0,00	0,97	NA	0,00	0,00	0,00	0,00	0,00	0,00	0,05	0,00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7	0,7	1,0	0,9	97,5	45,2	38,7	8,9	7,2	95,4	4,6	0,0	0,0	99,7	0,3	0,0	0,0	100,0	0,0	0,0	0,0	100,0	0,0	0,0	0,0	100,0	0,0	0,0	0,0	100,0	0,0	0,0	0,0
	DNF	Cost:	5740,0		FIN	Cost:	9380,0		FIN	Cost:	13020,0		FIN	Cost:	16660,0		FIN	Cost:	20300,0		FIN	Cost:	23940,0		FIN	Cost:	27580,0		FIN	Cost:	31220,0	
	0,99	0,00	0,99	NA	0,00	0,00	0,00	0,00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	0,7	1,2	1,1	97,0	68,0	29,1	2,2	0,8	98,0	2,0	0,0	0,0	99,9	0,1	0,0	0,0	100,0	0,0	0,0	0,0	100,0	0,0	0,0	0,0	100,0	0,0	0,0	0,0	100,0	0,0	0,0	0,0
	DNF	Cost:	6560,0		FIN	Cost:	10720,0		FIN	Cost:	14880,0		FIN	Cost:	19040,0		FIN	Cost:	23200,0		FIN	Cost:	27360,0		FIN	Cost:	31520,0		FIN	Cost:	35680,0	
	0,99	0,00	NA	NA	0,00	0,00	NA	0,00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Guests Waiting:	0	0<x <25	24<x <50	50+
Probabilites	25,0	25,0	25,0	25,0
X^2 p-value:	North	East	South	West

Kaizen	
FALSCH	
Design:	
75	

RECOMMENDATIONS

Kaizen: decrease in car utilization outweighs any possible benefits

Model 4/4: our clear recommendation!

Results of Neighborhood search: varying number of cars per train, does not increase performance

Layout A: more cost-efficient in most cases

THANK **YOU**

Any Questions **?**