IE3081 - MODELING AND DISCRETE SIMULATION

PROJECT REPORT

Zahide Gür Taştan 150119827

Merve Rana Kızıl 150119825

Zeynep Ferah Akkurt 150119824

System to model and simulate: A Basketball Stadium's Audience Entrance Gate

SYSTEM COMPONENTS

- Entities: A fan of the team (person)
- Attributes: Valid Ticket (ticket check), security (the owned materials/items), VIP
- Activities: Going to the game to watch.
- Events: Arrival of the fan to the one of the gates, arrival of the fan to the one of the ticket controls lines, entrance of the fan to the stadium.
- State variable: Number of fans waiting at each gate for security check, number of fans waiting for ticket check at each gate. Number of fans who are VIP and still waiting at the gate.

RELATION BETWEEN SYSTEM COMPONENTS

All the people who come to watch the game, firstly must get in the line for security check in Xray. After passing the Xray machine, if the person hasn't got any ticket, its need to purchased ticket for the entering the match. There is one reception point, and purchased ticket queue to purchase tickets. After the purchased ticket, if the ticket exists, there are 2 different lines.One of VIP and another for non-VIP. if the person is non-vip they have to be checked by security and then show their tickets at the same time. Ticket control will be made by reading the id code on the ticket. The difference between VIP and non-VIP is that they do not need to throw away the materials like battery or water etc. for security. There are restrictions for the people who have normal tickets.

Ticket check will be done depending on the person's gender. For example, if the person is a woman, a woman security guard will check the materials and the tickets if anything is wrong or not. If the person is VIP, at the end of the waiting line there is a machine who let the person in by checking the VIP ticket.

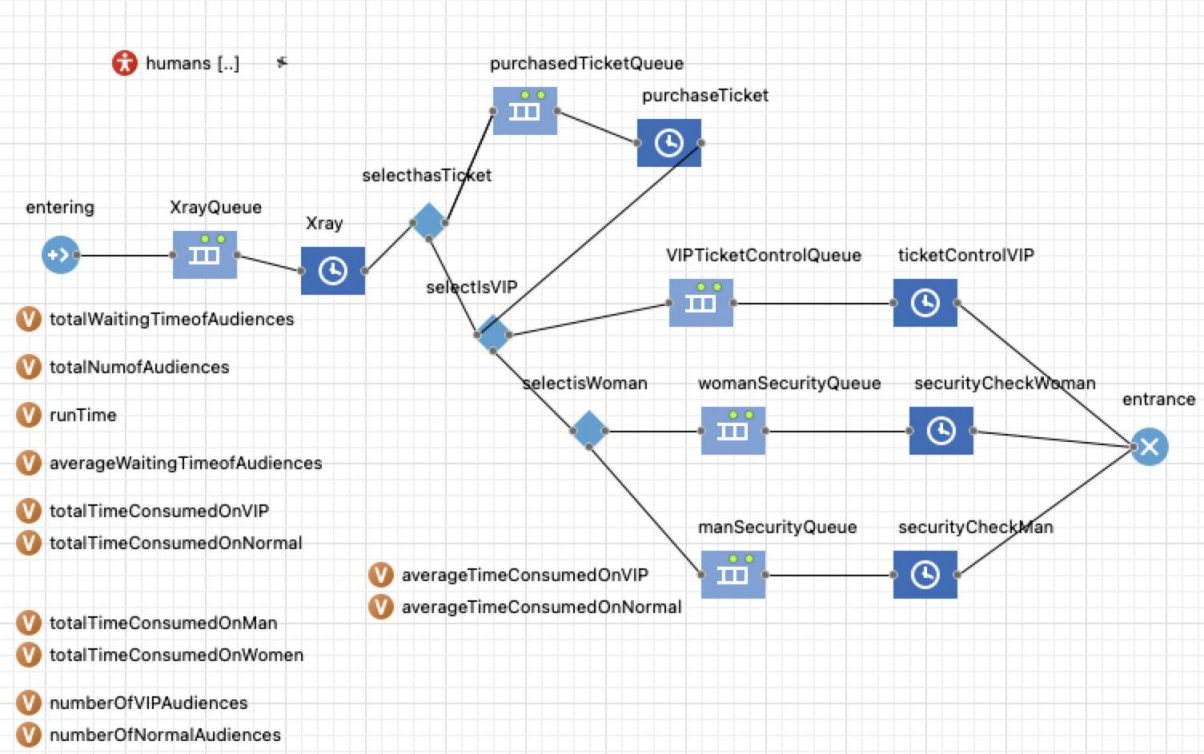
If there is no problem with the ticket, the person can enter the stadium and take her/his seats.

GENERATION OF RANDOM VARIATES

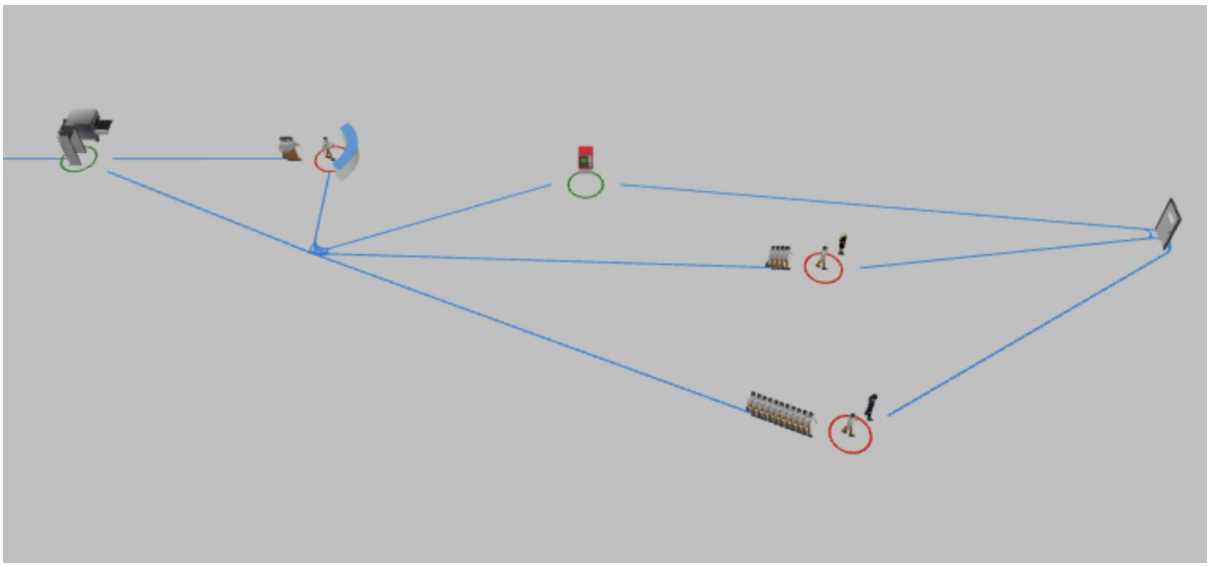
The waiting time for each person in any queue (xRayQueue, ticketControlQueue)

Each gate has random waiting times. For example when a person comes to XrayQueue, it takes minimum 3, maximum 4 seconds to pass it. But it is most likely 3 seconds.

2D MODEL



3D MODEL



INPUT AND OUTPUT VARIABLES

Input Variables

1. **Decision variables**

- Number of people as fans
- Number of VIP fans
- Number of gates for security XRay
- Number of gates for ticket control
- Number of security guards
- Number of machines for ticket control (only for VIP)

2. **Uncontrollable variables**

- Waiting time of each person in XRay queue
- Waiting time of each person in WomanSecurity Queue
- Waiting time of each person in ManSecurity Queue
- Waiting time of each person in the PurchaseTicket Queue.

The type and the values of input variables

Number of people as fans: 1000. Arrival rate is 15/minutes of the system.

Number of XRay machines: 1

Number of VIP fans: 100

Number of gate to purchase ticket: 1

Number of guards for security: 2 (one for women, another for men)

Number of machines: 1 (only for VIP)

Capacity of each gate: 100

Rate of being a woman = 0.4

Rate of being a VIP : 0.1

Rate of hasTicket = 0.1

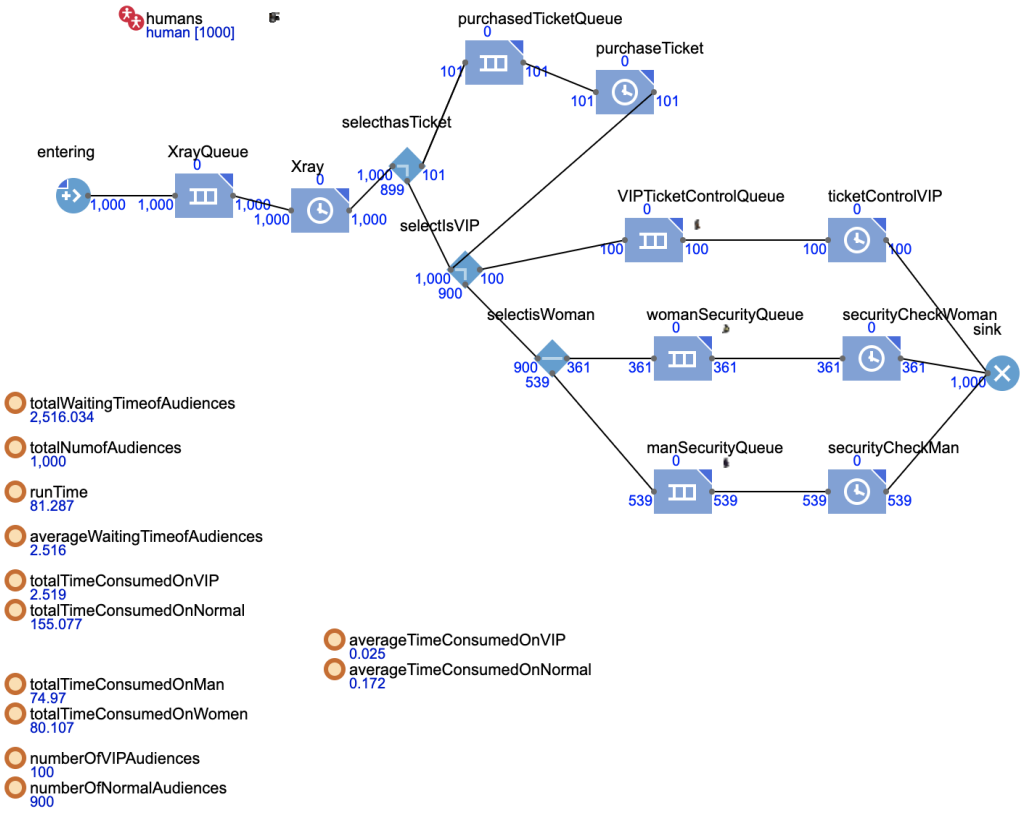
Output Variables

- numberOfVIPAudiences
- numberOfNormalAudiences
- totalWaitingTimeofAudiences
- totalNumofAudiences
- totalTimeConsumedOnMan: total service time spend in ticket control for men
- totalTimeConsumedOnWomen: total service time spend in ticket control for women

- totalTimeConsumedOnNormal: addition of women and men service time
- totalTimeConsumedOnVIP: : total service time spend in ticket control for VIP
- averageWaitingTimeofAudiences
- averageTimeConsumedOnVIP
- averageTimeConsumedOnNormal

Note: All times calculated as minute.

- A Simulation Example (Output Responses)



ANSWER OF QUESTIONS

For finding the mean values, Confidence Intervals, Prediction Intervals, we run the simulation 10 times with different seed values. After the found all of the parameters mean value, we calculated the Confidence interval, PredictionInterval for each of variables.

BEFORE								
	TotalWaitingTimeofAudiences	runTime	totalTimeConsumedONVIP	totalTimeConsumedOnNormal	totalTimeConsumedOnMan	totalTimeConsumedOnWomen	isVIP	isWomen
1	4539,52	87,141	2,09	162,01	76,36	85,65	85,00	383,00
2	3677,71	81,95	2,25	156,14	79,79	76,35	90,00	337,00
3	3235,55	81,51	2,94	151,25	70,80	80,44	117,00	363,00
4	4122,18	77,31	2,60	152,67	76,00	76,67	105,00	343,00
5	3891,99	85,60	2,05	158,28	73,66	84,62	83,00	381,00
6	2162,45	80,87	2,77	153,46	75,40	78,06	111,00	356,00
7	2798,25	80,38	2,19	154,23	74,45	79,78	89,00	365,00
8	2896,72	85,63	2,49	157,57	72,40	85,17	102,00	341,00
9	3157,38	80,65	2,00	157,97	79,87	78,11	80,00	349,00
10	2848,44	78,83	2,63	151,72	77,39	74,33	105,00	336,00
avg	3333,018	81,988	2,4004	155,5293	75,6115	79,9187	96,7	355,4
stdDev	717,3554403	3,172461	0,330685887	3,449725562	2,945120305	4,002056084	12,207	16,3841
2,262								
ConfidenceIntervalPlus	3846,147516	84,25728	2,636941998	157,9969136	77,71816578	82,78139956	105,43	367,12
ConfidenceIntervalNeg	2819,888484	79,71872	2,163858002	153,0616864	73,50483422	77,05600044	87,968	343,68
3,16227766								
PredictionIntervalPlus	5034,876074	89,51436	3,184921054	163,7134483	82,59851995	89,41320032	125,66	394,27
PredictionIntervalNeg	1631,159926	74,46164	1,615878946	147,3451517	68,62448005	70,42419968	67,74	316,53
1,048808848								

Then we added our system, two additional queues. We added the one queue on the entrance of the building that is the X Ray queue. And another queue is added on the ticket control for the man which is the most crowded queue of our system. After the changed our system, we calculated the same variables for the questions.

AFTER								
	TotalWaitingTimeofAudiences	runTime	totalTimeConsumedONVIP	totalTimeConsumedOnNormal	totalTimeConsumedOnMan	totalTimeConsumedOnWomen	isVIP	isWomen
1	1351,75	82,855	2,39	140,93	58,50	82,43	96,00	372,00
2	966,10	80,41	2,76	138,08	59,40	78,68	111,00	354,00
3	1658,74	79,79	2,29	141,14	62,41	78,73	91,00	355,00
4	1019,69	79,03	2,56	137,04	61,99	75,05	104,00	341,00
5	1599,95	78,33	2,99	135,60	59,07	76,53	119,00	341,00
6	2678,71	82,86	2,78	139,78	58,13	81,60	112,00	360,00
7	2041,13	81,61	2,23	140,92	60,51	80,41	91,00	361,00
8	2158,47	81,78	2,57	141,14	59,55	81,59	100,00	369,00
9	1149,50	76,83	2,46	137,62	63,72	73,91	97,00	334,00
10	1137,29	81,30	2,19	140,46	60,54	79,92	90,00	366,00
avg	1576,1328	80,4799	2,5214	139,2722	60,3819	78,8849	101,1	355,3
stdDev	566,1890621	1,983612	0,261577352	2,019362705	1,822238943	2,901580544	9,5755	12,2479
2,262								
ConfidenceIntervalPlus	1981,131916	81,89879	2,708508165	140,7166647	61,68536065	80,96042147	107,95	364,061
ConfidenceIntervalNeg	1171,133684	79,06101	2,334291835	137,8277353	59,07843935	76,80937853	94,251	346,539
3,16227766								
PredictionIntervalPlus	2919,36291	85,18583	3,141967579	144,0629474	64,7049899	85,76862597	123,82	384,357
PredictionIntervalNeg	232,9026902	75,77397	1,900832421	134,4814526	56,0588101	72,00117403	78,383	326,243
1,048808848								

For the first system design, total number of replications needed to estimate mean output parameters with 10% enhancement found as follows.

Margin of error is calculated.

$$MOE = (1.645)\frac{94.9808}{\sqrt{1000}} = 4.94$$

$$n = \frac{(1.645)^2(0.5)(1-0.5)}{(0.0494)^2} = 277.22$$

Total number of replications should be at least 278.

For the changed system design, total number of replications needed to estimate mean output parameters with 10% enhancement found as follows.

Margin of error is calculated.

$$MOE = (1.645)\frac{74.625}{\sqrt{1000}} = 3.882$$

$$n = \frac{(1.645)^2(0.5)(1-0.5)}{(0.03882)^2} = 448.9$$

Total number of replications should be at least 449.

For the first system, we calculated the Confidence Interval by 10% for the differences of the estimated parameters.

	1,833								
	ConfidenceIntervalPlus	3748,829849	83,8269	2,592080584	157,5289179	77,31862572	82,23847378	103,78	364,897
	ConfidenceIntervalNeg	2917,206151	80,1491	2,208719416	153,5296821	73,90437428	77,59892622	89,624	345,903
	3,16227766								

For the changed system, we calculated the Confidence Interval by 10% for the differences of the estimated parameters.

1,883								
ConfidenceIntervalPlus	1913,273974	81,66106	2,677158035	140,4746434	61,46696472	80,61266611	106,8	362,593
ConfidenceIntervalNeg	1238,991626	79,29874	2,365641965	138,0697566	59,29683528	77,15713389	95,398	348,007
3,16227766								