MS MOD 1

Model Characterization :-

Modelling is the process of creating a simplified representation or model of real world scenario. It helps us to understand how real system works, predict its behavior. Model characterization is the process of understanding & describing essential features, behavior & limitations of a model.

Eg. Imagine u want to build a model of toy car. So the essential features include wheels, body shape & size. U also need to understand how model car will behave like how it moves & turns, identify any limitations like max^m speed the model can achieve & materials it can be made from.

Model Development :-

Process of creating / building representation of system physically or virtually.

Eg. In continuation with toy car eg, model development involves building toy car based on features, behavior & limitations studied in model characterization. This means assembling components like chassis, wheels, axles. It could also involve building computer simulation of car using software where i/p are size, weight & engine power to create virtual scenario of how car will behave.

Simulation :-

Involves running a model over time or space to observe its behavior. It allows us to study how the model behaves without actually implementing it in real-life.

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Steps in Simulation study :-

1) Problem formulation :- Define specific problem u want to address through simulation, policy maker / analyst understand & agree with formulation.

2) Setting of objectives & overall project plan :- Objectives indicate qns to be answered by simulation & verify whether simulation is appropriate method for problem statement & qns asked. After verified, the project plan should include alternative systems to be considered, plans for study in terms of no. of people involved, cost, no. of days for each part & expected results of work.

3) Model Conceptualization :- Develop conceptual model that represents system being simulated. This involves identifying key components, behaviors of the system.

4) Data Collection :- As complexity of model changes, required data also changes so collect relevant data for simulation like historical data, or data collected from experiments. As this takes large amount of time of total time to simulate, it must start as early as poss.

5) Model Translation :- Translate conceptual model into formal representation that can be simulated using software or tools. Steps involves structure, parameters & eqns. GPSS/H or special purpose

6) Verified ? :- Is computer program performing properly ? If error found, debugging for correct i/p parameters & logical structure.

7) Validated ? :- The determination that model is accurate representation of real system, validation is achieved through calibration of model & comparing model's o/p with real world o/p's.

8) Experimental design :- Design different scenarios for simulation, decide length of simulation runs & no. of replications to be made for each run.

9) Production runs & analysis :- Estimate measures of performances, generate data & interpret.

10) More Runs ? :- Depending on system complexity, more runs can be done to explore add' aspects.

11) Documentation & Reporting :- Prepare document which includes model description, i/p data, design, results of model simulated & make effective report on this

12) Implementation :- Implement results & recommendations found from simulation study into real-world scenario with some modifications if needed.

- Programming Lang :- set of rules & syntax used to write instructions that computer can understand & execute. They allow developers to create software & simulations by writing code.
Eg. Python, Java, C++, MATLAB, R, Simul8 softwares.

- Organization :-
1) Structure :- This refers to how project is planned, managed & executed.
2) Roles / Responsibilities :- who does what part, diff. tasks assigned to team members involved in simu. process
3) Resources :- Tools, softwares, equipments etc.

- Terminology :-
1) Model :- simple representation of real world system.
2) Simulation :- running of model over time to see how system behaves.

3) Parameter :- A variable that affects behavior of model simulation, used to adjust features of model under diff scenarios.
4) Input :- Data provided to a model as an initial cond^n to initialize working.
5) Output :- Results produced by model in simulation. Model's behavior collected to analyze.
6) Validation / Verification :- Comparing results with real world o/p to measure correctness of model.
7) Scenario :- set of different cond^{n}s or parameters used in simulation.

- Simulation Egs :- Queueing, Inventory, Reliability & N/w analysis.

- Adv of MS :-

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1) Easy to understand :- Allows to understand how model operates without implementing in real-life.
2) Easy to test :- Allows to make changes to modify o/p.
3) Easy to upgrade :- Find system requirements using diff. config.
4) Easy to diagnose problems :- Find error & avoid it in real life.

- Dis Adv of MS :-

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1) Designing model requires domain knowledge, training, experience
2) Operations on model performed using random no's, thus diff. to predict result.
3) Time consuming process & requires more manpower.
4) Sim. Results diff to understand & experts required.
5) Expensive to implement.

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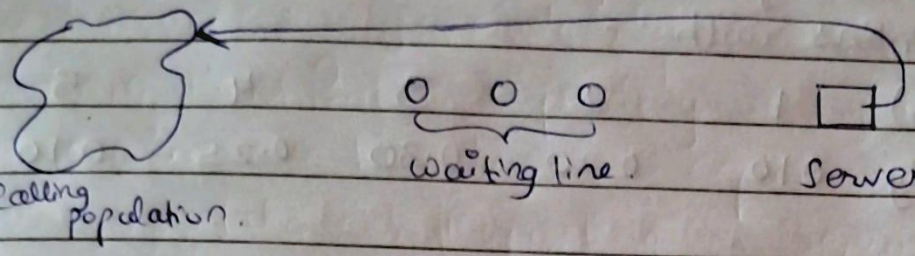
Queueing Systems :-

A queueing system is described by its calling population, nature of arrivals, service mechanism, system capacity & queing discipline.



1) In single channeled queue, calling population is infinite.
2) Arrivals for service occur one at a time in random fashion.
3) Service times are of random length according to probability distribution which doesn't change over time.
4) System capacity has no limit → any no. of units wait in line.
5) Units served on basis of FIFO.
6) State of system → status of server (busy / idle) & no. of units.
7) Events → set of circumstances that causes change in state of system i.e entry of unit in system or departure of unit from system.
8) Simulation clock :- used to track simulation time.

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• Eg. of Single channel Queue :-

Q. Grocery store has one checkout. Customer arrive at random from 1 to 8 mins & each interval time has same probability of occurence. Service time vary from 1 to 6 mins with :-

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Service (mins)	1	2	3	4	5	6
Probability	0.10	0.20	0.30	0.25	0.10	0.05

Simulate for 10 customers.

Random no's sequence :-

Random digit for IAT	302	915	48	235	15	500	650	423	258	700
Random digit for ST	83	45	74	65	17	79	30	61	89	20

→ Probability of customer occurence = 1/8 = 0.125

Time betⁿ arrival	Probability	Cum. Probability	Random digits Assignment
1	0.125	0.125	1-125
2	0.125	0.250	126-250
3	0.125	0.375	251-375
4	0.125	0.500	376-500
5	0.125	0.625	501-625
6	0.125	0.750	626-750
7	0.125	0.875	751-875
8	0.125	1.000	876-000

Distribution time betⁿ ~~interval~~ arrival.

Service Time.	Probability.	Cum. Probability.	Rand digit Assign.
1	0.10	0.10	1 – 10
2	0.20	0.30	11 – 30
3	0.30	0.60	31 – 60
4	0.25	0.85.	61 – 85
5	0.10	0.95.	86 – 95
6	0.05.	1.00	96 – 00

Service time distribution

Customer	Time since last arr.	AT	ST	ST Begins.	Time custorer wait in queue.	ST ends.	cust spend	IT of serve
1	–	0	4	0	0	4	4	0
2	8	8	3	8	0	11	3	4
3	1	9	4	11	2.	15.	6	0
4	2	11	4	15	4	19	8	0
5	1	12	2	19	7	21	9	0
6	4	16	4	21	5	25	9	0
7	6	22	2	25	3	27	5	0
8	4	26	4	27	1	31	5	0
9	3	29	5	31	2	36	7	0
10	6	35	2	36	1	38	3	0

1) Avg. waiting Time :- Total time cust wait in queue / Total no. of cust
= 25/10 = 2.5 mins.

2) Prob of cust waiting = No. of customers who waits / Total no. of customers
= 8/10 = 0.8

3) Prob of idle server = Total IT / Total runtime of simulation
= 4/38 = 0.105.

4) Avg wait Time for those who wait = Total time cust waits in queue / Total no. cust who wait

5) Avg Time betn arrival = Total time betn arri / (No. of arr) – 1

6) Avg time cust spends = Total time cust sperds in system / Total no of cust.

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• Eg. of Multichannel Queue :-

Q. Consider technical call centre. Time betⁿ calls ranges from 1 to 4 mins. 2 tech support people → Able & Baker. Able is more experienced & can provide service faster than Baker. Simulate for 6 customers.

→ Distribution of arrival time :-

Time betⁿ arrival.	Probability	Cum. Prob.	Random Digit Assignment.
1	0.25	0.25	1 – 25
2	0.40	0.65	26 – 65
3	0.20	0.85	66 – 85
4	0.15	1.00	86 – 00

Distribution of service time :-

For Able :-

Service Time.	Prob.	Cum Prob.	Random Digit Assign
2	0.30	0.30	1 – 30
3	0.28	0.58	31 – 58
4	0.25	0.83	59 – 83
5	0.17	1.00	84 – 00

For Baker :-

Sevice Time.	Prob.	Cum. Prob.	Rand. digit Assign.
3	0.35	0.35	1 – 35
4	0.25	0.60	36 – 60
5	0.20	0.80	61 – 80
6	0.20	1.00	81 – 00

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Random Digits :- 26, 98, 90, 26, 42
for arr

Random Digits :- 95, 21, 51, 92, 38
for service time

Customer	IAT	AT	Able		Baker		Caller Delay	cust spend
			TS Begins	ST TS ends	TS Begins	ST TS ends		
1	-	0	0	5 5	-	- -	0	5
2	2	2	-	- -	2	3 5	0	3
3	4	6	6	3 9	-	- -	0	3
4	4	10	10	5 15	-	- -	0	5
5	2	12	-	- -	12	6 18	0	6
6	2	14	15	3 18	-	- -	1	4

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• Inventory Systems :- (Eg).

Q yt Paper seller buys papers for 33 cents each & sells them for 50 cents each. Newspapers not sold at end of day are sold as scrap for 5 cents each. Newspapers can be purchased in bundle of 10 eg 50, 60, ... 3 types of Newsday's - good, fair & poor with prob 0.35, 0.45, 0.20. Determine optimal no. of newspapers the seller should purchase. This will be accomplished by simulating for 10 days & recording sales profit of each day.

→ Distribution of newspapers demanded on each of days :-

Demand	Good	Fair	Poor	
40	0.03	0.10	0.44	
50	0.05	0.18	0.22	(Given.)
60	0.15	0.40	0.16	
70	0.20	0.20	0.12	
80	0.35	0.08	0.06	
90	0.15	0.04	0.00	
100	0.07	0.00	0.00	

Random digits for types of newsday :- 58, 17, 21, 45, 43, 36, 27, 73, 86, 19

Random digits for demand :- 93, 63, 31, 19, 91, 75, 84, 37, 23, 02

Assume newsstand buys 70 newspapers per day.

Profit = (Revenue from sales) - (Cost of papers) - (lost profit from excess demand) + (salvage from sale of scrap)

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RDA for type of Newsday :-

Type	Prob	Cum Prob	RDA
Good	0.35	0.35	1–35
fair	0.45	0.80	36–80
Poor	0.20	1.00	81–00

RDA for newspapers demanded :-

Demand	Prob			Cum Prob			RDA		
	Good	fair	Poor	Good	fair	Poor	Good	fair	Poor
40	0.03	0.10	0.44	0.03	0.10	0.44	1-3	1-10	1-44
50	0.05	0.18	0.22	0.08	0.28	0.66	4-8	11-28	45-66
60	0.15	0.40	0.16	0.23	0.68	0.82	9-23	29-68	67-82
70	0.20	0.20	0.12	0.43	0.88	0.94	24-43	69-88	83-94
80	0.35	0.08	0.06	0.78	0.96	1.00	44-78	89-96	95-00
90	0.15	0.04	0.00	0.93	1.00	1.00	79-93	97-00	-
100	0.07	0.00	0.00	1.00	1.00	1.00	94-00	-	-

Day	Type	Demand	Revenue from sales ($)	Lost profit from excess demand (0.5-0.33)	Salvage from sale of scrap	Daily Profit
1	fair	80	70×0.5=35	10×0.17=1.7	-	10.20
2	Good	80	70×0.5=35	1.7	-	10.20
3	Good	70	35	-	-	11.9
4	fair	50	25	-	20×0.5=1	2.9
5	fair	80	35	1.7	-	10.20
6	fair	70	35	-	-	11.9
7	Good	90	35	3.4	-	8.5
8	Fair	60	30	-	0.5	7.40
9	Poor	40	20	-	1.5	-1.60
10	Good	40	20	-	1.5	-1.60
						70