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Improvement Test – May. 2018

Scheme & Solution

Sub:	SYSTEM MODELING AND SIMULATION					Sub Code:	10CS82	Branch:	CSE & ISE
Date:	21-05-18	Duration:	90 min's	Max Marks:	50	Sem / Sec:	VIII/ A ,B,C(CSE) , VIII/A,B(ISE)		OBE

Answer any FIVE FULL Questions — MARKS | CO | RBT

1 List and explain the characteristics of queuing system. Briefly explain queuing notations. [10] CO3 L1

Solution:

Explanation about characteristics **-6M,** Queuing notations **-4M** **(10Marks)**

characteristics of Queuing system

the key elements of queuing system are the customers and servers.

customers :— refers to people, m/c, trucks, mechanics, Patients airplanes, email etc..

servers :— refers to receptionists, repair person, cpu, any resource that provides requested service

the following table gives few examples of queuing system

system	customer	server
Airport	Airplanes	Runway
Hospital	patients	Nurses, doctor
Reception desk	people	Receptionist

the term customer means anything that arrives at a facility and requires service.

→ the characteristics of queuing system are

— calling population
— system capacity
— Arrival process
— Queue behaviour and queue discipline
— service time and service mechanism.

the calling population

the population of potential customers is referred as calling population.

→ the calling population can be either finite (or) infinite

→ the main difference b/n finite and infinite is based on how arrival rate is defined.

→ In infinite population the arrival rate is not affec by the no of customers who have left the calling popul and joining the queuing system.

Ex :- Hotel

→ In finite population the arrival rate depends on number of customers being served and waiting.

Ex :- ~~Bo~~ In a ~~bank~~ hospital where there are pri appointments the customers are patients here an arrival rate of patients depends on finite arrivals

2. System capacity :-

System capacity is defined as the maximum no customers allowed in system (or) in waiting queue.

Ex :- An automatic car wash might have room f only 10 cars to wait in line to enter the mechanism. An arriving customer who finds the system full does entered but returns immediately to the calling populatio

— Some systems such as concert ticket sales for stud may be considered to have unlimited capacity

3. The arrival process :-

Arrival process describe how customer arrive the arrival are distributed in time and whether th finite population model (or) infinite population model

→ Arrivals may occur at scheduled times (or) random tim

→ The most important model for random arrivals is poisson arrival process.

↳ If An represents IAT b/n customer n-1 and customer n then for poisson arrival process An is exponen distributed with mean 1/λ time units.

4) Queue behaviour and Queue discipline

Queue behaviour refers to the action of customer while in queue waiting for service to begin.

Queue behaviour are

→ Balk — leave when they see that the line is too long.

→ Renege — leave after being in the line when they see that the line is moving too slowly.

→ Jockey — move from one line to another if they think they have choosen a slow line.

— Queue discipline refers to how the customers are severed in the queue.

- FIFO, LIFO,
- SIRO — service in random

5) service times and service mechanism

service times are denoted by $S_1, S_2, S_3, \ldots$ They may be constant (or) of random duration.

the exponential, weibull, gamma, lognormal distributions are used to model the service times.

A queuing system consists of no of service centers and interconnecting queues. Each service center consists of no of servers c working in parallel. parallel service mechanisms are either single server (c=1), multiple server (or) unlimited servers.

Queuing notation

Kendall proposed a queuing notation as follows.

A/B/C/N/K

A represents Inter arrival time distribution

B represents service time distn

C represents no of parallel servers

N represents system capacity

K represents size of calling population

— common symbols for A and B includes M (exponential (or) markov), D (constant (or) deterministic), Ek (erlang of orde[r]) G (arbitrary, general)

Ex:- M/M/1/∞/∞

↳ A single server system that has unlim[ited] queue capacity and an infinite population of potential arrivals.

→ when N and K are infinite then they may be dropped from the notation

M/M/1/∞/∞ is shortened to M/M/1

2	Let the arrival distribution be uniformly distributed between 1 to 8 min. Develop a simulation table for 10 customers. The service time distributions are as follows.	[10]	CO2	L3

Service Time	1	2	3	4	5	6
Probability	0.05	0.10	0.20	0.30	0.25	0.10

Consider the following random numbers for inter Arrival Times and Service Times.
Random No for IAT: 913, 727, 153, 948 ,309 ,929 ,756 ,234 ,697
Random No for Service Times: 84, 10, 74, 53, 17, 79, 91, 67, 89, 38.
Find the average waiting time, average service time and average time customer spends in system.

Solution:

-For finding the cumulative probability and random numbers for IAT-1M

IAT	Probability	Cumulative Probability	Random No Assessment
1	0.125	0.125	0-125
2	0.125	0.250	125-250
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	876-999

-For finding the cumulative probability and random numbers for service times-1M

ST	Probability	Cumulative Probability	Random No Assessment
1	0.05	0.05	00-05
2	0.10	0.15	06-15
3	0.20	0.35	16-35
4	0.30	0.65	36-65
5	0.25	0.90	66-90
6	0.10	1	91-99

-Main Simulation table-6M
***The marks split up for this table is as shown below**
-For finding the Inter-arrival times and arrival times-2M
- For finding the service times from the random numbers-2M
-For finding the time service begins and time service ends-1M each

Customer	IAT	AT	ST	Time Service Begins	Waiting Time	Time Service Ends	Time Customer Spend in system	Idle time of server
1	-	0	5	0	0	5	5	0
2	8	8	2	8	0	10	2	3
3	6	14	5	14	0	19	5	4
4	2	16	4	19	3	23	7	0
5	8	24	3	24	0	27	3	1
6	3	27	5	27	0	32	5	0
7	8	35	6	35	0	41	6	3
8	7	42	5	42	0	47	5	1
9	2	44	5	47	3	52	8	0
10	6	50	4	52	2	56	6	0
	Total		44		8		52	12

-For finding the average waiting time and Probability of idle time of server- 2M

Average WT = Total WT/Total No of customers =8/10 =0.8 Min
Average service time = Total WT/Total No of customers = 44/10 =4.4 Min
Average time customer spends in system=Total time customer spend in the system/ Total No of customers=5.2 Min

3 A computer technical support is staffed by two people, Able and Baker who take calls and try to answer questions and solve computer problems. The time between the calls ranges from 1 to 4min with the distribution as shown in the table 1.1 below. Able is more experienced and can provide service faster than baker which means that, when both are idle able takes a call. The distribution of service times are shown in the table 1.2 below. [10] CO2 L3

Table 1.1 : Inter arrival time(IAT) distribution

Time b/n arrivals	1	2	3	4
Probability	0.05	0.30	0.30	0.35

Table 1.2 : Service time distribution of Able and Baker

Service Time of Able	2	3	4	5
Probability	0.35	0.25	0.20	0.20

Service Time of Baker	3	4	5	6
Probability	0.25	0.15	0.40	0.20

Consider the following random numbers.
Random no for Arrivals: 26,98,90,26,42,74,80,68,22,48 &
Random no for Service Time: 95,21,51,92,89,38,13,61,50,49

Simulate this system for 10 callers by finding i) Average waiting time
ii) Average inter arrival time iii) Average Service Time of Able
iv) Average Service Time of Baker

Solution:

-For finding the cumulative probability and random numbers for IAT-1M

IAT	Probability	Cumulative Probability	Random No Assessment
1	0.05	0.05	00-05
2	0.30	0.35	06-35
3	0.30	0.65	36-65
4	0.35	1	66-99

-For finding the cumulative probability and random numbers for service times-1M

Service Time of Able	Probability	Cumulative Probability	Random No Assessment
2	0.35	0.35	00-35
3	0.25	0.60	36-60
4	0.20	0.80	61-80
5	0.20	1	81-99

-For finding the cumulative probability and random numbers for service times-1M

Service Time of Baker	Probability	Cumulative Probability	Random No Assessment
3	0.25	0.25	00-25
4	0.15	0.40	26-40
5	0.40	0.80	41-80
6	0.20	1	81-99

Main Simulation table-3M

Caller ID	IAT	AT	Server Chosen	ST	Time Service Begins	Time Service Ends		Caller Delay	Time Customer Spend in system
						Able	Baker		
1	-	0	Able	5	0	5	-	0	5
2	2	2	Baker	3	2	-	5	0	3
3	4	6	Able	3	6	9	-	0	3
4	4	10	Able	5	10	15	-	0	5
5	2	12	Baker	6	12	-	18	0	6
6	3	15	Able	3	15	18	-	0	3
7	4	19	Able	2	19	21	-	0	2

8	4	23	Baker	5	23	-	28	0	5
9	4	27	Able	4	27	31	-	0	4
10	2	29	Baker	5	29	-	34	0	5
Total	29								

Average waiting time, inter arrival time , Service Time of Able, Service Time of Baker -4M

Average WT = Total WT/Total No of customers =0/10 =0 Min

Average Inter arrival Time = Total IAT/Total No of customers-1 =29/9 =3.22 Min

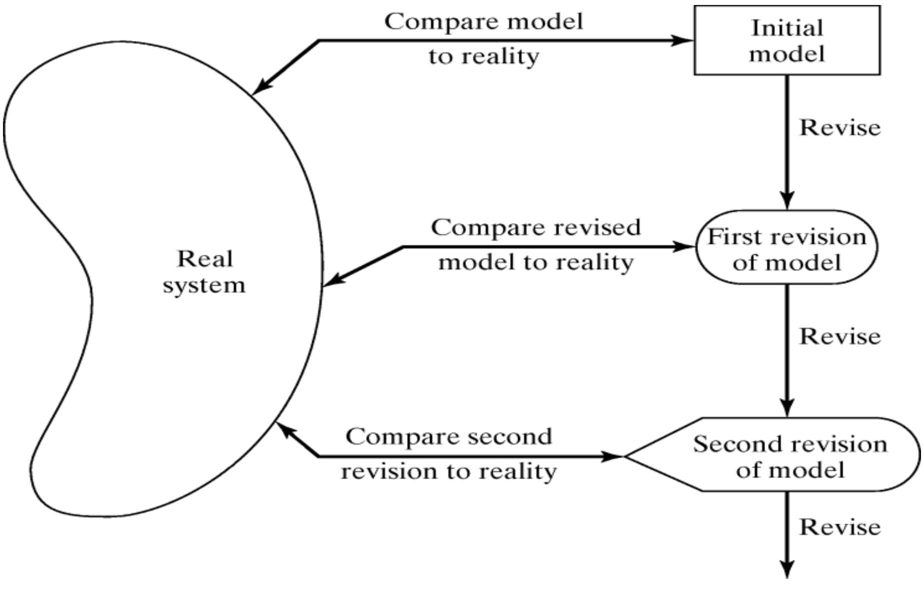
Average ST of Able = Total ST of Able/Total No of customers =22/10 =2.2 Min

Average ST of Baker = Total ST of Baker/Total No of customers =19/10 =1.9 Min

4 Describe the three steps approach to validate by Naylor & Finger in the validation process. [10] CO6 L1

Solution:

Figure:3M,Explanation:7M=10M



Calibration and Validation of Models

• Verification and validation although are conceptually distinct, usually are conducted simultaneously by the modeler.

• Validation is the overall process of comparing the model and its behavior to the real system and its behavior.

• Calibration is the iterative process of comparing the model to the real system, making adjustments to the model, comparing again and so on.

• The figure above shows the relationship of the model calibration to the overall validation process.

• The comparison of the model to reality is carried out by variety of test.

• Tests are subjective and objective.

• Subjective test usually involve people, who are knowledgeable about one or more aspects of the system, making judgments about the model and its output.

• Objective tests always require data on the system's behavior plus the corresponding data produced by the model.

As an aid in the validation process, **Naylor and Finger** formulated a **three step approach** which has been widely followed:-

1. Build a model that has high face validity.
2. Validate model assumptions.
3. Compare the model input-output transformations to corresponding input-output transformations for the real system.

FACE VALIDITY

• The first goal of the simulation modeler is to construct a model that appears reasonable on its face to model users and others who are knowledgeable about the real system being simulated.

• The users of a model should be involved in model construction from its conceptualization to its implementation to ensure that a high degree of realism is built into the model through reasonable assumptions regarding system structure, and reliable data.

• Another advantage of user involvement is the increase in the models perceived validity or credibility without which manager will not be willing to trust simulation results as the basis for decision making.

• Sensitivity analysis can also be used to check model's face validity.

• The model user is asked if the model behaves in the expected way when one or more input variables is changed.

• Based on experience and observations on the real system the model user and model builder would probably have some notion at least of the direction of change in model output when an input variable is increased or decreased.

• The model builder must attempt to choose the most critical input variables for testing if it is too expensive or time consuming to: vary all input variables.

Validation of Model Assumptions

• Model assumptions fall into two general classes: structural assumptions and data assumptions.

• Structural assumptions involve questions of how the system operates and usually involve simplification and abstractions of reality.

• For example, consider the customer queuing and service facility in a bank. Customers may form one line, or there may be an individual line for each teller. If there are many lines, customers may be served strictly on a first-come, first-served basis, or some customers may change lines if one is moving faster. The number of tellers may be fixed or variable. These structural assumptions should be verified by actual observation during appropriate time periods together with discussions with managers and tellers regarding bank policies and actual implementation of these policies.

• Data assumptions should be based on the collection of reliable data and correct statistical analysis of the data.

Validating Input-Output Transformation

• In this phase of validation process the model is viewed as input –output transformation.

• That is, the model accepts the values of input parameters and transforms these inputs into output measure of performance. It is this correspondence that is being validated.

• Instead of validating the model input-output transformation by predicting the future, the modeler may use past historical data which has been served for validation purposes that is, if one set has been used to develop calibrate the model, its recommended that a separate data test be used as final validation test.

• Thus accurate ― prediction of the past‖ may replace prediction of the future for purpose of validating the future.

• A necessary condition for input-output transformation is that some version of the system under study exists so that the system data under at least one set of input condition can be collected to compare to model prediction.

• If the system is in planning stage and no system operating data can be collected, complete input-output validation is not possible.

• Validation increases modeler‘s confidence that the model of existing system is accurate.

• Changes in the computerized representation of the system, ranging from relatively minor to relatively major include :

1: Minor changes of single numerical parameters such as speed of the machine, arrival rate of the customer etc.

2: Minor changes of the form of a statistical distribution such as distribution of service time or a time to failure of a machine.

3: Major changes in the logical structure of a subsystem such as change in queue discipline for waiting-line model, or a change in the scheduling rule for a job shop model.

4: Major changes involving a different design for the new system such as computerized inventory control system replacing a non computerized system .

5 Consider the following inter arrival times and service times. Using time advance algorithm prepare a simulation table based on the following activities and stop the Simulation when clock reaches 20. [10] CO2 L3

Inter arrival Time	3	2	6	2	4	5
Service Time	2	5	5	8	4	5

Solution:

[10] CO2 L3

-For defining the system states like LQ(t),LS(t) – 2M
-For defining the Future Event List-4M
-For Updating the Cumulative statistics like B and MQ-2M
-For Simulation table defining all the above entities-2M

Clock	System State		Future Event List	Comments	Cumulative Statistics	
	LQ(t)	LS(t)			B	MQ
0	0	1	(D,2)(A,3)(E,20)	1st Customer arrived	0	0
2	0	0	(A,3)(E,20)	1st Customer departured	2	0
3	0	1	(A,5)(D,8)(E,20)	2nd Customer arrived	2	0
5	1	1	(D,8)(A,11)(E,20)	3rd Customer Arrived	4	1
8	0	1	(A,11)(D,13)(E,20)	2nd Customer Departured	7	1
11	1	1	(A,13)(D,13)(E,20)	4th Customer Arrived	10	1
13	1	1	(A,17)(D,21)(E,20)	5th Customer Arrived & 3rd Customer Departured	12	1
17	2	1	(A,21)(D,21)(E,20)	6th Customer Arrived	16	2
20	2	1	(A,21)(D,21)	End of simulation time	19	2

6. One Company uses 6 trucks to haul manganese ore from kolar to its industry. There are two loaders to load truck, After loading a truck moves to the weighing scale to be weighed. The queue discipline is FIFO. When it is weighed a truck travels to the industry and returns to the loader queue. The distribution of loading time, weighing time and travelling time are as follows.

Loading Time	10	5	5	10	15	10	10	10
Weighing Time	12	12	12	16	12	16	12	
Travel Time	60	100	40	40	80	60		

Estimate Loader Utilization and Scale Utilization. Assume that 5 trucks are at the loaders and 1 is at the scale at time “0”. Stopping time T=76 min.

Solution:

[Main Simulation table:8M]

Clock (t)	LQ(t)	L(t)	WQ (t)	W(t)	Loader Queue	Weigh Queue	FEL	BL	BS
0	3	2	0	1	DT4 DT5 DT6		(EL,5,DT3) (EL,10,DT2) (EL,12,DT1)	0	0
5	2	2	1	1	DT5 DT6	DT3	(EL,10,DT2) (EL,5+5,DT4) (EL,12,DT1)	10	5
10	1	2	2	1	DT6	DT3 DT2	(EL,10,DT4) (EL,12,DT1) (EL,10+10, DT5)	20	10
10	0	2	3	1		DT3 DT2 DT4	(EL,12,DT1) (EL,20,DT5) (EL,10+15, DT6)	20	10
12	0	2	2	1		DT2 DT4	(EL,20,DT5) (EL,12+12, DT3) (EL,25,DT6) (ALQ,12+60,DT1)	24	12
20	0	1	3	1		DT2 DT4 DT5	(EW,24,DT3) (EL,25,DT6) (ALQ,72,DT1)	40	20
24	0	1	2	1		Dt4 DT5	(EL,25,DT6) (EL,24+12, DT2) (ALQ,72,DT1) (ALQ,24+100,DT3)	44	24
25	0	0	3	1		DT4 Dt5 DT6	(EW,36,DT2) (ALQ,72,DT1) (ALQ,124,DT3)	45	25

36	0	0	2	1		DT5 DT6	(EW,36+16, DT4) (ALQ,72,DT 1) (ALQ,36+40 ,DT2) (ALQ,124,D T3)	45	36
52	0	0	1	1		DT6	(EW,52+12, DT5) (ALQ,72,DT 1) (ALQ,76,DT 2) (ALQ,52+40 ,DT4) (ALQ,124,D T3)	45	52
64	0	0	0	1			(ALQ,72,DT 1) (ALQ,76,DT 2) (EW,64+16, DT6) (ALQ,92,DT 4) (ALQ,124,D T3) (ALQ,64+80 ,DT5)	45	64
72	0	1	0	1			(ALQ,76,DT 2) (EW,80,DT6) (EL,72+10, DT1) (ALQ,92,DT 4) (ALQ,124,D T3) (ALQ,144,D T5)	45	72
76	0	2	0	1			(EW,80,DT6) (EL,82,DT1) (EL,76+10, DT2) (ALQ,92,DT 4) (ALQ,124,D T3) (ALQ,144,D	49	76

							T5)		

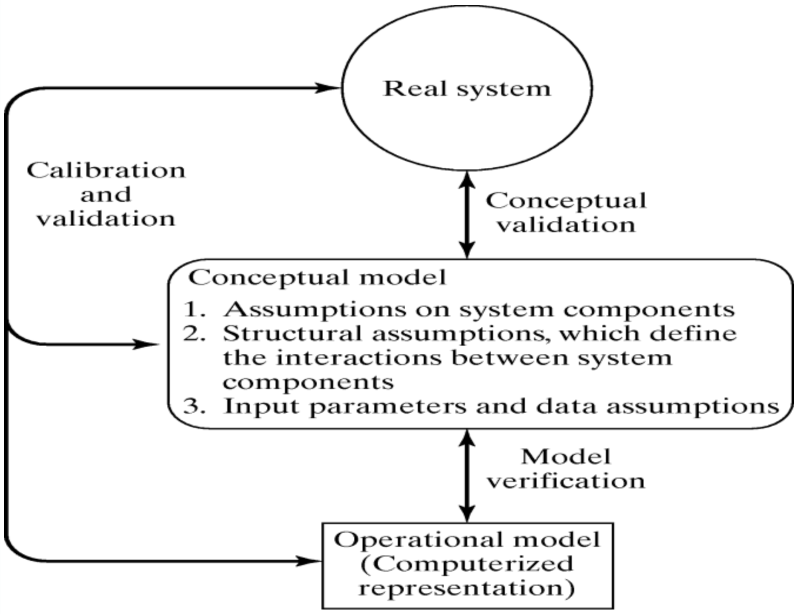
Average Loader Utilization, Scale Utilization-2M

Average Loader Utilization = (49/2)/76 = 0.32
Average Scale Utilization = 76/76 = 1

7	Discuss with the help of neat diagram model building, verification & validation.	[10]	CO6	L1

Solution:

Figure:3M,Explanation:7M=10M



The first step in model building consists of observing the real system and the interactions among its various components and collecting data on its behavior.

• Operators, technicians, repair and maintenance personnel, engineers, supervisors, and managers under certain aspects of the system which may be unfamiliar to others.

• As model development proceeds, new questions may arise, and the model developers will return, to this step of learning true system structure and behavior.

• The second step in model building is the construction of a conceptual model – a collection of assumptions on the components and the structure of the system, plus hypotheses on the values of model input parameters, illustrated by the following figure.

• The third step is the translation of the operational model into a computer recognizable form- the computerized model.

Verification of Simulation Models

• The purpose of model verification is to assure that the conceptual model is reflected accurately in the computerized representation.

• The conceptual model quite often involves some degree of abstraction about system operations, or some amount of simplification of actual operations.

Many suggestions can be given for use in the verification process:-
1: Have the computerized representation checked by someone other than its developer.

2: Make a flow diagram which includes each logically possible action a system can take when an event occurs, and follow the model logic for each a for each action for each event type.

3: Closely examine the model output for reasonableness under a variety of settings of Input parameters.

4. Have the computerized representation print the input parameters at the end of the Simulation to be sure that these parameter values have not been changed inadvertently.

5. Make the computerized representation of self-documenting as possible.

6. If the computerized representation is animated, verify that what is seen in the animation imitates the actual system.

7. The interactive run controller (IRC) or debugger is an essential component of successful simulation model building. Even the best of simulation analysts makes mistakes or commits logical errors when building a model. The IRC assists in finding and correcting those errors in the follow ways:

(a) The simulation can be monitored as it progresses.

(b) Attention can be focused on a particular line of logic or multiple lines of logic that constitute a procedure or a particular entity.

(c) Values of selected model components can be observed. When the simulation has paused, the current value or status of variables, attributes, queues, resources, counters, etc., can be observed.

8	Discuss output analysis for terminating simulation in detail.	CO5	L2

Solution:

Explanation-10M

Types of simulations with respect to output analysis :

There are 2 types of simulations

1. Terminating simulations
2. Steady state simulations

A terminating simulation is one that runs for some duration of time T_E where E is the specified event that stops the simulation

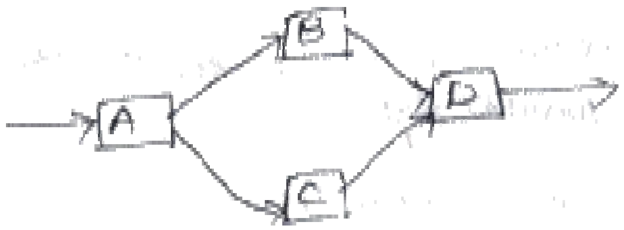
Ex :- A retail shop closes every evening from which it opens from 9 am to 5 pm.

L Here E = atleast 7 hours of time has been used

2) A company which sells a product would like to decide how many items to have in inventory during planning for 100 months.

L Here E = 100 months .

3) A communication system consists of several components plus several backup components, as in fig.



Here E = consider the system over a period of time T_E until system fails.

E = {A fails, (or) D fails (or) B and C fails}

- In this case we cannot predict E in advance bcz we do not knows when the component fails

Ex :- Telephone and other communication systems like Internet, hospital emergency rooms, fire departments, police dispatching and patrolling operations.

→ Non terminating systems are also called steady state simulations.

Ex :- consider a manufacturing process running continuously from monday morning to saturday morning begining with the second shift. It is desired to estimate long run production levels and production efficiencies

↳ Here to estimate long run performance the analyst could decide to simulate for any length of time T_E (13 shifts (or) longer). Here T_E cannot be determined by the nature of the problem as it was in terminating simulations.