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Discrete Event Monte-Carlo Simulation of Business Process for Capacity Planning: A Case Study

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Abstract:

Strategic capacity planning is generally done using static mathematical analysis. Simulation of operational scenarios during capacity planning provides more insights into the real system behavior. This ensures better preparedness to handle operations. This case study demonstrates the benefits of discrete event Monte-Carlo simulation of business process over simple mathematical analysis for capacity planning.

Introduction:

Simulation, traditionally associated with Operations Research, is used as a planning tool to support strategic decision making. Using simulation an attempt is made to model the system and generate several representative scenarios to see how the system works. While simulation is an important aspect in design of products, engineering processes and systems, business process simulation (BPS) is just becoming popular.

The simulation of business process is similar to simulation of other discrete event processes. Most business processes are dynamic and interrelated and over time become very complex and simple spread-sheet analysis does not provide enough confidence for basing strategic decisions. While managers have many hypotheses/hunches for changing business processes based on their experience, intuitively selecting a process may sometimes lead to lower performance instead of any improvement. Simulation enables examination and testing of decisions prior to actually making them in the "real" environment.

Process simulation involves a series of activities like creating business process map/ model, collecting data on model parameters like cost/time, conducting experiments, and comparing result (Aguilar 1999, Tumay 1995). The business problem and the solution space should be understood before attempting to model the process. The problem and solution space gives an idea about the facets of a business process to be modeled.

Business Process Simulation Model

First requirement of process simulation is modeling the business process. The process model at a basic level is a diagram showing ordered sequence of activities with work flow control. The activities consume resources and take time to execute. The resources (say manpower or machine) involved in the process have a cost and become busy when they are working on a task. If resource can handle one job at a time, which is generally the case, then sometimes jobs will wait if resources are not available. In

general all the activities can have queues of waiting jobs. The information of cost and time for process activities is represented as probability distributions in the process model.

Second task is to allocate resources (type and number) to activities. The resources will be available for work as per some schedule. Say an operator is available from 08:00 hrs to 12:00 hrs and from 13:00 hrs to 17:00 hrs.

Third task is to schedule the customer (or job/token) arrival in the process, which primarily represents the number of instances of the process execution and their frequency. A process instance may be triggered by a random event, say break down of a machine triggers breakdown maintenance; a fixed time, say every day at 6 PM make summary of all the cash flow from all operations in a bank branch; or job flow, say after every 50 pieces are made, check the quality of one piece.

These three steps create a simulation model which can now be simulated in a BPS tool. The BPS tool will simulate the token arrival, the flow of tokens (work/tasks) between activities from start to end based on the simulation model. The BPS tool executes a series of sub-runs of the modeled system to simulate the outcomes of the process as in real-life scenario. The token arrival time, waiting time, resource used, process cycle time etc are recorded which are used to estimate process performance.

A series of experiments are needed to simulate "what-if" scenarios. We may alter resource allocation, work allocation in different activities or operating policies to create scenarios of interest. The insights about process performance, gathered in simulation, helps in understanding the behavior of business processes and helps in decision making related to process design, capacity planning, resource utilization process policies etc.

Business process simulation with its obvious benefits has many challenges which have hindered its adoption by business analysts and process owners (Hlupic 2000). It requires business process models to be recreated in the BPS tool instead of being able to reuse existing models and process data. It is difficult to model resources accurately and to the detail required, as it involves extensive data analysis and skilled knowledge to infer from historic data. Most process simulation models focus on the steady state of the process rather than transient, and exception scenarios. In spite of the capability for dynamic analysis, it is used as a static analysis tool. Simulation is used as a design tool and not as a decision support tool by managers, due to the challenge of linking the simulation model to the runtime process data.

Typical scenarios recommended for usage of simulation are automation of complex business processes, large scale implementation of enterprise systems or BPM systems. While in most cases the effort to gather data and build simulation models is justifiable in some scenarios it is not suitable or even possible to simulate.

Next we discuss a case when business process simulation is done to assist in decision making.

Case Study of Business Process Simulation

Background-

A pharmaceutical company is planning to set up a tele-calling centre in India. This company has a treatment called Peritoneal Dialysis for people with chronic kidney disease and end-stage renal disease. In this treatment the patient uses a machine and some chemicals to do dialysis at home. The company supplies the machine and the chemicals, provides training in its use and addresses any complaints about the machine and the supply of chemicals.

The key success factors in the business is retention of patients on the therapy for a long duration of time especially the peritoneal dialysis patient where the company breaks even when the patient continues therapy for at least 7 months. People in India speak many languages so multilingual call centre is needed.

To facilitate acquisition of new patients and retention of existing patients, the renal business unit in India is structured in two teams, the Acquisition team and the therapy services team both reporting to the Renal Business unit director.

I.   Acquisition teams primarily visits physicians and consultants to promote products and generate prescription for new patients they also ensure uninhibited availability of medicines and disposables at the various retail & hospital outlets.

II.   Therapy services team headed by national therapy services manager is primarily responsible for visiting the peritoneal dialysis patients at their home / place of nursing and assist them in learning proper self administration of therapy, they also help the patient in trouble shooting and assisting in case of drug/disposable availability issues, this is a critical process in the value chain as it ensures proper drug administration and hence better efficacy outcomes , In turn it helps in developing stronger connect with the patient and motivates the concerned physician to prescribe higher share to company's brand in relation to competition.

The business volume of Peritoneal Dialysis is directly related to the number of patients acquired and retained. The unit follows a strategy of planning the number of patients it needs to maintain for achieving its financial objective. In 2008 the company had 10000 patients on Peritoneal Dialysis therapy. This number is expected to grow at a CAGR of 15% in the next five years.

Challenge

The company employs field people, called Clinical Coordinators to visit the patients, train them and take care of their problems. One Clinical Coordinators covers on an average 40 patients. The current sanctioned Clinical Coordinators' strength of 95 poses a serious problem in the growth.

The problem

The company wants to start a tele-centre. This will reduce load on Clinical Coordinators and now one Clinical Coordinator will be able to handle 75 patients. How many people should be hired for the TELE centre? What should be there language composition? What operational policy should be adopted, like shift duty or only day duty? How much will be the net gain or loss from this tele-centre project?

Data Collected

DATA on WORKLOAD

We need to know how many patients will call at the call centre and how much time a patient will take they will take so that we can know the staffing level required.

The company mangers did a mock trial and they expect a patient calls takes an average of 7 minutes with standard deviation of 4 min.

INBOUND CALLS

On the basis of its experience in managing patients the company expects three types of inbound calls which would address most of the patient requirements

1. Old patient calls – In the year 2008 old patients are expected to call up the centre for

a)- Peritonitis- Average 300 Patients/Mth , 2calls/Mth. (=600 calls per month)

b)- Mechanical Problems - Average 200 Pts/Mth, 2Calls/Mth (=400 calls per month)

These calls are expected to grow by 15% in 2009, 25% in 2010 and 30% per Annum thereafter.

2. New patient calls- Each new patient enrolled is expected to call up the centre at the time of enrolment in the therapy (=500 Calls per month)

3. Therapy related calls – Across all patients company expects them to call up the centre during 2008 for solutions to

a)   Diet Queries - Average 300pts/Mth , 1call/mth (=300 calls per month)

b)   Distribution query - Average 500pts/Mth , 1call/mth (=500 calls per month)

4. Placement of orders- 2 calls per month per patient (=20000 calls per month)

Total inbound calls= 22300 calls per month or 743 calls per day

With time the awareness level of the service among patients will increase and these calls are expected to grow at a compounding rate of 20% per annum.

The patients are distributed in different states of India. The patients can be divided into a few major language groups. We assume that some people from all the regions also speak English. Linguistics diversity of patients is shown below.

Table: Distribution of patients according to linguistic and geographic regions

Sl. No.	Region	Language	%
1.	UP, RJ, MP, BR, DL, HR, HP, JH, UT, CH,GJ, OR (HINDI)	Hindi	43%

2.	WB, ASSAM and NE states- Bengali	Bengali	9%
3.	MH and GOA- Marathi	Marathi	8%
4.	KK	Kannada	6%
5.	KL	Malayalam	3%
6.	AP	Telugu	6%
7.	TN	Tamil	7%
8.	English	English	18%

Static Analysis of manpower requirements

Incoming calls would require average 7 minutes of actual call time and average 1 minute for updating records/ writing mail. Each caller can receive on an average 7.5 calls per hour. Patients generally take a nap in the afternoon so they call more often from 8AM to 12 AM and 3 PM to 7 PM. The call centre will be operational from 6AM to 2 PM and 2 PM to 10PM in two shifts.

This analysis will give us initial starting solution for manpower requirements. Since the requirement is 22300 inbound calls per month. Out of these calls 3/4th comes in peak period and 1/4th comes in non peak period. During peak period call arrival rate is 70 calls per hour (22300*3/4/30/8). During lean period it is 23 calls per hour.

We need 9.33 persons to take calls during peak period. The linguistic division of these employees should be done in the ratio of the patients in those language groups.

Table 1: Linguistic division of employees as per static analysis

Sl. No.	Language	%	Calculated no of people of the language needed	Rounding off to higher side
1.	Hindi	43%	4.01	4
2.	Bengali	9%	0.83	1
3.	Marathi	8%	0.74	1
4.	Kannada	6%	0.56	1
5.	Malayalam	3%	0.28	1
6.	Telugu	6%	0.56	1

7.	Tamil	7%	0.65	1
8.	English	18%	1.67	2
	TOTAL	100%	9.33	12

Simulation

We are concerned about attending all the incoming calls on time during peak period. How many employees should be assigned to the incoming call centre and what should be language composition of these people. What should be language composition of these 18 employees? How much will be the average waiting time for incoming calls?

We use simulation for this information. We start with the preliminary solution as given in the static analysis. The figure below shows the process diagram. A patient calls the centre and based on his preference for language, his call is diverted to corresponding workbench.

We have to find out schedule of employees (RESOURCES), calling pattern of patients (TOKENS) and logical business process diagram (PROCESS MAP)

Token arrival rate for incoming calls during peak period= 70 calls per hour

Mean token arrival rate = 1.166 per minute or 0.857 minutes inter arrival time.

Average Processing time 7 minutes, standard deviation sigma 4 minutes, 1 minute setup time to update the records
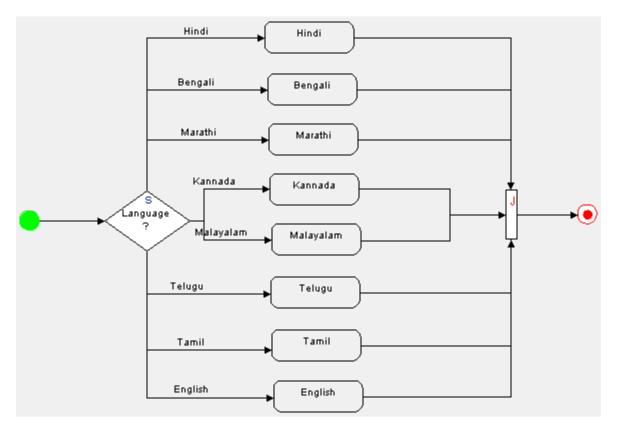
Fig.1: Business process diagram for taking inbound calls at call centre

Resources – Resource utilization- waiting time - iteration one

The starting point for simulation is static analysis results. We take total 12 tele-callers and see the results

Table2: Results of iteration one for peak period

Sl. No.	Language	Total patients in 8 hours peak period	No of tele-callers	Resource utilization in %	Maximum waiting time in Minutes	Average waiting time in Minutes
1.	Hindi	218	4	88%	95	46.23
2.	Bengali	48	1	76%	32	9.612
3.	Marathi	45	1	72%	59	16
4.	Kannada	30	1	50%	22	3.839
5.	Malayalam	13	1	19%	7	0.643

6.	Telugu	29	1	44%	18	4.414
7.	Tamil	47	1	76%	55	19.312
8.	English	110	2	81%	41	18.589
	TOTAL	540	12	71%		27.2

This shows that maximum waiting time and average waiting time for Hindi, Bengali, Marathi, Tamil and English are unacceptable. Increasing the resources in these work benches and running the simulation again gives us the results as shown in the table below.

Table 3: second iteration for simulation after increasing resources

Sl. No.	Language	Total patients in 8 hours peak period	No of tele-callers	Resource utilization in %	Maximum waiting time (min)	Average waiting time (min)
1.	Hindi	250	5	74%	12	2.2
2.	Bengali	47	2	34%	9	0.6
3.	Marathi	46	2	34%	5	0.5
4.	Kannada	21	1	29%	11	1.5
5.	Malayalam	10	1	18%	0	0
6.	Telugu	27	1	45%	23	2.8
7.	Tamil	35	2	26%	2	0.1
8.	English	111	3	58%	12	0.8
	TOTAL	547	17	48%		1.5

In second iteration we observe that maximum waiting time and average waiting time are acceptable but utilization of Hindi speaking tele-callers is more while utilization of other languages is very less and only 18% utilization for Malayalam. This gives an opportunity to try a different strategy. Can we have tele-callers who are fluent in two languages. We try with the following combination and run the simulation again.

Table 4: Results of third iteration

Sl. No.	Language	Total patients in 8 hours peak period	No of tele-callers	Resource utilization in %	Maximum waiting time	Average waiting time
1.	Hindi	212	5	73%	11	2.52
5.	Malayalam	20			10	1.45
2.	Bengali	48	4	38%	6	0.55
4.	Kannada	36			5	0.24
3.	Marathi	46	3	42%	6	0.58
7.	Tamil	40			12	1.12
6.	Telugu	35	3	53%	6	0.85
8.	English	102			6	0.63
	TOTAL	539	15	54%		1.44

The results in table above shows a marked improvement in utilization at the same time average waiting time and maximum waiting time are as good as in second iteration.

Discussion

The case is written to highlight a few aspects. Static analysis was not sufficiently capturing the complexity of the business process. The results of iteration 1 suggested that we need more resources because of dynamic nature and distribution of customer arrival. The results of iteration 2 gave us reasonable waiting time for customer but leads to under-utilization of resources.

Since we simulated and saw the results in more detail we could develop a new hypothesis that we can improve the utilization by clubbing language groups. We got an opportunity to test the hypothesis also. We can attribute this hypothesis to the two simulation runs.

In this case we simulated only for peak period in both the shifts. System performance in Lean period in both the shift is not of interest. The interest is decided by the business problem and solution space relevant to the problem. It is also observed that there may be a lot of data easily available which may not be used in simulation. The key point is that it should help in decision making. The decision making process involves judgment

based on experience and information. Simulation removes some ambiguities in the judgment. In complex situations, simulation gives reasonable confidence to act.

Conclusion

The value of simulation lies in accuracy of modeling, adequate detailing in the model, ability to capture what if scenarios and predicting performance of the real life system before doing costly implementation. Generally process simulation is used by business analysts as a design time tool. But it can also be used by operational managers in runtime environment as discussed. Many business problems are suitable for simulation including designing supply chain, vehicle routing, warehousing location, just in time or lean manufacturing, capacity planning, processes outsourcing/ relocation, flexible automation decisions, manpower requirement planning, production scheduling optimization, e-governance process improvements and work task allocation among workbenches, etc.

Business process simulation can act as a bridge between methodologies like Six Sigma and Lean which focus on use of quantitative data for process improvements and BPM methodologies covering process modeling, orchestration and execution.

With the increasing adoption of BPM in enterprises, process models and process execution data is available which can be leveraged for BPS. Business Process simulation requires certain skills and systems which need to be acquired before implementation. Once an initiation investment in creating process models, guidelines and templates for simulation model is made, Process analysts and business managers can be trained to use BPS to achieve higher confidence in process design, planning and decision making.

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