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Discrete Event Monte-Carlo Simulation Based Decision Support System for Business Process Management

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ABSTRACT

This paper presents a discrete event Monte-Carlo simulation based decision support system (DSS), which helps in managing business processes. Process managers use available information on work load, resource availability, task time, etc. and use their experience to predict the performance of the process and take corrective action, if required. We describe here a method and a system which takes available information about work load, and resource availability, to predict near future system performance using discrete event simulation, and compares the expected performance with desired service level and alerts the manager to take corrective action. The DSS assists operational managers in handling more complexity in decision making. This paper describes the framework for design of such a system which can be used in conjunction to a business process Management system.

Keywords

Decision Support System, Monte-Carlo Simulation, Run-time Simulation, and Business Process Management.

INTRODUCTION

Business processes are being executed and managed using specialized business process management systems (Van der Aalst, Hofstede, Benatallah and Paik 2003). These systems manage the work flow across activity centers. Under normal circumstances, when resources available to execute the activities are slightly more than that required for the jobs, the systems function optimally. In all other circumstances either the resources are underutilized or jobs keep waiting. Both the cases need managerial intervention. When we observe managerial work, we realize that managers take decisions under uncertainty and with insufficient information. Even when they have reasonably good and detailed information, the bounded rationality may prevent them from taking into account the process complexities. To handle more complexities, managers make thumb rules. These thumb rules reduce the complexity of the relationships between these variables, but give less accurate results. It has been observed that some conservative managers over estimate work load and hesitate to grant leave to operators. While others may under estimate work load and staff less which may lead to long queues and high waiting times.

Using simulation, it is possible to handle the complexities encountered in process management and thus improve the quality of decision making. For processes being executed on Business process Management (BPM) systems, the data about pending jobs, resources, processing time etc., is available and can be used to predict near term process performance (using business process simulation). Managers can use this tool and their experience to take corrective actions (Melao and Pidd 2003). Many of the available BPM products have business process simulation (BPS) features (Jansen- Vullers and Netjes 2006). Most of these BPS tools support process design activities and have features to take in historical process execution data from the BPM systems. We propose a tool with features which can be customized during BPM implementation to provide decision making support for operational managers of business processes. As our problem suggests the tool should be able to handle practical operational scenarios like slack, leave plans, work allocation policies, back log, overtime, etc.

RESEARCH METHOD

The paper reflects the authors' observation of manager's work in process operations. The authors observed managers of three business process outsourcing units very closely (Bhat, Fernandez, Kumar, Goel 2009). These units used Business Process Management software for managing some parts of their operations. The authors demonstrated the capabilities of simulation software to the managers and explored how these capabilities can help them. A literature survey revealed other cases where simulation was used in shop floor control systems to predict system behavior using the current status and was used for "look ahead" scheduling (Drake, Smith and Peters 1995; Smith, J. R. Wysk, D. Sturrock, S. Ramaswamy, G. Smith, and S. Joshi 2009). Further Wynn M.T., M. Dumas, C.J. Fidge, A.H.M. ter Hofstede, and W.M.P. van der Aalst (2008) have put forth the capabilities required for the process simulation environment to be able to support operational decision support over already deployed and running processes within a BPM system.

Based on the discussions, observations of process work and inputs from existing research on using simulation in decision support we evolved a framework for a simulation based system, which can help managers in decision making and managing their processes better. This framework is elaborated further so that it can be implemented in a generic software tool.

FRAMEWORK FOR DECISION MAKING IN BUSINESS PROCESS OPERATIONS

A decision support system for business operations needs to provide capabilities like process performance forecast, resource estimates and process changes required to meet goals, predict ability to meet a goal based on current state of process execution, process optimization for optimal usage of resources, etc. The various modules of a system which can cater to these needs are described in the following sections.

Performance Forecast

A business manager first observes previous shift's pending work, new shift's expected work load, resource availability and the activities in the process to estimate process performance. If the process performance does not meet performance targets or service level agreements (SLA), he tries to reconfigure the resource distribution. Sometimes managers change the priority of jobs and may keep some jobs pending while managing to complete others on time. Figure 1 describes the framework for decision making and performance forecasting.

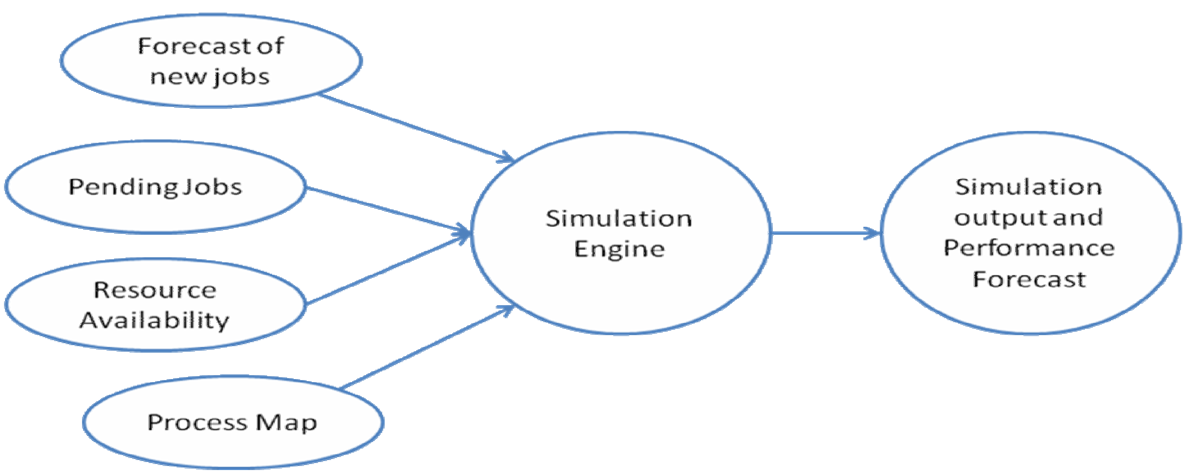

Figure 1: Framework for decision making in business process operations management

We explore the various components in Figure 1 to derive the detailed requirements below,

Forecast of New Jobs

Forecast of new jobs is done by experience in manual systems. If sufficient data exist then forecasting can be automated to some extent. Forecasting may depend on time series data, some external factors in cause-effect relationship, or it can be taken by aggregating estimates from experts. Figure 2 describes forecasting requirements.

A generalized forecasting module should take all these into account and provide the operations manager with a rider to correct/ adjust the calculated figure. The job creation can be done randomly using exponential distribution or other distribution or new job arrival time can be submitted using a table.

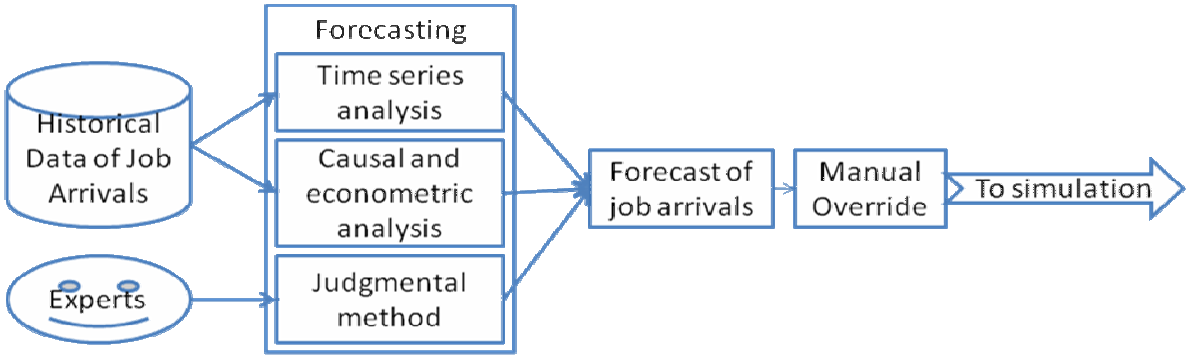

Figure 2: Forecast of job creation for simulation for specified time frame

Pending Jobs

Pending jobs are available in the business process execution system. The number of jobs pending at each activity place and their priority need to be transferred to simulation system. Jobs under processing and arrival times of all these jobs need to be supplied to the simulation system. Figure 3 gives a schematic diagram of the pending jobs to be used in simulation.

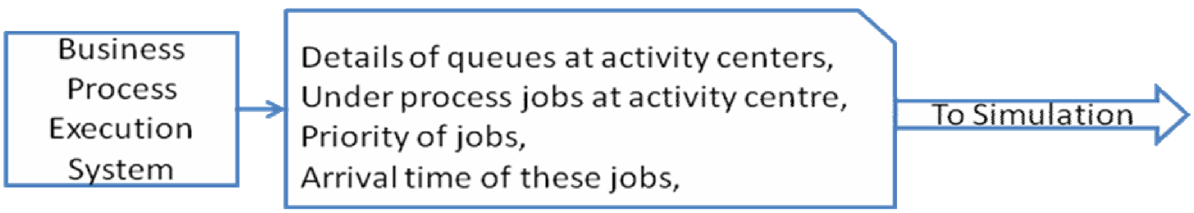

Figure 3: Pending jobs at activity points

Availability of Resources

Employees are the most common resources which need to be modeled in business process simulation. Employees may not be available for work, due to sickness, leave or any other cause, or they may be doing some other one off kind of task and not deployed on the business process under consideration. Managing employees and looking after their deployment is the primary concern of operations managers. The attendance and work allocation of employees may be done manually, or through some computer application, it will need fine tuning and options to change. Efficiency of employees is not uniform, but increases (to some extent) if more work is to be finished in less time. Sometimes for short durations employees can increase their productivity. Tarumi, H., Matsuyama, T., and Kambayashi, Y. (1999) divide the employees into four categories, like lazy, fast, concurrent etc. Resource module should be able to simulate resources individually. The user of the simulation module should be able to change the resource count, efficiency and resource type. Machines, work stations etc are also resources that need to be modeled. But if these things are relatively constant over time, then it can be incorporated in the process map. Since the reliability of office machines and computers is generally very high, the complexity of simulation can be reduced by incorporating them in the process model. User acceptance of the simulation system will depend on its usability and ease of learning and hence the system should not be complicated unnecessarily. Only the components that are needed most of the time should be planned in the simulation tool. Figure 4 gives a schematic diagram of resource module.

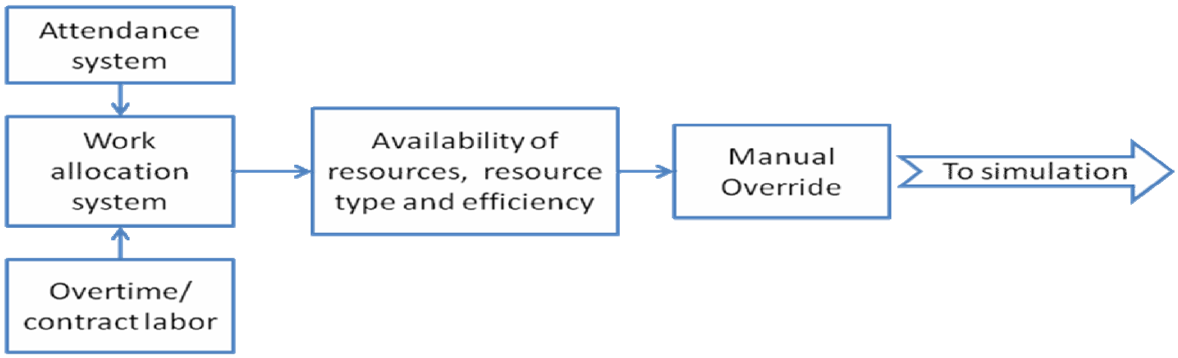

Figure 4: Resource availability module

Process Map

The process Map needs some modifications when used for simulation. The simulation starts with questions and issues whose answers are being sought. The simulation model can be slightly different from that of the process execution model. The tool should provide mechanisms by which the process execution model can be scaled down for simulation, so that users are motivated to use the simulation system.

Goal seek

Business process Managers have other requirements which helps them in decision making. One such requirement is the 'Goal Seek' facility. Typical questions faced by managers are of the type- 'How much resources will be needed to get average turnaround time of Y hrs, given that job arrival rate is N per hour.' Such questions cannot be handled by Monte Carlo simulation, but can be answered analytically. The process model needs to be an analytical model. The generalized model for goal seek will be set parameter Y (one of the process outcome variable) to some value by changing parameter X (an input variable). The system needs to support the ability to create the analytical model for the process model and calculate the input variables based on the output parameters.

Queue Modeling

Every activity which consumes some resource has a queue whenever the resource is busy and cannot attend to a job immediately when the job arrives. Usually queues are first in first out (FIFO), but other queue processing types are last in first out (LIFO), or priority based. Priority is based on the type of token. If the credit card lost complaints and credit card billing issues are handled by the same set of resources, we may give high priority to credit card lost complaints. Sometimes some requests may come from important/influential customers (say senators); they may be given higher priority.

Another queue management problem is related to the same resources or a set of resources handling two or more activities. Both the activities may have queues, and activity will be done first and how it can be modeled gives a few more options. For scheduling purpose, it can be considered a joint queue and the token that came first at any activity can be handled first, or activity 1 queue always takes priority over activity 2 queue, or it is based on token type, important token vs. less important token, followed by activity priority.

Optimizer Module

Many a times, same level of SLA can be achieved by more than one option. For example, say there are two activities to be done in series to complete a business process. If we want to achieve the SLA of a service time we can reduce activity 1 service time and increase activity 2 service time. This may lead to consumption of more/ better resources at activity 1 and poor/ less resources at activity 2. Operations manager may like to optimize total cost of resources at activity 1 and 2, while trying to meet the SLA.

Generally optimization and simulation are run sequentially. We optimize the function whose value is calculated using simulation (Andradottir 1998). It should minimize or maximize a function. The function can be dependent on any outcome of simulation result and any input to simulation. There should be facility to write constraints. The variables that can be changed are the input values to the simulation.

Output Module

The outputs of interest are SLAs, maximum turnaround time, 90th and 95th percentile of turnaround time etc. The output parameters should have check boxes, so that user can get only those variables which are of interest to him. SLAs are indexes which can be a combination of a few output parameters. Figure 5 describes output module.

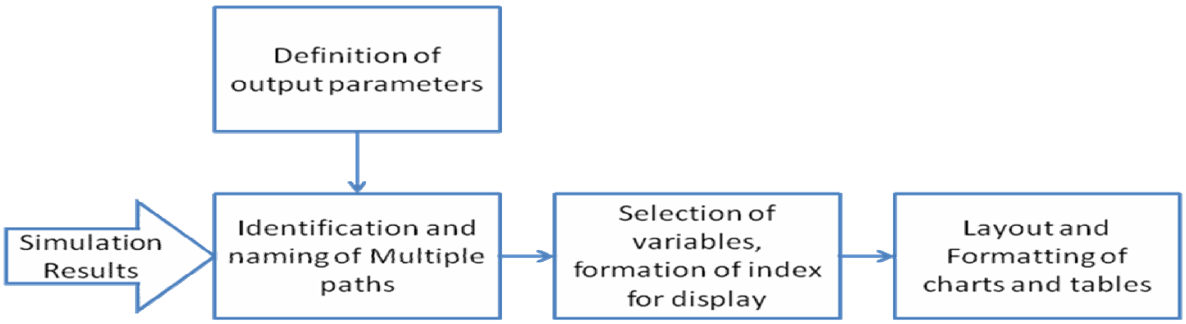

Figure 5: Output Module

Analysis of multiple paths

The token may move in more than one path and managers may be interested in knowing simulation results based on paths also, say 10% works are audited. A sequence of activities from start to end gives a path. Different paths can be named. The outputs parameters should be displayed for these paths.

The functionality should include path identification, naming of paths and selection of outputs to be displayed for the paths.

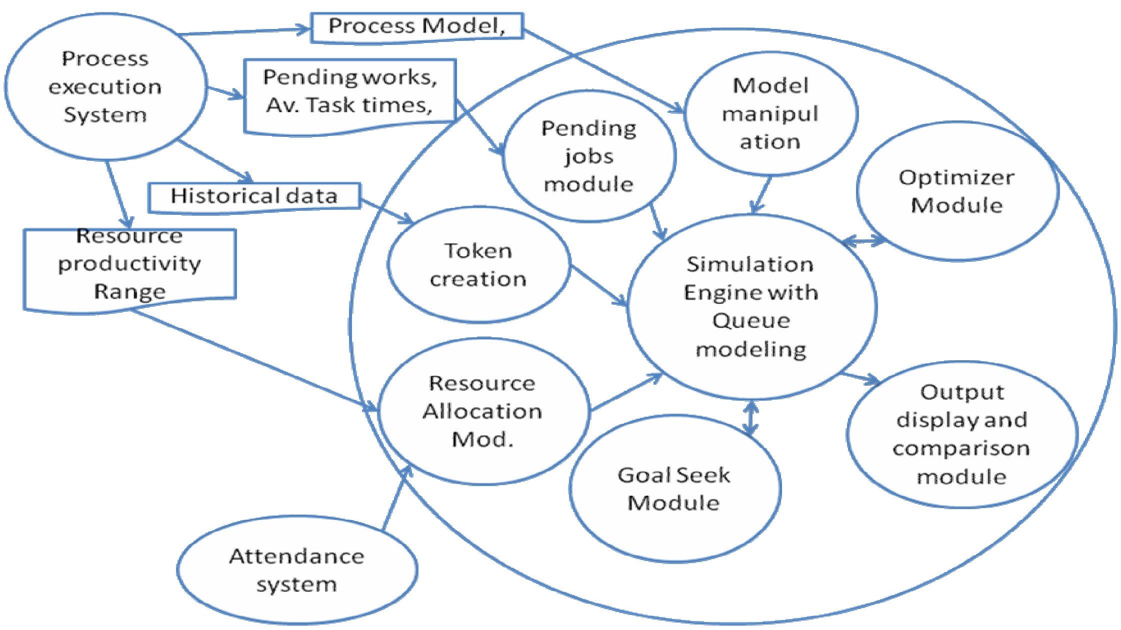

Figure 6: Schematic diagram of simulation system for operations management of business process.

By integrating all the modules detailed above we get the requirements as in figure 6. Goal seek and optimizer will be plug-ins to the simulation engine. Token creation module will take care of new job arrivals. Pending jobs will be fetched from process execution system. Resource allocation module will take inputs from any attendance system and productivity data and productivity range from process execution system. Productivity range is necessary because during heavy work load employees work harder and deliver more. Assuming average productivity at all time will not be practically correct. This phenomenon is commonly observed but not discussed in simulation of human behavior.

CONCLUSION

Simulation is generally not used by operations managers. Simulation tools are very complex for them and it does not solve their problems directly. A simulation system which can handle more complexity, can estimate the near future performance without expecting statistical knowledge from the users may find user acceptance. We have developed the requirements for a generic tool, which can be customized and handed over to operations managers at the time of BPM systems implementation. Each module explained above has been tested out by conducting a proof of concept using spreadsheets and manual calculations. We have found the results to be acceptable to the business managers. An integrated system offering all the functionality described in the framework has to be piloted with users and refined based on results. Another challenge for such a system is to ensure it is high on usability and the learning curve is kept minimum. We are currently in the process of developing such a system. The simulation system will take one or two rounds of user trials and refinement before getting accepted by process managers.

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