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SIMULATION MODELING--A FIRST-TIME MODELER'S EXPERIENCE

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ABSTRACT

This paper illustrates the steps in simulation model development and discusses interpretation of model output. It shows how a model can assist in answering existing questions and provide the framework for formulating and testing new hypotheses.

1 INTRODUCTION

Simulation modeling addresses the issue of variability in patient arrival patterns and in distributions of procedure times. Although the mean time yields a convenient, single-number estimator, it ignores the impact of variation in patient arrival times, procedure times, and delays associated with mismatches between arrival rates and service times--service complete and next patient unavailable or arrivals too frequent for the service configuration.

A model of the pre-op screening process of a same day surgery unit (SDSU) was written in SLAM II, Version 4.0, the simulation modeling language by Pritsker (1986). The discussion will cover six aspects of the modeling process: 1)the assumptions document, 2)process description, 3)the model, 4)model output, 5)results and conclusions, and 6)next steps.

2 ASSUMPTIONS DOCUMENT

All simulation modeling projects should begin with an assumptions document which identifies the initial purpose, scope, and expected outcomes. The document should contain a flow chart depicting the level of detail desired. The document should be updated periodically to reflect the latest status of the project. It provides a chronology of the modifications to original assumptions and the key decision points occurring within the project. The assumptions document serves as the principal reference for those involved in the project and as the basis for final report preparation.

3 PROCESS DESCRIPTION

The registrar presently registers all pre-op SDSU patients at arrival. One of three physician's assistants (PAs) reviews the chart, completes a history and physical, and refers the patient to a nurse for EKG and/or lab tests (82%). If the patient brings required test results (18%), the PA does a nursing assessment and the patient exits without seeing the nurse. Approximately 12% of patients seen by the nurse will also require a physician consult.

4 THE MODEL

The simulation model contains approximately 300 lines of code including comment lines. The code consists of two basic types of program statements--control statements and network statements. Control statements assign the general operating characteristics of the program and network statements describe the particular process being modeled.

Actual patient arrival and service times were collected by nursing and subsequently identified as exponential and lognormal distributions respectively. Uniform distributions were used for consult wait and service times.

Patients are created based on their arrival time distributions and introduced into the model during a 450 minute (7.5 hours) time-span. No new patients are generated after 450 minutes, but the model clock continues to run until all patients have exited the model.

Patients are routed through the model conditionally by attribute type or by previously established probabilities. Patient service times are determined by sampling from service time distributions.

5 MODEL OUTPUT

The SLAM II default output consists of four sections titled: 1)Statistics For Variables Based On Observation, 2)File Statistics, 3)Regular Activity Statistics, and 4)Resource Statistics.

The first sections summarize the results of a particular run providing the overall clock time; the mean, minimum, and maximum values of each type of activity; and the number of observations in each category. The file statistics section includes statistics on average, maximum, and current line length and average wait time. The regular activity and resource statistics sections show average, maximum, and current utilization and entity counts. Review of the results in each section indicates whether the model is behaving as intended.

A scan of the four sections should include, but not be limited to answers to the following questions: 1)Did the model create the expected number of patients? 2)Does the total number of patients created equal the total number that exited? 3)Did routing occur at expected levels? 4)Are the mean service times reasonable? 5)Are all current line lengths zero? If not, patients were left in the model and this was not the intention of the programmer. 6)Are utilization levels what was expected? If not, can they be explained? Has the explanation uncovered a problem which would have gone undetected without simulation? 7)Do utilization statistics in different sections correspond? 8)Did all activity labels print out as programmed?

6 RESULTS AND CONCLUSIONS

A decision was made to move the emergency room (ER) from the general out-patient clinic area to the SDSU area with the proposal that the SDSU registrar register both SDSU and ER patients. The original reason for model development was to assess the impact of the increased workload on the registrar.

Ten runs of the model under initial conditions (without ER registrations) showed the following utilization ranges: registrar, 25% to 43%; PAs, 27% to 71%; and nurse, 27% to 66%. Mean time in system for all patients was 112 minutes. The mean and maximum registration wait minutes were 5.96 and 48.49 respectively. Maximum line length was 4. Results suggested that registrar, PA, and nurse utilization was low.

Ten runs of the model under proposed conditions (with ER registrations) showed these utilization ranges: registrar, 35% to 75%; PAs, 28% to 67%; and nurse, 36% to 65%. Mean time in system for all patients was 120 minutes. The mean and maximum registration wait minutes were 11.69 and 64.80 respectively. Maximum line length was 6.

The model was also run for an extended period (113,850 minutes) under each of the conditions mentioned above. Utilization rates with ER registrations excluded were: registrar, 33%; PAs, 50%, 48%, 50%; and nurse 43% and mean time in system for all patients was 104 minutes. Utilization rates with ER registrations included were: registrar, 60%; PAs, 49%, 48%, 50%; and nurse 44% and mean time in system for all patients was 109 minutes. The mean and maximum registration wait minutes were 3.13 and 65.50 in the model excluding ER registrations and 8.96 and 96.10 in the model including ER registrations. Maximum line length was 5 when ER registrations were excluded and 7 when they were included.

Even with the potential for greater maximum waiting time and increased maximum line length, it was decided to incorporate ER registrations into the SDSU registrar's job. The simulation model provided insights which enabled the project team to better understand and appreciate the dynamics of the process.

7 NEXT STEPS

Review of the model by the project team lead to the formulation of three additional questions: 1)Why is the range in utilization rates so wide? How does scheduling practice influence this? 2)What would be the effect of reducing the number of PAs from three to two? 3)What would be the effect of having the three PAs absorb the nursing function? Space limitations preclude a more detailed examination of the existing model and leave the answers to these questions open for further investigation.

This paper and copies of the poster session display are available by contacting the author.

REFERENCES

Pritsker, A. A. B. 1986 *Introduction to simulation and SLAM II.* 3d ed. New York: Halsted Press.

AUTHOR BIOGRAPHY

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