Challenges of Simulating Hospital Facilities[1]

Track: Health Systems

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Abstract

We present two simulation studies conducted at Jackson Memorial Hospital in Miami. The focus of the paper is not just the usage of simulation, but the challenges encountered when building the models. These challenges include acceptance by hospital staff, availability of staff to describe the various processes, and the existence of useful data. Hospitals collect immense amount of data for each patient, which may lead one to believe that developing stochastic models of hospital activities should be easy; however, elicitation of useful information may end up being a bottleneck because of the diverse information systems that these facilities use.

Introduction

Jackson Memorial Hospital (JMH) is a licensed and accredited public, not for profit, teaching hospital that maintains a symbiotic relationship with the University of Miami School of Medicine. Since its inception in 1918, the hospital has attained national and international recognition for the outstanding quality of its clinical programs, comprehensive public mission, and unique structure of governance. In 1924, it was christened Jackson Memorial Hospital in memory of its 1st president James M. Jackson, who died that year. In 1986, the hospital was identified as one of the top 25 medical centers in the nation. Ten years later, the hospital received the highest accreditation score of any hospital in the public sector in the United States. The hospital is licensed to operate 1,576 inpatient beds, making it Florida's single largest hospital facility. It has the largest Trauma Center, Burn Center, Children's Hospital, Women's Hospital, Transplantation Program, and Emergency Room (JMH, 2001).

The hospital has the Department of Management Systems Engineering (MSE), which is responsible for seeking the means and ways to increase efficiency within the hospital. Consistent with the current trends, the department is using simulation modeling to aid in the evaluation and improvement of hospital processes. It is the goal of the MSE department to develop models that will enable better understanding and new alternatives within the hospital. Discrete simulation is fairly common in the manufacturing sector, but in the health sector is relatively new. We present two efforts to implement the usage of simulation modeling as a modeling and analysis tool at JMH. The first study is that of the Radiology Department (Centeno, et al. 2000); the second study is that of the Operating Rooms. The focus of the paper is not just the usage of simulation, but the challenges encountered when building the models. These challenges include acceptance by hospital staff, availability of staff to describe the various processes, and the existence of useful data.

Section 2 and 3 provide a description of the two case studies. These sections include part of

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the results obtained. Section 4 is a discussion of the challenges encountered while developing the models. The last section presents a summary of the lessons learns and offers some potential avenues to overcome the challenges.

Case 1: Radiology Department

The main goal of this study was to provide means to increase efficiency and improve the processes within the Radiology Department. Specifically, this study sought to determine the most adequate number of technologists to be used per operation, while maximizing the utilization of OR's and staff. A simulation model of the department was built to explore current conditions as well as five additional scenarios.

Patients arrive at a designated rate for each weekday (see Figure 1). Transportation from an outside department brings the patients to the radiology area in which a scheduler takes proper action to attend the patients as soon as possible. Room assignment takes place immediately and the necessary staff is arranged accordingly. Neuro angio procedures take place at the OR labeled NR18, while the other angio procedures take place in SP25, SP26 and SP27. The remaining angio room (SP24) is only used to perform simple procedures because it is equipped with less sophisticated apparatus.

The model was developed using MedModel. The model was set up to gather data about 1) Idle time of the operating rooms, 2) Number of daily procedures, 3) Waiting time to access the operating rooms, 4) Technologists' utilization rate, 5) Staffing costs, 6) Turnover time of the operating rooms, and 7) Starting and final procedure time for each day. These assumptions were made.

- The hours of operation range from 8:00am to 10:00pm plus the additional time to process the remaining patients in radiology and recovery area.
- Emergencies during the night shift are not modeled since the study focuses on the normal operating hours of the facility.
- The attending doctor in the model does not impose nor become a constraint for the model at any time, except for the neuro procedures where he/she is modeled as an integral part of the necessary staff. This design resolution was forced by the lack of statistical data on the attending.
- Transportation time is measured only from the elevator location to the waiting area. Transportation times and delays are embedded in the statistical distribution used to compute the time between arrivals to radiology.

The model was executed six different scenarios: 1) current system, 2) one technologist per procedure, 3) two technologists per procedure, 4) introduce another neurological operating room to the facility, 5) a 6-day weekly schedule, 6) tests the possibility of re-opening the pre-holding area to have better access to the radiology.

Case 2: Operating Rooms

The construction of new Operating Rooms initiated the consideration for developing a simulation of the existing Operating Rooms. The study modeled the use of the existing 31 Operating Rooms for 29 different service types. The boundary of the OR includes the Holding Area and the Post Operation Disposition (Recovery Area). This area currently experiences several problems, which it was thought to be due to ineffective scheduling of the OR services. The study sought to devise alternatives to formulate recommendations based on strategies that will maximize the current utilization of OR rooms and staff and to determine the number of rooms needed for the efficient flow of procedures through the Main OR area.

An intensive analysis of the procedures performed within the Main OR was undertaken to identify the factors that affect the patient's flow within this system. Five factors that may affect patient flow: 1) the amount of time a the patient waits in the holding area, 2) the specific process the patient has to undergo, 3) the staff schedule, 4) room availability, and 5) time of day.

Figure 2 shows schematics of the flow of patients. The Holding Area serves as the entrance to the system and the Post Operation Disposition functions as the exit. Patients enter the system at the OR Holding Area. The patient then travels to the Operating Room with an anesthesiologist, a circulating nurse, and a scrub nurse. The surgeon meets the patient after the patient arrives in the room. After a procedure is completed, the anesthesiologist and the circulating nurse wheel the patient to the Post Operation Disposition (Recovery) area. The *Holding Area* represents the common lobby area where the patient waits prior to entering the Operating Room. *Operating Rooms* represent the general area of 31 rooms that the patient may be assigned dependent on the procedure they are to undergo. Following the completion of a procedure, the patient may travel to any one of the 17 recovery units in the *Post Op Disposition* area (Figure 3).

The model was developed using the ARENA simulation package. The study concentrated on five measures of performance: 1) number of procedures per day, 2) average O.R. case time, 3) staff utilization, 4) room utilization, 5) average waiting time within the holding area. The model was developed under the following conditions:

- Although the OR is scheduled to be open for less than 24-hours, to ensure model integrity, the simulation was run at 24-hour increments to allow for the entrance of emergency cases.
- The model is considered as non-terminating system to allow for the 24-hour condition.
- Doctors and nurses are already present at the beginning of the simulation.
- The system will be devoid of patients when the system is initiated.
- OR operation on weekends and holidays is treated as special cases. Although the process the patient follows is consistent with the general OR procedure, these times are considered special cases due to the dissimilar pattern of patient arrival and the probability of cancellation.
- All of the staff members are identical according to their staff classification and are capable of performing each type of service.
- Once the staff is assigned to a patient, they are not used again unless the surgery is cancelled, aborted, or has been performed.
- Only a single case is assigned to a patient and performed. It was mentioned that occasionally a patient might undergo a procedure other than the one scheduled or only one if multiple procedures scheduled. These instances are considered special cases.
- Cancellations or procedure abortion may occur as follows:
  a. Patients may be cancelled prior to entering an Operating Room.
  b. Once a patient enters the Operating Room, they may be aborted at any time prior to incision.
- The distance from each room to each Post Op room is currently defined in the model as 40 feet.

- Whenever possible, the staff that wheels the patient to the Operating Room and the Post Operation room walk the shortest distance available.

Challenges

Our experience on the usage of simulation in medical facilities has shown that the technique can be utilized effectively in many areas. However, there are certain challenges that must be overcome that may be unique to the health systems. Among these challenges are acceptance of simulation, availability of staff to support the project, elicitation of data to establish inputs to the model, and model validation (Alvarez and Centeno (1999a, 1999b), Alvarez, et al. (1999), Centeno, et al. (2000), Correa, et al. (2000), Garcia, et al. (1995)).

Acceptance by and Availability of Staff

Medical personnel typically do many of the managerial aspects as well as decision making at hospitals. These individuals are excellent professionals that have moved through the ranks, and in recognition to their valuable contributions they are promoted to management. Because their background is medical, they have not necessarily being exposed to many of the existing modeling and analysis techniques. In many instances, as is the case of JMH, hospitals form a department that is staff with industrial engineers to help them better managed their processes. Even under this scenario, when the technique being used in the modeling and analysis is not intuitive, the analyst faces the up-hill battle of gaining the buy-in of those who, in the end, will benefit from the analysis. Our experiences at two different hospitals, as well as the experiences of others, documented in the literature, indicate that there are at least four possible attitudes that one may find when introducing simulation to medical personnel:

- *Total Skepticism:* This can be noticed when staff begins expressing phrases such as “it will not work because the procedures we use are too complex,” “every case is unique, so it is not possible to generalized,” “patients are supposed to be on time, but they are not,” “there is no pattern as to what a patient will do in regards to their appointment,” “you never know when an emergency will occur.”
- *Magical Excitement:* This is a tricky attitude because it is not readily seen, but the staff begins to form expectations that dwell on the magical. Simulation is perceived as the magic wand that will solve all problems … magically.
- *Uncommitted Support:* Staff is interested, sees the potential, but believes it has no time or resources to support the effort.
- *Supportive:* Staff recognizes the value of it and is willing to support the effort in as much as they can.

Skepticism is the toughest attitude to encounter; however, if the analyst goes in aware of it, he or she can address it in several forms. He or she may take the educational approach as to what simulation can do in general, and from there proceed to a what simulation can do for them in their hospital department. The key is to create an environment of dialog, informative, of questions and answers. The words “exploratory study” are of great value when trying to overcome skepticism. Skeptics tend to be so because they really do not know much about the topic, but once they understand it, and see the value of it, they may become the strongest supporters of it. Magical excitement may be a double jagged sword. Individuals form extremely high expectations, and when the simulation study does not delivers them, total discontent sinks in. Having some one with this attitude is a golden mine though, if and only if it is tapped to promote the study, but at the same time the individuals are educated as to the limitations of the simulation technique. Uncommitted support is a natural attitude in medical staff because they have a very stringent and demanding work schedule. Hence, even though they may recognize the value of using simulation, they also realize that the day only has 24 hours, and that committing to one more thing is just simply impossible. In these cases, the analyst should have support from upper level management, so that the staff gets assigned to the project with the appropriate release of other duties to make the time. In every group of people, there are those individuals that are visionaries. They tend to be proactive in their approach to their work; hence, they have an open mind to new ideas and new approaches. The analyst must nurture these individuals, so that they become the support point to reach the rest of the staff involved and affected by the project.

Once moderate to strong support has been attained, the process of understanding the business practices as well as operations becomes the issue. Typically, visits to the facility and interviews with staff are necessary. The availability of personnel may go either way: available on demand, or not available. Regardless of which one is the case, one must be prepared to elicit crucial information regarding operational issues. For example, in the studies at JMH, the visits revealed that the problems within the OR environment were rooted in factors such as the poor scheduling of other departments, the late start of the first cases within the OR, the poor scheduling of procedures, which leads to equipment delays, and the use of common staff to transfer patients. The late start of the first cases within the OR and the poor scheduling of procedures are correlated. First cases are usually delayed due to the lack of equipment for a procedure, which may have been discovered when the circulating nurse is seized by a patient in the holding area. The late arrival of the trays used for a procedure from another department contributes to the waiting for the start of a procedure. These problems may be eliminated if the procedure schedule would be restructured, but since other departments are involved, finding a solution would require the use of multiple techniques of which simulation modeling is only one of them.

Existence of Useful Data

Originally the projects were set to compare different alternatives to better understand how the patient flow could be improved so that room turn over time is minimized. Experimentation was to include various staffing configurations as well as various scheduled hours of operations to maximize the utilization of O.R. rooms and staff. However, when we began looking into establishing the inputs to the simulation model, we realized that it would take longer than anticipated.

JMH, like many other hospitals utilizes software information systems to collect data and generate information. For example, JMH has an extensive database describing the various activities within the Radiology Department. Records from this database can easily be extracted and analyzed to establish probabilistic models for the inputs of the simulation model.

A first hurdle that one has to deal with is the vast amount of records. Even for a small department, we are talking thousands of records. Once the means to extract and manage these records has been established, the second hurdle shows up: quality of the data. Quantity does not mean quality. It is relatively easy to populate a database, but to populate it with the correct data is another story; hence, a thorough analysis of the records must be done to ascertain which records are good, and which records should be discarded. Filtering records out can only be done if there has been enough candor during the interviews with the staff. Staff tends to be cautious about what they say if the data entry process is their responsibility. It is human nature to be quick to tell on others, and to shy away when it comes to us.

Once the good records have been selected, the analysis begins and the focus turns to explaining why the data values vary so much, and establishing percentages as needed. For instance, we identified that special and neuro procedures do not occur in a steady fashion; thus, they had to be treated as special cases that occur with a certain percentage. In both studies, we found that the data vary significantly due to the subjective nature of the procedures. Some physicians take longer than others and may have different methods of performing the procedures. Furthermore, physicians rotate every week; therefore, the data may contain weekly patterns depending on the attending physician. Consequently, it may be necessary to redefine the scope to break the project in two phases. Phase I would entailed the creation of a reasonable model of the current system. The model would include as much detail as necessary to convey current system. In Phase II, the model would be refined to encompass more detail with better inputs.

In the end, exisiting databases should lead to a good set of inputs to the model. In our two studies we were able to determined statistical distributions for: 1) the arrival rate of patients to the Operating Rooms, 2) the turnaround time, 3) the probability of being cancelled or aborted, and 4) the rooms each service type may be performed in.

Validation

Validation is the process of insuring that the model truly represents the real world. The *customers* of the model must believe the model for them to accept the recommendations. Validation may be done by observing the behavior of the model through animation, and by looking at the results and ensuring that the processing times, waiting times, number of patients per day, etc. gave reasonable results. Practical ways of validating the model include 1) the utilization of constants in lieu of distributions, 2) enabling traces over time, 3) engaging in *walk throughs* of the model to ensure that patients are routed correctly through the system. But of all the empirical techniques, there is nothing like animation to achieve customer buy-in that the model is valid. Seeing the patients as well as the resources flow through the system on the screen really makes a lot of believers.

Summary

Simulation has proven to be a useful tool to determine patient flow for the OR and the Radiology departments. Cohesive and feasible recommendations can be derived form. For example, based on the extensive analysis performed on the department of radiology, and the outputs collected from the simulation study, we concluded that performing procedures with only one technologist is a cost effective solution and will reduce the need for more staff, at least in the short-run. The slightly reduced throughput using this configuration is not significant enough to exclude this configuration from the feasible alternatives. Moreover, this scenario gives the possibility of reducing staff, and it allows the department the flexibility to schedule more daily procedures if needed. The effectiveness and acceptance of the technique, however, requires patience and an understanding of the psychology of medical personnel. The simulation analyst must be prepared to deal with skepticism. The analyst should be ready to educate the staff otherwise the project may fail.

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Figures

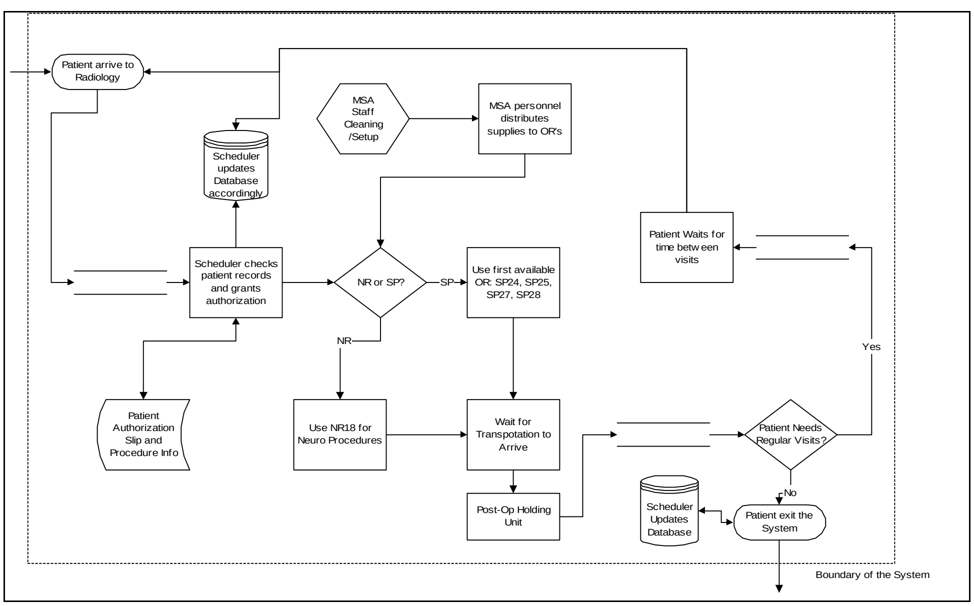

Figure 1: Schematic Representation of the Radiology Model

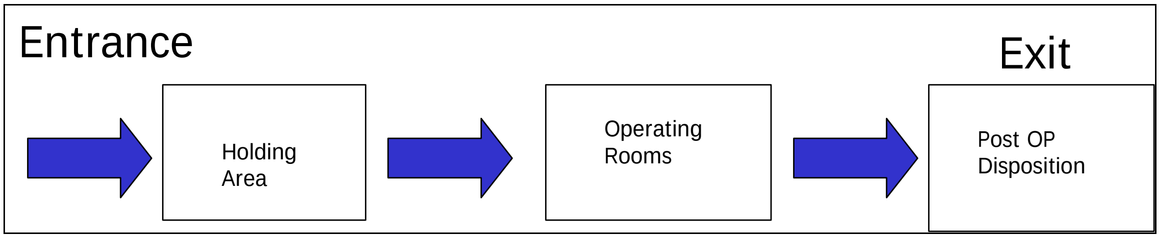

Figure 2: Schematic Representation of the O.R. Model

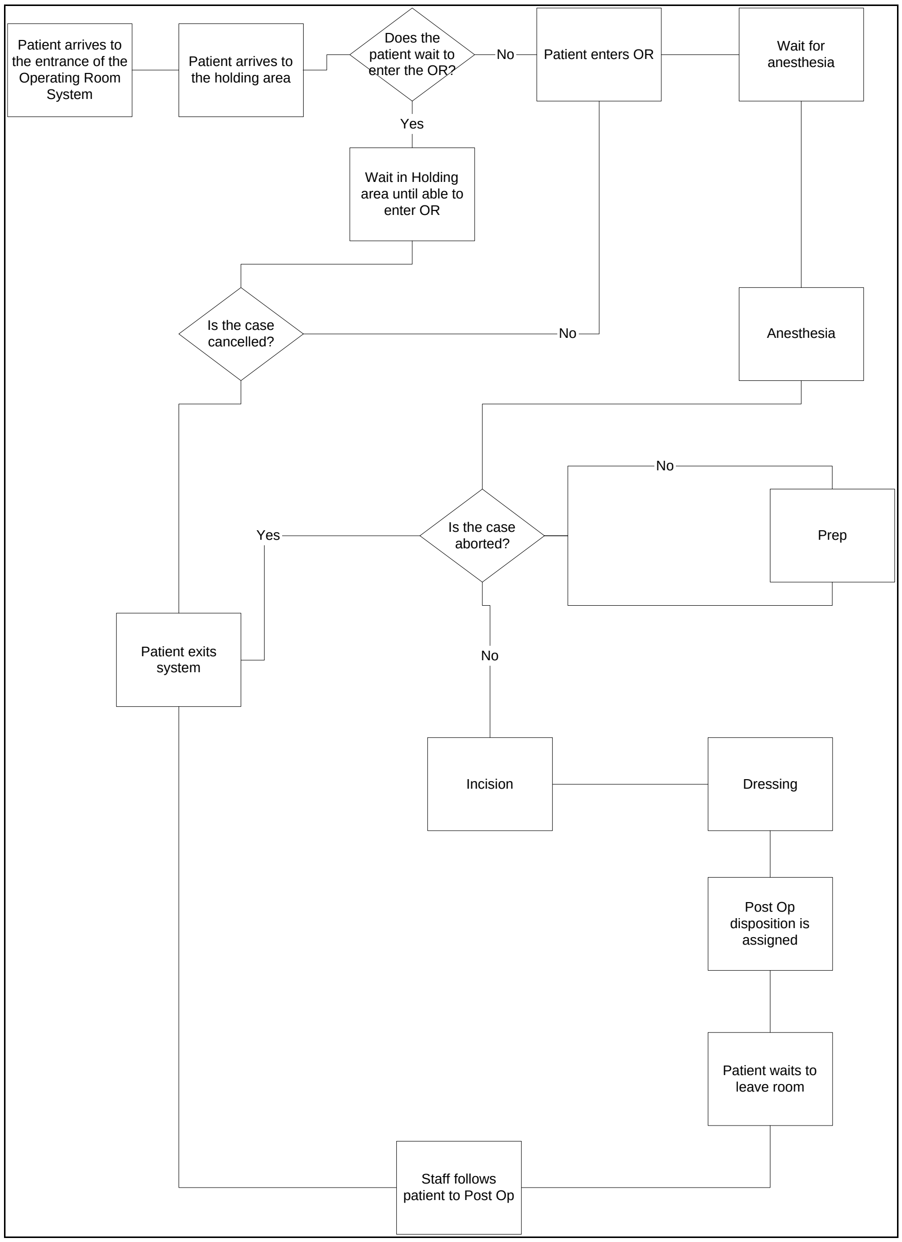

Figure 3: Flow of Patients for O.R.