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A FLEXIBLE SIMULATION MODEL AIMED TO IMPROVE INPATIENT UNITS IN HEALTH CARE

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ABSTRACT

In the past few decades, simulation in healthcare has gained immense attention from researchers because of its ability to detect problems that help in the improvement of the facility. It is important for any healthcare to know how many beds, nurses, and therapist they need in their facility to improve their service. In this research, we have created a customized object that is used to design simulation model for progressive care unit in a hospital. The objective of this research is to a make a flexible simulation model that can easily be extended and re used to make simulation model for any facility. The simulation model built would help the health care personnel in determining the number of beds, therapists and nurses in their facility.

1 INTRODUCTION

"A simulation model is a representation that incorporates time and the changes that occur over time" [1]. Simulation can help the health care companies in utilizing their resources suitably. Using simulation they can decide if they need to increase a number of beds or need to increase a number of therapists in their facility. In the past, researchers have used simulation as a decision making tool for improving the health care facilities [2] However, simulation models built in the past were mostly flat simulation models and were built using the objects from the standard library supplied by software. In this research, we have created a new customized object which handles all the patient procedures during his/her stay at Progressive Care Unit (PCU). The customized object is re-usable. The customized object is extended and combined to create a complete simulation model of the PCU unit. The model is built using Simio [3].

2 PROGRESSIVE CARE UNIT (PCU)

The patients come to PCU for post-procedural care from various other departments in the medical center. The departments may be an emergency department, ICU, surgery, or direct admissions. The duration of patients stay in the PCU depends on their acuity levels: low, medium and high acuity levels. The patients are accompanied by a regular nurse to their beds when they arrive. During a patient stay, he/she is assigned to a regular nurse, a therapist and an assistant nurse. They perform three different procedures: treatment by the therapist, regular nurse rounding, and assistant nurse rounding multiple times during a patient stay in the unit (with regular intervals).The patient leaves the PCU when his/her stay time expires in the PCU, meaning that they recovered.

3 METHODOLOGY

A customized bed object is created. Based on above mentioned procedures there are three processes created in the bed object. Figure 1 describes the flow of procedures during a patient stay in the unit. The processes are triggered based on the shortest remaining time for an activity to happen in future. For example, in Figure 1 it is assumed that at time 0 a regular nurse visits the patient. After every four hours, the nurse visits the patient and the assistant nurse visits after every five hours. The therapist visits after every seven hours, so

when four hours are passed a regular nurse would come again for his/her rounding, but after that assistant nurse activity has the shortest time followed by the therapist and so on.

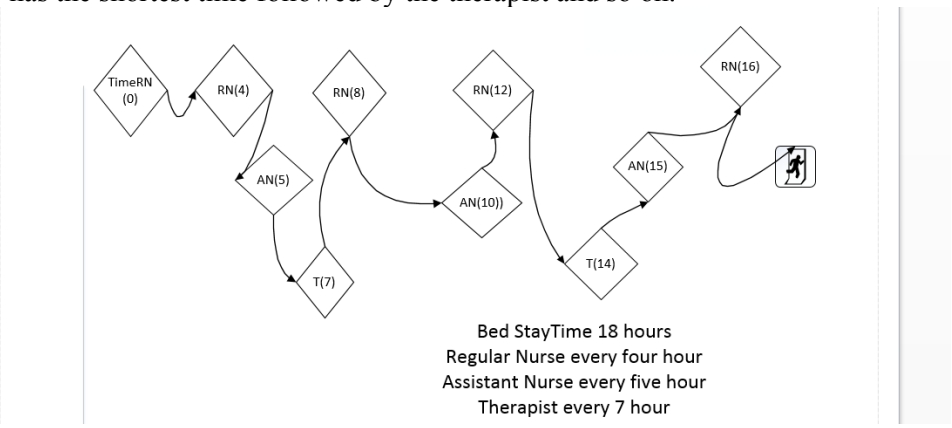

Figure 1: Flow of Patient Procedures

An activity would only occur if the time remaining for that activity to happen and the process time is less than the patient remaining hours left in the unit.

The processes that are created in the bed object are defined below:

- Bed Occupied: This process is triggered when a patient enters the bed. This process assigns patient stay time in the bed based on his/her acuity level which is defined as a model entity property. This process assigns rounding time and the check-up time for each of the resources. This process determines who would visit the patient first when he/she started his/her recovery process in the unit.
- Regular Nurse Process: This process is triggered if the regular nurse has the shortest interval time. This process recognizes the nurse who admitted the patient and seizes that nurse for each regular nurse rounding. The process keeps track of the future rounding of the same regular nurse to the patient. After the end of the regular nurse visit to the patient this process then determines who would come to see the patient next and after how much time.
- Therapist Process: This process is triggered if the therapist has the shortest interval time to happen in the future. This process assigns a therapist to the patient and makes sure that same therapist visits the patient during his/her tenure at the unit. The process keeps track of all the therapist rounding to the patient and assigns the next visit (activity time) of the therapist to the patient. In the end, the process assigns who would visit the patient next during his/her stay in the unit.
- Assistant Nurse Process: This process is similar to the assistant and the therapist process. When the process is triggered the first time it assigns an assistant nurse to the patient. The assistant nurse would not change during patient tenure in the PCU. The process keeps track of assistant nurse visits to the patient and after every visit determines who would visit the patient next.

Once the bed object is created the process is used to make simulation model of a PCU which has six beds. The model entity (patient) properties are defined in this model. The data used for defining the model entity properties is the real data collected by a PCU unit. The patient properties are described in Table 1 below.

Table 1 Patent properties in the bed model

Property	**Description**
BedStayTime	The time a patient stays in the bed for recovery
RegularNurseRounding	The time interval fora regular nurse would come for a routine check-up.
AssistantNurseRounding	The time interval an assistant nurse would come for a routine check-up.
TherapistRounding	The time interval a therapist would come for a routine check-up.
RegularNurseCheckTime	The regular nurse check-up time
TherapistCheckTime	The therapist check-up time
AssistantNurseCheckTime	The assistant nurse check-up time

The simulation model of PCU with six beds is shown in Figure 2. The medium and high acuity patients go through transfer in before going to the admission process. At admission process, a regular nurse is assigned to the patient. The patients wait at the output node of admission if no beds are available. The capacity by default for each bed object is one. However, it can be increased for experimenting purposes. The patient leaves the system when his/her stay time is expired.

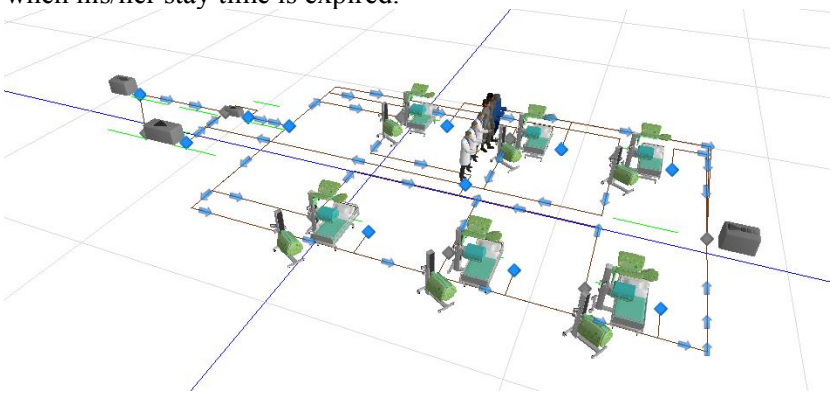

Figure 2: Simulation Model of PCU with six beds

4 EXPERIMENTATION AND RESULTS

The model was run for four weeks. The key features in the service level are analyzed. The key features are the number of resources in the PCU. The Table 2 and Table 3 show the simulation results.

Table 2: Beds schedule utilization

Resource	Schedule Utilization
Bed 1	91.58
Bed 2	93.92
Bed 3	89.37
Bed 4	93.25
Bed 5	86.84
Bed 6	93.22

Table 3: Average flow, number created and destroyed for each entity

Model Entity	Time in System [h]	Number Created	Number Destroyed
Low	49.37	24	21
Medium	60.88	73	63
High	73.86	53	46

The results show that PCU needs to increase the number of beds to improve their service. It is observed that patients wait at admission until a bed becomes vacant.

5 CONCLUSION

The research presented in this case study would help the PCU managers in organizing their resources in an optimal manner. The future work includes more experimentation by increasing the number of beds in the facility. Also, the model needs to be extended for the patients whose acuity level changes during their stay at PCU.

6 REFFERENCES

[1] I. I. Carson and S. John, 2004. "Introduction to modeling and simulation," in *Proceedings of the 36th conference on Winter simulation*, pp. 9–16.

[2] S. B. Issenberg and R. J. Scalese, 2007. "Simulation in Health Care Education," *Perspect. Biol. Med.*, vol. 51, no. 1, pp. 31–46.

[3] W. D. Kelton, J. S. Smith, and D. T. Sturrock, 2014. *Simio & Simulation - Modeling, Analysis, Applications*, Third edition. McGraw Hill.