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Abdominal surgery process modeling framework for simulation using spreadsheets

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ABSTRACT

We provide a continuation of the existing Activity Table Modeling methodology with a modular spreadsheets simulation. The simulation model developed is comprised of 28 modeling elements for the abdominal surgery cycle process. The simulation of a two-week patient flow in an abdominal clinic with 75 beds demonstrates the applicability of the methodology. The simulation does not include macros, thus programming experience is not essential for replication or upgrading the model. Unlike the existing methods, the proposed solution employs a modular approach for modeling the activities that ensures better readability, the possibility of easily upgrading the model with other activities, and its easy extension and connectives with other similar models. We propose a first-in-first-served approach for simulation of servicing multiple patients. The uncertain time duration of the activities is modeled using the function “rand()”. The patients movements from one activity to the next one is tracked with nested “if()” functions, thus allowing easy re-creation of the process without the need of complex programming.

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1. Introduction

Healthcare process simulation is an interesting technique for research and practice. Many different approaches exist for modeling a healthcare system [1], such as system dynamics, agent-based modeling, optimization techniques, electronic medical records information system [2], disease management-process modeling approach [3] and discrete event simulation (DES) [4]. The paper focuses on the usage of DES. The model considers the limitations of the Slovenian hospital for abdominal surgery in terms of the number of available beds, the mean time of activity durations and the number of available doctors.

This paper proposes a two-step general modeling framework for healthcare process simulation. Firstly, the Activity table modeling technique is applied. Secondly, spreadsheets are used for simulation of the patient’s flow. The applicability of the proposed modeling framework is demonstrated on a real-life case study of the abdominal surgery process. The modeling starts with defining the process workflow using the activity table technique [24]. Next, the spreadsheet is used as a tool to simulate the healthcare process.

The motivation for using the spreadsheet is threefold. Firstly, a spreadsheet provides a complete overview of the process at any point of time (the location of the patient, the availability of beds, and the availability of resources). Secondly,

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the simplicity of a spreadsheet allows upgrading the model by Excel users, without the need of performing complex programming tasks. The combination of the simplicity of spreadsheets and their supportive presentation of data has proven to be of a higher importance than complex and detailed model representation for decision support on operational-level models [5], and for policy-level models [6]. Furthermore, a spreadsheet allows easy upgrade of the model to connecting different hospital departments, thus leading to a step forward toward modeling the hospital as a whole system.

Thirdly, the issue has a particular practical merit. Many of the discrete event simulation models described in the literature were built for a specific hospital, and are never reused due to economic reasons or the complexity of the models [1]. In order to overcome this obstacle, this paper provides enough details of the simulation approach so that it can be easily recreated by an Excel user, for different hospital departments. The aim of this paper is therefore to test the proposed two-step modeling framework on a specific healthcare process, not focusing on the comparison to other commercial products. Suggested framework points to an optimal management of resources and relative time, as well as supports a review of the presented structure of the activities.

The approach applied in this work starts by modeling the process discussed using the Activity table modeling technique, and continues by transmitting the process model developed into a spreadsheet in order to simulate it.

The starting point for simulation of the healthcare process was based on the simulations performed by [7] who use one spreadsheet to simulate an emergency department for patient flow. We changed and improved their approach in the following manners:

1. The simulation approach is performed without macros, thus no Visual Basic programming experience is required in order to replicate the model, or to upgrade it; however, a proficient knowledge of using formulas in Excel is required.
2. The solution employs a modular approach for modeling of the activities. It means that each activity is described in a separate worksheet instead of using only one. This way we ensure: better readability; the possibility of easily upgrading the model with other activities; and its easy extension and connectives with other Clinic's models;
3. Three different modeling elements are introduced depending on their functionality: activity, transaction, and gate; in addition we provide two models for activities with multiple inputs;
4. The serving priority of the activities with multiple inputs is solved with the principal of first-in-first-served.

2. Activity table modeling technique

There are more than fifty tools [8] or methods that are mentioned in the literature that are available for business process modeling, which makes the selection of the proper tool difficult. An extensive comparison can be found in [9] where an empirical review of existing methodologies, tools and techniques for business process change are given, including a reference framework to assist the positioning of tools

and techniques that improve re-engineering strategy, people, management, structure and the technology dimensions of business processes.

The criteria that is of greatest interest when comparing the techniques for business process modeling are: the relevance, the completeness, and the simplicity of the built models [10,11]. Additionally, the process modeling tools must be capable of showing interconnections between the activities and conducting a decomposition of the processes. A common way to represent a consecutive flow of activities in health-care which includes all encounter criteria is through workflows [12,22,23] or mapping [13]. Here we chose Activity table modeling technique as a tool for representing the activities and the existing relations among them.

The Activity Table consists of two parts. The first part (first few columns) provides information about each activity listed by defining a number of parameters that describe the activity. The second part is a tabular-graphical representation of the process. To develop the activity table, information about process functioning should be gained during interviews that are organized with knowledgeable employees.

2.1. Part 1

In the columns of Part 1 of the Activity Table a number of the following parameters are defined for each activity(*i*), where *i* ranges from 1 to the number of activities.

- *Description*. A short and precise description of what exactly is the work carried out by the activity defined in row(*i*)
- *Time*. The expected duration needed for activity(*i*) to be processed and accomplished
- *Rule*. One or more constraints or rules that must be satisfied in order for activity(*i*) to be performed
- *Input/Output*. Input(s) and output(s) of activity(*i*)

2.2. Part 2

Process: For each process, a new Activity Table is created. This table represents a model called the "as-is" process model, which describes the behavior of the process as it exists in reality. Thus, the name of the process selected is written in the first column of the Activity Table (see Fig. 1).

If the process is large and complex, then it should be partitioned into a set of sub-processes, which are in this case listed in the second column of the Activity Table. Each process consists of a number of work processes.

Work Processes: A work process is a process that is performed within a department or organization unit. In this step all work processes of the process discussed are listed in the Work Process column of the Activity Table. For each work process listed, the name of the department in which the work process is performed, is written in the first row of the table (see Fig. 1). A work process is a process that consists of a set of activities.

Activities: This step deals with identifying the activities performed within each of the work processes defined in the previous step. An activity is a simple micro-process that consists of one or more tasks that represent well-defined work performed by one resource. An activity may consist of a

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