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Simulation of the Health Care Process Surgery

NADJA DAMIJ, MSc, MPhil
Sisenska 27
1000 Ljubljana
SLOVENIA

Abstract: The objective of this work is to use the simulation of the health care process Surgery in order to improve it. To do that, health care process Surgery was first modeled using the flowchart technique and then the simulation process was run using iGrafx software. The simulation results showed that the process Surgery is well modeled. Moreover, the results also indicated the bottlenecks of the observed process which may reflect the need for potential improvement.

Key-Words: Health care process, Business process, Process simulation, Flowchart diagram.

1 Introduction

Authors in [1] review the development of information systems in the field of medical informatics as follows: In the past, clinical information systems were used in healthcare mainly for administrative purposes and for recording medical patient data.

The majority of processes were developed over time or badly modeled. Such processes became ineffective and need to be improved. For this reason, process modeling and simulation became an important way of ensuring changes in an organization's functioning in order to create a better and successful organization.

The aim of this work is to show that process simulation could be used as an essential tool to carrying out process improvement. The process modeling and simulation is done using iGrafx software.

The paper consists of four sections. Section 2 discusses the process simulation. Section 3 introduces the flowchart technique as a tool used by different software packages to run the simulation. Section 4 represents the results of simulation of a process called Surgery. The final section contains some useful remarks and conclusions.

2 Simulation

Modeling, analysis, simulation and improvement of processes are on the increase as only a thorough comprehension of the processes within on organization can lead to effective, efficient and value-adding systems.

Furthermore, conceptual modeling of processes is deployed on a large scale to facilitate the development of software that supports the processes, and to permit the analysis and re-engineering or improvement of them [2]. Processes are modeled with the aim of analyzing their current states within the organization, as well as improving them through the execution of potential "what-if" simulation scenarios.

Currently, few organizations maintain a formal model of their process network [3]. Even so, these formal models were usually the product of a series of interviews, reviews, examinations, etc. conducted at a time when the organization encountered apparent and serious problems.

Construction of a process model makes use of several accepted modeling constructs: delays associated with performing work, statistical distribution of these delays to represent observed variability, dependence of processes on completion of earlier processes, queuing of input entities waiting to be "processed", decision logic that directs entities into alternate flow paths depending on their characteristics, application of resources to the work of a process, and the costs associated with these resources [3]. Consequently, an "as-is" model encompasses the above constructs with the aim of imitating the real process under inspection within the organization.

Simulation modeling according to [4] is based on very simple principles: the analyst builds a model of the system of interest, writes a computer program which embodies the model and uses a computer to initiate the system's behavior when subject to a variety of operating policies. Furthermore, it is thought that simulation modeling extends the potential of process modeling and analysis.

According to [3], modeling and simulation of a process network serves three immediate purposes: organizing the results of interviews and research, identifying the cause of observed performance issues, and exploring alternate process network configurations that improve performance. The aim is to efficiently image the process network. Authors in [3] argue that hierarchical modeling tools are the most useful, as they contain features like simultaneous understanding of high-level and detailed views, as well as the manageability of the model.

Simulation is the imitation of the operation of a real-world process or system over time [5]. A simulation model enables the analyst to observe and study the system's behavior as it advances through time.

Simulation represents a powerful approach for analysis and quantitative evaluation of processes [6]. Furthermore, they classify simulation models into three groups depending on their attributes:

- Static or dynamic. A static model is a model where time within the real process is insignificant, and a dynamic model incorporates changes over a time period.
- Deterministic or stochastic. A deterministic model is defined by a sequence of events such as input recognition enabling the output definition, whereas a stochastic simulation model has, according to [5], one or more random variables as inputs.
- Discrete or continuous. A discrete model is a model that consists of discrete events which are events that happen at particular times, and a continuous one consists of variables changing continuously over time.

Consequently, [6] state that processes are in general represented as computer-based dynamic, stochastic, and discrete simulation models which are defined as abstractions of the actual processes, represented in the computer as a network of connected activities and buffers through which jobs or customers flow, and must also capture the resources and various inputs needed to perform the activities. Discrete-event simulation describes how a system with discrete flow units or jobs evolves over time [6]. Therefore, according to [5] discrete-event simulation examines the modeling of systems in which the state variable changes only at a discrete set of points in time. What differentiates a discrete-event model from a continuous one is the fact that it deals with the attribute time only when the event actually happens.

Consequently, according to [6], such a perspective of the events and time enables significant time compression because it makes it possible to skip through all time segments between events when the state of the system remains unchanged. Simulation packages enable simulation runs of vast and various numbers of events that may in reality happen over a long period of time. A discrete-event simulation model focuses on the state of the process at specific time points when the events occur. Hence, when executing the simulation run, the simulation clock jumps between the events and regards the system as staying the same in the meanwhile.

A simulation model is normally based on a set of assumptions regarding the system's operation. These assumptions are expressed in mathematical, logical, and symbolic relationships between the entities, or objects of interest, of the system [5]. After a simulation model has gained form and been validated, it is deployed to examine various "what-if" questions regarding the real-world system, so that any future alterations of the system are first simulated and as a result it provides forecasts about the impact of the alterations on systems effectiveness.

Authors in [6] summarized some of the main attributes that make simulation powerful:

- Simulation, like analytical modeling, provides a quantitative measure of performance.
- Simulation, unlike analytical and symbolic models, is able to take into consideration any kind of complex system variation and statistical interdependencies.
- Simulation is capable of uncovering inefficiencies that usually go undetected until the system is in operation.

The availability of special-purpose simulation languages, massive computing capabilities at a decreasing cost per operation, and advances in simulation methodologies have made simulation one of the most widely used and accepted tools in operations research and system analysis [5].

3 Flowchart

A flowchart is a simple diagram used by different software packages such as iGrafx to model and run the simulation of a process under discussion. iGrafx software was used in this work to run the simulation of the health care process Surgery.

A flowchart is defined as a formalized graphical representation of a program logic sequence, work or manufacturing process, organization chart, or similar formalized structure [7]. A flowchart is commonly used to show the flow of a process from its start to its end. It usually consists of different symbols connected by lines, arranged in such a way to lead us in correct sequence order through a series of steps. Process flow is traced by following the connecting lines between the symbols drawn. These symbols include start and end, activity, input and output, decision, and department.

A flowchart begins with a starting point and finishes with an ending point. The terminus symbol is commonly used in flowcharting to designate the beginning and the end.

An activity is represented by a rectangle and means an elementary task or a subprocess. The path by which processes flow through the diagram consists of connecting lines between activities. A set of activities could be contained by a container called a department. An input is indicated by an arrow, which enters an activity. An output is shown by an arrow, which leaves an activity. An arrow connects one activity to another, showing the movement of the diagram.

A decision specifies alternative paths based on some Boolean expression and is shown by a diamond. There can be only one input path to a decision, but there can be many output paths [8]. A decision is a point at which the process flow can take one of several possible paths based on a defined criterion.

To model a task performed simultaneously by different departments or to model parallel activities, we define different outputs from an activity as split outputs. A split is made by defining multiple paths from a single activity to a set of activities. After parallel tasks have been performed, outputs of those activities which performed the parallel tasks could be modeled to enter a single activity; this is called a joint input.

According to [9], flowcharts are built to offer an enhanced comprehension of the process, which is a requirement for process improvement. By grouping tasks into logical areas of activity (processes) and drawing flowcharts of the events which occur, it is possible to get a concise picture of the way particular processes are completed within the organization[1]. The flexibility of the flowchart technique is argued by some authors to be its advantage as it allows each modeler to unite various pieces of the process together to obtain the overall picture as he/she feels they fit best. On the other hand, other authors argue that the technique is too flexible, describing large models without illustrating the hierarchy of different layers.

4 Results

The process Surgery leads the patient, who needs to have surgery, through a number of activities in different departments of the hospital such as Reception Office, Clinic, Laboratory, X-Ray, Anesthesia and Surgery Block. Simulation of the process Surgery is shown in Diagram 1 taking into consideration a Clinic for abdominal surgery with a capacity of 30 beds.

The process Surgery was simulated with 20 patients, who were already in the Clinic in different phases of the process, and with 30 patients who were scheduled for different surgeries. In addition to this, it was postulated that 3 patients, from the planned 30 patients, were hospitalized every day.

To do that, a standard calendar was used, that is, 8 hours/day, 5 days/week and 22 days/month. And the following resources were defined: 1 Nurse and 1 Doctor in the Reception Office, 4 Nurses and 4 Surgeons in the Clinic, 1 Nurse in the Laboratory, 1 Nurse and 1 Doctor in the X-Ray, 1 Nurse and 1 Doctor in Anaesthesia, 2 Anaesthetists and 2 Nurses for performing anaesthesia in the Surgery

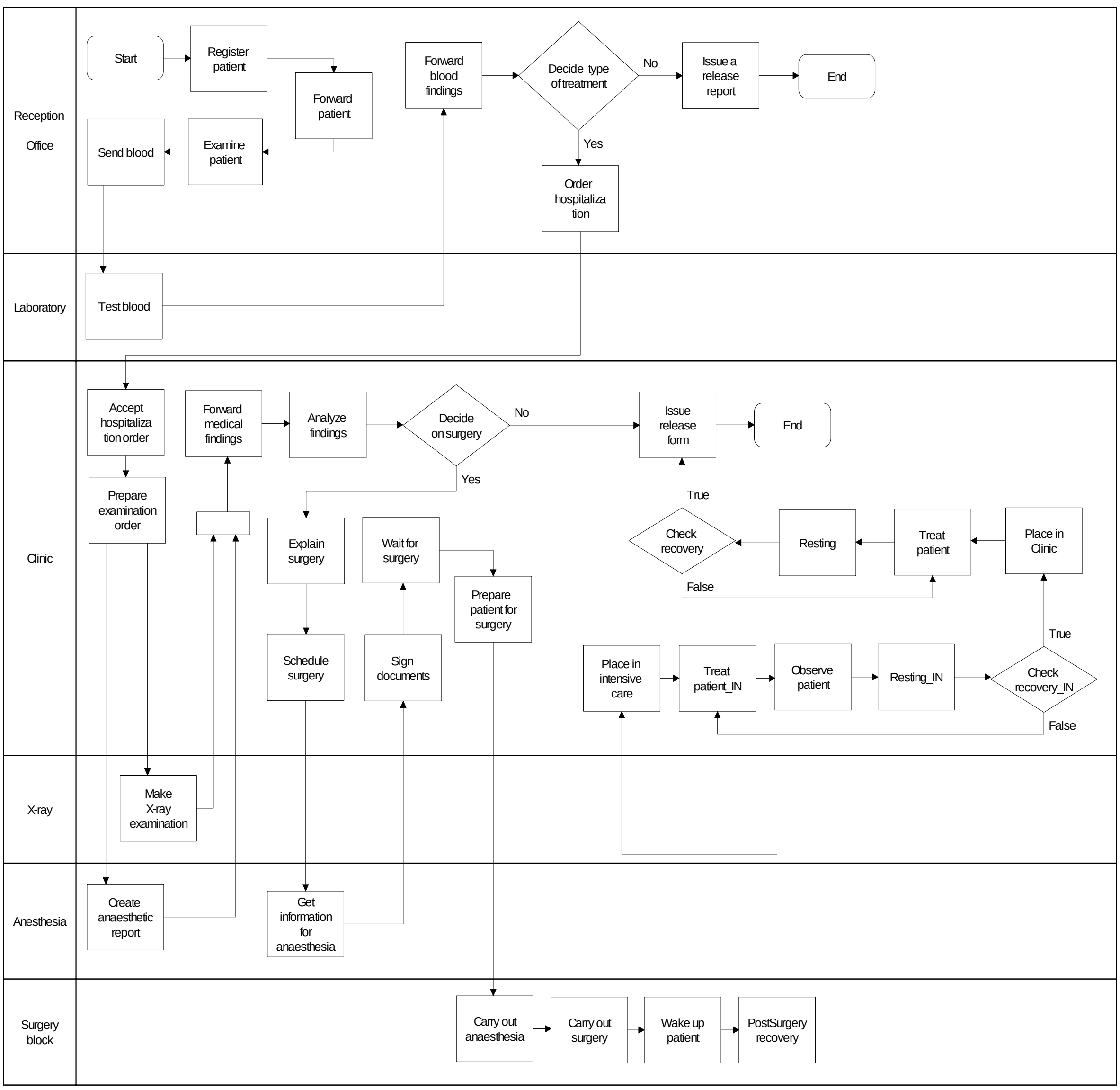
[1] http://www.hci.com.au/hcisite2/toolkit/flowchar.htm

block, 2 Anaesthetists and 2 Nurses for waking up patients and post surgery recovery in the Surgery block, and 2 Nurses working with the Surgeons to carry out operations in the Surgery Block.

The results of running the simulation of the health care process Surgery were as follows:

- Average cycle time for one patient is 14.68 days;
- Elapsed time for carrying out surgeries for 30 patients is 25.57 days. This is understandable because the software needed 10 days to enter 30 patients into the Clinic (3 patients per day);
- Average time for performing different activities before surgery is 2.94 days. This is 1.43 days for performing various medical examinations in the Reception Office and Clinic, and 1.51 days waiting for surgery;
- Average time for performing anaesthesia, surgery and post surgery recovery in the Surgery block is 7.1 hours;
- Average time for recovery in Intensive care is 4.26 days;
- Average time for recovery in Clinic is 6.39 days;
- Average time for creating a release form is 0.78 hour.

Diagram 1. Flowchart of the health care process Surgery



5 Conclusion

The results of running the simulation of health care process Surgery show that the process considered is well modeled. The results of the process simulation are very encouraging and show that process Surgery does not have major problems.

Nevertheless, the process could be improved by shortening the time of 2.94 days spent before surgery; this is 1.43 days for performing different medical examinations in the Reception Office and Clinic and 1.51 days waiting for surgery. Some of the medical examinations could be done before hospitalization and also the time of waiting for surgery could be shortened. Furthermore, the recovery time in Intensive care (4.26 days) and the Clinic (6.39 days) could be reconsidered.

I am aware that these suggestions cannot be generalized for all patients, but they are good points for the medical staff to rethink. To conclude, these results confirm the necessity of using the simulation as a tool for improving business processes.

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