HEALTHCARE PROCESS IMPROVEMENT USING SIMULATION

Nadja Damij and Talib Damij
Faculty of information studies, Novi trg 5, SI-8000 Novo mesto, Slovenia
Faculty of economics, University of Ljubljana, Kardeljeva ploščad 17, SI-1000 Ljubljana, Slovenia

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Abstract: This study is concerned with business process modelling and improvement as an essential work in creating a successful and competitive enterprise. To achieve this goal, we use a technique called the Activity Table to develop an as-is process model. When the process model is created, it must be checked and validate to find out if it reflects the real process. Then the model is analysed carefully using different "what-if" questions. Scenarios of process behaviour are then simulated to find out their impact on process performance and to compare them in order to choose the best solution. The business process ‘‘Surgery” is used as an example to demonstrate the implementation of the methodology.

1 INTRODUCTION

In recent years process improvement has become a very important way of ensuring changes in an organization’s structure and functioning to create a better, more competitive and successful enterprise.

The purpose of this study is to present the utilization of a simulation technique in the field of business process improvement, which is invaluable in developing an efficient, competitive and successful organization.

In addition to the introduction, the paper has four other sections. In Section 2, we introduce business processes and the problem of business process modelling using the Activity Table modelling technique.

In Section 3, we discuss simulation as an imitation of the functioning of a real-world process over time. The functioning of the process is observed in order for it to be completely understood. Understanding the behaviour of a process over then time enables us to develop a model and create one or more simulation scenarios that are then tested by running the simulation software.

In Section 4, process improvement is presented as a method to improve the organization’s processes by carrying out changes in their functioning necessary to make them more effective, with a high quality level, without duplication of procedures and activities, and with reduced costs, in order to achieve greater customer satisfaction. A process called "Surgery" is used to demonstrate the simulation technique in process improvement. In Section 5, some useful remarks and conclusions are presented.

2 PROCESS MODELLING

The functioning of any enterprise may be represented by a number of processes, called business processes. Most of the problems faced by enterprises concern are internal business procedures that are neither well defined nor particularly efficient (Hales, 1993).

A business process is defined by (Hammer et al., 1993) as a collection of activities that takes one or more kinds of input and creates an output that is of a value to the customer.

A business process is defined as a structured, measured set of activities designed to produce a specified output for a particular customer or market (Davenport, 1993).

Business processes are horizontal processes that link together the various functional activities that deliver the output of the enterprise. They consist of functional work processes that either produce or provide support services for those work processes that do (Watson, 1994).

Work processes are the sets of procedures or activities, tasks, and steps where the real work of the

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organization is accomplished to produce the economic output that generates the profitable return on the capital employed (Watson, 1994).

Business process modelling generates a model to describe a certain business process in an enterprise using different techniques. The model is a representation of a business process and reflects its reality by capturing all the necessary information on process behaviour. The modelled process is then analysed and improved instead of the real business process. In this paper, we present process modelling using a technique called the Activity Table.

The activity table is organized as follows: the first column represents the business process and the second column shows the work processes of the business process discussed. The activities of the listed work processes are shown in the rows of the third column. The resources are introduced in the remaining columns of the second row grouped by the departments to which they belong.

To make the activity table reflect the real world, we link the activities horizontally and vertically. Horizontal linkage means that each activity must be connected with those entities in the columns which are involved in it. Vertical linkage is used to define the order in which the activities are performed. Each activity is connected with one or more predecessor activities, except the first one, and is also linked to one or more successor activities, except the last activity.

To model a process, the activity table uses symbols such as: □, ◇, →, ↓, ○, and ◎.

Symbol □ in square(i,j) means that resource(j) performs activity(i), where j ranges from 1 to the number of resources and i ranges from 1 to the number of activities. Symbol ◇ in square(i,j) means that activity(i) is a decision activity. Symbols → and ↓ are used to connect the activity horizontally and vertically. An arrow → drawn from square(i,j) to square(i,k) shows the horizontal linkage of activity(i). An arrow ↓drawn from square(i,j) to squre(k,j) indicates that activity(i) is linked vertically to its successor activity(k). Symbol ○ indicates a start of the process and symbol ◎ means an end of the process.

Surgery: The business process “Surgery” was modelled by developing Table 1, which represents the activity table.

3 SIMULATION

A simulation is the imitation of the operation of a real-world process or system over time. Simulation involves the generation of an artificial history of a system, and the observation of that artificial history to draw inferences concerning the operating characteristics of the real system (Banks et al., 2001).

The functioning of the process discussed is observed in order for it to be understood completely. Understanding the behaviour of a process over time enables as to model it and create a simulation scenario based on a set of data and assumptions about the operation of its activities.

When the process model is created, we have to check and validate it to find out if it reflects the real process. Then the model is analysed carefully using different "what-if" questions to test several options and possibilities concerning the functioning of the process. Such versions of process behaviour are then simulated to find out their impact on process performance and to compare them in order to choose the best solution.

Business processes are modelled with the aim of analysing their current states within the organization, as well as improving them through the execution of potential ‘‘what-if” simulation scenarios (Aguilar-Saven et al., 2002). The use of scenario-based what-if analyses enables the design team to test various alternatives and choose the best one (Laguna et al., 2005).

Process modelling, creating scenarios of its behaviour, and running its simulation enable the analyst to obtain knowledge and new ideas that could be very important in process improvement. This is usually achieved by changing the simulation input data and analysing the simulation outputs. This technique leads us to find out which data or parameters are essential for process improvement.

Discrete-event system simulation is the modelling of systems in which the state variable changes only at a discrete set of points in time. Discrete-event models are appropriate for those systems for which changes in system state occur only at discrete points in time (Banks et al., 2001) and business processes are such systems.

Below we list some of the major concepts of a discrete-event model of a system, as they are defined in "Discrete-Event System Simulation" by Banks, Carson, Nelson and Nicol:

- System: A collection of entities (e.g., people and machines) that interact together over time to accomplish one or more goals;
- model: An abstract representation of a system that describe a system, usually containing structural, logical, or mathematical relationships

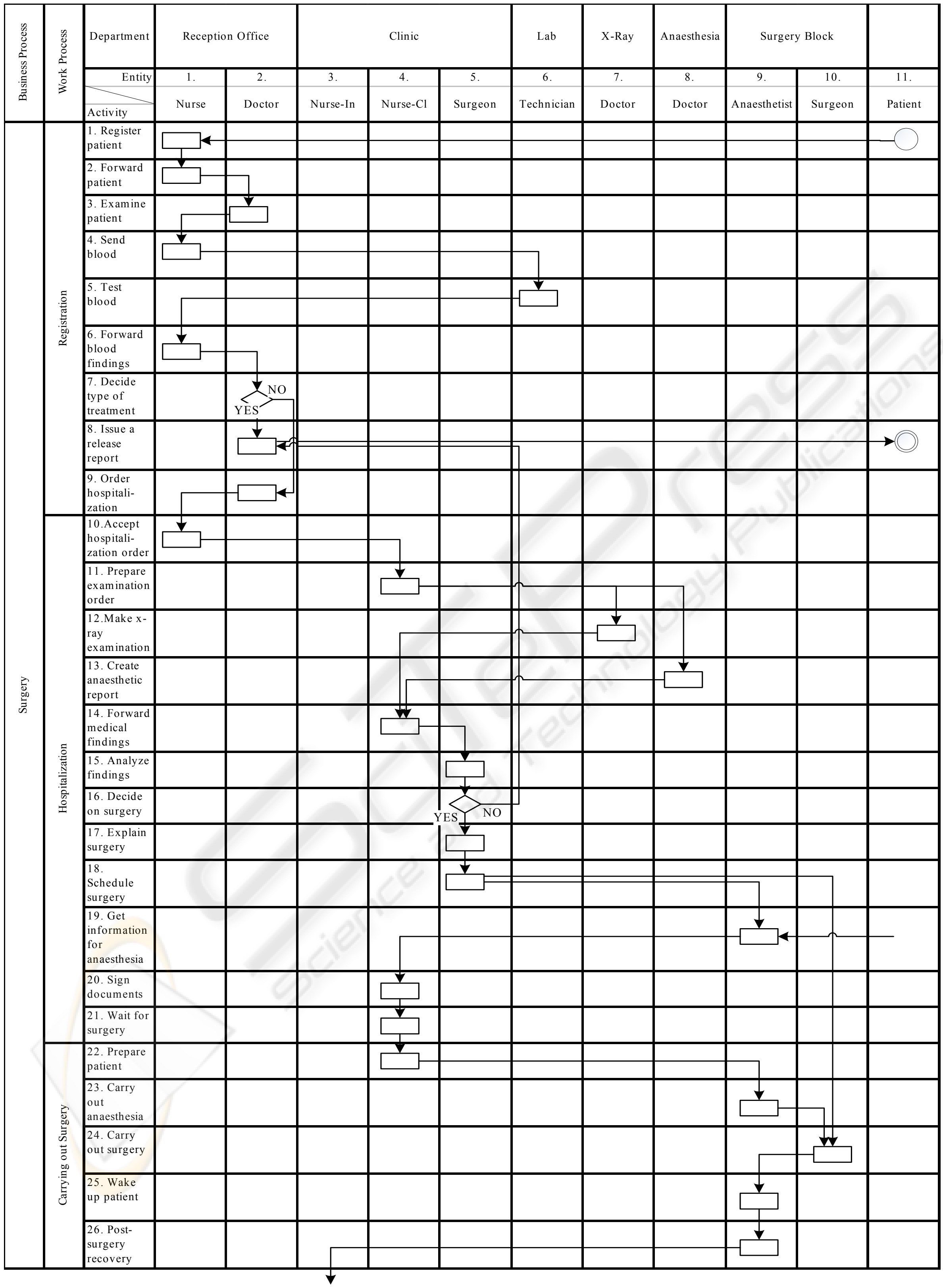

Figure 1: The Activity table.

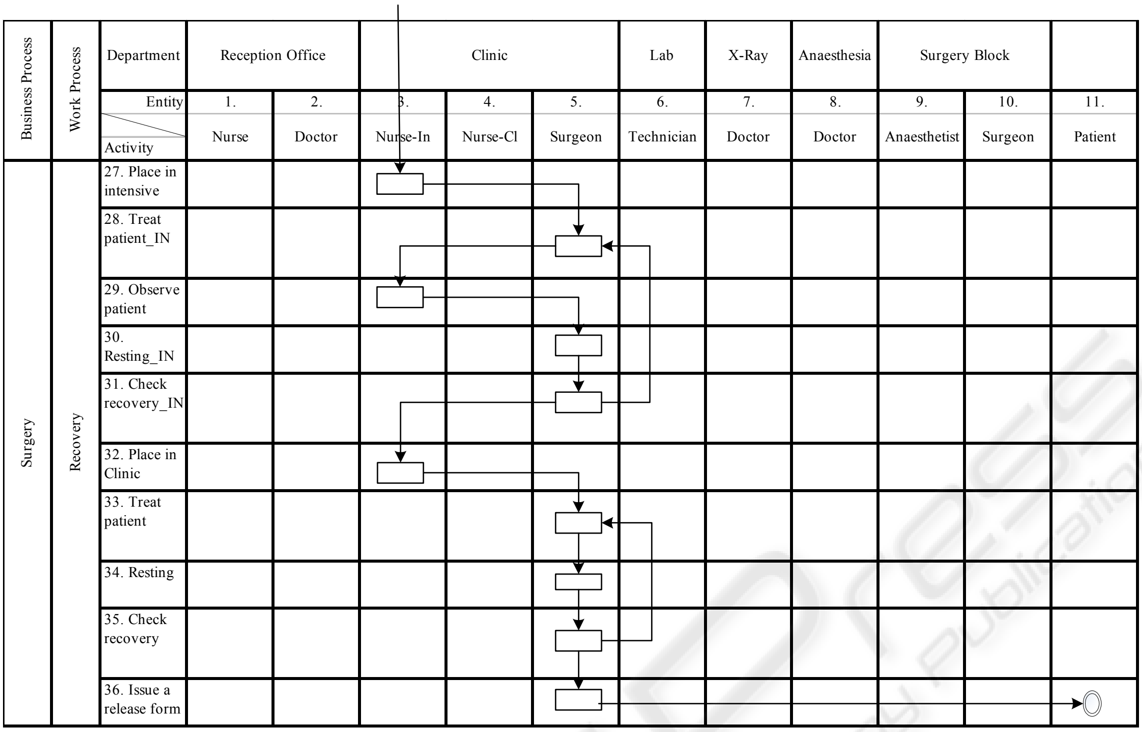

Figure 1: The Activity table (cont.).

which describe

- the system in terms of state, entities and their attributes, sets, processes, events, activities, and delays;
- State: A collection of variables that contain all the information necessary to describe the system at any time;
- Entity: Any object or component of the system which requires explicit representation in the model (e.g., a server, a customer, a machine);
- Attribute: The properties of a given entity (e.g., the priority of a waiting customer, the routing of a job through a job shop);
- Activity: A duration of time of specified length (e.g., a service time or arrival time), which is known when it begins (through it may be defined in terms of a statistical distribution);
- Delay: A duration of time of unspecified indefinite length, which is not known until it ends (e.g., a customer's delay in a last-in, first-out waiting line which, when it begins, depends on future arrivals);
- Clock: A variable representing simulated time.

4 PROCESS IMPROVEMENT

The relationship between the essence of business process modelling and overall business effectiveness and the efficiency of the organization depends on the consumer's satisfaction with the desired output. If the latter is everything the consumer required and aimed for, business processes are well-designed, efficient, as well as effective and will in time result in successful organizations (Al-Mashari et al., 2000). On the other hand, if the consumer lacks appropriate satisfaction or the organization's growth and profit are decreasing, it is crucial to understand that improvement of business processes has to be planned and carefully carried out.

The purpose of business process improvement is to improve the way an organization functions by carrying out the necessary changes in their processes to give them more value, increase effectiveness, without duplication of procedures and activities, and to make them less costly, in order to achieve greater customer satisfaction.

A great deal of effort has been focused on continuous improvement of subprocesses, activities, and tasks (Harrington et al., 1997). If the management of the organization stops the evolution of the process once business process improvement has been completed, the organization will lose the value gained. Consequently, continuous improvement tasks need to be performed.

The purpose of this work was to carry out process improvement using a simulation technique. To do that, we simulate one or more alternative versions of the business process discussed in order to change its functioning and improve it by solving real problems, removing obstacles and identifying existing bottlenecks in the process.

To run the simulation, we used iGrafx software. The steps of process simulation are summarized as follows:

a) Create the process model from the information stored in the activity table;
b) Define the properties of process activities;
c) Define process simulation parameters and run the simulation;
d) Carefully analyse the simulation results;
e) Make changes to improve the process if possible; and
f) Return to c if changes have been made.

Business process improvement is an iterative process and therefore it should be repeated several times in order to produce a better and more efficient business process.

Surgery:

To carry out simulation of the process ‘‘Surgery”, a process model was built by using the information stored in the property table (Table 1) to define the model’s characteristics.

The simulation of the process ‘‘Surgery” was run taking into consideration a Clinic for abdominal surgery with a capacity of 30 beds; 20 patients were already in the Clinic in different phases of the process, and 30 patients were scheduled for different forms surgery. In addition to this, we postulated that 3 patients of the planned 30 patients were hospitalized every day.

To do that, a standard calendar was used, that is, 8 h/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 unit, 1 Nurse and 1 Doctor in Anaesthesia, 2 Anaesthetists and 2 Nurses for performing anaesthesia in the Surgery 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.

Iteration 1: The results of running the simulation of the business process ‘‘Surgery” are as follows:

- Average cycle time for one patient is 14.68 days;
- Elapsed time for carrying out surgery for 30 patients is 25.57 days. This is understandable because the simulation 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 7.1h;
- Average time for recovery in Intensive care is 4.26 days;
- Average time for recovery in the Clinic is 6.39 days;
- Average time for creating a release form is 0.78h.

Iteration 2: These results show that the process ‘‘Surgery” could be improved by considering the following suggestions:

1. The time for performing different activities before surgery (average is 2.94 days) could be shortened by carrying out most of these activities before the patient’s hospitalization or organizing them better;
2. The recovery time in Intensive Care (average is 4.26 days) should be reduced when possible; and
3. The recovery time in the Clinic (average 6.39 days) should be shortened when possible.

To implement the above suggestions, we changed the process model and prepared a new simulation scenario that takes into the account the following changes:

- To implement the first suggestion, activities 11-13, 16-18 and 21 are removed from the process model because the patient obtains the necessary medical findings before hospitalization;
- To implement the second suggestion, the recovery time in the Intensive Care (activities 27-31) is reduced by 0-3 days;
- To implement the third suggestion, the recovery time in the Clinic (activities 32-36) is reduced by 3-7 days.

After running the simulation using the new scenario, we obtained the following results:

- Average cycle time for one patient is 9.14 days (instead of 14.68 days);
- Elapsed time for carrying out surgery for 30 patients is 19.20 days (instead of 25.57);

- Average time for performing different activities before surgery is 5.6 hours (instead of 2.94 days);
- Average time for performing anaesthesia, surgery and post-surgery recovery in Surgery block is 6.99 hours (instead of 7.1 hours);
- Average time for recovery in Intensive Care is 0.72 days (instead of 4.26 days);
- Average time for recovery in the Clinic is 6.28 days (instead of 6.39 days);
- Average time for creating a release form is 0.59 hour (instead of 0.78 hours).

The simulation results obtained from iteration 2 represent a great improvement of the "Surgery" process and should be implemented.

5 CONCLUSIONS

The aim of this paper was to introduce simulation as an important and very helpful technique capable of handling the difficult and complex problem of business process improvement.

To demonstrate this, simulation of the business process "Surgery" was carried out in two iterations. In the first iteration, we ran the simulation of the as-is model of the business process; that is, the model of the process as it exists in reality. This iteration of the process simulation helped us to imitate the process and discover all its problems. In the second iteration, we ran the simulation of the “to-be” model of the process; that is, the model after making changes necessary to improve it.

The results obtained from both models were very encouraging, and a simple comparison between them shows that a great improvement was made to process performance by reducing the average cycle time for one patient from 14.68 to 9.14 days. This result may lead to an increase in the quality of the process (e.g. by reducing waiting time).

Also, the time elapsed for carrying out surgery for 30 patients was reduced from 25.57 to 19.20 days. This fact means reducing the cost of the surgery carried out. Unfortunately, we cannot show the value of cost minimization because the staff of the Clinic refused to divulge any information concerning the costs of their activities or medical personnel.

In addition to this, we are certain that further improvements are possible, particularly in the framework of the work process Recovery.

Finally, we maintain that this simulation is a very capable and useful technique, and could be utilized successfully widely in the field of business process improvement.

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