Business Process Management: Use of Simulation in the Public Sector

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BUSINESS PROCESS MANAGEMENT: USE OF SIMULATION IN THE PUBLIC SECTOR

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Methods and techniques of business process management known in the private sector are being increasingly used in the public sector. This paper demonstrates their applicability to systems where the human factor is more important. It describes a case study of reengineering the process of filling unoccupied capacities in an old people's home. The simulation techniques are used as a replacement for exact deterministic planning. Our research shows that the simulation allows the prediction of the effects of the renovation and the duration of processes and bottlenecks and thus the avoidance of bad decisions.

Keywords: Public administration management; Business process modeling; Discrete event simulation; iGrafx

1. Introduction

Reserve management is a process that ensures that adequate official public sector foreign assets are readily available to and controlled by authorities to meet a defined range of objectives for a country or union (IMF, 2010). Organisations are often not aware of the 'internal reserve' they have in their every day functioning, especially when they are not forced to keep track of all expenditure. This usually happens when they have an absolute monopoly in the market. This is often the case in the sphere of public services.

Our case study deals with an old people's home. It operates in an environment where demand fully exceeds the available capacities. There are currently more than 17,000 people on the waiting list (SSZS, 2010) for about 18,500 places. It is therefore little wonder that not enough attention was being paid to the time needed to fill a space that has become released. The existing information system of the old people's home was not organised so as to show the time lost between the event of a place being released and the occurrence of its reoccupation.

The research had two main goals. The first was to prove that there are internal reserves in the organisation regarding the admission process in the old people's home. Some of them can be acquired by reorganising the process. The second goal was to demonstrate that discrete simulations can be a substitute for an incomplete information system. They are some kind of extension to the existing information system. This is a similar thesis to that already confirmed by Moon and Phatak (2005). They demonstrated that the limited planning functionality of the Enterprise Resource Planning (ERP) system can be complemented by discrete-event simulation models.

With the aim of achieving these goals two models of the admission process were developed. In the first one, the existing process as it was organised before the reorganisation was modelled. The second model represents the same process after the reorganisation. Both models were produced with the MicroGrafx iGrafx Process 2007 software. Simulations of both models show gains and benefits of the reorganisation. By comparing the results of both models the second goal was achieved. It showed that simulations can play a significant role in the information system where they can reveal data which cannot be gained through regular software supporting Enterprise Resource Planning.

2. Business Process Modelling and Simulation Modelling

Simulation can be used in the analysis of any system to ensure the quality and efficiency of stochastic, complex processes that operate in resource-constrained environments. Further, most service systems are fairly well-defined discrete processes (Laughery et al., 1998). After the first simulations which were used to simulate the production process, they have also been used to analyse services. The need to use simulations in the public sector was suggested by Rouillard (1999). Now, simulations are a constituent part of modelling and analysis which, together, form the first phase of the business process management lifecycle according to the service-oriented architecture (SOA) (Juric and Pant, 2008). They are a common tool for testing a new process model before its implementation (Harmon, 2003; Kritchanchai and MacCarthy, 2002; Eldabi et al., 2002; Robertson and Perera, 2002).

There are many cases of using simulation for processes in the public sector. Greasley and Barlow (2005) analysed a business process approach to a change in a custody-of-prisoner process. Ozbay and Bartin (2003) studied an incident management situation with the Arena simulation package. Hlupic and de Vreede (2005) used simulation modelling and analysis to reduce the risk of business process innovation in an outpatient's department. Kovacic and Pecek (2007) studied the influence of legal changes on the process productivity of social grant applications.

It is common to all of these studies that the main observed value is the transaction cycle time. By Kaplan and Norton (1996) it is the indicator of throughput time. It helps visualise the impacts and implications on a new process (Chen, 1999).

In our research another very important key performance indicator was exposed. We wanted to find out the number of unused beds per year or the average number of days needed to reoccupy a released place. They would show the administration's agility in finding a new patient.

As the information system was unable to give an answer about the time lost between the release of a place and its reoccupation we decided to acquire this data from a simulation model.

The Rockwell Arena software is the most popular software for discrete simulation modelling (Anglani et al., 2002; de Swan Arons and Boer, 2001; Perera and Liyanage, 2000; Fowler and Rose, 2004). The Micrografx iGrafx Process 2007 is a similar tool to the Arena software. They both provide a simulation support environment (SSE) in which it is possible to quickly create system models interactively and manage all phases of the simulation project, including the generation of the simulation code needed in execution of the simulation (Seila, 2005; Melao and Pidd, 2006). iGrafx was chosen for the research. The deciding point reflected the fact that iGrafx uses a swim lane diagram for the basic process drawing instead of the plain block diagram in the case in the Arena software. Only a few articles mention this software in connection to simulation engineering (Bosilj Vuksic et al., 2002; McCarthy and Stauffer, 2001; Groznik et al., 2003; Noakes, 2005; Kovacic and Pecek, 2007; Damij et al., 2008).

For the drawing technique a swim lane diagram was chosen. It is one of the diagrams used in the Unified Modelling Language which many authors recognise as a "de facto industrial standard for the information engineering" (e.g., Engels et al., 2000; Siau and Halpin, 2001; Pender, 2003).

3. The Existing Admission Procedure Practice

3.1 The Admission Process before the Reorganisation

The home under consideration cares for about 200 patients. On average, free spaces became available and were released between 60 and 65 times a year (2006: 62; 2007: 69; 2008: 59). The procedure for accepting a new client was simple and, more or less, carried out as follows: The client filled in an application. The administration accepted it and analysed the space available. If no place was available, the administration prepared information conveying the temporary overcrowded status and sent it to the applicant. It was suggested that he or she try again in two or three weeks. If a free place was available then the applicant was registered and sent for a medical check-up. A medical council decided whether the applicant really needed medical nursing and was suitable for acceptance. In this case, the competent commission convened on the morning following the examination. On the basis of a free place and the medical council's diagnosis, the acceptance commission made a final decision on accepting the applicant. According to their health care and needs, applicants were sorted into four categories: self-dependent, occasional help needed, demanding, and 24-hour demanding. An applicant might be refused if the type of free place and the client's demands were incompatible. In the case of such a rejection, information on the rejection was prepared. Otherwise the administration prepared a contract. The applicant or his/her relatives signed the contract. (In the majority of cases, the relatives accepted the stated conditions). The applicant referred to was accepted the following morning when his or her documents were prepared. The medical council described the nursing required. If the conditions of the contract were not accepted the application was withdrawn.

In the situation where an applicant was refused due to overcrowding, the results of the medical counsel or by the acceptance commission, they were advised to try again in two or three weeks.

The most surprising fact was the realisation that no waiting list or similar reference was kept for the rejected applications. As to the question 'why', the answer was simple: "there is no need for it. In many cases, after a new free place was released and offered, the applicant would not need it any more". Regarding the fact that a free place remained unoccupied until the next application arrived, a very convincing answer from authorities was given: applications arrived every day, so it does not represent any problem at all.

The existing bookkeeping system did not offer any tracking about unoccupied places and was therefore unable to give any information about vacancies available at the old people's home. We could say it was unable to furnish any figures about lost opportunities. Any unoccupied place of at least one day represents a lost opportunity for the institution as it cannot be charged to anyone. Although it may be hard to imagine, the reason for not tracking these lost opportunities was very simple: nobody was ever interested in such data. The main goal of the existing information system was to keep track of all payments and to request debtors to pay their bills.

After a new member is admitted in the activity "admission", the current time from the simulation clock is recorded again. The difference of days between the "Starting_free_time" and the "Ending_free_time" is summed into the scenario attribute "S.Sum_free_time".

3.2 The Simulation Model for Admissions

The model of the described admission procedure is presented in Figure 1. The diagram shows data on the process dynamics. The abbreviation "d" stands for days, "m" for minutes and "s" for seconds. The data were provided by the operative staff.

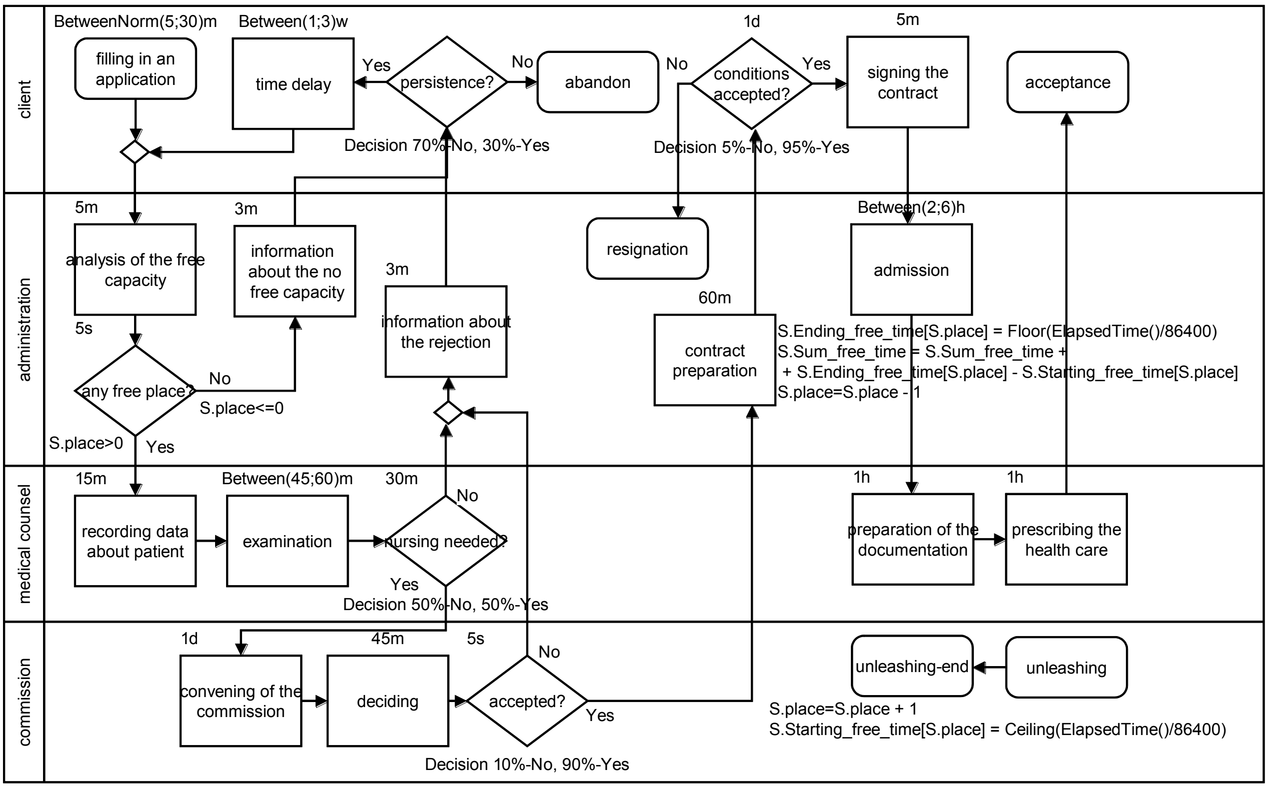
With the intention of making the model as realistic as possible, three additional modifications of the activities were made. The activity "convening of the commission" was marked as only taking place at the end of the day, while "examination" and "admission" occur in the morning. Both definitions are entered in the program on the page describing the input properties of the action by marking "collect transactions on input" with the "gate by time" option.

Two transaction generators are implemented in our model. The first one simulates occurrences of released places. The frequency of transactions was calculated by data showing that on average there are about 60 to 65 releases per year. Therefore, transactions are generated with the uniform distributed time of between 1 and 12 days. This generator is integrated in the activity "unleashing". The second one simulates the appearances of applications. It was assured that they arrive nearly every day, at least every second day. Therefore, the uniform distributed "interarrival" time between 0 and 2 days was the frequency of the generator implemented in the activity called "filling in an application".

The goal of the simulation is to calculate the number of lost days. These are days when one place – one bed – is unoccupied. This aim is achieved with the help of attributes and several in-built functions.

The first generator which simulates the occurrences of releases has only one task: it increases the number of free places. It is done in the numeric scenario attribute "S.place". At the same time, the temporary current simulation day is recorded in the numeric scenario attribute "S.Starting_free_time". This is done by the in-built function "ElapsedTime()" which returns the temporary simulation time in seconds.

Figure 1. Model of the Admissions Process AS-IS



In the decision "any free place?" the procedure continues over the path "yes" if the attribute "S.place" is greater than zero, otherwise it continues over the path named "no".

3.3 Results of the simulation

The simulation scenario was prepared to simulate 55 years with 5 warm up years. We planned the number of repetitions of the simulation with a different seed number according to the procedure described in Karian and Dudewicz (1999), noting that the same procedure is also described in Harrell et al. (2004):

Step 1: we decided to make 15 initial runs (n_0 = 15) of the simulation for the first estimation of the number of lost – unoccupied – days. From $\omega = t^{-1}_{n_0-1}((1+P^*)/2)/d$, a confidence P* = .99 and a tolerance interval ± 100 days in a 50-year period a $t^{-1}_{n_0-1}(0.99) = t^{-1}_{14}(0.99)$ = 2.624 was stated from the Student t-distribution.

Step 2: 15 occurrences of the simulation for the observed model were completed. Results for each individual run are given in Table 1.

Step 3: Calculations from the sample for $\overline{X}(n_0)$ = 20360.6 and s = 952.73 were made.

Step 4: A number of occurrences (n) of simulation runs

Table 1. Results of Simulations of the AS-IS Model of the Admissions Process

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	X	SD
Sum of free days	19379	21428	20896	18910	20849	20685	18876	20889	20778	19719	20592	21573	20411	18941	21483	20360	952.73
Accepted number	2969	3021	2982	2945	3009	3006	2951	3038	3049	3017	3036	3020	2995	2988	3019	3003	31.05
Releases in 55 years	3269	3329	3281	3240	3323	3326	3243	3337	3347	3306	3334	3325	3310	3283	3315	3304.5	33.72
Examinations in 55 years	7649	7794	7675	7580	7775	7779	7588	7809	7826	7734	7801	7779	7741	7682	7758	7731.3	78.77

for the stated confidence of 0.99 and a tolerance (d) of ± 100 days were set: $n = \max\left\{n_0 + 1, \left\lceil \left(t_{n_0-1}^{-1}\left(\left(1+P^*\right)/2\right)\right)^2 s^2 / d^2 \right\rceil\right\}$, where $\lceil . \rceil$ denotes rounding up to an integer. So $n = \max\left\{16, \left\lceil (2.624)^2 * (952.73)^2 / (100)^2 \right\rceil\right\}$ $= \max\{16, \lceil 624.94 \rceil\} = \max\{16, 625\} = 625.$

Step 5: 625 simulations runs each with a different initialisation of the random number were undertaken. 58 minutes were needed to complete the simulations on a computer powered by a 2.4 GHz CPU.

Step 6: A calculation for the 625 simulation runs was made and $\overline{\overline{X}}$ = 20100.22 was calculated

Step 7: We can claim with a confidence of 0.99 that the average lost number of days in a 50-year time period is between 20000.22 days and 20200.22 days. This means that on average about 402 days are lost each year.

3.4 Verification and Validation of the Model

Verification is the process of making sure that a simulation program actually represents the intended model (Pidd, 1998; Chung, 2003; Banks et al., 2001; Law and Kelton, 2000; Seila et al., 2003). Validation is the process of determining if the model is a useful representation of the real system (Seila et al., 2003; Birta and Arbez 2007; Wainer 2009). Like Celik and Sabuncuoglu (2007) we used iGrafx trace option.

For the first test of validation the number of released places per year was considered. It was established that this number varied between 60 and 62 persons. This confirms the expected number according to data for the last three years. On the other hand the activity "analysis of free capacity" was executed about 19500 times per simulation – in the 50-year period. This means that there were inquiries every day! This confirms that both generators simulate the reality of the process.

The main validation was done thru the observation of the exact number of days needed for the free bed reoccupation. Like in Potter et al. (2007) this was a difficult task as it required a manual detailed tracing of everyday changes to the occupation of resources. This supervision was taking place for a month and a half. During this time, seven releases were traced. It was expected that, on average, a released bed is reoccupied in about 6.7 days (402 days divided by 60 acceptances). The actual data showed that on average this period is longer. There were manual observations of seven cases. It took 9, 7, 12, 6, 9, 6 and 11 days which gives an average of 8.6 days with σ = 2.19. A detailed analysis of the reason showed there were many subjective reasons that extended the process – like the illness of the administrator, vacations, holidays etc. This should be included in the model, but would demand the detailed observation of the probability that something goes wrong and thus expand the process. In any case, the analysis showed that the actual data do not differ from the simulated result ($z = (\bar{x} - \mu)/(\sigma/\sqrt{n-1})$ = $(8.6 - 6.7)/(2.19/\sqrt{6})$ = 0.78). At least it was concluded that the model was not pessimistic. To the contrary, it even calculated an optimistic version whereby everything goes as planned. Therefore, it was stated that the model satisfies the expectations and the model was therefore verified and validated.

4. The New Admissions Process

4.1 Model of the new improved process

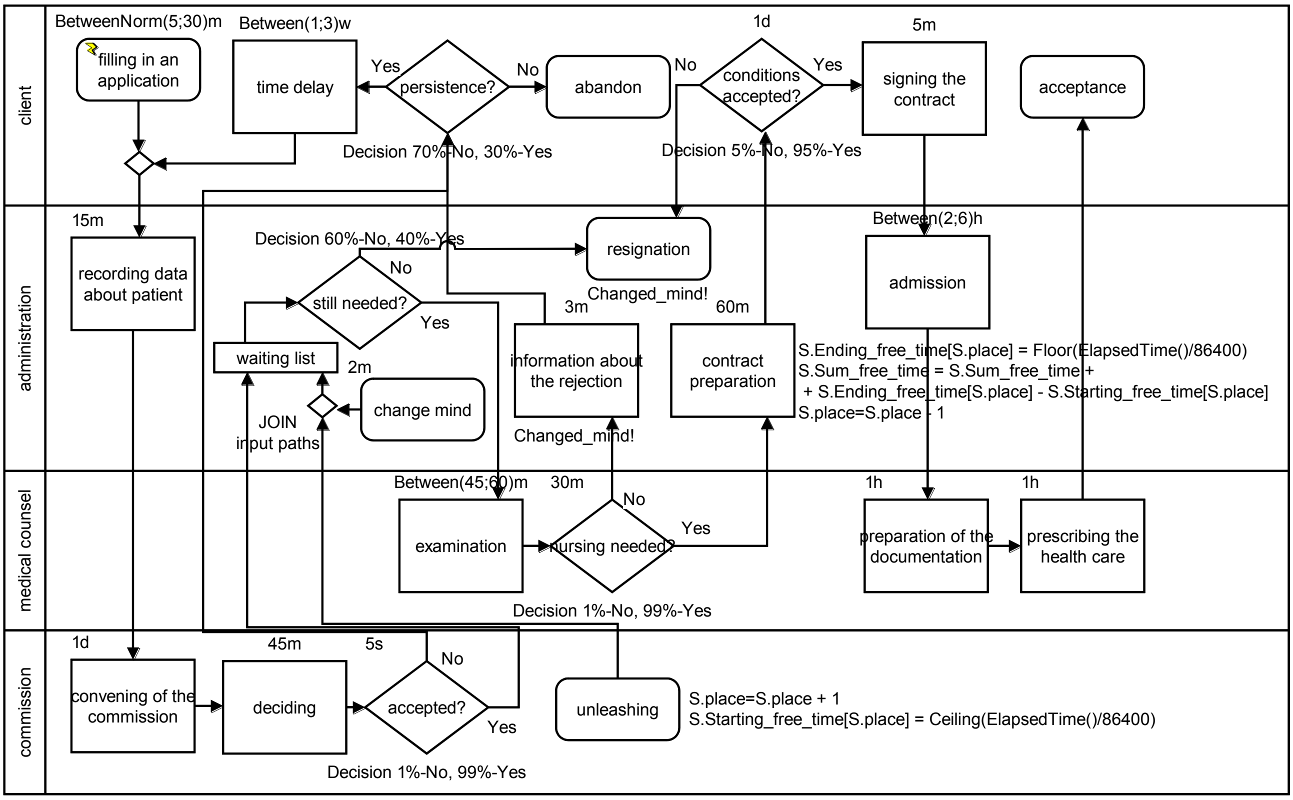
After calculating time wasted in the current process, an interesting question arose: "what do we gain if applications are not rejected, but put on a waiting list? Would that have any effect on the efficiency of the institution?" Therefore, a new modified version of the admissions process was established. It was organised on the following foundations:

- Each candidate is obliged to have the prescribed medical exam of their abilities at their own expense by any general practitioner. The diagnosis is added to the application.

- Each application is accepted and placed in the waiting list.

Now the process after the transaction generator goes to the administration which records the data about the patient. Afterwards, the commission confirms the candidate and adds them to the waiting list. The commission does not have many reasons to reject the application. It decides according to the submitted medical certificate prepared by the general practitioner outside of the institution. Therefore, we stated that only 1% of applications are rejected. After a new place is released, the first one on the waiting list is called and medically examined. The medical counsel can only reject the applicant if the medical condition is in fact different to the diagnosis enclosed with the application. This can only happen where there has been a dramatic change to one's health condition during the time waiting in the queue. Therefore, the same probability was used. If the nursing required is confirmed by the

Figure 2. Model of the New Modified Admissions Process TO-BE



medical counsel a contract is prepared, signed by the client and they are admitted. The counsel prepares the documentation and prescribes the health care.

There is a very important decision called "still needed" after a new application from the waiting list starts. It may happen that an applicant who is finally called to be admitted is no longer interested in living in the institution. Either they have found a new solution or the service is not needed any more. Therefore, we predicted that more than half of the people offered a place would reject the invitation (60%). It such a case there needs to be a feedback signal in the waiting list so that another candidate from the waiting list is lined up for admission.

This was achieved by inviting the third generator "change mind". In the case that a feedback signal is needed a new scenario attribute "S.changed_mind" is increased by 1. And every time this attribute is increased, the "change mind" generator generates a new transaction in the waiting list where a new waiting applicant is picked from the queue and launched for acceptance.

The model of the new reorganised procedure is shown in Figure 2.

4.2 Results of simulating the modified process

The simulation scenario for the modified process was the same as the previous one. It simulates 55 years with 5 warm up years. The same procedure as for the previous model was used (Karian and Dudewicz, 1999;

Table 2. Results of Simulations of the Modified TO-BE Model of the Admissions Process

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	X	SD
Sum of free days	8976	9036	8945	8866	11350	10396	8759	9051	9118	9044	9117	9367	10104	8939	9056	9341.6	716.86
Accepted number	2968	3018	2981	2945	2991	2994	2948	3036	3051	3016	3035	3015	2995	2988	3018	2999.9	31.23
Releases in 55 years	3269	3329	3281	3240	3323	3326	3243	3337	3347	3306	3334	3325	3310	3283	3315	3304.5	33.72
Examinations in 55 years	3475	3534	3488	3446	3513	3521	3446	3545	3560	3516	3544	3531	3505	3491	3523	3509.2	34.34

Harrell et al., 2004) was used to calculate the number of simulation repetitions:

Step 1: Again, 15 initial runs of the simulation were performed. With the same level of confidence P* = 0.99 and the tolerance interval ± 100 days in a 50-year period a $t^{-1}_{n_0-1}(0.99) = t^{-1}_{14}(0.99) = 2.624$ was stated from the Student t-distribution.

Step 2: 15 occurrences of the simulation for the observed model were completed. Results for each individual run are given in Table 2.

Step 3: Calculations from the sample for $\overline{X}(n_0)$ = 9341.6 and s = 716.86 were made.

Step 4: The number of occurrences (n) of simulation runs for a tolerance (d) of ± 100 days was set:

$$n = \max\left\{16, \left\lceil (2.624)^2 * (716.86)^2 / (100)^2 \right\rceil\right\} =$$

$$= \max\left\{16, \lceil 353.8 \rceil\right\} = \max\{16, 354\} = 354.$$

Step 5: An additional 354 simulation runs were undertaken.

Step 6: A calculation for the 354 simulation runs was made and $\overline{\overline{X}}$ = 9148.12 was calculated.

Step 7: We can claim with a confidence of 0.99 that the average number of lost days in the 50-year period is

9148.12 ± 100 days. This means that on average about 183 days are lost in a single year.

The simulation shows that the new, reorganised process has shortened the time of reoccupying a released bed from 402 to 183 days. This means that the new process has reduced the time of reoccupying a released free place by nearly 55 %. Now, there is an average waiting time for a new client of nearly 3 days.

In the first test the number of patients accepted was considered. The figures from both models were compared and are identical. They generate the same number of releases and the number of accepted people also differs very little. Therefore, it can be assumed that both generate the same conditions.

Again, a manual observation and tracking of free time was performed for 16 cases. In six cases the reoccupation time was 2 days, in seven cases 3, one case 4 and in two cases 5 days. This yields an average of 2.93 days and a deviation of 1.03.

5. Interpreting the Results

Simulations of both models clearly show that the number of days lost when an unoccupied place occurs seriously decreases when the process is newly organised to include the creation of a waiting list. The calculation shows that, on average, it can be expected that 219 fewer days a year will be lost in the new way of organising the process.

In 2009 the cost of a single day in the old people's home was EUR 40. This means that about EUR 8,700 in savings arise. Perhaps some might claim that the net saving created by the reorganisation is low. Perhaps some would even say it was not worth developing the simulation model for such a modest sum. Yet perhaps the most important reason for the research stands out. It has been proven that the organisation has internal reserves which can be used instead of just waiting to increase the prices. And this is a very important message to the organisation in an environment where demand highly exceeds the supply.

Some other aims are realised by reorganising the procedure. The medical counsel no longer needs to record a candidate's data for the medical exam. This can be done by the administration. A very useful value is the fact that in the new model only a little more than the accepted patients are examined by internal staff of the old people's home. Candidates need to acquire the medical certificate in advance from their general practitioner. Therefore, just a routine verification is needed to confirm that the health condition of the person has not changed drastically since the examination was performed. The number of examinations therefore significantly decreases from 7731 to 3509 in a 55-year period. (The warm up time of 5 years in included in this number). It is worth mentioning that this activity is by far the most expensive of all. It needs a doctor and a nurse who are always over-occupied with everyday work.

6. Conclusion

Today's rapidly changing business environment, competition and technological changes are forcing organisations to react rapidly to market needs and to ensure continuous business improvement. The analysis and design of organisational processes can be assisted by the development of business process simulation models. A simulation can provide a valuable mechanism for addressing the challenge of the quantitative and qualitative evaluation of prospective designs of business processes. Further, a simulation can facilitate experimentation with and the study of multiple perspectives of organisations, thereby contributing to a holistic view of enterprises and, ideally, to increasing the quality of change decisions. The benefits realised from an investment in simulation methodology and tools are both tangible and intangible. Most savings are expected in a reduction of the amount of time required for manual calculations, a decrease in the amount of time required to perform analyses, an improvement in the quality of solutions, and an increase in reusable corporate assets (business models, business rules and knowledge). Concerning this case study, general acceptance of the simulation approach provides benefits for internal and external business process activities. Internal benefits are quality, time, cost reduction, innovations, customer service, or product performances that create long-term profitability for the organisation.

By providing important numbers to decision-makers, simulations have proven they are no longer merely exotic laboratory experimental tools. They can become and need to be part of the renovation of an enterprise's business process. The main idea of business renovation is to look at organisations from the process point of view. Business renovation is not about changing the current state but creating a new and more competitive organisation. Many projects in the past have failed since the orientation of projects was strictly to business processes that generated major changes but without involving other aspects. Business renovation, besides business processes, includes other organisation aspects like organisational structures, technology, people and culture. The last two aspects mentioned are in a way the most important when organisations seek to implement changes suggested in project documentation. A business renovation project is a difficult and long-term project. It is vital that it includes professionals with a precisely defined strategy. The risk involved in such projects is very high as the project team may confront many obstacles. The basis to start such a project is to have the complete support and co-operation of top management which has power to control the employees and can also assist if problems arise.

This case study confirms that the analysis and carefully used simulation of business processes is indeed useful since it provides insights into policies, practices, procedures, organisation, process flows and consequently shifts people's minds from a functional to a process-oriented orientation. Both hypotheses stated at the beginning of the research have been proven. Without any serious effort being expended, a new type of process was shown to be legitimate. No extra money was invested in the reorganised procedure. On the other hand, it provides not insignificant savings to the institution.

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