BUSINESS PROCESS REDESIGN IN HEALTHCARE: TOWARDS A STRUCTURED APPROACH

MONIQUE H. JANSEN-VULLERS

Department of Technology Management
Eindhoven University of Technology
Pav. D13, 5600 MB Eindhoven
The Netherlands
e-mail: m.h.jansen-vullers@tm.tue.nl

HAJO A. REIJERS

Department of Technology Management
Eindhoven University of Technology
Pav. D14, 5600 MB Eindhoven
The Netherlands
e-mail: h.a.reijers@tm.tue.nl

ABSTRACT

This paper focuses on the potential contribution of Business Process Redesign to society's demand for decreasing costs of healthcare. Our focus is on the reduction of throughput times and service times by exploiting business process redesign techniques, i.e. rules of thumb that aim to optimise the business process by improving its tasks, its routing structure, the resource organisation, etc. We define a redesign approach based on a set of existing redesign heuristics (Reijers, 2003) and apply this approach in a mental healthcare case. We show seven alternative redesigns for an intake process and evaluate their impact on throughput times and service times. Our conclusion is that the approach is feasible and results in a fruitful input for the organisation in question. This result is in line with results from the evolutionary approach of (Buchanan, 1998).

The application of best practices in the mental healthcare setting shows its potency in this specific context and very similar settings. A next necessary step towards a wider application in healthcare seems to be a more structured method on how to select or combine an effective set of best practices for a specific medical context.

Keywords: Mental health care, process reengineering, throughput time.

1. INTRODUCTION

Demands on the healthcare institutes are increasing, as are the costs of healthcare. To be able to meet this demand, service times and throughput times in healthcare institutes should be reduced as much as possible while the quality of service should at least stay the same. Business Process Redesign could contribute to that by optimising the tasks, the routing structure for those tasks, the way that resources are allocated to the process, etc.

In this paper, we consider an approach for Business Process Redesign that is based on redesign heuristics, and that has been applied in a mental healthcare institute. As a result of this approach we come up with seven scenarios that are alternatives for the current situation. The effect of each scenario, with respect to service time and throughput time (also known as lead time or sojourn time) follows by analysis of the business process model and simulation experiments.

The intent of this paper is to show how the use of a checklist of redesign heuristics may help to improve the performance of healthcare processes. Applying this approach may result in similar scenarios for organizations or processes similar to the ones studied here; however, this application may also result in significantly different scenarios if circumstances are different. The presented case is thought to be of interest for a broad audience of healthcare professionals and

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representative for many of the current process layouts, since the intake procedure is rather common for many institutes and hospitals. Furthermore, the approach seems to be applicable for many healthcare processes, especially with respect to those processes that do not involve an intensive participation of the patient throughout the entire process.

The paper is organised as follows. In section 2 we describe the background of the research: business process redesign, redesign heuristics and business process redesign in healthcare. In section 3 the initial situation of the healthcare case is given textually and in the form of a model. In section 4 we present the approach we followed, the seven redesigns of the initial situation that were the result of this approach and the evaluation of the scenarios with respect to improvements in throughput time and service time. In section 5 we discuss the contribution of the presented redesign approach and we present two alternatives for this approach. Finally, in section 6 we reflect on the applicability of the redesign heuristics approach, and we discuss requirements for further research.

2. BACKGROUND

2.1 Business Process Redesign (BPR)

This paper focuses on the control of business processes from an information systems perspective. Advances in information technology introduced new possibilities for the design of business processes. Especially the rise of generic software packages for the control of business processes, so-called workflow management systems (WFMS) are important (Aalst and Hee, 2002). At the same time, the introduction of such new technology is a significant enabler for the redesign of business processes.

In the early nineties, the first reports appeared on more or less systematic approaches to generate radical performance improvement of *entire* business processes (Davenport and Short, 1990; Hammer, 1990; Davenport and Short, 1990). Their major vehicles were the application of information technology on the one hand and the restructuring of business process on the other. This approach was coined with the terms "Business Process Reengineering" (Hammer, 1990) and "Business Process Redesign", to both of which we will refer to as "BPR".

The BPR guru's of the first hour propagated the "clean sheet" approach, i.e. a process should be designed from scratch without considering the existing process in too much detail. However, most BPR projects take the existing business process as starting point (Reijers, 2003): Within the setting of a workshop, several parties involved (management consultants, business professionals, and managers) try to think of favorable alternatives to the business process as a whole or parts of it. IT-specialists, change management experts, and other specialists to implement the new layout of the process within the organization then use the resulting process design.

The technical heart of BPR is the sensible application of a number of recurring redesign practices. (Hammer and Champy, 1993) presents several examples, such as "Small tasks in a business process should be combined into larger tasks". An extensive literature survey in this field, extended with actual BPR experiences, has rendered 29 practices that are often applied in the redesign of a business process (Reijers, 2003). This survey will be taken as the basis for exploring the possibilities to apply BPR for a health application (see appendix).

(Brand and Kolk, 1995) distinguish four main dimensions in the effects of redesign measures: *time*, *cost*, *quality*, and *flexibility*. Ideally, a redesign of a business process decreases the time required to handle the case, it decreases the required cost of executing the business process, it improves the quality of the service delivered, and it improves the ability of the business process to react to variation. The appealing property of their model is that, in general, improving upon one dimension may have a weakening effect on another. For example, reconciliation tasks may be added in a business process to improve on the quality of the delivered service, but this may have a drawback on the timeliness of the service delivery. To signify the difficult trade-offs that sometimes have to be made they refer to their model as the *devil's quadrangle*.

Awareness of the trade-off that underlies a redesign measure is very important in a heuristic redesign of a business process. Sometimes, the effect of a redesign measure may be that the result from some point of view is worse than the existing business process. The application of *several* redesign rules may also result in the partly deactivation of the desired effects of each of the *single* measures.

2.2 BPR in healthcare

BPR may contribute a lot to healthcare, provided that it is carried out carefully. BPR projects involving IT investment in the US healthcare system not only led to increased profitability but also resulted in reduced patient mortality and increased patient satisfaction (Devarj and Kholi, 2005). A Delphi study among healthcare informatics experts ranked BPR as one of the main research topics in healthcare informatics (Brender *et al*, 2000). Also (Bliemel and Hassanein, 2004) mention that the area of reengineering in healthcare will grow substantially, both practically and academically.

Many studies already report about individual BPR projects in the healthcare domain and also several papers report on more general studies regarding this topic (e.g., (Buchanan, 1998); (Mitchell and Zmud, 1999) and (Bliemel and Hassanein, 2004). Buchanan focuses on organisational change and project management issues of BPR in a politicised hospital context. The research of Mitchell and Zmud pointed out that the performance of a BPR project improved with tightly coupled IT and work process strategies and with loosely coupled strategies when implementing imitations. The research of Bliemel and Hassanein focus on a framework that identifies the e-health technologies and processes that could support the effective application of BPR within a healthcare environment.

The studies we found in literature have two main limitations. The first kind of limitation is caused by the particular starting point of a redesign, e.g. the aim to implement an Electronic Health Record. The focus of such a project is clearly defined. However, the scope of the project may be too narrow since other redesign options may even increase quality and efficiency or reduce lead-times more effectively.

The second kind of limitations is based on the type of framework or approach being used. Both (Buchanan, 1998) and (Mitchell and Zmud, 1999) do not really support the actual derivation of new process designs, but describe issues and requirements to create a fruitful environment for process derivation. (Bliemel and Hassanein, 2004) does focus on the derivation process itself, starting from a set of general issues in healthcare. However, this study has a specific link to technology and thus excludes several other interesting principles. Furthermore, the principles mentioned are still somewhat at a high level. As stated in (Buchanan, 1998): "The reengineering literature offers few templates for determining the appropriate definition of process, or for deciding the appropriate approach to process mapping."

The problems listed above can also be found in other domains. BPR in healthcare has a lot in common with BPR in several other domains, such as banking, insurance and other service industries. A paper that is frequently referred to is (Kettinger *et al*, 1997), which describes a widely applicable approach of methodologies, techniques and tools. A major limitation of this approach is that it lacks an adequate level of detail to support the derivation of a design. A study that aims to contribute to the derivation process of new process designs is (Reijers, 2003). This paper is validating that approach for the healthcare domain.

3. INITIAL SITUATION

In this section we describe the case of an intake procedure to process new requests for non-urgent treatment at a mental healthcare institute in the Netherlands. The procedure is slightly simplified from the procedure in actual use at this institute. We describe the procedure in plain English and with a process model, represented by Petri-net based workflow nets (Aalst and Hee, 2002). For the latter we use the process-modelling tool Protos (Pallas Athena, 1997). The section ends with a description of the current performance of the intake procedure.

3.1 The intake procedure

An intake of a treatment case starts with a notice by telephone at the secretarial office of the mental healthcare institute. The secretarial worker inquires after the name and residence of the patient to determine the nursing officer responsible for the part of the region that the patient lives in.

The nursing officer makes a full inquiry into the mental, health, and social state of the patient in question. This information is recorded on a registration form, handed in at the secretarial office, stored in the information system and subsequently printed. For new patients, a patient file is created. The registration form as well as the print from the information system are stored in the patient file. At the secretarial office, two registration cards are produced for respectively the future first and second intaker of the patient.

Halfway the week, at Wednesday, a staff meeting of the entire medical team (social-medical workers, physicians, and a psychiatrist) takes place to assign all new patients. Each patient will be assigned to a social-medical worker, who will act as the first intaker of the patient. One of the physicians will act as the second intaker. The assignments are recorded on an assignment list, which is handed to the secretarial office. For each new assignment, it is also determined whether the medical file of the patient is required and added to the assignment list.

The secretarial office stores the assignment of each patient of the assignment list in the information system. It passes the produced registration cards to the first and second intaker of each newly assigned patient. For each patient for which the medical file is required, the secretarial office prepares and sends a letter to the family doctor of the patient, requesting for a copy of the medical file. As soon as this copy is received, the secretarial office will inform the second intaker and add the copy to the patient file.

The first intaker plans a meeting with the patient as soon as this is possible. During the first meeting, the patient is examined using a standard checklist, which is filled out. Additional observations are registered in a personal notebook. After a visit, the first intaker puts a copy of these notes and the standard checklist in the patient's file.

The second intaker plans the first meeting only after the medical information of the physician – if required – has been received. Physicians use dictaphones to record their observations, which are typed out by the secretarial office and added to the patient file.

As soon as the meetings of the first and second intaker with the patient have taken place, the secretarial office puts the patient on the list of patients that reach this status. For the staff meeting on Wednesday, they provide the team-leader with a list of these patients. For each of these patients, the first and second intaker together with the team-leader and the attending psychiatrist formulate a treatment plan. This treatment plan formally ends the intake procedure.

3.2 A model of the intake procedure

This process is in use to handle all non-urgent notices for mental healthcare to people who reside in the region that this institute is responsible for. The described procedure is depicted as a workflow net in Figure 1. Note the use of the triggers "Wednesday morning" and "Wednesday morning 2". They refer to the same event and indicate that the respective tasks "Assign intakers" and "Determine treatment" have to await the first staff meeting, which takes place every Wednesday.

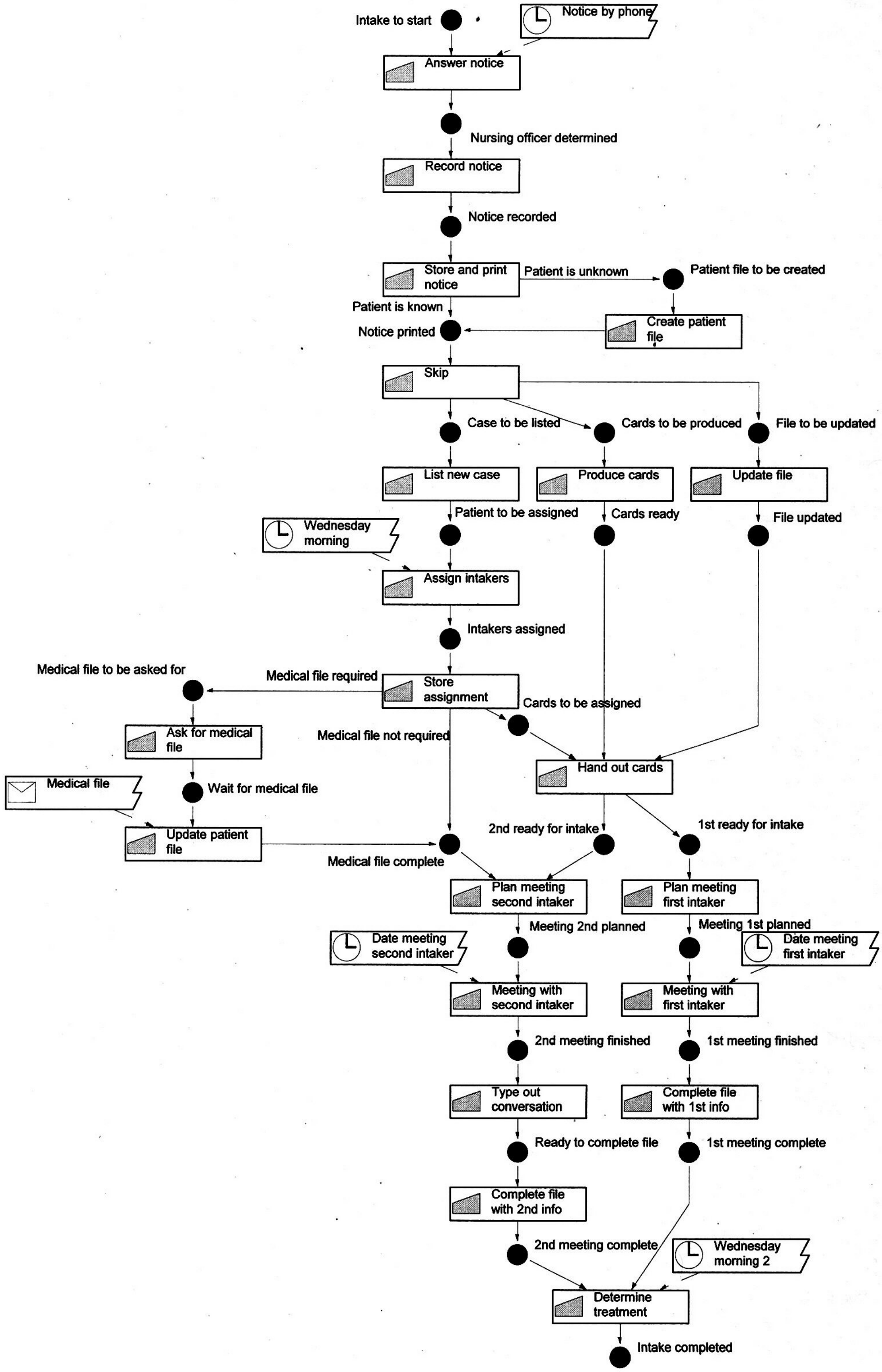
We distinguish nine roles: secretarial worker, nurse officer, medical team member, social-medical worker, physician, psychiatrist, team-leader, first and second intaker. Note that roles are not the only important characteristic to classify the resources in this process; next to the different roles, there is also an organizational characteristic, which is used to distinguish resource classes. The precedence relations of these roles are in effect according to the routing component.

We assume that all resources maintain a First come – First served discipline.

3.3 Performance

Within the setting of this process, the medical team consists of 16 people: eight social medical workers, four physicians, two team-leaders, and two psychiatrists. Each member of the medical

Figure 1: The intake process: current situation



team works full-time and spends about 50% of his time on the intake of new cases, except for the psychiatrists who spend 10% of their time on the intake of new cases. (Most of the resources' remaining time is spent on the treatment of patients). The secretarial office consists of eight workers, who work full time. About 50% of their time is spent on the intake of new cases.

The current performance of the process is measured in two ways. As a way of making the external quality of the process operational, the average throughput time is taken. For the internal efficiency, the average total service time per case is taken.

The average throughput time is slightly more than 10 working days. On each case, the following time is spent on average:

- By the secretarial office: 46 minutes.
- By the social-medical workers: 65 minutes.
- By the physicians: 37 minutes.
- By the team-leaders: 15 minutes.
- By the psychiatrists: 10 minutes.

Therefore, the total time spent on a new case averages two hours and 53 minutes. This means that the total service time makes up slightly less than 4% of the total throughput time. Each day, slightly less than 20 cases arrive. By using Little's law (see, e.g., (van der Aalst en van Hee, 2002), we can deduce the number of cases in progress, regardless of the interarrival pattern, distribution of processing times and number of resources. The only assumption is that the system is stable, i.e. it does not become congested with cases. The number of cases in progress (L) is a product of the intensity of the interarrival process (λ) and the average system time (S). The average completion time for a case is 10 days (S = 10) and on average 20 cases per day arrive (λ = 20). So, the average number of new, non-urgent requests for treatment being in process at any time is 200 (L = 200).

This concludes the description of the initial situation. Note that we did not give full information on the durations of tasks, the variation of their durations, and the routing fractions of the cases. Instead of merely summing these up, we will present these figures when discussing the effects of the investigated redesign measures. (Some of these figures will turn out to be surprising on closer inspection.) Each unmentioned figure is used *ceteris paribus* for each situation described. Each figure that is expected to change due to a redesign measure is explicitly stated when describing a redesign scenario.

4. ALTERNATIVE REDESIGNS

In this section, we first present the approach to define scenarios for a particular redesign project. Subsequently we will discuss several redesign scenarios as alternatives to the intake process. Finally, we evaluate the effect of each scenario with respect to the total average service time: This follows directly from the described changes or from exact analysis of the process model. Changes in throughput times follow from simulation experiments with the alternative process design. In this discussion, we see throughput time as being composed of the following types of time:

- Service time: the time that resources actually spend on handling the case,
- Queue time: the time that a case spends waiting in queue because there are no resources available to handle the case,
- Wait time: all other time a case spends waiting, most notably because synchronization must take place with an external process.

It is interesting to note here that service time in many situations amounts to less than 5% of the throughput time of a case (Platier, 1996), so the 4% in this case is no exception.

4.1 Redesign approach

The backbone of the redesign approach is the set of redesign heuristics as has been described in (Reijers, 2003). Subsequently we carry out the following steps:

1. The process is modeled in such a way that it is a realistic image of the real process and that it can be used for simulation purposes. The result of the simulation needs to be validated with the process owner.
2. For each redesign heuristic we consider which part(s) of the process may benefit from this particular heuristic. This step results in (a) a list of redesign heuristics that may be applicable for this particular process, and (b) a list of process fragments that may be influenced by one or more redesign heuristics.
3. For each process fragment, we decide which (combination of) heuristic(s) is interesting, either from the viewpoint of the process owner and/or the viewpoint of the redesign consultant. This step results in a number of redesign scenarios.
4. For each scenario a new process model is created, i.e. the original process model is changed based on the redesign heuristics for the relevant process fragment. We evaluate the effect of a scenario with respect to the total average service time, calculate confidence intervals and compare them with the results of the original process model. The constraints of the implementation of a scenario are validated with the process owner.
5. The final step is to decide which scenarios will be taken into account when actually redesigning the process. In cooperation with the process owner, the set of scenarios is determined; the resulting redesigned process model is delivered and can be used for simulation and evaluation. The constraints for implementation are further detailed.

In the next section we focus on steps 2 and 3, as they provide insight into the heart of the approach when following the defined steps for the intake process at the healthcare institute.

4.2 Redesigns scenarios

4.2.1 Post

A considerable part of the throughput time in the intake process is taken by the wait time for the medical file to arrive by post. On the basis of the *integration* (INT) and *technology* (TECH) heuristics we consider the alternative that medical files become on-line available to the mental healthcare institute. In many countries this may be implemented in the form of an electronic health record (EHR) or electronic patient record (EPR). An EPR is a system of storing and making readily available items, which comprise a paper-based patient record, such as test results and discharge letters (Bennett, 2001). In the Netherlands, communication of EPRs is in its infancy. Implementation an EPR supposes a considerable application degree of technology: doctors should store their patient information electronically and communication facilities should be present. An EPR cannot by itself guarantee that information is communicated effectively or efficiently (Bennett, 2001; Elberg, 2001). Besides this aspect, we realize that implementing an adequate EPR that many social, organizational and political aspects will influence its success (Heatherfield *et al*, 1999; Essex, 2005) (Hough *et al*, 2005).

By the direct availability of the medical file, the task "Ask for medical file" in Figure 1 is replaced by a task "Access medical file" which is performed by the secretarial office. The same time they used to spend on preparing and sending a request letter is now assumed to be required for accessing and printing the patient file. The task "Update client file" stays in place, but it loses the external trigger "Medical file".

The wait time for the medical file is completely reduced, which leads to an average throughput time of approximately 8,5 days. This is a reduction of 16%. The total service time spent on a case is not reduced.

This result is in line with the benefits reported by, e.g., (Hough *et al*, 2005) and (Essex, 2005).

4.2.2 Periodic meetings
In the intake process the staff meeting is planned at regular weekly intervals on the Wednesday. During a staff meeting two important things take place, which are as follows:

1. For new cases, the first and second intakers are assigned.
2. For cases for which both intake interviews have taken place, treatment plans are determined.

From a modern process perspective, periodic restrictions on activities are rather odd. Additional analysis of the intake process points out that the first activity does not really require a meeting context, provided that the team-leader has sufficient information on the criteria used for new assignments. On the other hand, the second activity is indeed best performed in the context of a meeting. This is because of the limited availability of the psychiatrists, which prohibits more flexible measures.

On the basis of the *case-based work* heuristic (CASEB) we consider as an alternative for the current process that the team-leader will carry out new case assignments as soon as they are due; the weekly meeting is strictly used for determining treatment plans. The process structure as depicted in Figure 1 then changes in the sense that the time trigger is removed from the task "Assign intakers". Because the information is available to the team-leader to base his assignment decision on, we expect that the original duration of the task also decrease from 5 to 2 minutes on average. This time includes the report of the assignment to the secretarial office. Both the social-medical worker and the physician will no longer spend this time on the case.

The throughput time of an average case will drop by about 2,5 working days, as this is the expected time a new case has to wait before it is assigned (half a working week). This is a reduction of 25%. The reduction of the total service time is 13 minutes, an 8 % reduction.

Note that a similar result could be achieved by doubling the frequency of the staff meetings (assuming this is possible). For each meeting, the expected wait time of 2,5 workdays drops to 1,25 days, which leads to an overall reduction of the throughput time of 2,5 working days.

4.2.3 Social-medical worker
We consider on the basis of the *extra resources* heuristic (XRES), the hiring of an additional resource within the setting of the intake process. Because the social-medical worker spends on average the most time on each new case, the choice for hiring an extra social-medical worker is made. He or she will exclusively work on the intake of new cases.

The average time spent on a case does not change on the basis of this measure. Also, the throughput time does not notably decrease either. This we consider an expected outcome. The number of resources is sufficient: Most of the throughput time in the intake process is determined by wait time, not by queuing. Although it is frequently applied in practice, the intuitive measure to add resources to decrease throughput time is not always effective.

4.2.4 Medical file
For each new case it is decided whether his or her medical file will be asked for. This information is then requested from the family doctor. The family doctor is also the one who notifies the new case at the start of the process. This raises the question whether the *contact reduction* heuristic (REDUC) may be applicable. Closer inspection of the routing of individual cases shows that in 95% of all new cases the medical file is requested for. This extremely high figure justifies consideration of the *exception* heuristic (EXCEP). After all, not requiring the medical information seems to be the exception.

A combined application of the *contact reduction* heuristic, the *exception* heuristic and the *resequencing* heuristic (RESEQ) leads to an alternative process design where the secretarial office directly asks for the medical file after the family doctor makes contact with the mental healthcare institute. The routine to determine for each case at a staff meeting whether medical information is required is dropped, which in itself does not lead to a reduction of service time. The process structure of this alternative is depicted in Figure 2.

Note that in this case, the exception heuristic coincides with the secondary interpretation of the *triage* heuristic (TRI). The once alternative task of asking for medical information has become a general part of the process.

The average total service time increases by one extra minute, as the secretarial office will have to request for *each* case – and not for 95% only – the medical information. This is an increase of 1 %. The average throughput time is reduced by 1,4 working days, which is a reduction of 13 %.

4.2.5 Notice recording

Within the intake process, the nurse officer records the notice by the family doctor on a conventional form. This information is subsequently entered in the information system of the institute. On the basis of the *task automation* heuristic (AUTO) we investigate the following alternative. An electronic version of the registration form is designed that is used by the nursing officer to record the new case. The information from a completed electronic form will be automatically transferred into the information system of the institute. It will also be automatically printed at the secretarial office and the new application checks whether the patient is already known.

Compared to the original structure of the process as depicted in Figure 1, the complete task "Save and print file" can be omitted. We can interpret this as an application of the *task elimination* heuristic (ELIM). This elimination reduces the work effort of the secretarial office on storing and printing, which on average took 10 minutes. The task "Record notice" is now assumed to be supported in the way as described. We do not expect significant changes in the service time of this task spent by the nursing officer.

The average throughput time is not notably influenced by this measure. The total service time is reduced by ten minutes, which is a reduction of 6%.

4.2.6 Registration cards

The secretarial office in the intake process produces the registration cards for the future first and second intaker of the new case, completes the patient file with the registration form, and adds the patient on the list of new notices. These three actions are combined in the "Close case" task. On the basis of the *task composition* heuristic (COMPOS) we question the composition of this task. If we consider the registration cards for a case, it is clear that they are only required *after* the intakers are assigned. Only the addition of the patient on the list is required for assigning a new case. We assume that the completion of the file will be required just before the cards are handed out.

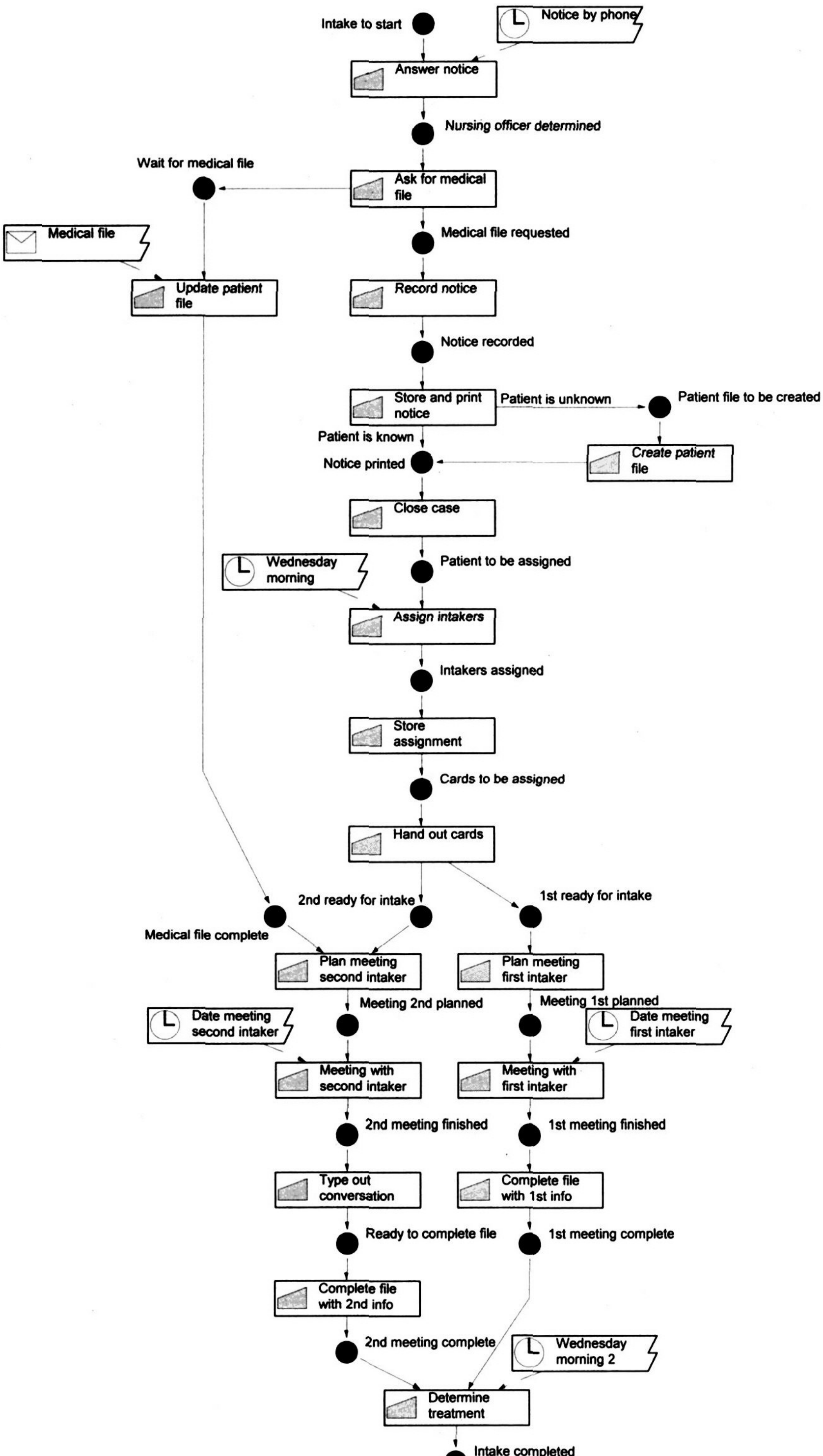
Dividing the "Close case" into its separate parts allows us to put the production of the registration cards and the completion of the patient file in parallel to the assignment sub flow of the process. This is an application of the *parallelism* heuristic (PAR). We assume that the original average service time of the "Close case" task of 4,5 minutes is equally divided over the three new tasks, but we expect an additional set-up time for each of these tasks of 1 minute. The resulting process structure is depicted in Figure 3. Note that for routing reasons a transition labelled "Skip" is added; it represents no real task.

In spite of the parallelism, the throughput time in this scenario is not reduced. This can be explained from the fact that the effect of parallel executions of the new tasks "List case", "Produce cards", and "Update file" do not speed up the average wait time of 2,5 days for the staff meeting. The service time does increase with 3 minutes, which is a 2% change for the worse.

4.2.7 Treatment plan

In the original process, a team of the first intaker, the second intaker, the psychiatrist, and the team-leader determines the treatment plan. Closer inspection on how a treatment actually comes

Figure 2: Direct request for medical file



about in the intake is that the first and second intaker propose a treatment plan, which is usually approved of by the psychiatrist and team-leader. On the basis of the *empower* heuristic (EMP), we consider as a design alternative the situation that the intakers themselves determine the treatment plan. Note that in reality, this kind of measure may not conform to accepted medical protocols. However, it can be envisioned that the team-leader and psychiatrist only check the treatment plan afterwards. Currently, in the Netherlands experiments are going on with so called "family doctor assistants". These assistants, while having a medical background without being full doctors, operate under the responsibility of a real doctor to deal with patients' simple complaints. Like in this scenario, the responsible doctor makes only post-checks.

As a result of the described measure, the intakers have to meet with each other to determine a treatment plan. It is reasonable to expect that this meeting takes approximately as long as the discussion during the staff meeting, on average 10 minutes. It is expected also that because of planning reasons this meeting is maximally delayed with one day after the last intake interview has taken place. The wait time of 2,5 working days on average for the staff meeting is on the other hand eliminated. As a result, the total throughput time is reduced by 2 days, which is a reduction of 20%. The total service time is reduced by 20 minutes, because the team-leader and the psychiatrist are ejected from the decision making process. This is a 12% reduction. Note that we assume, at this particular healthcare institute, the probability that the team leader and/or psychiatrist will not approve is considered to be very small, which is not necessarily the case in general.

4.3 Results

In this section we show the simulations and the results for each of the redesign scenarios. We conclude which scenario is the most favourable one in terms of throughput time and service time. The reliability of these results is reported upon at the end of this section. The results of the various redesign scenarios we considered in this section are summarized in Table 1.

For the reduction of the throughput time, the "Periodic meetings" scenario is the most favourable one. This scenario was based on application of the *case-based work* heuristic. A cut of service time is best accomplished by the "Treatment plan" scenario, based on the *empower* heuristic. Both scenarios eliminate strongly traditional process structures, respectively non-case based work and hierarchy.

The application of the *extra resources* heuristic in the form of the "Social-medical worker" scenario is rather ineffective, as it does not speed up the process. The automation of a task in the "Notice recording" scenario also has no effect on the throughput time. The important thing that can be learned from these results is that throughput times may consist for only a small part of queue time and for an even smaller part of service time.

The most unsatisfactory scenario is the "Registration cards" scenario. Although it exploits one of the most powerful heuristics available – the *parallelism* heuristic – it renders no result. Yet, the scale of parallelism in this case was small. Actual benefits from this heuristic may be expected rather in settings where substantial parts of the process are put in parallel.

We end this section with a justification of the throughput time results of the various scenarios. These results have been obtained using the software package ExSpect (Hee *et al*, 1989; Aalst, 2004) which supports discrete event simulation, i.e. the type of simulation where the state in the simulation model changes at discrete points in time that are not necessarily equidistant (see e.g., (Law and Kelton, 1982)). Non-terminating models have been used for an analysis of the steady-state behaviour of the process. Each simulation of a scenario has been split up into a number of simulation runs. Two start runs were used to eliminate the effects of the initial transient from the analysis. The remaining simulation consisted of ten subsequent sub runs of 20 working days, which allowed for a sufficient analysis of the reliability of the simulation results.

Presented in Table 2 are the 99% confidence intervals of the measured average throughput time for each simulation. For other measurements, this type of information is not given.

From this table it follows that the confidence intervals of the original situation, the "Social-

Figure 3: Division and parallelism of the completion task

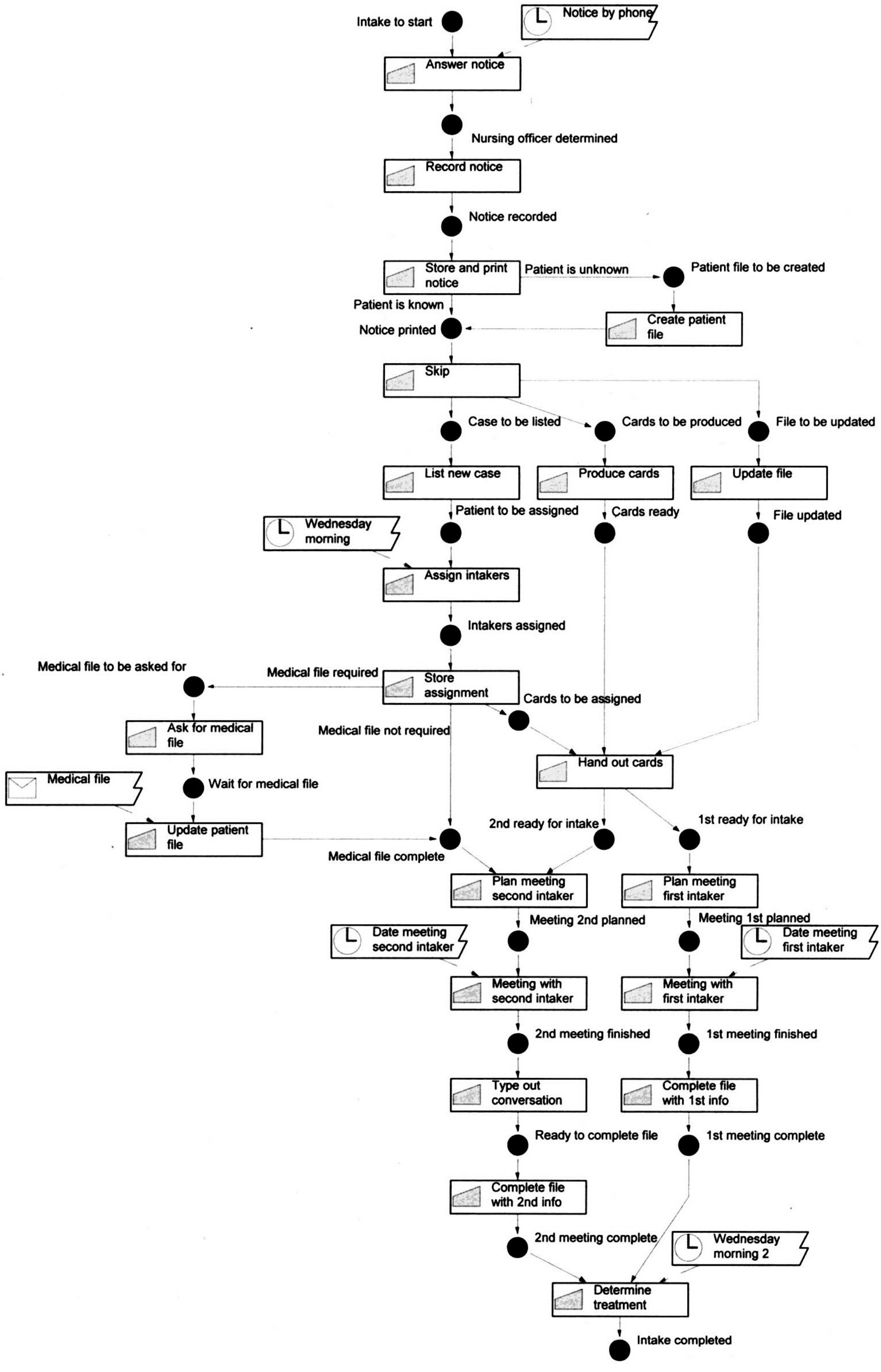


Table 1: Summary redesign alternatives results

	Gain avg. total throughput time		Gain avg. total service time	
Redesign scenario	days	%	days	%
Post: INTG & TECH	1,6	16	0	0
Periodic meetings: CASEB	2,5	25	13	8
Social-medical worker: XRES	0	0	0	0
Medical file: REDUC, EXCEP, RESEQ,& TRI	1,4	13	–1	–1
Notice recording: AUTO & ELIM	0	0	10	6
Registration cards: COMPOS & PAR	0	0	–3	–2
Treatment plan: EMP	2	20	20	12

Table 2: Simulation analysis throughput times with 99% confidence interval; significant improvements denoted with '*'

	Average throughput time (days)		
Simulations	Left bound	Mean	Right bound
Original situation	10,13	10,20	10,27
Post*	8,45	8,59	8,73
Periodic meetings*	7,59	7,66	7,73
Social-medical worker	10,11	10,16	10,21
Medical file*	8,80	8,91	9,02
Notice recording	10,04	10,14	10,19
Registration cards	10,05	10,18	10,30
Treatment plan*	8,09	8,18	8,26

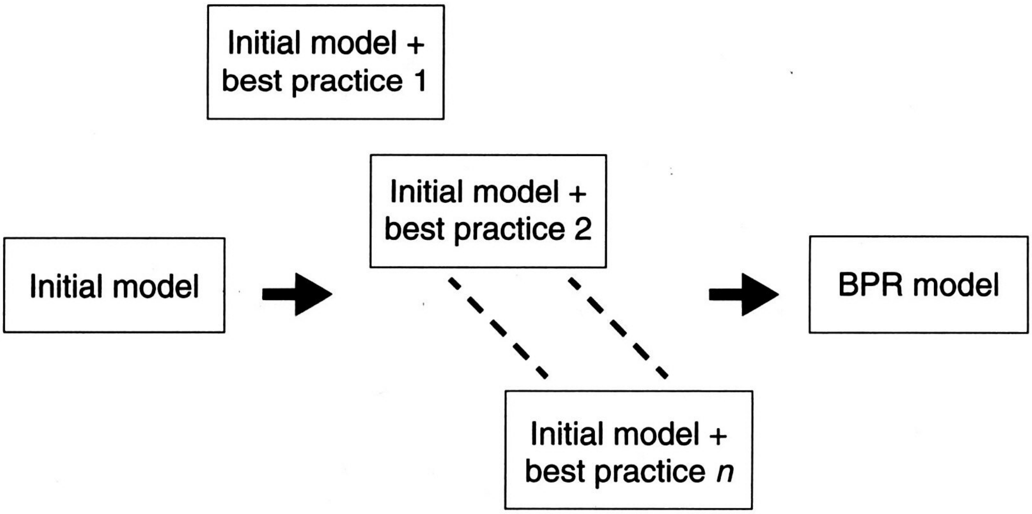
medical worker" scenario, the "Notice recording" scenario, and the "Registration cards" scenario overlap. In other words, at the used confidence level these particular scenarios cannot be considered as improvements of the throughput time of the initial intake process.

5. DISCUSSION

The application of best practices in the mental healthcare setting shows their potency in this specific context. This is to some extent surprising, because many of the best practices originate from manufacturing settings such as the automobile industry.

A next, necessary step towards a wider application in healthcare seems to be a more structured method on how to select and/or combine an effective set of best practices for a specific medical context. As we indicated, this decision-making process for the described case was undertaken in 5 steps (see Section 4.1) in a rather intuitive and highly participative fashion. This even led to the inclusion of a scenario (social medical worker, Section 4.3.2), which on objective grounds perhaps could not be expected to deliver significant results, e.g. in terms of reducing lead time. This kind of approach may still be preferred when healthcare professionals are purposefully tightly involved in the redesign effort. At the very least, this will facilitate the implementation of such a jointly developed redesign scenario. However, under the pressure of increasing healthcare demand and decreasing budgets, it may be expected that occasions for such participative designs are few. The use of a more structured method that for a large part can be undertaken by people external to the process or by computer systems would therefore be a valuable asset. In this section we will discuss two of our very recent attempts to derive a subset of best practices for inclusion in a redesign in such a way.

Figure 4: A redesign approach based on multiple simulations



5.1 A simulation approach

For two Dutch organizations, a local municipality and a branch of the national public works department, we used the same set of best practices as applied in the mental healthcare case to derive a redesign for three business processes (see Reijers and Limam, 2005). Simulation was the most important component in the process of deciding on which best practices to include. The procedure is shown in Figure 4.

The starting point for all these models is the *initial model*. This initial, simulation model captures the existing process structure and includes real behavioural data of the process on the arrival patterns of cases, resource capacity, service time characteristics, etc. In (Reijers, 2004) we explain in more detail how this initial model is built, how the data has been gathered and how the model is validated against the real world.

Next, in preparation of the *BPR-model*, we determined for each single best practice whether it would be applicable in the context of the specific process. If so, we constructed for such a *single* best practice a simulation model where the effect of this specific best practice was incorporated on top of the *initial model*. To model the best practice accurately, we used estimations from experts from both organizations to approximate the local effect of such a single BPR best practice within the process. Finally, for each of the three business processes under consideration, the *BPR-model* incorporates a subset of all applicable best practices. This subset seemed the best combination in terms of performance improvement. Whether a best practice was included in the final *BPR-model* was determined during two workshops that involved end users, managers, and IT professionals for both organizations.

In comparison with the approach taken in the healthcare case, considerable less emphasis is put on expert involvement to evaluate the effectiveness of each single best practice, i.e. steps 2 and 3 of the redesign approach of Section 4.1. This facilitated a much more focused discussion on what kind of best practices to combine for a final redesign scenario, because the effectiveness of best practices could be supported by simulation results. In addition, non-medical experts were able to prepare and carry out large parts of the decision-making, freeing medical experts from such an effort.

5.2 An algorithmic approach

Considering the relevant literature in the field and our own experiences with the application of the best practices in the various cases we discussed, we identified a recurring set of criteria that influence the decision on which best practice to apply. These criteria include a best practice's popularity, its specific impact on a redesigned process, the initial redesign goals and the identified risks (e.g. limited implementation time, poor information system architecture, limited funds, employee resistance, lack of managerial support and lack of top management commitment). For a more detailed discussion of these criteria, see (Limam Mansar *et al*, 2005).

The idea was then born to evaluate whether a multi-criteria decision making method would be useful to guide this process. A survey on multi-criteria methods resulted in choosing the Analytical Hierarchy Process (AHP) (Ounnar, 1999), as it is widely used to classify alternatives based on a range of criteria. AHP is a method for complex multi-criteria problems for which quantitative and qualitative aspects must/could be taken into account (Saaty, 1980). Its application consists of a number of steps, i.e. building a hierarchical model for the decision's problem and a relative weight appraisal between the elements of the various levels of the model.

For sake of clarity, we will not give the details of the hierarchical AHP model we built, as it involves four different levels and six tables of pair wise comparisons of criteria. They can be consulted in the paper we referenced (Limam Mansar *et al*, 2005). What is important to note here is that *only a part* of the model is specific for the project/process at hand. This includes the specific redesign goals and the applicability of potential risks. For *another part*, i.e. the impact of each of the best practices, their popularity, their effectiveness with respect to various redesign goals, and their sensitiveness for the various potential risks, we already gathered a set of data from our previous redesign encounters to create it. In other words, the decision-making algorithm is for a large part fed and validated with earlier redesign experiences and augmented with project-specific data.

We experimented with the application of the AHP algorithm and the model we built, by parameterizing it with the data we gathered and imitating the redesign project for the public works department, e.g. in setting the redesign goal. This delivered the following result. AHP advised the implementation of the integration, task elimination and task composition/resequencing best practices as first choices. Apart from the integration best practice, this is actually the set preferred in our earlier described case study using simulation, see (Limam Mansar and Reijers, 2005)! Interestingly, the integration best practice was originally identified as an applicable best practice for the public works department, but did not deliver good results in the simulation model.

Considering this algorithmic approach, it seems that it allows to reduce expert involvement to the smallest possible extent, namely by having them to provide the goals of the redesign, the identification of a set of potential risks and, finally, the appraisal of the proposed set of best practices to apply. In other words, steps 1 to 5 from our initial procedure are almost completely carried out by the algorithm (see Section 4.1). Compared to the simulation approach explained in the previous section where experts were asked to supply estimations of the impact of best practices on the one hand and performance data of the current process on the other, not even this kind of information is required.

6. CONCLUSIONS

In this section we draw some conclusions on the applicability of our approach to improve the efficiency and effectiveness of healthcare processes and give our ideas for further research.

Section 4 illustrates the application of some heuristic rules and their possible effects. We concluded that four of the seven redesign scenarios resulted in an improvement of throughput time. Application of redesign heuristics enabled the mental healthcare institute to come up with new ideas, which actually improved their intake procedure.

Our results are supported by the findings of (Buchanan, 1998). The study of Buchanan focused on BPR for acute hospitals to schedule patients to the operating theatres and to their surgical teams in a manner that avoids both delays and overruns to schedule. He concludes that a reengineering frame of reference is of great help to support the redesign of such processes. He advocates a process orientation contributing to the politics of problem definition and problem solving, the import of new working practices and the visual representation of the entire process to provide a broad overview.

The results of this particular case study cannot be generalised for all processes in healthcare. However, an intake procedure as described in section 3 is rather common for many institutes and hospitals. Furthermore, the described redesign approach based on redesign heuristics fits well within the evolutionary approach of (Buchanan, 1998). As Buchanan's approach is applicable for healthcare in general, we expect a similar, wide applicability for our approach based on the redesign heuristics. Overall, we expect that a redesign approach as we sketched will have the largest potential for those healthcare processes that do not involve an intense participation of the patient throughout the entire process. After all, the required presence and involvement of a patient during various steps will result in tighter constraints on alternative process structures. For example, it will not be possible to introduce process steps that involve diagnostic tests on the same patient at various departments. Therefore, primary targets for our approach are administrative and support processes in a medical context, as well as preparatory and concluding parts of patient-intensive processes.

In the discussion on the participative and partly intuitive method we applied to derive a process design, we described in Section 5 two alternative, structured methods based on the same set of redesign heuristics. Comparing these methods, they particularly seem to differ in the required level of expert involvement. This does not mean that one of these approaches can be considered to be generally preferable over the other. This will depend on the context of the project at hand. One can expect the algorithmic approach to be less costly and less time-consuming than the simulation approach, which is generally a great asset in a redesign project. At the same time its outcomes may be less reliable. After all, it builds partly on empirical data not being specific for the project at hand. In situations where there is more budget and less time pressure, the simulation approach may be preferable, or even a more participative approach as we used for the mental healthcare case.

With respect to future work, the survey by (Reijers, 2003) already revealed that many authors published one or more redesign heuristics, but only few of them (Buzacott, 1996; Seidmann and Sundararajan, 1997; Dewan *et al*, 1998; Aalst, 2000) have adequate support of an analytical or empirical study. Additional work should point out the conditions or domain validity where a best practice would give the expected results in terms of cost/time reduction or quality/flexibility improvement. This kind of information may very well be included in a more structured and partly automated redesign method.

For the alternative, more structured methods we discussed in Section 5 holds that they are still in an experimental stage. We see various ways to improve these methods and they will probably lead us to consider other options as well. Nonetheless, we hope to have made plausible that the set of best practices may be a fertile basis for deriving process redesigns in healthcare, because:

a) They seem to be feasible and potentially effective in a medical setting such as the intake procedure, and
b) There are promising attempts for structured methods to decide on which of the complete list of best practices to apply in a specific situation.

APPENDIX

BPR best practices (Reijers, 2003)

Task best practices
Task best practices focus on optimizing single tasks within a business process.

1. Task elimination (ELIM): delete tasks that do not add value from a client's viewpoint.
2. Task addition (ADD): check the completeness and correctness of incoming materials and check the output before it is send to clients.

3. Task composition (COMPOS): combine small tasks into composite tasks and divide large tasks into workable smaller tasks.
4. Task automation (AUTO): introduce technology if automated tasks can be executed faster, with less cost, and with a higher quality.

Routing best practices
Routing best practices try to improve upon the routing structure of the business process.

5. Resequencing (RESEQ): move tasks to more appropriate places.
6. Knockout (KO): execute those checks first that have the most favorable ratio of expected knockout probability versus the expected effort to check the condition.
7. Control relocation (RELOC): relocate control steps in the process to others, e.g. the client or the supplier, to reduce disruptions in the process.
8. Parallelism (PAR): introduce concurrency within a business process to reduce lead times.
9. Triage (TRI): consider the division of a general task into two or more alternative tasks.

Allocation best practices
Allocation best practices involve a particular allocation of resources to activities.

10. Case manager (MAN): make one person responsible for the handling of a specific case.
11. Case assignment (ASSIGN): let workers perform as many steps as possible for single cases.
12. Customer team (TEAM): consider assigning teams out of different departmental workers that will take care of the complete handling of specific sorts of cases.
13. Flexible assignment (FLEX): assign resources in such a way that maximal flexibility is preserved for the near future.
14. Resource centralization (CENTR): treat geographically dispersed resources as if they are centralized.
15. Split responsibilities (SPLIT): avoid assignment of task responsibilities to people from different functional units

Resource best practices
Resource best practices focus on the types and availability of resources.

16. Numerical involvement (NUM): minimize the number of departments, groups and persons involved in a process.
17. Extra resources (XRES): if capacity is not sufficient, consider increasing the number of resources in a certain resource class.
18. Specialist-generalist (SPEC): consider making resources more specialized or more generalized.
19. Empower (EMP): give workers most of the decision-making authority and reduce middle management.

Best practices for external parties
This type of best practices tries to improve upon the collaboration and communication with the client and third parties.

20. Integration (INT): consider the integration with a process of the client or a supplier.
21. Outsourcing (OUT): relocate work to a third party that is more efficient in doing the same work, to reduce costs.
22. Interfacing (INTF): consider a standardized interface with clients and partners.
23. Contact reduction (REDUC): combine information exchanges to reduce the number of times that waiting time and errors may show up.
24. Buffering (BUF): subscribe to updates instead of complete information exchange.
25. Trusted party (TRUST): replace a decision task by the decision of an external party.

Integral process best practices
This type of best practices applies to the business process as a whole.

26. Case types (TYPE): determine whether tasks are related to the same type of case and, if necessary, distinguish separate processes and case types.
27. Technology heuristic (TECH): try to elevate physical constraints in a process by applying new technology.
28. Exception (EXCEP): design processes for typical cases and isolate exceptional cases from normal flow.
29. Case-based work (CASEB): get rid of constraints that introduces batch handling may significantly speed up the handling of cases.

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