Case-Based Reasoning as a Technique for Knowledge Management in Business Process Redesign

Selma Limam Mansar and Farhi Marir
London Metropolitan University, UK
s.limam@londonmet.ac.uk
f.marir@londonmet.ac.uk
Hajo A. Reijers
Eindhoven University of Technology, The Netherlands
H.A.Reijers@tm.tue.nl

Abstract: Business Process Redesign (BPR) helps rethinking a process in order to enhance its performance. Practitioners have been developing methodologies to support BPR implementation. However, most methodologies lack actual guidance on deriving a process design threatening the success of BPR. In this paper, we suggest the use of a case-based reasoning technique (CBR) to support solving new problems by adapting previously successful solutions to similar problems to support redesigning new business processes by adapting previously successful redesign to similar business process. An implementation framework for BPR and the CBR's cyclical process are used as a knowledge management technical support to serve for the effective reuses of redesign methods as a knowledge creation and sharing mechanism.

Keywords: Business process redesign, Case-based management, Workflow, Best practices, Knowledge management.

1. Introduction

Business Process Redesign (BPR) addresses the reengineering of one specific process within the firm. It distinguishes itself from Business Process Reengineering where the focus is rather on developing a "business architecture", which later requires in depth re-thinking and re-assessment of the firm's mission and of the processes required in order to fulfil it, (Edward and Peppard 1994). So BPR helps rethinking a process in order to enhance its performance. Academics and Business practitioners have been developing methodologies to support the application of BPR principles (for an overview: see Kettinger et al. 1997). However, most methodologies generally lack actual guidance on deriving a process design threatening the success of BPR. Indeed a survey has proved that 85% of projects fail or experience problems (Crowe et al. 2002).

In this paper, we suggest the use of a case-based reasoning (CBR) technique. CBR solves new problems by adapting previously successful solutions to similar problems (Marir and Watson 1994). It is a cyclical process comprising *the four Res*:

- Retrieving the most similar case,
- Reusing the case to attempt to solve the problem,
- Revising the proposed solution if necessary, and
- Retaining the new solution as a part of a new case (Aamodt and Plaza 1994).

In the context of BPR, CBR can be applied to assist the decision-making process. On the other hand, the case-based reasoning technique can serve for the effective reuses of redesign methods in an attempt to improve the level of success of BPR implementation. Using the proposed framework and a CBR tool will help supporting knowledge transfer strategies in business process reengineering consultancy firms. As (Wiig et al. 1997) explain it, organisations may pursue five different knowledge management (KM) strategies: KM as business strategy, Intellectual asset management strategy, personal knowledge asset responsibility strategy, knowledge creation strategy and knowledge transfer strategy. The latter is defined as *a focus on knowledge systematic approaches to transfer knowledge to points of action where it will be used to perform work. It also includes knowledge sharing and adopting best practices* (Wiig et al. 1997). This present work provides the consultancy firms or any organisation that needs to redesign its processes with a tool that supports such knowledge creation, sharing and transfer mechanisms. Indeed, building up cases within the CBR tool helps to organise, restructure and memorize the knowledge acquired after redesigning a process. The memorisation process is a good technical support for sharing the knowledge and adopting the best practices in business process redesign as our framework (see section 5) describes it.

In this paper we investigate how CBR can be applied to BPR as a support for knowledge transfer. The paper is structured as follows:

Section 2 first introduces Business Process Redesign and the context of this study.

Section 3 introduces case-based reasoning and its cyclical process. This part also includes

a brief definition of case representation, indexing, storage, retrieval algorithm and adaptation.

Section 4 is a state of the art of CBR or knowledge-based systems applied to business process redesign.

Section 5, focuses on the construction of a case for BPR implementation. It describes the development procedure for a CBR project with a focus on the knowledge acquisition and representation. In that perspective, the framework for BPR that we have developed will be described and, briefly, the thirty best practices included in this framework. On their basis we will develop a domain-dependant case hierarchy.

Section 6 explains how CBR can be used as a tool for knowledge management in Business Process redesign.

Finally, in section 7, conclusions and future research orientations are provided.

2. Business Process Redesign and context of the study

The purpose of this research is to develop a technique that would allow practitioners (consultants and senior managers in enterprises) to access previous redesign projects and, possibly, reapply some of the best findings. CBR should support BPR implementation in the following perspective: the starting point is the acknowledgment of a need to redesign a business process (or an organisation). Knowing the current process and knowing the problems those need to be addressed (reducing costs, improving the quality, etc.), a consultant might wish to know whether similar processes with similar problems (weak performance) have been already redesigned. He might wish to find out which rules (best practices) have been applied to solve that problem and the technical and organisational solutions adopted in that previous case. Another situation might be that the consultant has already an idea about some rules he wished to apply but he is not sure about the impact of applying them, or he wants ideas about possible adopted solutions. CBR can help in finding a similar business process, with a similar problem and similar rules applied.

In the sequel we describe what is CBR and how it helps in the context of Business Process Redesign.

3. Case Based reasoning

CBR is a computer technique, which combines the knowledge-based support philosophy with a simulation of human reasoning when past experience is used, i.e. mentally searching for similar situations happened in the past and reusing the experience gained in those situations (Leake 1996). The concept of case-based reasoning is founded on the idea of using explicit, documented experiences to solve new problems. The decision-maker uses previous explicit experiences, called *cases*, to help him solve a present problem. He retrieves the appropriate cases from a larger set of cases. The similarities between a present problem and the retrieved case are the basis for the latter's selection (Gonzalez and Dankel 1993).

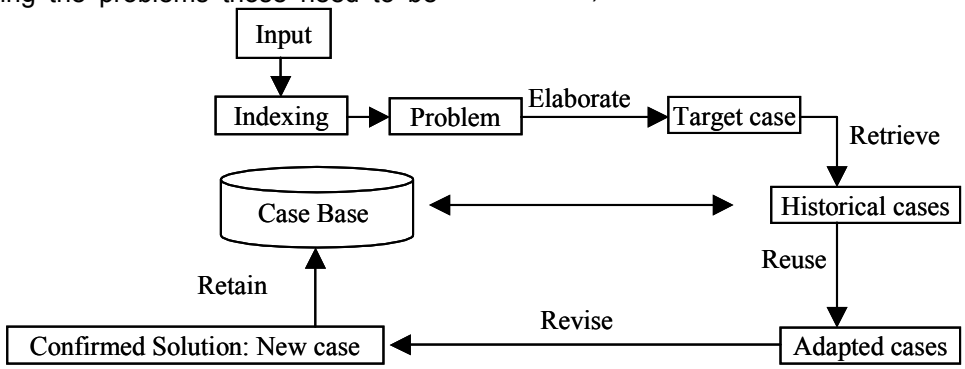

Figure 1: The CBR cycle, Adapted from Choy et al. 2003.

Figure 1 shows the process involved in CBR represented by a schematic cycle. In CBR, the knowledge cases are structured and stored in a case base, which the user queries when trying to solve a problem. Actually, a new problem is matched against historical cases in the case base using heuristically cased indexed retrieval methods with one or more similar cases being retrieved (in fact the system evaluates the similarity between each case in the case base and the problem. The most similar case(s) are presented to the user as possible scenarios for the problem at hand). A solution suggested by the matching cases is

then reused and tested for success (Namely, the user decides if the solution retrieved is applicable to the problem). At this stage, if the best-retrieved case is the best match, then the system has achieved its goal and finishes. However, it is more usual that the retrieved case matches the problem case only to a certain degree. In this situation, the closest retrieved case may be revised using some pre-defined adaptation formulae or rules. Many of the most successful CBR systems however do not perform adaptation. They either simply reuse the solution suggested by the best matching case or they leave adaptation to people. When the user finds a solution (automatically or manually), and its validity has been determined, it is retained with the problem as a new case in the case base for future reuse ((Choy et al. 2003), (Haque et al. 2000)).

From a technical point of view, there are many arguments supporting using CBR against other knowledge-based methodologies (Luger 2002). Researchers have claimed that CBR provides the potential for developing knowledge-based systems (KBS) more easily than with rule- or model-based approaches. They argue that the concrete examples provided by cases are easier for users to understand and apply in various problem-solving contexts than complex chains of reasoning generated by rules or models and that record-like representations of cases used in some CBR systems allow for straightforward storage in relational databases and entry and update by end users. As a result it combines the efficiency of data management and retrieval of database systems with the intelligence and the power of inference engine of KBS. Another benefit is that the presence of the validation and update steps provides a framework for learning from experience, thus incorporating knowledge acquisition as part of the day-to-day use of a CBR application (Allen 1994). However CBR may not be as effective as rule- or model-based approaches for applications where theory, not experience, is the primary guide to problem solving, and where solutions are unique to a specific problem instance and not easily reusable (Allen 1994).

4. CBR applied to BPR Implementation

4.1 State of the art

In the sequel, examples of CBR systems applied to business process reengineering or redesign are described and discussed.

(Allen 1994) reports two examples of commercial CBR applications to business process reengineering (and not redesign). The use of case retrieval in both examples can be viewed as a special instance of the application of case retrieval to the automation of business processes:

- SMART is a CBR customer services application developed by Compaq Computer in 1992. The system analyses incoming Compaq's customers problems and retrieves the most similar cases from its case base and present them to the customer service analyst, who then uses them to resolve the problem.
- Prism telex classification system is a CBR system developed by Cognitive Systems, Inc in 1990. The system is used in several banks to route incoming international telex communications to appropriate recipients.

(Min et al. 1996) have developed a commercial CBR Intelligent Bank reengineering System (IBRS) that is used by Battelle Company. The system is based on three stages. A generation stage that identifies BPR alternatives based on user requirements and strategic goals, an evaluation stage that applies the workflow analysis and functional economic analysis to compare BPR alternatives and finally a choice stage where the user selects the combination of BPR alternatives based on the generated evaluation statistics.

On the business process reengineering perspective, (O'Leary and Selfridge 2000) describe a Knowledge-Based System Approach to reengineering. The system was built to test the notion that best practices reengineering process knowledge could be captured as a knowledge-based system for analysis and reuse. Though this application is not a CBR system, it exploits the notion of "Best Practices" in business process reengineering. The system targets procurement reengineering and applies the seven principles of reengineering listed by (Hammer 1990).

Similarly, in (Nissen 2001) a knowledge-based, process-redesign system called KOPeR-lite. This is not a CBR system. However, it provides automated redesign support through measurement-driven inference system. The system targets similar generic processes as described in (Limam et al. 2003) and summarised in section Domain knowledge acquisition for BPR implementation). The fundamental difference with our BPR/CBR approach is that we target to exploit previous

consultants' knowledge using CBR. The underlying hypothesis being that reasoning is reminding (problem solving utilises past experiences (Madhusudan and Zhao 2003)).

CBR has also been employed successfully to other similar activities such as:

- Workflow design: (Kim et al. 2002) using a clean-sheet approach, (Madhusudan and Zhao 2003) using previous redesigned processes,
- Concurrent product development (Haque et al. 2000),
- And business automation (Cheung et al. 2003).

4.2 BPR-CBR approach

The state of the art shows clearly that the above CBR systems were targeting reengineering business processes, either with the purpose of automating tasks (as an application of BPR principles), or with the purpose of retrieving similar cases that can be adapted to design a new business process. However in all systems, the emphasis was on specific types of business processes or specific types of business activities. The systems cannot thus be reused to support the redesign of *any* type of business process.

The aim of this paper is to study the relevance of developing a BPR/CBR system which role would be to support organisations in redesigning their processes. The present work is targeting consultants in the field. CBR can be used to collect, store and reuse the knowledge and best practices from previous redesign efforts. Its application to BPR should improve the decision-making abilities of workers. Indeed, BPR relies on designers' experiences. Best practices in the field are often used and combined to redesign similar processes. In this context, our main interest in CBR relies in that it allows a system to avoid past errors and exploit past successes. This is a key issue in Business Process Redesign where practice has proved that successes are few and failures quite common (Crowe et al. 2002). Another argument in favour of using CBR for BPR implementation is that, traditionally, redesign has been the area of consultants and "experts" in the field. Thus, redesign is often the result of the application of so-called "best practices" rather than on the use of analytical methods (theoretical models and heuristics) to derive improved or redesigned processes (Reijers et al. 2003). Some authors are working on the development of such analytical tools. However none of them is currently capable of dealing with every particular aspect of a redesigned business process. In fact much of the redesign still rely on past experiences and on the application of the aforementioned best practices. In this context, CBR can be viewed as a good compromise between a completely empirical study and redesign of business processes and a pure analytical method. CBR can support the redesign process by finding similar cases: experts or consultants can then compare and learn which best practices to apply and also, hopefully avoid past mistakes.

5. Case construction for BPR implementation

To undertake a CBR project it is important to set up a clear development procedure. The steps for developing a BPR-CBR system are usually as follows and are represented in Figure 2. In this paper we focus on steps one and two only.

1. Step 1: Domain Knowledge acquisition: in this step, every effort is made in order to understand the problem domain and the symptoms. Information about the diagnostic of the problem and the solutions adopted are also collected in this step. For BPR implementation, this means (a) conceptually defining a business process that needs to be redesigned, (b) identifying the goals and targets behind the redesign effort, (c) defining the rules to apply to redesign the process and (d) the technical or organisational solutions adopted as a result of the redesign. To undertake this step we have based our research on studying previous methodologies and frameworks used in the literature for BPR. The results of this section are summarised in sections 5.1.1, 5.1.2 and 5.1.3. A complete study should also include interviews with experts and consultants and a collection of some initial cases.
2. Step 2: Case representation: in this step, the software to be used for knowledge representation should be selected. The next step is to describe the case. The results of this section are summarised in section 5.2.
3. Step 3: System implementation: this describes the final system including the database of cases and the indexing and retrieval process within the chosen software. This is a future research development.

4. Step 4: Verification and validation: in this step, some informal verification and validation should be conducted (Chan et al. 2000). Verification aims at "demonstrating the consistency, completeness and correctness of the software" (Adrion et al. 1982), that is, it aims at "building the system right" (O'Leary 1993). Hence, the question posed in verification is: "do the cases correctly represent the experience and knowledge we obtained?" Validation is the "determination of the correctness of the final program or software produced from a development project with respect to the user needs and requirements" (O'Leary 1993). This implies showing the system to practitioners not involved in the development of the system and see whether they are satisfied of the tool or not.

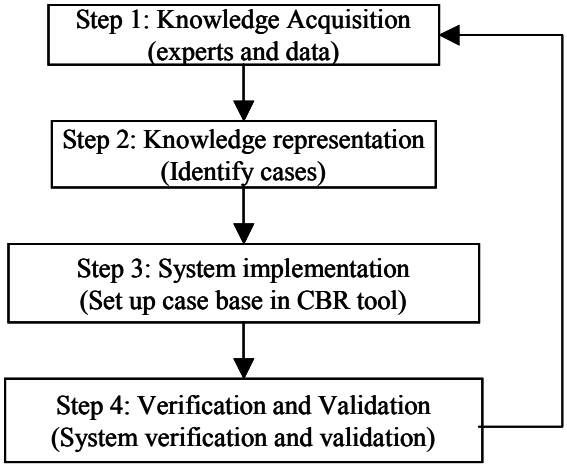

Figure 2: Case-Based system development procedure (Adapted from Chan et al. 2000).

5.1 Domain knowledge acquisition for BPR implementation

Our approach to Business process redesign relies on the prior definition of an implementation framework. Its role is to provide guidelines towards which important elements should be redesigned. Within each defined element, consultants and practitioners have been applying a set of best practices for redesign purposes. We have reviewed on a previous paper (Limam and Reijers 2002) these best practices and classified them according to our BPR framework. The framework and the related best practices serve as a guidance to which rules should be considered when implementing BPR.

5.1.1 The BPR framework

The idea behind a framework is to help practitioners by identifying the topics that should be considered and how these topics are related (Alter 1999). In this perspective, the framework should identify clearly all views one should consider whenever applying a BPR implementation project.

For BPR, we suggest to use the framework described in Figure 3. It is derived as a synthesis of the WCA (Work-Centred-Analysis) framework (Alter 1999), the MOBILE workflow model (Jablonski and Bussler 1996), the CIMOSA enterprise modelling views (Beriot and Vernadat 2001) and the process description classes of (Seidmann and Sundarajan 1997).

In this framework, six elements are linked as shown in Figure 3.

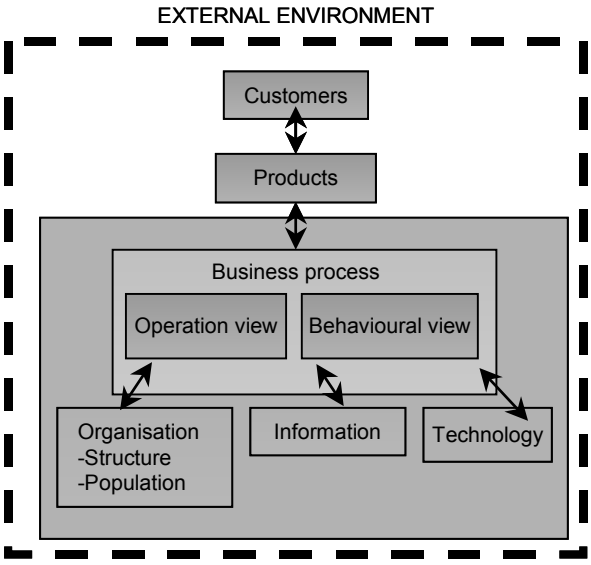

Figure 3: Framework for BPR implementation.

5.1.2 BPR Best practices

Knowledge acquisition for BPR implementation is based on the framework described in The BPR framework) and on a set of BPR best practices. Over the last twenty years, best practices have been collected and applied in various areas, such as business planning, healthcare, manufacturing, and the software development process (e.g. (Martin 1978); (Butler 1996); (Golovin 1997)). In this section we describe such best practices, which can actually support the redesigned of a business process in facing the technical BPR challenge: the implementation of an improved process design.

Improving a process is a matter of improving any of the components of the framework we

adopted in the BPR framework section. Thus we classify the best practices in a way that respects the framework we have adopted.

Table **1** summarises the identified best practices within the implementation framework). We identify best practices that are oriented towards:

- *Customers*, which focus on improving contacts with customers.
- *Business process operation*, which focus on how to implement the business process,
- *Business process behaviour*, which focus on when the business process is executed,
- *Organization*, which considers both the structure of the organization (mostly the allocation of resources) and the resources involved (types and number).
- *Information*, which describes best practices related to the information the business process uses, creates, may use or may create.
- *Technology*, which describes best practices related to the technology the business process uses or may use.
- *External environment*, which try to improve upon the collaboration and communication with the third parties

.

Table 1: BPR best practices classified according to our BPR implementation framework

Framework elements	Best practice name
Customers	Control relocation Contact reduction Integration
Products	NONE.
Operation view	Order types Task elimination Order-based work Triage Task composition
Behavioural view	Resequencing Parallelism Knock-out Exception
External environment	Trusted party Outsourcing Interfacing

Framework elements	Best practice name
Organisation: structure	Order assignment Flexible assignment Centralisation Split responsibilities Customer teams Numerical involvement Case manager
Organisation: Population	Extra resources Specialist-generalist Empower Control addition
Information	Buffering
Technology	Task automation Integral Business Process Technology

Examples:

- Example 1: illustrates how the *Task composition* best practice can be applied to a conference registration process to improve the operation view. In the initial process, the conference is organised in a way that attendees are invited to register, to pay the fees and to book for an accommodation as separate steps. The task composition rule can be applied by sending a single email where the attendees are invited to proceed with the three tasks at the same time. This improves the quality of the registration process.
- Example 2: illustrates how the *Control addition* best practice can be applied to mortgages applications processes to improve the Organisation view. The rule promotes adding controls before sending materials for customers. Mortgages for buying homes involve constituting a file with numerous documents and papers. Checking the list of requirements against applicants' specifications before sending them can save the organisation the hassle of numerous correspondences.

5.1.3 BPR goals and targets

For the construction of a case we still need to define the "problem". Yes a practitioner might wish to retrieve cases of similar business processes and similar best practices but he also would like to do it in order to achieve a

target. Different goals might lead to completely different redesign options. (Brand and Van der Kolk 1995) demonstrate this issue using their "devil's quadrangle". The authors 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 an order, 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 attractive property of their model is that, in general, improving upon one dimension may have a weakening effect on another. In order to reflect this difficult reconciliation between the targets and goals of the BPR implementation, it is important to include it as part of a case's characteristics. Goals and targets can be classified as simply "reducing cost or time", "improving flexibility or quality", or a broader range of goals and targets can be used depending on the type of processes that are being redesigned. The classification by (Guimaraes and Bond 1996) offers a wider range of goals and targets that can be used as an initial vocabulary for the CBR cases. **Error! Reference source not found.** shows some of these targets and goals.

Table 2: Possible goals and targets for BPR implementation (adapted from (Guimaraes and Bond 1996)).

Possible targets and goals
Increase own competitiveness by improving the quality
Increase own competitiveness by reducing costs
Increase own competitiveness by shortening product development
Focus on end results and objectives
Set aggressive business process goals
Use Information and Technology
Operate across organisational units
Reduce production times…

The impact of the initial target and goal on a redesign can be illustrated by revisiting both examples provided in the previous section:

- Example 1: we have applied the “task composition” rule to a conference registration process. The target here is clearly to “reduce the production times”. However if the target was to “improve the quality” then it is very unlikely that this rule would have been applied as it results in less flexibility to participants to decide, later on, on accommodation for example.
- Example 2: We have applied the “Control addition” rule to a mortgage application process. The target here was clearly to “reduce the costs”. It is unlikely that this rule would have been applied if the target were “focus on end results and objectives”. In the latter case, the focus would have rather been on redesigning the product in itself (mortgage) rather than on the process.

This first step, knowledge acquisition, is now complete. According to Figure 2, the next step is to define the knowledge representation.

5.2 Case representation for BPR implementation

In this section we describe the case base, i.e. how the storage scheme needs to be structured in a systematic fashion. We adopt, for case-base description, the formalism used in (Kim et al. 2002) and (Suh et al. 1998). Our case base is organised in the form of a hierarchical case tree from the top layer (business area) to the bottom layer (Applied rules); see Figure 4. It has a structure of is-a hierarchy, called a domain-dependent case hierarchy. If a new BPR Solution is created, it is saved in the relevant location according to the hierarchical path from the business layer to the BPR Solution layer. The upper three floors (business area, sub-business area, processes) represent more abstract generic features of the cases, while the three lower layers (BPR solution, goals and targets and applied rules) represent more specific features to the current BPR case.

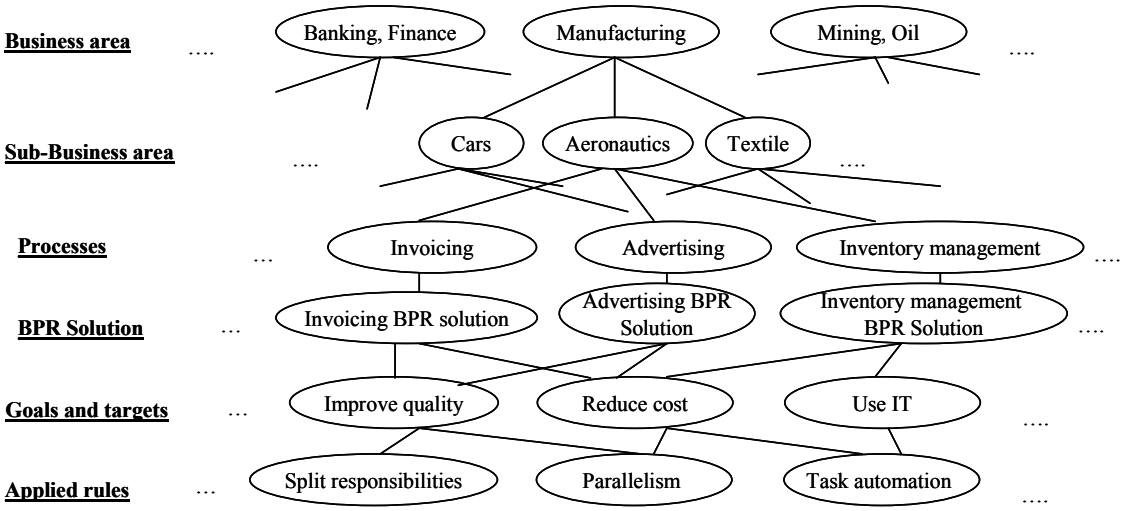

Figure 4: A domain-dependent case hierarchy.

Our case base can be represented by the use of the notations for class diagrams of UML. A BPR solution has relationships with the initial goals and targets and the applied rules; i.e. a BPR solution consists of a set of goals and targets for which some rules have been applied. The shaded parts (processes, goals and targets and Applied rules) should have indexes for case retrieval. They may have similar terms, which will constitute the principle indexes for retrieving similar cases from the case base. Further details are available in (Limam et al. 2003).

For both examples described in sections 5.1.2 and 5.1.3, the cases are indexed as follows:

- Example 1: <Business area> “Education”, <Sub-Business area> “Research”, <Processes> “Conference registration process”, <BPR Solution> “Conference registration process BPR Solution”, <Goals and targets> “Reduce the Production Times”, <Applied rules> “Task composition”.
- Example 2: <Business area> “Banking, Finance”, <Sub-Business area> “Financial products”, <Processes> “Mortgage”, <BPR Solution> “Mortgage BPR Solution”, <Goals and targets> “Reduce the Costs”, <Applied rules> “Control addition”.

6. CBR as a technique for knowledge management in Business Process redesign

In the sequel we explain how the CBR/BPR tool can be used to enhance knowledge transfer strategies in Business process Redesign.

The CBR/BPR tool plays the role of a knowledge-handling tool. The information (which best practices are used for business processes) is first collected from practitioners and then stored in the case database and organised logically (see section 5.2). Basically, Our implementation framework and the set of best practices are the basis for cases classification for CBR. They can be used in two ways:

- A practitioner wishes to apply a given set of best practices to a specific process and would like to retrieve cases where similar best practices were applied. In this situation the best practices are used to characterise a case,
- A practitioner doesn't know which rule to apply. He would like to retrieve cases where similar business processes have been redesigned. In this case the rules are an intrinsic part of the solution used in the historical case to solve a similar problem.

The information is then made accessible to practitioners to be used. The knowledge can be shared through the CBR/BPR tool by entering new cases to the case-base system or informally by people sharing the knowledge, talking and socialising with one another or exchanging information in digital or analogue form. The CBR/BPR tool thus supports the stages of knowledge management as described in figure 3.

Collecting information	➔	Storing information	➔	Making the information available	➔	Using the information

Figure 5: The stages of Knowledge Management, (Martensson 2000).

7. Conclusion

According to a study conducted with 11 organisations participating in the arena of knowledge management and published in (Sadri et al. 1999), the practice of knowledge management starts by creating, finding and collecting internal knowledge and best practices, then sharing and understanding those practices so they can be used and finally adapting and applying those practices to new situations. In this paper we have discussed the use of case-based reasoning for the reuse of previous Business process redesign projects to similar processes (sharing and adapting previous practices). This includes collecting the knowledge and storing it into the CBR case base and making it available so that knowledge about BPR is shared, adapted and applied to new situations. We have demonstrated through knowledge acquisition and knowledge representation that applying CBR is possible for BPR implementation and would benefit for (re) designers in the following way: Knowing the current process and knowing the problems those need to be addressed, similar processes with similar problems might be retrieved to find out which best practices have been applied and which technical and organisational solutions were adopted. Another situation might be that the consultant has already an idea about some rules he wishes to apply but he is not sure about the impact of applying them, or he wants ideas about possible adopted solutions. CBR can help in finding a similar business process, with a similar problem and similar applied rules.

We have also explained how the CBR/BPR tool can support knowledge management by collecting, storing and making the information available to practitioners to be used.

On the CBR tool level, two more steps need to be accomplished: the system implementation and the verification and validation of the implemented system. For the implementation, there should be a discussion about the most suitable CBR tool to use for our case. A library of cases is also to be constituted. Finally, metrics should be defined for the similarity-based case retrieval to find the closest-matching case.

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