HOW KNOWLEDGE BASED SYSTEMS SUPPORT BUSINESS PROCESS RE-ENGINEERING

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ABSTRACT

Four examples of how KBS can support BPR are introduced in this paper. The first is hypothetical and looks at the how an organisation can reengineer its business to accommodate data warehouses. The second example is based on a theoretical treatment that uses case based retrieval techniques to support strategic purchasing in firms that have been reengineered specifically to interface with external supply chains. The third and fourth examples are case studies that illustrate how an organisation can use KBS in BPR to orient itself towards and support the customer.

KEYWORDS: Knowledge Based Systems, Business Process Reengineering, Data Mining, Strategic Purchasing, Customer Support

1. INTRODUCTION

Knowledge Based Systems (KBS) (sometimes called expert systems) are a powerful force for technological change and advancement in all types of firms and businesses. They can add value and provide benefits such as consistency in decision making to firms ranging in size from SMEs (Small to Medium Enterprises) to large industrial companies. Until now, their introduction to an organisation was a painful process, mainly because they lacked a business-orientated operating framework. This framework has now been developed successfully, and is known as Business Process Reengineering (BPR). It is not a panacea for IT / KBS development, but it does shift the focus onto the business, how it operates, its weaknesses and strengths, etc. This results in an analysis where IT / KBS may be targeted into processes and areas where maximum value may be obtained.

The four areas described in this short paper indicate the benefits, potential or realised, to be gained from the application of KBS in support of BPR. The paper consists of an introduction to KBS and some of its spin-off technologies, an introduction to BPR and the use of KBS in BPR, the four case studies, and a conclusion.

2. KNOWLEDGE BASED SYSTEMS

A KBS is a computer program that contains specialist or expert knowledge about how to solve a problem [1]. It differs from a conventional program because the knowledge is usually encoded using high level knowledge representation formalisms. These formalisms include rules, facts, objects, frames, cases, etc. The source knowledge for a KBS may come from an expert, manuals, online database, or all three in any combination. The development of a KBS usually requires special techniques, and these range from knowledge acquisition techniques that capture the knowledge, to prototyping (or Rapid Application Development (RAD)) which can assist in scoping the problem. Collectively, these techniques are known as *knowledge engineering*.

The focus of development in KBS is moving from traditional rule based systems containing the accumulated knowledge of a particular expert to systems that learn from corporate data and gain insights into the data. Two technologies in particular illustrate this. They are case based reasoning and data mining.

2.1 Case Based Reasoning

Case Based Reasoning (CBR) is a subset of KBS. It is based upon work done in cognitive science and computer science communities [2,3]. In CBR, a new problem or situation case is compared with a library of stored cases: a case base. Using heuristically based indexed retrieval methods, the most relevant cases are made available to the user. At this stage, if the best retrieved case is a perfect 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 case may provide a sub-optimal solution; or the closest retrieved case may be adapted using some pre-defined adaptation formulae or rules. Adaption in CBR systems means that such systems have a rudimentary learning capability, which can improve (become more discriminatory) as the number of cases increases.

2.2 Data Mining

Data Mining, also known as knowledge discovery from databases, has been defined as the “non-trivial process of identifying valid, novel, potentially useful and ultimately understandable patterns in data” [4]. Knowledge discovery in databases has a very close relationship to machine learning techniques employed in artificial intelligence. To derive new knowledge, these methods are used in collaboration with methodologies which can handle uncertainty in existing data, such as fuzzy logic, neural networks, rough sets or evidence theory. These knowledge discovery algorithms usually generate either association rules or decision tress to represent ‘sifted nuggets’.

3. BUSINESS PROCESS REENGINEERING

Business Process Reengineering (BPR) is the name of the method that enables an organisation to make fundamental changes in the way it carries out its business. In BPR, the focus moves from function to process where, for example, traditional functions such as sales are overhauled, simplified and reconstituted as processes. Supporters of BPR advocate that the reengineering of a company’s important business processes should be a revolutionary event [5], and not evolutionary or revelationary. However, recent work on practical application of BPR [6] suggests that an evolutionary approach, more recently called *morphostatic* BPR [7], may be more acceptable to management and staff than the revolutionary, or *morphogenic*, approach. The morphostatic approach may act to prepare an organisation for the more rigorous application of morphogenic BPR. For this reason, morphostatic BPR is sometimes termed *first order* BPR, while morphogenic BPR is termed *second order* BPR.

The rewards of BPR are across the board improvements in value, quality, customer support, and productivity; which are achieved by the new business process possessing inherent flexibility, agility and responsiveness.

BPR is powered by Information Technology (IT). Historically, IT has facilitated business processes within functional areas of companies such as manufacturing. However, this application of IT makes the *a priori* assumptions that companies are optimally organised already, and that the functional approach manages change elegantly. As a result, adding IT to the old functionally-based processes can guarantee only to computerise non-optimal processes that will be difficult to change.

4. USING KBS TECHNIQUES IN BPR

Using IT to support BPR is the key to successful use of this technique. In new, lean business processes where non-value added tasks have been removed, IT can enable manufacturing philosophies like Optimised Production Technology (OPT) or Just-In-Time (JIT). However, complex problem areas will still exist in reengineered companies. These problems will occur with large and small companies, and basic IT cannot address them. They include the handling of incomplete, conflicting and vague data, the discovery of knowledge in massive data sets, the interpretation of legislation and inter-organisational contracts, the management of change, and the reapplication of an expert’s accrued experience and expertise. KBS techniques provide a series of tools that can help to assess, manage and ameliorate these problems [8,9]. Knowledge engineering, which is the name given to the process of building KBS, applies specialised techniques to acquire, represent and use business process knowledge. There have been a number of reported success stories where KBS have added value to business processes [10,11], and in fact made their reengineering possible in the first place.

5. REENGINEERING FOR DATA MINING

Most existing database environments are mainly designed for On-Line Transaction Processing (OLTP); a methodology that enables a functionally-oriented organisation to perform the typical tasks required, such as payroll processing. OLTP can be sufficient for first-order reengineering, which is an evolutionary BPR approach that uses the status quo of the overall business structure, but changes IT-related procedures incrementally. An exemplar scenario would be a specially set up team that focuses on the process within an existing business, rather than on its functions themselves. Such a multi-disciplinary BPR team would consist of IT staff to plan and administrate data management as well as security aspects, production employees to guarantee quality of goods, financial personnel for monetary transactions, and administrative staff to guarantee consistent logistics. Additionally, an external consultant with expertise in the field of knowledge discovery should join the team to provide information about changing the business process flow(s) to provide all data needed to allow successful knowledge discovery.

To fully profit from the powerful abilities of the data mining technology, second-order reengineering is highly desirable, if not a prerequisite. This revolutionary BPR approach can dramatically change process allocation, task organisation, responsibilities, hierarchies, and so forth. The major objective is to move from an OLTP driven environment to an On-Line Analytical Processing (OLAP) directed enterprise. OLAP has been defined by its inventor [12] as the “dynamic synthesis, analysis and consolidation of large volumes of multi-dimensional data”. Data Warehouses are designed to handle cross-functional, process-orientated data and fully embed OLAP. The implementation of second-order BPR has to be realised in co-operation with all affected participants, and, again, with external expertise to design a data warehouse that can be connected smoothly to data mining solutions.

There is much discussion going on in the BPR community about ‘how much reengineering’ has to be done to take advantage of the potential of IT. But, at any critical stage of the reengineering process - in an evolutionary as well as in a revolutionary scenario - collaboration with external knowledge engineering expertise is highly recommended. This exterior support is not only required for the business process re-structuring, but also for the technical data mining process itself. Incorporating knowledge discovery facilities in an existing IT landscape is not a straightforward procedure that can be solved with off the shelf tools; many business sensitive adoptions have to be performed, such as data pre-processing, embodying domain knowledge, knowledge post-processing and so forth. Thus, it always has to be kept in mind that the chosen data mining paradigm depends on the type of information required and the domain knowledge being discovered.

6. STRATEGIC PURCHASING - THE MAKE OR BUY DECISION

One of the core issues to have emerged in strategic purchasing over the last number of years has been the growing importance of the make or buy decision for organisations. Within organisations the make or buy decision is being given more consideration because of its strategic implications. The make or buy decision can often be a major determinant of profitability making a significant contribution to the financial health of the company [13]. This section outlines an approach to the make or buy decision which involves a distinct number of processes, involving a cross functional business team. It illustrates how the power of KBS techniques can be exploited in the redesigning of a business process. KBS supports the re-engineering process by allowing tasks to function more independently and in a modular way. The model includes the application of both rule based and case based reasoning technology. This section focuses on the issues involved in the application of case based reasoning techniques to the automation of the make or buy decision. An outline will be presented on how Case Based Reasoning (CBR) can be applied to one of the processes, i.e., the assessment of the technical competence of potential suppliers in relation to the purchasing company.

In the past, buying by organisations has been done largely on the basis of obtaining the best price, exceptionally taking into account a few other factors such as quality and delivery. However, in many cases a significant number of factors such as delivery reliability, technical capability, cost capability and the financial stability of the supplier were not taken into consideration [14]. Some of the key problems encountered by companies in their efforts to formulate an effective make or buy decision are as follows:

- No Formal Method for Evaluating the Decision. Many companies have no firm basis for evaluating the make or buy decision. Blaxill and Hout [15] have found that many firms make sourcing decisions primarily on the basis of overhead costs.

- Inaccurate Costing Systems. In many instances, companies base their sourcing decisions on cost issues. However, the results of studies carried out on the cost accounting practices and financial performance systems used by US manufacturing systems has shown that many of these organisations’ accounting systems have not kept pace with the changes in industry and the technology used in production [16].

The make or buy model is intended primarily for use with strategic items focusing on a partnership relationship with a selected supplier.

6.1 Analysis of the Technical Capability Categories

The objective of this stage is to determine the best technically competent suppliers and the technical capability of the purchasing company in relation to their ability to supply the item. The performance of potential sources of supply (internal and external) is assessed and evaluated against the identified categories and criteria. This involves carrying out the following tasks:

(i) Weighting the importance of each criterion in each category to the purchasing decision. The importance weights must accurately reflect each criterion's importance to the sourcing of the purchased item. For example, in the Quality category, Quality Costs/Sales Ratio may be considerably more important than all the other criteria in the category combined.

(ii) Entering the 'ideal' values for each criterion in each category. These 'ideal' values represent the most technically competent performance rating from a supplier along each criterion. The purchasing company may have an objective for each criterion, or it may be the best possible value for the criterion. For example, if a supplier has carried out a contract for the company with zero defects, then this will be the best possible value for this criterion.

(iii) The system will then retrieve the potential sources which most closely meet the 'ideal' criterion values set out by the user group. The potential retrieved sources will be comprised of both the potential suppliers and the purchasing company. It must be noted that the 'ideal' profile for each category will also be compared against the internal performance of the purchasing company. It is not just a case of comparing the 'ideal' profile against potential suppliers, both the internal and external dimensions are considered.

This system attempts to overcome some of the problems associated with the make or buy decision, and act as a decision aid for an organisation in the make or buy decision. The system has illustrated the immense impact that knowledge based systems technology and case based reasoning in particular can have upon the re-engineering of a strategic area of the business.

7. PROVIDING RAPID RESPONSE TO A COMPANY'S SALES FORCE

The company in this case study is a rapidly expanding medical packaging firm, with ever increasing numbers of customer orders manually being 'processed' through the system. Like many SME's the company is split into 'functional' areas such as Production, Finance, Sales, Customer Service, Production Engineering etc. As the company grew, increasing number of sales queries and orders resulted in many different functional areas being consulted in response to customer enquiries. This resulted in delayed response times, potential duplication of effort, and inconsistent responses emanating from different functional areas. As a consequence, the company suffered reduced effectiveness in a number of key areas:

- Order Cycle time. The length of time to 'process' a new order increased.
- Time taken to quote. Increase in time taken to perform an initial quotation, resulting in a potential loss of customers.
- Feasibility assessment. A job could be quoted and an order placed before engineering had judged it feasible.
- Modelling. Increased time taken for customer changes in order and calculating the consequences for order feasibility and price.
- Errors in Order. Due to human error, the more human contact in the order chain, then the increased likelihood of human error entering the order.

- Duplication of data. As each functional area required common data, this was often duplicated.
- Inconsistent Data. Lack of co-ordination meant different functional areas were sometimes using different 'standard' figures for their costing formulas, etc.
- Wastage. Due to human error, and inconsistent data / procedures, the 'optimum' product routing and material selection may not always be selected, resulting in unnecessary wastage.
- Inaccurate Quotes. Due to lack of confidence in the quotation system, the sales force would sometimes change prices without consultation with the company.
- No analysis of quotations is available, therefore there is no scope for control or 'follow up'.

It soon became apparent that some kind of re-engineering process needed to be conducted and Business Process Reengineering was deemed a useful approach. The introduction of a BPR approach enables the individuals who use the output of the processes (product feasibility assessment, product engineering & quotation) i.e., the salespeople and customer services, to actually 'perform' the process - via the aid of a knowledge-based automated rapid response system. The aim is to improve performance in the above mentioned areas.

7.1 The Approach

A systematic redesign approach was adopted. Although based on the existing process, it is easier to implement incrementally by identifying and understanding the existing processes associated with the order life cycle, then systematically working through them to add value to existing processes, and create new more efficient processes. The objective was to:

- Eliminate all non-value adding tasks;
- Simplify the remaining tasks;
- Integrate remaining tasks - to effect a smoother flow;
- Automate as much of the process as possible - To speed them up and to reduce errors.

It was felt that a multi-department, cross-functional project would pay the greatest rewards in terms of speed, efficiency, and customer satisfaction.

7.2 The Method

A series of knowledge elicitation interviews were conducted with staff from each of the functional areas to identify and extract the 'processes' involved within and between the functional areas, with a view to specifying and constructing an automated 'Rapid Response System' which traversed and integrated all of these areas. A *Knowledge Document* was constructed, containing the interview transcripts and flowchart descriptions of processes interpreted from the interviews. The automated system was constructed using an 'evolving' rapid prototyping approach, which facilitated additional knowledge extraction from the process owners/experts as well as confirming, verifying and validating their earlier knowledge.

7.3 The Results

What were previously separate functional departments (production, planning, customer services, accounts, quality, engineering) have now been dissolved. Employees from each of these functional departments are now combined to form 'business units'. The result is a self-sufficient structure which operates not on a functional level, but instead focuses on the processes involved across the entire manufacturing cycle. The employees within the units are cross-trained.

This re-structuring, combined with KBS/IT (Rapid Response System) support has led to the following improvements.

Increased integration of every part of the sales operations (distribution, pricing, invoicing, settlement, accounting and ordering). This has led to an increase in the scale and scope of processes, (across these different functional areas) - resulting in 'flatter' functions. The common data source should also help eliminate costly duplication and redundancy, and facilitate consistent results to data queries.

Shorter quotation/order cycle times has been the most measurable outcome from the implementation of the rapid response system. This in itself reduces costs through a reduction in employees' the time spent on chasing up incomplete orders, and reduction in human error and material wastage. The shorter quotation cycle time should encourage new business by reducing the time it takes to close sales, by increasing the productiveness of the sales force (who can now rapidly construct modelling queries) and by providing an overall better customer service.

The 'automation' aspect in itself has eliminated existing paper-based ordering, quoting and specification processes and has electronically linked tasks enterprise-wide.

7.4 Management Viewpoint

From management's perspective the major benefits resulting from the BPR exercise as a whole, and more specifically the introduction of the rapid response system are that the expertise and knowledge concerning all areas of the business has been spread throughout the company as opposed to being localised in previously functional areas. Under-pricing previously presented management with problems. Often sales reps under-price a job because they can't accurately predict exactly how much it would cost to produce a product. The rapid response system now quickly arrives at a price which is based on actual production costs that would be incurred rather than a 'first guess' by the sales rep. In addition, the managers can use the rapid response system as a modelling tool to investigate pricing consequences of various routing / specification configurations.

7.5 Users' Viewpoint

The sales reps are not the only users, but are perhaps the most salient, as the BPR exercise was an effort to exercise a degree of control over their processes whilst at the same time making their job easier through automation of the factory processes on which they would normally have to wait. From a sales reps perspective the major problems that the BPR exercise is intended to solve are slightly different - as they have different priorities. These are as follows:

- Keeping track of the current (most up-to-date) price quoted to a customer. Often the quotes come from many sources - themselves, customer services, management, accounts. Automation resulting from the BPR exercise holds the most recent quote centrally and everybody can have access to it before talking to the customer.

- Time taken to re-quote based on changed customer specification or different order quantities. In fact, Product Engineering may find that the job is impossible to do and may require relaxation of certain specification parameters. Using the automation resulting from the BPR exercise, this may be performed instantly by the sales rep sitting with the customer.

- Check tooling availability. With automation resulting from the BPR exercise, tooling availability and information regarding stock levels of machine parts may be accessed via a central database.

7.6 Difficulties

The main aims of the rapid response system part of the BPR exercise were to reduce order cycle time, reduce errors, reduce costs and improve the quality of customer service. The automation of most of the processes involved via the introduction of knowledge-based techniques has succeeded in achieving these objectives, however it can't cope with all possible order types, as sometimes customers want very specialised specifications - these can still be dealt with manually and entered onto the central computer system at a later date. The BPR exercise itself initiated debates and issues that had not previously been brought to the surface, and in this sense it was a useful exercise in making people within the functional areas 'aware' of looking at their tasks from a process point of view, and prompted useful suggestions from the individuals closest to the tasks.

The BPR exercise helped the company to focus on key business issues, enabling them to manage considerable growth and sustain their position as market leaders in the medical packaging industry. In conclusion, it must be said that everybody gained from the exercise, and most especially the customer.

8. EMBEDDING CBR IN CUSTOMER SUPPORT

The area of Customer Support is one that is continually changing and needs constant appraisal of customer needs. The key features of quality, dependability, professionalism and cost effectiveness are all necessary for a company to sell their product. In the case where the product is a service, the same ethos applies. The aerospace company Short Brothers have taken a proactive step to meeting the needs of the customers in the product support of their SD3 Aircraft Range.

BPR in this particular case study was applied on an intra-functional basis to the traditional function of Customer Support. The business processes that are involved in Customer Support are initiated by the external customers, operators of SD3 Aircraft in the form of a technical query and a result is offered by the Customer Support staff, Headquarters Engineers (HQE) to the initial technical query.

8.1 Background

The technical support is provided for a variety of short range commuter and military aircraft. The aircraft range consists of 368 civilian and 28 military aircraft. These aircraft are in service in over 40 countries with at least 100 different operators. It is envisaged that the aircraft for which the division SD3-Aircraft provide technical support will be in operation for the next 10-20 years and will therefore require technical support for this period of time.

The original processes that were used to solve technical queries were based purely on a paper system which relied heavily on the day to day management of Mail In and Mail Out books. The vast majority of technical queries from operators arrive at technical support in the form of a fax. The queries are usually of an urgent nature with a status of AOG (Aircraft On the Ground) as grounded aircraft result in lost revenue for the operator. The scope of a technical query covers problems such as accident damage, corrosion, technical defects, or request for data.

Within technical support there is a wealth of information stored in maintenance manuals, flight manuals, and in previously solved technical query files that are continuously being updated as new technical queries are solved. The HQE's use their expertise and knowledge of the domain to solve the new technical queries.

Through systematic redesign, the primary operational process of providing a service to the SD3 operators and the secondary process of management were highlighted as the two key processes in the traditional function of Customer Support. The operational processes where defined as the service of taking the customer's requirements and satisfying them by providing the required service. The management processes were defined as the performance monitoring of the Headquarters Engineers and the planning and resource management of technical query handling.

8.2 Benefits

The processes defined above were used as the foundation to develop the KBS. The KBS, which utilises case base and data base technology, is able to provide the following benefits all of which enhance and improve the service that is provided to the operators of the aircraft, the customer. Automation has also proved beneficial for the management processes of performance monitoring, planning and resource management.

Accurate management information can be obtained for statistical analysis on technical queries. This information can be generated in either graphical or report format. Information on staff workloads, on-going technical queries, quantity of technical queries handled in set periods, operator query loads etc. can be gleaned from the system.

The system acts as a data and knowledge capture tool where all technical queries are compiled over time and stored in electronic format for future re-use. This is one of the majors advantages that re-engineering of the business processes has produced. When technical queries have been made into a case by a case base administrator they can then be retrieved to help solve any future technical queries. The 'value added' factor is the knowledge which the HQE's add to the solution. The major benefit is the re-use of known solutions to past experiences for solving new problems whose solution is unknown.

Additional benefits which are key to satisfying the customers initial requirements are faster response times to operator queries with the ability to provide consistent answers which have been proven to work in the past. The knowledge of how to solve technical queries is retained within the company if key members of staff leave or if paper files are removed and destroyed.

8.3 Findings

In this particular case study radical changes in the processes that are used have only been applied to function of Customer Support. The use of the case based tool has meant changes for all staff concerned in their day to day work with the major change being automation. The introduction of IT to key business processes has provided a means for the capture and dissemination of knowledge and expertise. The re-engineering process proved to be a trouble free experience with maximum desire for change from both management and staff. Information technology in the form of a KBS has proved to have been a successful and integral component of BPR within the Customer Support business area.

9. CONCLUSIONS

Four examples of how KBS can support BPR have been discussed in this paper. The first is hypothetical and looks at the how an organisation can reengineer its business to accommodate data warehouses. Increasingly, companies in the financial market sector are becoming aware of the market intelligence held in their databases. These companies must reorient their information resources so that they may more easily extract and exploit this knowledge for commercial advantage in an increasingly open and competitive market. This requires a move towards OLAP and the related use of data mining algorithms and high performance (parallel) computing architectures, and a reengineering of their business processes that will accommodate the commercial needs and desires of their customers. The second example is based on a theoretical treatment that uses case based retrieval techniques to support strategic purchasing in firms that have been reengineered specifically to interface with external supply chains. The model, which will be tested in the near future, uses KBS techniques at key parts of the supply chain analysis to provide knowledge based decision support capabilities in the reengineered processes.

The third and fourth examples are case studies that illustrate how an organisation can use KBS in BPR to orient itself towards and support the customer. In both, KBS techniques manage key parts of the business processes, providing access to high-level company knowledge and empowering the employees to deliver high quality and highly consistent decisions.

In general, the most successful companies see the expertise and knowledge of their workers as their most valuable asset. In this paper, it has been shown that the knowledge of the workers can be embedded, as KBS, within IT that supports the reengineered business processes. This can lead to the company whose business is lean (no non-value added tasks), agile (reengineered processes designed for change), and knowledge based (much of the company's collective experience is held in KBS).

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