Case Based Reasoning as an Element of Case Processing in Adaptive Case Management Systems

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Abstract— **The paper sets out from a proposition that the concept of Case Based Reasoning could improve business decisions and optimize case processing in modern Adaptive Case Management (ACM) systems. While depicting the state of the art in the continued efforts to blend Artificial Intelligence (AI) with Business Process Management (BPM), Knowledge Management (KM) and Adaptive Case Management, the authors take notice of how the classical ACM platform has recently been evolving. The dynamic and adaptive nature of some business processes poses challenges that the classical BPM approach cannot adequately address. Adaptive Case Management has been developed to better cope with such challenges. ACM not only makes it easier to align a business to rapidly changing requirements and conditions, but it also enables organizations to more effectively exploit the potential inherent in the organizational knowledge and information resources. The paper discusses the evolution of ACM systems and proposes to apply Case Based Reasoning (naturally coupled with AI) in optimizing ACM outcomes.**

I. Introduction

A completely new approach employing the existing ACM tools and the Case Based Reasoning model has been developed to address the problem of decision support within business case processing. The idea involves integrating the Case Based Reasoning method into Adaptive Business Case Management.

This paper describes an approach that is founded on the application of Case Based Reasoning to deploy decision support and was preceded by a literature based discussion on Artificial Intelligence (i.e. the CBR method) and its application to support Adaptive Business Case Management. Attention is focused on ACM and CBR, with an aim to provide a complete theoretical framework for reflection on their proposed integration and for applying the integrated methods to exploring a set of business problem solutions.

The paper advances and investigates the following theses:
a) The Case Based Reasoning method may be used to support ACM by providing faster access to the information needed to make business decisions.
b) Supporting ACM with Case Based Reasoning makes the process of exploring a set of business problem solutions faster and more effective.

The paper deals with the application of the Case Based Reasoning method in supporting the ACM method. Case Based Reasoning (CBR) is an artificial intelligence method based on reusing the outcomes of previously solved problems: when a new problem arises, the problem solving process begins with an effort to find the closest matching solution to the problem within a set of historical solutions. Once a matching solution is found, it is adapted to the specific problem and an attempt is made to apply it. The new solution is too stored in a dedicated repository. With each subsequent problem solved, the repository becomes larger.

Adaptive case management processes are of dynamic character, since they are not defined until at runtime. To master the unpredictability of processes and hence facilitate process management in contexts where processes are mostly complex and where relevant decisions are affected by a large number of factors, more and more organizations choose to switch to Adaptive Process Management systems. ACM allows perfect visibility and full control of each specific case, whether it is handled by a predefined or an ad hoc process, or by a combination of the two.

An important part of a problem solving process is to define the case and represent it in a machine readable format, i.e. one that can be handled by a computer. If the case has been defined and represented accurately, and if the case repository is adequately structured, the process of recording a particular problem can be carried out parallel to problem solving.

The paper presents the authors' original solution that extends the capabilities of ACM through the addition of functionalities typical of CBR.

An enterprise that is run in line with the ACM concept will be intrinsically capable of combining its core business activities with a day-to-day ability to create and review innovative solutions. Since process operators can modify processes dynamically, the entire business management system is open to creative initiatives from staff at large, while at the same time avoiding chaos that might arise as a result of spontaneous changes to operating properties. In addition, since it possible to examine the outcomes of changes as they emerge, information on which practices and

solutions deliver the best results and which produce the worst can be appended to organizational collective knowledge. This stands for day-to-day improvements and adaptations to business processes relying on the best knowledge of a large portion of personnel and becoming validated through feedback from customers.

A fundamental principle of ACM is associated with the belief that any organization should continually collect, process and utilize knowledge on the mechanisms governing its business environment, and that such an approach is not only most effective, but simply essential if you want to be able to respond to customers' expectations and keep pace with the rapid changes in today's marketplace. ACM is often said to be focused on building a learning organization. Improvements to an organization's internal processes take place across several dimensions and engage executives and staff alike. The paper describes a methodology for integrating the AI-based CBR method into the ACM domain, thereby improving the standard ACM mechanisms.

It needs to be stressed that a dynamic Business Process Management model can be implemented within an organization irrespective of the products and/or services its offers, and that the effects of its implementation largely depend on the professional skill of personnel, their effectiveness in managing organizational knowledge, and their ability to make optimal business decisions – which entails the requirement for all staff to be involved in developing and formulating new solutions.

II. BACKGROUND AND RATIONALE

The CBR field has been growing rapidly over the last 20 years, The increased interest in CBR is evident in the number of research papers presented at major conferences, and in the availability of commercial tools and successful applications in daily use.

What is Case Based Reasoning about? What it basically does is try to solve new problems by recalling previous instances of similar cases and reusing information and knowledge on those cases. CBR can be therefore described as a problem solving paradigm. It is able to utilize specific knowledge on previously experienced, concrete problem cases; it attempts to find a similar past case and reuse the related information in addressing a new problem. CBR is at the same time an approach allowing incremental, sustained learning, since new experiences are retained each time a problem has been solved, making them immediately available in addressing new problems that will arise in the future.

Under CBR terminology, a "case" usually denotes a problem situation. A previously experienced situation that which was captured and learned in a way that makes it possible to reuse the experience in solving future problems, is referred to as a "past case", "previous case", "stored case", or "retained case". Accordingly, terms such as "new case" or "unsolved case" refer to a description of a new problem to be

solved. Case Based Reasoning is – in effect – a cyclical, integrative all-round process of problem solving, learning from this experience, and solving new problems.

The affinity between ACM and CBR goes beyond cycles alone. At the research level, ACM literature recommends that effective case management solutions target people, processes, information and technology [1]. From a CBR perspective, Aamodt and Nygård argued – decades ago – that CBR research should address practical applications and focus on optimizing the linkages between the CBR system and its user rather than on the CBR system alone [2]. This encourages a perception whereby CBR appears as an approach that contributes to ACM and Knowledge Management.

In the paper, it will be demonstrated that Case Based Reasoning (CBR) is intrinsically applicable to Case Management.

III. LEARNING FROM THE CBR AND ACM PERSPECTIVE

A very important feature of Case Based Reasoning is that it is intrinsically coupled with learning. The driving force behind Case Based methods stems, to a large extent, from machine learning (a subfield of machine learning [3]). Thus, no matter how cases are acquired, the notion of Case Based Reasoning designates a reasoning method as well as a machine learning paradigm that enables sustained learning by updating a case base on solving each problem. Under CBR, learning occurs naturally as a by-product of problem solving: when a problem is successfully tackled, relevant experience is retained with a view to solving similar problems in the future; if an attempt to solve a problem fails, the reason for the failure is diagnosed and memorized in order to avoid making the same mistake in the future.

Case Based Reasoning favors learning from experience, since it is usually easier to learn by retaining a concrete problem solving experience than to generalize from it. Still, effective learning in CBR requires sophisticated methods to extract relevant knowledge from experience, incorporate cases into an existing knowledge structure, and index them for subsequent matching with similar cases.

The term "memory" is often used to designate a storage structure that holds existing cases, i.e. a case base. Memory thus refers to what has been memorized from past experiences. Accordingly, "reminders" or "pointers" are structures referencing, or pointing to, some part of the memory.

ACM standardizes information, processes, and people, allowing for each case to be presented fully and in many aspects. Case management stands for coordinating the service activities undertaken in an effort to achieve a specific objective. Typically, it involves creating a case file and performing certain tasks (e.g. including the right documents in the file). These tasks may be standardized (or pre-defined) actions related to the type of process at hand, or actions that are designed and added *ad hoc* when dealing with

a particular case. Each case file contains a description of the customer, product, project, patient, etc. The description can be defined freely, either internally or externally.

What ACM essentially does is shift the process of knowledge gathering from the template analysis, modeling or simulation phase into the process execution phase. An ACM system collects actionable knowledge – without an intermediate analysis phase – from business users. All information that might be required in processing a case is stored in the ACM system (a repository, case history, case-related communications, etc.).

Moreover, ACM helps manage the unpredictable by enabling knowledge workers to effectively cooperate and share their knowledge, thus improving the functionality of any decision support system [4].

Users engaged in solving tactical and strategic problems will rather expect the system to become a "partner in problem solving." Interestingly enough, we have found that the lowest skill levels are associated with the highest expectations from the system, including a proactive attitude in assisting the user. Conversely, the expectations of most advanced and creative problem solvers are limited to being offered an efficient technology and a rich collection of presentation tools.

Knowledge workers will convert restricted-access knowledge into open-access knowledge, thus building up organizational resources of information/knowledge on business cases. The learning process results in expanding the organizational knowledge base and improving the staff's creativity, which allows business cases to be handled more effectively. Users can retain proven operating procedures within embedded structures and templates consisting of business case process components, such as data models, process models, user interface ingredients, rule sets, and case configurations. Users are allowed to add their own templates and create complete case processing applications that will satisfy their industry-specific needs and/or their specific expectations [5].

An effective Adaptive Case Management solution should be able to support organizational learning from previous cases. The learning may lead to defining new processes, designing new procedures, enhancing the efficiency of online help services, etc., whereby lessons learned by knowledge workers are immediately applied in the process improvement cycle. The phrase "formalized experience" is often used to describe established practices that have been transformed into automated steps and/or procedures aimed at assisting the processing of future cases.

The classical process improvement cycle (e.g. in BPM systems), administered by process leaders and involving such consecutive steps as process modeling, performance monitoring, formulating conclusions and, eventually, utilizing the findings to improve the process, is far too slow and therefore inadequate. What is more, in the event that some customers have conflicting expectations, it might be impossible to design a "universal" process that would be acceptable to all stakeholders.

The learning approach of Case Based Reasoning is sometimes referred to as Case Based learning. Central tasks that all Case Based Reasoning methods have to deal with are to identify the current problem situation, find a past case similar to the new one, use that case to suggest a solution to the current problem, evaluate the proposed solution, and update the system by learning from this experience.

IV. HOW CBR IS RELATED TO ACM

At the highest level of generality, the following four processes may describe a general CBR cycle:
- RETRIEVE the most similar case or cases,
- REUSE the information and knowledge on a case to solve a current problem,
- REVISE the proposed solution,
- RETAIN those parts of the experience that are likely to be useful in future problem solving.

A new problem is solved by retrieving one or more previously experienced cases, reusing the case in one way or another, revising the solution based on reusing a previous case, and retaining the new experience by incorporating it into the existing knowledge base (case base). Each of the four processes involves a number of more specific steps that will be described in the task model.

The CBR paradigm comprises a range of methods for organizing, retrieving, utilizing and indexing knowledge retained from past cases. Cases may be kept as individual experiences or as generalized cases made up of sets of similar cases; stored as separate knowledge units, or split up into subunits and distributed within a knowledge structure; indexed by prefixed or open vocabulary, within a flat or a hierarchical index structure. Solutions from previous cases may be directly applied to current problems or modified to allow for differences. Matching the cases, adapting the solutions, and learning from experience may be guided and supported by either a deep model of general domain knowledge or by shallow and compiled domain knowledge; or else it may be based on apparent syntactic similarity alone. CBR methods may be wholly self-contained and automatic, or they may interact heavily with the user for support and guidance of their choices. Some CBR methods assume a rather large amount of widely distributed cases in their case bases, while others are based on a limited set of typical ones. Past cases may be retrieved and evaluated sequentially or in parallel [6].

CBR can be easily and effectively used in ACM environments. It can be seen as a natural extension to the existing ACM system functions and a way to improve organizational performance in solving business cases, managing organizational knowledge, and supporting decisions made by knowledge workers. With an ACM system in place, all the data and information related to each case, gathered while processing it, is stored in a case

repository. Descriptions contained in case files can be defined freely and may include e.g. customer and/or supplier information, applications or requests, customer information obtained from external sources, product specifications, financial reports, legal documents and opinions, statements, correspondence, test results, X-ray scans, photographs, technical drawings, and many other similar resources.

Case management typically involves creating a case file and performing certain tasks. These tasks may be standardized (pre-defined) or added dynamically when dealing with a case. All information pertinent to the case, accumulated in the case file, can be used by all personnel engaged in handling the case and working together in processing and closing it. Corporate executives can then use such information in monitoring the process of dealing with a particular case. This is an idea that is perfectly consistent with CBR.

All the steps and decisions taken by a knowledge worker, as well as all other information related to the processing of a particular case, are stored within ACM structures. The organization's internal, restricted-access expertise, guidance and resources needed to solve a specific case are all contained within ACM structures. Most frequently, the information on a case is structured as shown in the following diagram.
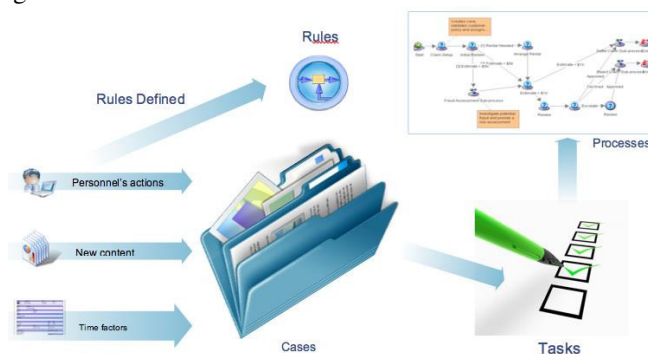

Fig. 1 A typical case structure within an ACM system

Once a case is closed, the information on the case is stored for audit purposes (in compliance with certain regulations) or for use in other long-term business processes. The idea described in this paper proposes to extend the application of such information to the processing of new cases via CBR.

ACM allows the employee to create rules by reference to a repository of previous cases representing best practices. The availability of information on similar problems, and on optimum solutions to these, leads to minimizing repetitive work.

V. INCORPORATING CBR INTO ACM

Under CBR methodology, an initial problem description defines a new case, which is then used to RETRIEVE a case from the collection of previous cases. The retrieved case is combined with the new case – through REUSE – into

a solved case, i.e. a proposed solution to the initial problem. Through the REVISE process this solution is tested for success, e.g. applied to the real world environment or evaluated by a teacher, and further refined if the test fails. During the RETAIN phase, useful experience is retained for future reuse, and the case base is updated by including the newly learned case or modifying some of the existing cases. The CBR process could be therefore depicted as follows:
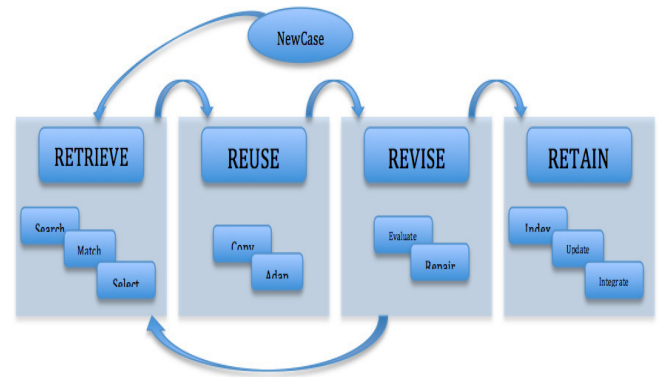

Fig. 2 A CBR model

The application of CBR to support the operation of an ACM system may, for example, proceed as follows:

An event is triggered by e.g. scanning a new document found in incoming mail, initiating a new business case that immediately enters the system. The document is analyzed via an automated OCR process to roughly determine its content, and a new case is opened. Now, the relevant CBR functions may be mapped for processing the case within the ACM system.

RETRIEVE

1. As a first step in the process, the available case data (metadata, content, case type, solution template proposed, etc.) is read. All these data are offered in a legible format by the basic ACM system functions.

2. The next step is to search the case repository in an attempt to find historical cases whose characteristics match the case under examination as closely as possible (metadata, content, document classes, etc.).

3. An initial match: the system selects the cases/information whose characteristics most closely resemble those of the case being examined: similar metadata, business cases, case domains, etc. Unstructured data analysis tools (e.g. asset correlation testing with the use of IBM Watson Content Analytics) can be used to refine the search.

The resulting algorithm reproduces the first functional area (phase) of CBR.

REUSE

1. After selecting a set of similar business cases (based e.g. on such criteria as the sequence of tasks or user activities from the model case retrieved from the case base), it is possible to pick a case processing template created by the

knowledge worker dealing with the previous case and apply the template in handling the new case.

2. In addition, if any documents have already been created in dealing with the case (e.g. replies, clarifications, or notifications conveyed to a customer), these can be included in the file for the case being handled.

These CBR functions can quite naturally become an add-in to, or an extension to, the basic functions of an ACM system. They not only accelerate the decision making process (case processing) but also account for better, more relevant decisions.

REVISE

The case manager software provides analytical tools that can be used to draw specific conclusions from information artifacts related to the case, which may include unstructured and/or structured information.

The third phase of the CBR model involves an evaluation of the extent to which the choice of stored case files (data, information, results) really matches the new case. Within an ACM system, this process can be supported with the use of business analysis tools [7]:

1. Detailed analysis and decision making improvement tools that can be used to optimize case processing in both general and specific terms. An ACM environment supplies analytical tools that help form very specific and detailed conclusions based on case-related information, whether structured or unstructured:

- At the level of individual users, such analyses make it possible to prioritize, assign tasks, and make decisions regarding individual cases.
- At the general level, such tools can help identify certain patterns and trends across a group of cases or evaluate the impact that each of the cases might have on specific organizational units or departments.
- With such information available, managers are able to proactively optimize performance, for example by changing work allocation, hiring additional experts, providing additional information on particular cases, or improving the quality of training.

Although the outcomes of the REVISE phase can bear very positively on the performance of the knowledge workers processing particular business cases in an ACM system, market research data, including ACM usage statistics, show that this phase will not be actually applied in each business case, because it places high demand on the system.

RETAIN

The purpose of this phase of CBR is to update the business case base/repository with information on the history of processing and solving a particular case [3]. Here, ACM will automatically transfer a case into the archive, and store all related documents and metadata in the repository. Once CBR comes into play, the algorithm or workflow path for a particular type of cases is likely to be changed permanently based on previous business cases. When the success statistics are high (accurate decisions, short problem solving times), the ACM system may, with the use of Case Based Reasoning, modify the business rules related to the processing of a particular type of cases. The outcome of the final phase of CBR is that it permits the ACM system to record a history of operations involved in case processing (e.g. task execution, decisions, communication with experts), thus converting restricted-access knowledge into open-access knowledge and expanding the organization's intellectual capital.

A company's body of knowledge is partitioned and distributed among staff and across worker groups; before it can be brought to productive use, it has to be properly organized. Any modern enterprise needs to have a Knowledge Management system, which can be described as a complex blend of understanding and experience, explicit and tacit knowledge, material and social technology [8].

The following are the principal goals of Knowledge Management in organizations:

- to make the most of the knowledge that is already available within the organization, and
- to create new knowledge.

It has taken some time for companies and researchers to realize that, besides data as such and besides information that can be interpreted by humans, there exists another vital resource that becomes increasingly crucial to a company's performance but cannot be captured and managed via standard information management methods – and that is knowledge. It can be either explicit knowledge, readily accessible e.g. from an Internet portal, or tacit knowledge that resides in the staff's minds and originates in their individual experience, training and talent.

VI. APPLICATION EXAMPLES

The Knowledge Worker perspective:

Under modern ACM systems, knowledge workers (KWs) will start work without any templates or ready-to-use solutions –with a blank ACM system alone. If they wish so, they can continue to work in that way forever, adding case by case. In the beginning, each case seems different from all other cases. However, as work becomes repetitive, individual knowledge workers will learn to identify snippets of cases that they could convert to personal templates, and reuse. KWs can thus benefit from CBR methodology that has been tailored to the duties they execute within an ACM environment.

For example, on having handled several similar cases, KWs in the back office will recognize that some software checks appear regularly, so it would be best to include them in a template. Furthermore, it should be borne in mind that their reasoning on future cases is augmented through learning from previous cases.

KWs understand that if they can make a template available to their colleagues, they will be able to ask their co-workers once in a while to perform the checks for them – and save some time in this way. Therefore, they will search for a case that contains such checks, copy the part into a new template, and edit the template to provide instructions that other KWs can follow. KWs share their knowledge by publishing that template across the library section for their group, so that other KWs can access it. If a similar case comes up, KWs can copy the template into their case. This example highlights all of the CBR phases at once. In effect, KWs can save some of their time while at the same time sharing their expert knowledge and giving guidance to the other team members through case patterns/templates.

Users of templates can rate them, tag them, and make suggestions for improvements. A template can be promoted to a policy status in order to gain more visibility to KM. The CBR process ensures that templates are not promoted to policies until they have been reviewed and approved by the participants and parties involved. The same is true of discarding templates/policies that are no longer in use. Hence, none but practically proven cases can become templates, and the set of templates is constantly improved: new templates are created on an as-needed basis while obsolete templates are disposed of. This implies that CBR is adapted in iterative cycles. As a consequence, the template library can be adjusted to new processes and new business situations as necessary. This can be accomplished by combining ACM features with the CBR idea to automate a case processing solution.

The Manager perspective:
A manager or team leader needs a workspace that contains team goals and team sprints/milestones, while the team members' personal goals and milestones remain in their individual workspaces. Most of the manager's work is done in the CBR area of REUSE and REVISE.

Since the knowledge work environment is characterized by frequent changes, managers need to have an analytical method of evaluating case data. Where changes occur very often, it is very important to be aware of how many goals have already been achieved, what percentage of goals have been altered, and where the bottlenecks or areas of high goal volatility are. Managers have to be able to instantly establish the reasons why a given case is not progressing, and find out who is responsible for the holdup. Hence, the ability to mine the goals and cases is of great relevance to managers. The key contribution of analytics is brought by making relevant case data available. CBR, on the other hand, having mapped a previous solution to the target problem, takes care of testing the solution in real world settings (a simulation may be performed) and, if necessary, revising it.

An ACM system has an unquestionable merit in coping with staff turnover. Past shared cases, such as e.g. customer service cases, are readily available for retrieval; at the same time, best practices are available in the form of templates and policies. Understandably, most knowledge workers are not inclined to share their experience and expertise unless it directly benefits and speeds up their own work; a degree of mutual trust is an obvious prerequisite for sharing these. Software technology that does not account for the unpredictability of cases is not fit for the purpose. Workspaces offer the right means to protect data, while at the same time allowing the sharing of all that is needed.

VII. The possibility of extending the application of CBR to ACM

Parts of Case Based Reasoning methodology have been used to fuel techniques for retrieving literal information, delivering performance superior to traditional databases. In this way, two new technologies supporting team work have emerged, i.e. Structured Contextual Search (SCS) and Dynamically Contextualized Knowledge Representation (DCKR).

These days, a number of software vendors promote contextual search and natural language search that is informed by the context of information comprised in knowledge bases. Transcending the search paradigm that relies on keywords and connectors, these techniques create room for users to sophisticate their searches toward a more elaborate and more effective approach. A search is considered "contextual" and "structured" when it meets the following criteria:

1. the context of documents stored in the system is taken into account;
2. it is the context that guides the entry, as well as comparison and selection, of documents [9].

It seems that this approach is widely accepted. IBM incorporates natural language processing and unstructured data analysis components into the core of ACM (IBM Case Manager). IBM Watson is a tool that can read and understand natural language, which is key to analyzing unstructured data and hence an invaluable asset in a world where 80 percent of case data are unstructured. Watson enables users to perform unstructured analysis based on a structural pattern detection process.

ACM software packages contain suites of personalizable tools providing whatever organizational and technical means it takes to raise organizational competence, improve the staff's education and learning capability, and boost collective intelligence. It supports the development and use of state-of-the-art mechanisms for semantic content analysis and industry-specific glossaries aiding communication among knowledge workers within an organization [8]. Owing to enhanced text analysis techniques, it makes it possible to discover trends, patterns and relationships within unstructured data as well as within related structured data. The resulting observations become part of organizational knowledge and can be used in decision making, forecasting, and setting business targets. In ACM environments such as

the IBM Case Manager, the user interface and the system vocabulary are customizable and can be adapted to the language specific to a given professional/business area (e.g. medical or other discipline-specific terminology).

The findings of a survey conducted by the authors indicate that the most frequently used creative problem solving tools include:

– context-sensitive help along with access to historical data and similar cases,

– group work support tools, such as discussion forums or (widely popular) instant messengers.

The integration of IBM Content Analytics Watson with IBM Case Manager enables the crawler to link to the most relevant data. Through repeated use, tracking feedback from its users and learning from both successes and failures, Watson gets increasingly smart over time – which also overlaps with the CBR concept.

VIII. SUMMARY

The paper presents the idea of applying the CBR method in the daily activities of a knowledge worker, thus enhancing the performance of an ACM system. It outlines a theoretical underpinning for the use of Case Based Reasoning to support business decision making in case processing. The concept is illustrated with practical examples and a discussion of design implications.

Hopefully, the paper has demonstrated that the application of Case Based Reasoning within ACM can accelerate access to information that is critical to making reasonable business decisions. The integration of Case Based Reasoning into ACM facilitates the exploration of solutions to business cases, which translates into streamlining the problem solving process and, consequently, into making better and more timely business decisions. This indicates that the concept can be beneficial both from the knowledge worker and the middle management perspective.

The proposed incorporation of CBR into ACM systems can provide substantial additional support to managers and knowledge workers, improving the rationality of the decision making process, reducing the risk of decisions made under uncertainty, hence increasing the chances of success. Based on their preliminary research findings, the authors anticipate that the CBR approach might be useful in supporting strategic decision making, especially under Adaptive Case Management systems.

In addition, by delineating a trajectory for optimizing ACM through the incorporation of AI methods, the paper seeks to initiate discussion of the roadmap for the future evolution of ACM systems.

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