

# Knowledge Management and Case-Based Reasoning: a Perfect Match?

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## Abstract

This paper demonstrates that case-based reasoning is ideally suited to the creation of knowledge management systems. This is because of the close match between the activities of the CBR-cycle and the requirements of a knowledge management system. The nature of knowledge within an organisation is briefly discussed and the paper illustrates the dynamic relationship between data, information and knowledge, showing how case-based reasoning can be used to help the manage the acquisition and reuse of knowledge.

## 1 Introduction

The function of knowledge management (KM) is to allow an organisation to leverage the information resources it has and to support purposeful activity with positive definable outcomes (Checkland & Scholes 1990). Knowledge and consequently its management is currently being touted as the basis of future economic competitiveness, for example:

*In the information age knowledge, rather than physical assets or resources is the key to competitiveness... What is new about attitudes to knowledge today is the recognition of the need to harness, manage and use it like any other asset, This raises issues not only of appropriate processes and systems, but also how to account for knowledge in the balance sheet (Moran, 1999).*

Entrepreneurs are no longer seen as the owners of capital, but rather as individuals who express their tacit knowledge by "knowing how to do things" (Casson, 1997). Boisot (1998) sees information as the key organizing principle of the organization; "information organizes matter."

The introduction of information technology on a wide scale in the last thirty years has made the capturing and distribution of knowledge widespread, and brought to the forefront the issue of the management of knowledge assets (Davenport 1997). The "knowledge management" function is spreading throughout the organisation, from marketing, information management systems and human resources.

With knowledge now being viewed as a significant asset the creation and sharing of knowledge has become an important factor within and between organizations. Boisot (1998) refers to the "paradox of value" when considering the nature of knowledge, in particular its intangibility and inappropriateness as an asset and also the difficulty of assessing and protecting its value (Priest 1994).

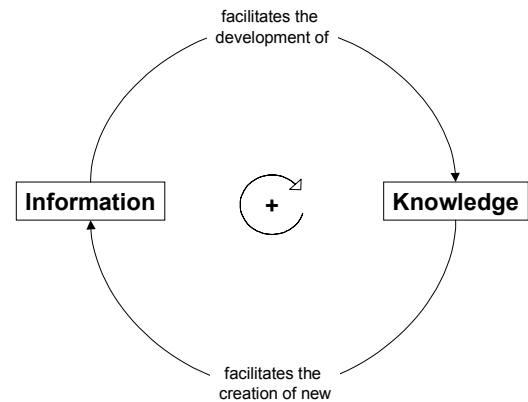


Figure 1. The Dynamic Relationship between Information and Knowledge

If, as this paper postulates, CBR is of significant value in KM we first need to consider the nature of knowledge.<sup>1</sup>

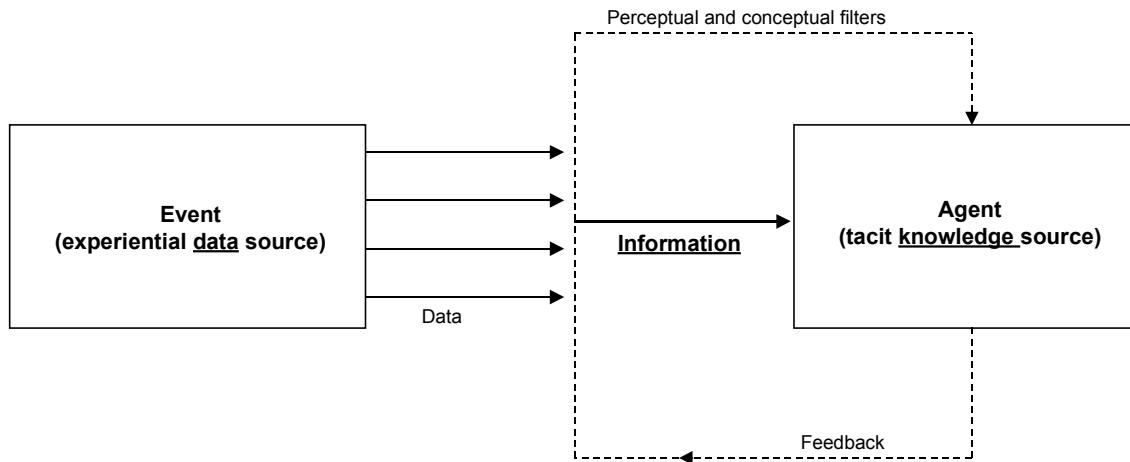
## 2 A Knowledge Framework

A common approach to considering knowledge often highlights its relationship to information in terms of difference. This perceived distinction between information and knowledge is not helpful and has led to the current confused preoccupation in the management literature with what is conceived of as a clear distinction between "knowledge management and information management. Indeed, it is common to see document management systems branded as KM systems.

Although the relationship between information and knowledge may be seen as "closely associated," it should be more appropriately seen in terms of a "dynamic and interactive relationship." Information facilitates the development of knowledge, which creates more information that deepens knowledge, ad infinitum. For example, Nonaka and Takeuchi (1995) stated:

*Information provides a new point of view for interpreting events or objects, which makes visible previously invisible meanings or sheds light on unexpected connections. Thus information is a necessary medium or material for eliciting and constructing knowledge (Nonaka & Takeuchi, 1995).*

<sup>1</sup> Since this paper is delivered to a CBR audience I am assuming familiarity with the basic processes of CBR. An introduction to CBR can be found in Watson (1997).



Source: Adapted from Boisot (1998)

Figure 2. Data, Information and Knowledge (Boisot, 1998)

Whilst Polyani (1967) and Choo (1998) have viewed this dynamic interactive relationship as part of the process of knowing which facilitates the capacity to act in context. The dynamic nature of this relationship is illustrated below in Figure 1.

Similarly, to look at information purely in terms of the degree to which it has been processed, i.e., the data, information, knowledge hierarchy (Davenport 1997; Checkland & Howell 1998) oversimplifies the complex relationship between the three intangibles. Stewart (1997) notes:

*The idea that knowledge can be slotted into a data-wisdom hierarchy is bogus, for the simple reason that one man's knowledge is another man's data (Stewart 1997).*

The categories defined by Boisot and their interactions may be seen in Figure 2. It is important to note the feedback element within this figure that illustrates the dynamic and interactive relationship of information and knowledge as a positive feedback loop.

Data is discrimination between states - black, white, heavy, light, dark, etc. - that may or may not convey information to an agent. Whether it does or not depends on the agents prior stock of knowledge. For example, the states of nature indicated by red, amber and green traffic lights may not be seen as informative to a bushman of the Kalahari. Yet, they may perceive certain patterns in the soil as indicative of the presence of lions nearby.

Thus, whereas data can be characterised as a property of things, knowledge is a property of agents predisposing them to act in particular circumstances. Information is that subset of the data residing in things that activates an agent - it is filtered from the data by the agent's perceptual or conceptual apparatus (Boisot, 1998). This has a direct echo in Alan Newell's principle of rationality:

*"If an agent has knowledge that one of its actions will lead to one of its goals, then the agent will select that action"* (Newell 1982)

### 3 CBR is a methodology for KM

What then are the requirements of a KM system? At a recent workshop held at Cambridge University a group of people active in KM and AI identified the main activities needed by a KM system (Watson 2000). These were mapped to AI methods or techniques. The main KM activities were identified as the: acquisition, analysis, preservation and use of knowledge. This section will show how CBR can meet each of these requirements.

I argued in 1999 that CBR is not an AI technology or technique like logic programming, rule-based reasoning or neural computing. Instead, CBR is a methodology for problem solving (Watson 1999). Checkland & Scholes (1990) define a methodology as:

*"...an organised set of principles which guide action in trying to "manage" (in the broad sense) real-world problem situations"* (Checkland & Scholes 1990)

Now consider the classic definition of CBR:

*"A case-based reasoner solves problems by using or adapting solutions to old problems."* (Reisbeck & Schank 1989)

This definition tells us "what" a case-based reasoner does and not "how" it does what it does. It is in Checkland's sense an organised set of principles. The set of CBR principles are more fully defined as a cycle comprising six activities<sup>2</sup> called the CBR-cycle as shown in Figure 4.

<sup>2</sup> Note that the original CBR-cycle of Aamodt & Plaza (1994) comprised only four activities.

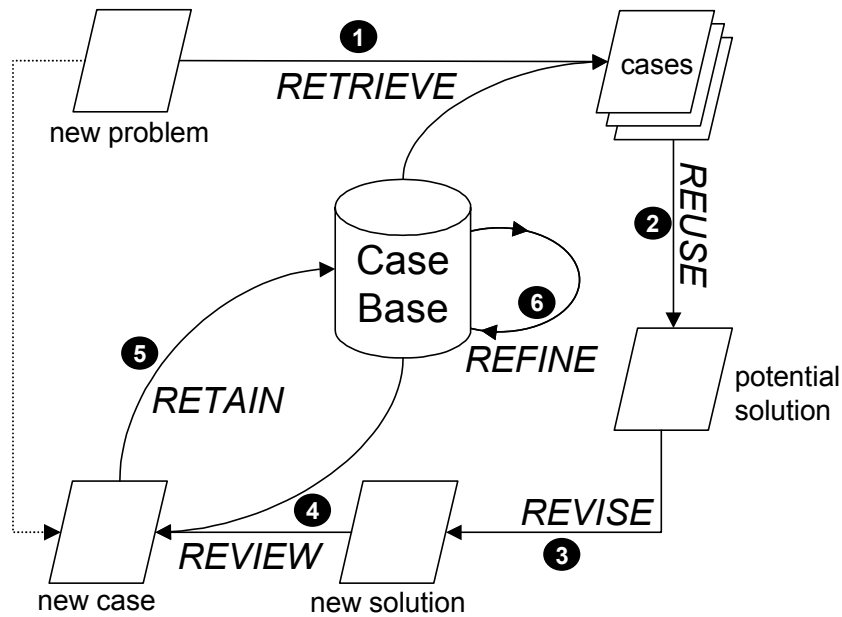


Figure 3. The CBR-cycle

This cycle comprises six activities (the six-REs):

1. *Retrieve* similar cases to the problem description
2. *Reuse* a solution suggested by a similar case
3. *Revise* or adapt that solution to better fit the new problem if necessary
4. *Review* the new problem-solution pair to see if they are worth retaining as a new case
5. *Retain* the new solution as indicated by step 4.
6. *Refine* the case-base index and feature weights as necessary.

The six-REs of the CBR cycle can be mapped to the activities required by a knowledge management system. Let us revisit Figure 2 and superimpose the steps of the CBR-cycle upon it.

Now we can easily see that the event is the episodic data that comprises a case. The case is *retained* in a case-base but typically undergoes some pre-processing and filtering (indexing and feature weighting in CBR terminology). The agent or the reasoner *retrieves* the case to solve some problem and attempts to *reuse* it. This may result in some *revision* or adaptation of the case's solution resulting in a new episodic data and hence a new case being created. The new case is reviewed (involving comparing it against cases already retained in the case-base) and if it is judged useful *retained*. In addition, the use of the case (successfully or otherwise) may result in the case-base's indexing scheme being or the feature weights *refined*. This completes the knowledge management cycle indicated on Boisot's original diagram.

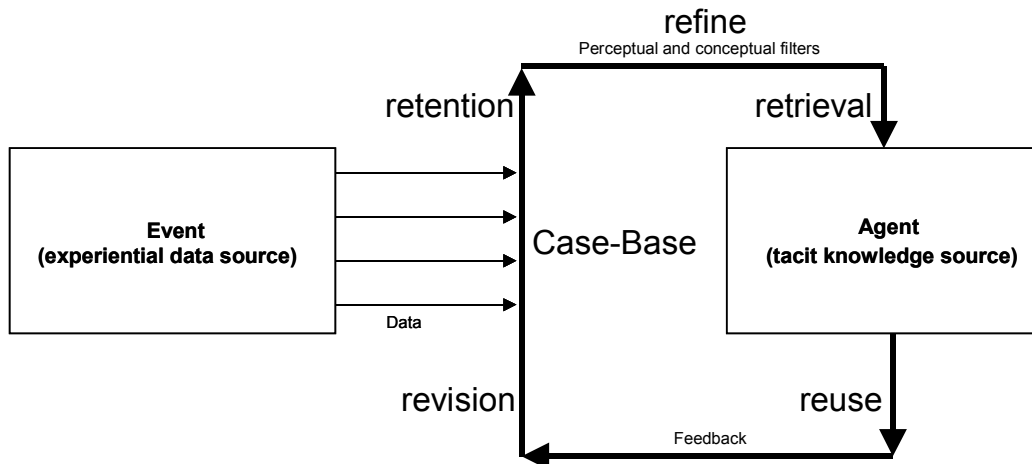


Figure 4. The CBR-cycle supporting Knowledge Management

## 4 Multiple Knowledge Sources

CBR systems have traditionally been built around single case-bases designed to solve a particular problem (Watson 1997). However, KM systems may draw upon multiple heterogeneous knowledge sources, just as you might use several sources when researching a paper. Conventional CBR systems that use a proprietary case-base format cannot integrate knowledge resources and therefore may not support a user with complex knowledge needs. Note that creating multiple case-bases each searched by the same interface is only a partial solution to this problem.

Brown et al., (1995) proposed a solution whereby knowledge could be drawn from multiple distributed heterogeneous sources and temporarily held in “virtual cases.” This would still require someone (probably a knowledge engineer) to design the structure of the virtual cases in advance. The content of the virtual case-base would be obtained on demand. This is again only a partial solution though it does have merit were real-time dynamic data is used in cases.

Dubitsky et al., (1999) describe the architecture of a CBR-warehouse that could contain multiple heterogeneous case-bases to solve this KM problem. Their system relies on the use of an ontology to overcome the semantic differences between case-bases. Thus, allowing a single CBR retrieval system to retrieve cases from different knowledge sources.

eGain<sup>3</sup> (www.egain.com) have developed a product called eGain Knowledge Gateway that provides seamless access to multiple knowledge sources through a single interface (eGain, 2001). This system uses a core CBR component to retrieve solutions based upon a conversational query from a user. Knowledge can be retrieved from Lotus Notes databases, Microsoft Office documents, HTML and PDF files, e-mails as well as specifically authored case-bases.

## 5 Conclusion

CBR therefore closely matches KM’s requirements for the acquisition (revision and retention), analysis (refinement), preservation (retention) and use of knowledge (retrieval, reuse and revision). Dubitsky et al. (1999) refer to this as KM/CBR synergy and it explains why CBR has been used successfully in many KM systems (Aha et al., 1999). However, it is not a one-sided relationship. KM has as much to offer the success of CBR as vice versa. In particular KM researchers and practitioners have recognise the importance of organisational issues in the success of a KM system and there is much that CBR practitioners can learn from the KM community.

KM systems are perhaps best viewed in a holistic system-thinking manner (Checkland & Howel, 1998) rather than the more restrictive technology view of a system. As such, a KM system must support all activities that would encourage a knowledge sharing culture within a learning

organisation. CBR only provides methodological support to some of those activities.

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<sup>3</sup> eGain have recently acquired Inference Corp. a pioneering CBR company

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