Developing a Theory-Based Ontology for "Best Practices" Knowledge Bases

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Abstract

Knowledge management systems are becoming more widespread. As part of those knowledge management systems, increasingly, firms are developing best practice knowledge bases that summarize a wide range of enterprise processes. Central to those particular knowledge bases are common languages, also referred to as ontologies, that are used to facilitate access and navigation through the knowledge base. This paper summarizes some of the evidence as to the necessity of common languages in best practice databases. In addition, some of the problems standing in the way of these common languages and the way that they have been built to-date also are summarized.

Then this paper proposes a process for building an ontology or a common language for such best practice databases. That process is based on using the enterprise model of resources, events and agents to generate meta-level requirements, and function as an "ontology generator." Generic process description is available from the value chain work of Porter. The REA structure would then be used to analyze a generic process description, teasing out necessary ontology information, in order to develop an ontology for that process.

1. Introduction

Increasingly, firms are developing "best practices" knowledge bases as part of their knowledge management systems. Best practices (or leading practices) knowledge bases provide access to enterprise processes that appear to define the best ways of doing things. At the base of these best practices knowledge bases are ontologies (Gruber 1983), what the developers (e.g., Price Waterhouse, 1997) call a "common language" or (International Benchmarking Clearinghouse 1997).

The purpose of this paper is to summarize some of the uses of common languages in best practice knowledge bases and present a model for generating a best practices common language. The model is theory-based, employing the REA enterprise model (McCarthy 1982) as a means of establishing ontology requirements in order to generate the ontology (an ontology "generator"), and the value chain model (Porter 1985) as a source of process knowledge.

Scope

Consulting firms, such as the "big five" have developed best practice knowledge bases for their own internal direct use. Arthur Andersen (AA) and Price Waterhouse (PW) apparently were among the first such developers. Each of these firms have publicly available materials regarding their best practices knowledge bases(Arthur Andersen 1997, APQC 1997, International Benchmarking Clearinghouse 1997, Price Waterhouse 1995 and 1997). Unfortunately, the other big five firms have not made such information publicly available. As a result, the scope of this paper is primarily limited to information available from those publicly available sources.

This Paper

This paper proceeds as follows. Section 2 provides some background information on the theoretical bases of the best practices ontology development. Section 3 presents a summary of best practices knowledge bases. Section 4 discusses why it is necessary to have a common language. Section 5 provides a discussion of common languages in best practices knowledge bases, while section 6 discusses the barriers to developing a common language. Development of a theory-based approach would mitigate each of the barriers and problems developed in sections 5 and 6. Section 7 develops a theoretical model for developing a best practices common language. Section 8 provides a brief summary and contributions.

2. Background

This section provides a brief summary of ontologies, the REA enterprise model, and Porter's (1985) value chain.

Ontologies

An *ontology* is an explicit specification of a conceptualization (Gruber, 1993). It is a knowledge-based specification that typically describes a taxonomy of the tasks that define the knowledge. Ontologies are specifications of discourse between multiple agents in the form of a shared vocabulary. Within artificial intelligence, ontologies are necessary for multiple independent computing agents to communicate without ambiguity, and are the center of much research on reusability of knowledge bases.

What is the Relationship Between Common Languages and Knowledge Management Ontologies?

Issues relating to common languages in best practice knowledge bases are part of a larger set of issues referred to as a knowledge management ontologies (KMOs). Like ontologies in general, a KMO can be defined as knowledge-based specification that typically describes a taxonomy that defines the knowledge. Within the context of knowledge management systems, ontologies are specifications of discourse in the form of a shared vocabulary for agents. Ontologies can differ by developer and industry, depending on their users.

REA

REA (resources-events-agents) was first posed by McCarthy (1979, 1982) as a database structure for accounting and other transaction databases. A general entity relationship diagram is given in figure 1.

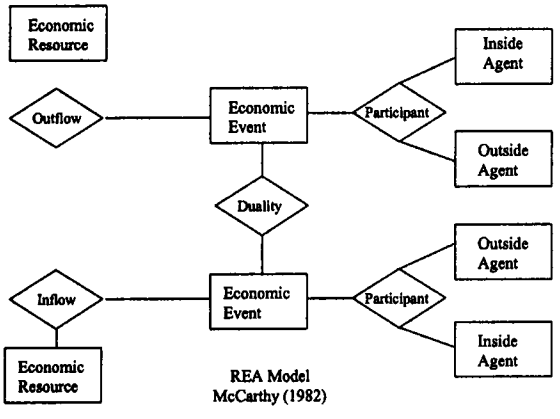


Figure 1

REA has three orientations: a database orientation, a semantic orientation and a structuring orientation. As noted by Dunn and McCarthy (1997, p. 36), a database orientation has three conditions:

1. data must be stored in their most primitive levels (at least for some period),
2. data must be stored such that all authorized decision makers have access to it, and
3. data must be stored such that it may be retrieved in various formats as need for different purposes.

Dunn and McCarthy (1997, p. 36) note that semantic orientation, " ... means that all potential users of a database pool their notions of information concepts and use that integrated set of ideas to build one conceptual data model that serves everybody." Dunn and McCarthy (1997, p. 37) further note that "... components of the models should reflect real world phenomena ... as declarative primitives."

Dunn and McCarthy (1997, p. 37) note that "a structuring orientation mandates the repeated use of an occurrence template as a foundation or accountability infrastructure for the integrated business information system." Perhaps the most intriguing structural characteristic of REAL is "duality." According to McCarthy (1982, p. 562)

> Duality relationships link each increment in the resource set of the enterprise with a corresponding decrement .... Increments and decrements must be members of two different event entity sets: one characterized by transferring in (purchase and cash receipts) and the other characterized by transferring out (sales and cash disbursements).

Value Chain

The value chain has been a well-accepted economic concept. As noted by Porter (1985, p. 36)

> Every firm is a collection of activities that are performed to design, produce, market, deliver and support its product. All of these activities can be represented using a value chain. .... A firm's value chain and the way it performs those activities are a reflection of its history, its strategy, its approach to implementing its strategy and the underlying economics of the activities themselves.

As part of the value chain concept Porter (1985) provided some generic descriptions of the wide range of processes

that make up the value chain. An illustration of the value chain is given in figure 2.

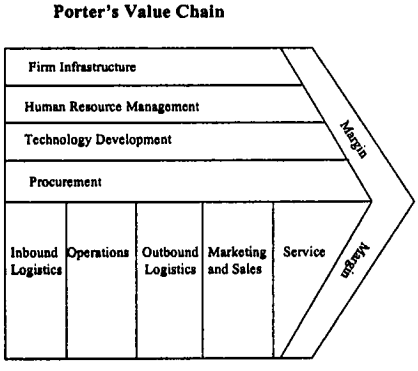


Figure 2

3. Best Practices Knowledge Bases

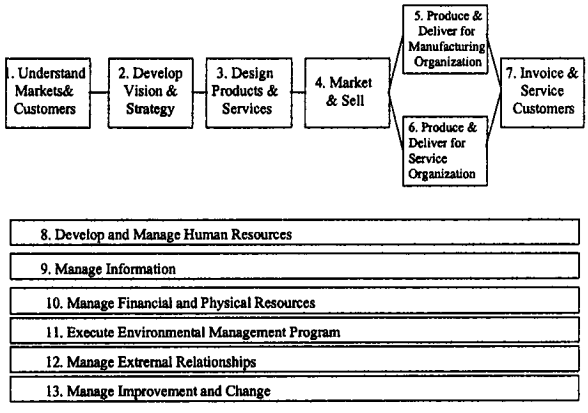
Best practice knowledge bases capture information and knowledge about the best way to do things. Best practice knowledge bases have found usage in a wide range of enterprises. For example, as noted by Davenport (1997), General Motors - Hughes Electronics capture best process reengineering practices in a database. In addition, major consulting firms also have developed best practice knowledge bases, including Arthur Andersen and Price Waterhouse.

Best Practice Knowledge Bases as Models of the Firm

Best practice knowledge bases typically are based on models of the firm, with particular emphasis on processes and how they relate to each other. Perhaps the best understood processes and the ones that are most frequently developed are best practices designed to process transactions. Those transaction processing best practices are the focus of this paper. Basic best practice models for Arthur Andersen and Price Waterhouse are given in figures 3 and 4.

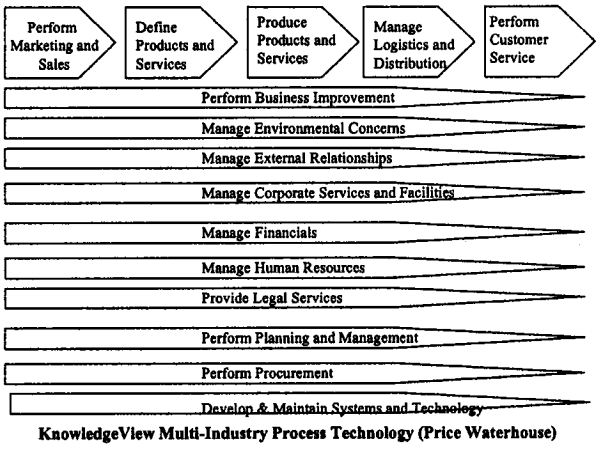
What is in Best Practice Knowledge Bases?

Best practice knowledge bases include a range of materials. Typically they include text and or graphic representation of best practice processes. Best practice processes may be generic or designed for specific industries. There may be reference to articles or other descriptions of the processes. Process measurements are also summarized providing a basis for benchmarking. Some best practice knowledge bases include war stories, and information relating processes and technology enabler information. Finally, the knowledge base may have reference to particular experts on the processes.



Global Best Practice Classification Scheme (Arthur Andersen)

Figure 3



KnowledgeView Multi-Industry Process Technology (Price Waterhouse)

Figure 4

The information describing the process provides a basis for organization of the best processes. As a result, best practices are organized by process, performance measure benchmarks, industry-based process information and reference materials, such as studies and articles.

When were Best Practices Knowledge Bases First Developed?

Formal best practice knowledge bases apparently are a recent development. Arthur Andersen (APQC 1997) and the International Benchmarking Clearinghouse (1997)

apparently began their joint effort in 1991. This is one of the earliest reports of best practice knowledge base development. It is not clear when Price Waterhouse first developed their best practice knowledge base. However, they published information about the knowledge base in 1995 (Price Waterhouse 1995).

Are Best Practices Knowledge Bases for Internal or External Use?

Initially best practice knowledge bases were designed for internal usage. Using best practice knowledge bases, consultants and auditors could have access to the best practices in order to help or understand their client's processes. Clients benefited indirectly through having consultants whom were more knowledgeable, and that had such knowledge easily accessible.

However, recently that has changed as firms are increasingly interesting in "bench marking" with other firms and improving their work processes. Recently, Arthur Andersen's KnowledgeSpace was made available as a service over the Internet to subscribers (http://www.knowledgespace.com). (In addition to access to best practice information, subscribers can access news, discussion groups and other resources.) As a result, clients can now directly access best practice information. Similarly, APQC makes their best practices available to subscribers (http://www.apqc.org/products/bpdb.htm).

Best Practice Knowledge Bases are Part of a Portfolio of Knowledge Bases

Typically, best practice knowledge bases are treated as a standalone knowledge base. However, best practice knowledge bases are only a part of the portfolio of knowledge management system knowledge bases. In consulting firms, those knowledge bases also include proposal knowledge bases, engagement knowledge bases, news and information databases, expertise databases and others.

4. Why is it Necessary to have a Common Language?

With each of the reports of best practice knowledge bases, there is also discussion of the need for a common language used to access and organize the knowledge base. The need for a common language derives from a number of factors including, knowledge reuse, knowledge organization, knowledge navigation, facilitation of cross industry comparisons, need to eliminate "insider terminology," and the broad base of constituencies.

Knowledge Reuse

Knowledge can be stored and reused. Knowledge about processes at one firm can be captured and used in other settings. As in artificial intelligence research, a common language facilitates reuse of best practice knowledge.

Knowledge Organization

A common language allows best practices knowledge to be organized in a number of views, based on the common language. For example, Price Waterhouse has organized their best practices knowledge base according to four different views that are part of their common language: business process, industry, performance measure and technology enabler.

Knowledge Navigation

As noted by Arthur Andersen (1997), a common language facilitates knowledge navigation through a best practice database

> Our experience taught us that the common organizing framework was very valuable -- it provides us with a common and understandable way to navigate through the knowledge.

Cross Industry Usage

One of the benefits of best practices is to be able to take a process in one industry and adapt it to another industry. Apparently, a common language can facilitate cross industry comparisons.

> The Process Classification Framework supplies a generic view of business processes often found in multiple industries and sectors -- manufacturing and service companies, health care, government, education and others. (International Benchmarking Clearinghouse 1997)

Eliminates Need for "Insider Terminology"

The International Benchmarking Clearinghouse (1995) argued that a common language allows them to break away from specialized language. In particular, they indicated that they

> ... were convinced that a common vocabulary, not tied to any specific industry was necessary to

classify information by process and to help companies transcend the limitations of insider terminology.

Broad Range of Constituencies

In addition, best practice knowledge bases are designed for a wide range of users for a wide range of uses. For example, Price Waterhouse (1995, p. 12) notes that "More than 30,000 ... professionals worldwide have access to this tool for the purpose of collecting, refining, and sharing their knowledge with clients to help them enhance organizational competitiveness. the uses within consulting firms also appears heterogeneous." As noted by Price Waterhouse, (1995, p. 9)

> With a common language to describe the processes and activities of all companies, any company can compare itself to another. Price Waterhouse, The Knowledge View taxonomy can serve as the basis for best practice comparisons across industries, languages, and time zones. In fact the taxonomy is already being used on five continents and has been translated into several world languages.

5. Common Languages in Best Practices Knowledge Bases

Best practice knowledge bases typically are organized around a common language / taxonomy. The existence of a common language for best practice knowledge bases raises a number of questions, each of which ultimately suggests the need for a theory-based approach to ontology generation.

- To what extent do Best Practices Knowledge Bases Require a Common Language?
- How are Common Languages Developed?
- How many Best Practice Common Languages are there?
- How do Best Practice Common Languages Interface with other Knowledge base Languages?

To what extent do Best Practices Knowledge Bases Require a Common Language?

There is evidence that developers have found the need for a common language in the best practice databases. For example, as noted by Price Waterhouse (1997)

> **A Common Language**
>
> It is almost impossible to make intelligent comparisons without a common set or reference point to describe the key processes and core capabilities of a business. Even within the same company, different divisions cannot compare processes when they lack a common language to describe what they do. The challenge becomes even greater when executives attempt to compare separate companies in the same industry or across different industries. Best practices must be accompanied by a common language that breaks business processes into activities that all companies recognize, understand and share.

How are Common Languages Developed?

There is limited information available regarding how these different common languages have been developed and how choice was made between alternative language representations.

The International Benchmarking Clearinghouse apparently made heavy use of a single source of expertise in order to develop their common language.

> The Center and Arthur Andersen & Co. have collaborated closely to bring the Process Classification Framework to life and enhance it over the past three years. The center would like to acknowledge the staff of Arthur Andersen for their research and numerous insights during this effort. (International Benchmarking Clearinghouse 1997)

Further, it is clear from figures 1 and 2 that Porter's Value Chain is likely to be the source of the over all structure on which AA and PW's common languages were developed. However, it is not clear that previous common languages have employed the REA or any other enterprise model to facilitate systematic ontology generation. As a result, there apparently is need for theory-based influence.

How many Best Practice Common Languages are there?

It is unclear how many different best practice common languages have been developed. However, to-date there have been reports of a few large companies, such as General Motors (e.g., Davenport 1997), and large consultants (Arthur Andersen 1997 and Price Waterhouse 1995 and 1997) each developing best practices databases and their own corresponding common languages. As a

result, there is likely to be substantial redundancy and redundant efforts. If a theory had been used such redundancies might be eliminated.

How do Best Practice Common Languages Interface with other Knowledge base Languages?

As a stand alone knowledge base, best practice common languages generally do not need to directly interface with other knowledge base languages. However, this is likely to change as knowledge management systems become increasingly integrated. As a result, it can be important to have a theoretical basis used to generate the common language to facilitate knowledge base interfaces.

6. Barriers to a Common Language in a Best Practices Knowledge Base

Although common languages broadly are seen as necessary, there are a number of barriers that stand in the way of their implementation. Each barrier suggests the need for development of a theory-based approach to generating best practice ontologies.

Common Languages are Costly to Develop

Best practice knowledge bases are particularly complex and difficult to develop. As noted by Arthur Andersen, 1997, p. 4,

> ... we underestimated the sheer effort necessary to translate ... knowledge about best practice into useful explicit knowledge. The central team could not, on its own extract the ... knowledge of the consultants and the professionals in the field .... After a significant effort, the team had produced a CD-ROM with the classification scheme, but only 10 of the 170 processes populated, and with limited information. Further, the information was not actionable -- it added little to those with deep knowledge of the area, and was not enough to help those who had less experience .... The initial offering almost died an early death -- it seemed much effort for little payoff.

A theory provides explicit knowledge, limiting the need to translate practice into theory, thus, potentially limiting cost and effort.

Communication Problems are not always solved with Common Language

Communication problems are often attributed to lack of a common language. For example, as note by Price Waterhouse (1995, p. 6) "Even within the same company, different subsidiaries and divisions are often unable to compare processes because they do not share a common language to describe what they do." However, as noted by Kuhn (1970, p. 201)

> ... two men whose discourse had previously proceeded with apparently full understanding may suddenly find themselves responding to the same stimulus with incompatible descriptions and generalizations. ... Such problems, though they first become evident in communication, are not merely linguistic and they cannot be resolved simply by stipulating the definitions of troublesome terms. ... They cannot, that is, resort to a neutral language which both use the same way and which is adequate to the statement of both of their theories or even both those theories empirical consequences. Part of the difference is prior to the application of the languages in which it is nevertheless reflected.

In this setting it is likely that the two men were resorting to different theories. As a result, focusing on a common theory could mitigate such problems with a common language.

What is included and what is excluded?

Common languages make specific inclusion and exclusion of particular concepts. For example, as noted by the International Benchmarking Clearinghouse (1997)

> The Framework does not list all processes within any specific organization. Likewise, not every process listed in the Framework is present in every organization.

How do developers decide what should be included or excluded? How do they choose between different terms to be included in their best practice knowledge bases? A theory-based common language could facilitate such decisions.

Individual Differences

Each of these barriers suggest that different individuals would have different preferences regarding the various terms and concepts included in or excluded from the common language. For example, some users may prefer information capturing industry-based information, while

others would prefer a "generic" view. As a result, even if there is a common language, there are likely to be divergent needs.

These individual differences, and varying levels of expertise suggest that firms would employ a broad range of individuals in order to generate these common languages. Accordingly, a theory-based model of how the ontology can be developed would be a helpful and important contribution.

7. Developing A Theory-Based Ontology for Best Practices

This section provides a theory-based approach to developing an ontology for best practices based, in part, on the enterprise model, REA developed by McCarthy (1979, 1982) and the value chain model developed by Porter (1985). REA is used as a specification of the requirements, and the value chain discussion provides the material from which the detail is teased out. REA provides the ontology generator, while Porter's discussion provides the material processed by the generator.

Using REA as an Ontology Generator

REA can be used to begin to populate an ontology, or specify information as part of a common language for a best practices, using information from Porter's analysis of the Value Chain (or human experts or equivalent). In particular, REA provides an entity template with a need for a variety of information, such as semantic knowledge about resources, events and agents. Thus, analysis of value chain information would begin with a search for all potential resources, events and agents.

Hollander et al. (1996) focus on events and the relationship between events in the design of systems using the REA approach. Similarly in the development of a best practice ontology the events also are the starting point, in part because of the structural characteristics of events. REA provides structural guidelines through, e.g., its use of duality. REA requires dual events be specified and that notions of inflow and outflow be used to specify relationships between dual events. Duality provides a "completeness" constraint of sorts. If a given value chain description has either the inflow or outflow, then as part of ensuring consistency with REA, development of a best practices ontology would require specification of the other outflow or inflow not part of the discussion. Duality also provides a vehicle to specify links between events in different parts of the value chain and conceivably with processes that are not part of the value chain model.

Further, REA includes specification of agent's control relationships for each event. As a result, roles such as "inside agent" can be instantiated as part of the ontology development.

Example – Procurement

Consider procurement, discussed by Porter (1985, p.41) "Procurement refers to the function of purchasing inputs used in the value chain..."

- Events would be those contained in **purchasing**, e.g., **ordering**, etc.

  Dual events could include **cash payment**, **receive goods**, etc.

  Inflows and Outflows - At one level, **inventory** comes in, **cash** goes out

- Resources

  "Purchased inputs include **raw materials**, **supplies**, **machinery**, **laboratory equipment**, **office equipment** and **buildings** ..." (p. 41)

  As a result, resources in the ontology would include raw materials, supplies, etc.

- Agents

  "Some items are purchased by the traditional **purchasing department**, while other items are purchased by **plant managers**, **office managers**, **sales persons** and even the **CEO** ..." (p. 41)

  > As a result, agents included in the ontology would include plant managers, etc. Further, we could specify plant managers as inside agents.

  External agent information include "suppliers," e.g., "Select **suppliers** who are especially competitive with each other, and divide the purchases among them." (p. 106)

Limitations to the Use of REA as an Ontology Generator

There are some potential limitations of REA as an ontology generator for best practices. Unfortunately, REA is underspecified as an ontology. There is no gold standard REA specification down to the entity or attribute level. For example, as noted by Dunn and McCarthy above, REA is based on "pooled" experiences. As a result,

REA provides only general guidance and the resulting ontology heavily depends on the material being used to describe the processes, in this case the value chain discussion.

REA contains no artifact information. In some cases, it may be useful to include artifacts as part of the indexing in order to facilitate finding process information, since in some cases our knowledge is of artifacts and not their content.

Limitations to the Use of the Value Chain

Although Porter (1985) describes each of the functions in the value chain, those descriptions have a tendency to be a bit thin. As a result, additional information could be sought out for each of the processes in the value chain.

8. Summary

This paper has investigated common languages and vocabularies used in best practices knowledge bases, also referred to here as knowledge management ontologies. The paper briefly discussed best practice knowledge bases and the importance of common languages. Advantages and disadvantages of using common languages were investigated in order to illustrate the importance of using a theory-based approach to elicit the ontology.

Then a theory-based approach to generating an ontology for best practice knowledge was developed. The approach employed McCarthy's REA enterprise model and Porter's value chain. REA provided the generator of the requirements, while Porter's material on value chain processes provided the domain specific best practice knowledge.

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