



White Paper No. Twelve

Enterprise Knowledge Management Modeling

and

Distributed Knowledge Management Systems

By

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Introduction

An Enterprise Knowledge Management (EKM) Model is a hierarchical network of rules that enables an agent to explain, anticipate and predict events and interaction patterns: (a) in the enterprise's Knowledge (Kn) Processes, or Knowledge Management (KM) Processes; and (b) in the enterprise's environment. An EKM model represents or models the Natural Knowledge Management System (NKMS) [1] of an enterprise.

An Enterprise NKMS is an on-going, conceptually distinct unit composed of enterprise organizational and human components and their persistent interactions, both having properties. These interaction properties are not determined by design, but instead *emerge* from the dynamics of the interaction process itself. Moreover, this interaction process determines the outcomes of the enterprise's knowledge processes. An Enterprise NKMS includes mechanical and electrical organizational components produced by it, such as computers and computer networks, as well as human and organizational agents.

An enterprise Artificial Knowledge Management System (AKMS) is an enterprise wide conceptually distinct integrated component produced by its NKMS:

- whose components are computers, software, networks, electronic components, etc.,
- whose components and interaction properties are determined by *design*, and
- whose overall purpose is to support the Kn and KM processes of the NKMS.

A key aspect in defining the AKMS is that both its components and interactions must be *fully designed*. The idea of *being fully designed* vs. being partly designed, or not-designed is essential in distinguishing the artificial from the natural. Thus, in an enterprise or any other organization, even though we may try to design its processes, our capacity to design is limited by the fact that it is a Complex Adaptive System (cas) [2] [3] [4]. If we understand a cas, we expect to be able to correctly design its components and certain aspects of its processes, but in the end we expect its behavior to be emergent and to not be a precise consequence of our design. Once the cas starts operating, it is self-organizing and controls its own behavior. At best, we can only interact with it and influence it.

On the other hand, with an AKMS, we design both its components and their interactions. The connection between the design and the final result is determinate and not emergent. When we interact with the AKMS, we can precisely predict what its response will be.

A Distributed Knowledge Management System (DKMS) [5] [6] [7] [8] [9] of an enterprise is a specific type of AKMS designed to manage the integration of distributed computer hardware, software, and networking objects/components into a functioning whole supporting enterprise knowledge production, acquisition, and transfer processes. The DKMS, in other words supports producing the enterprise's knowledge base. The relationship of the DKMS to the EKM model is one of mutual feedback and virtuous circularity over time. And it is also one of complexity and detail touching on many aspects of both the EKM model and the DKMS. This paper examines this relationship and articulates its many facets.

Enterprise Knowledge Management Models

Enterprise Models and Knowledge Processes

An Enterprise Model (EM) is a hierarchical network of rules that enables an agent to explain, anticipate, and predict events and interaction patterns in the enterprise and in its environment. An agent is a self-directed object. The self that directs it is its hierarchical network of rules including the subset of those rules we call its EM (if it has one). An adaptive agent is an agent able to modify its rules, that is, to learn, in response to changes in the environment. The greater the capacity to learn, the greater the intelligence of the agent.

Each rule in an EM's rule network relates antecedent attribute values to consequent attribute values, concepts, or rule sequences. The attributes involved belong to a number of concepts that represent the components of the model. Declarative Rule networks are those whose rules fire in parallel to determine an outcome. Procedural Rule networks are those whose rules fire in sequence. An EM is composed of both declarative and procedural rule networks. Figure One provides an illustration of declarative and procedural rule networks.

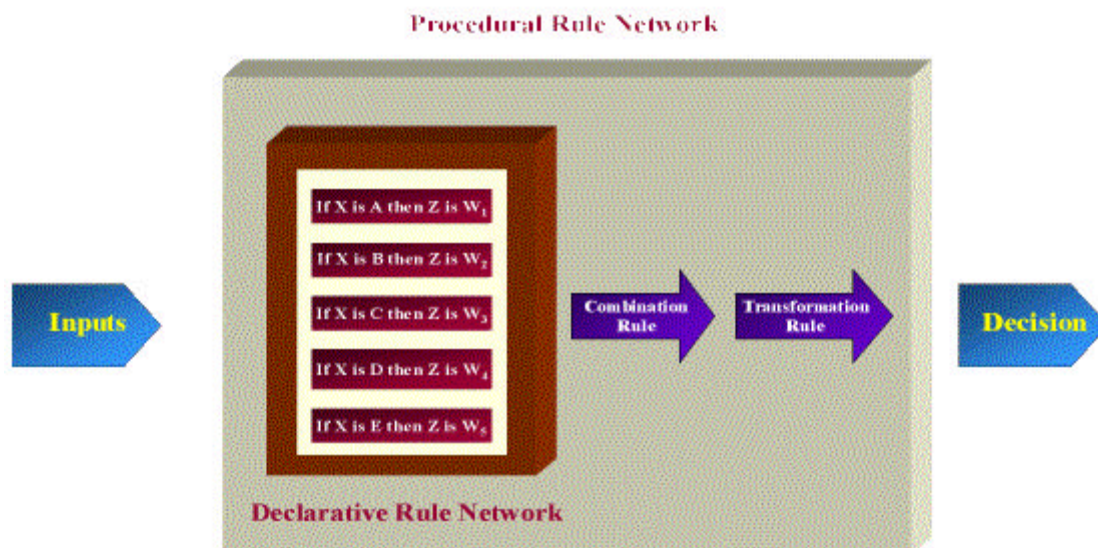


Figure One -- Declarative and Procedural Rule Networks

An EM's rule network is made up of rule patterns that an agent can use to describe, understand, and explain enterprise interaction patterns, in order to anticipate and predict future interaction patterns. The agent learns to anticipate and predict better by adding, removing, and changing these rule patterns based on its beliefs about the enterprise's experience, its knowledge validation criteria, and other competing models emerging from the

enterprise's knowledge creation, or knowledge retrieval processes. When an EM is confirmed by testing it against competing EMs, in the context of validation criteria, and by evaluating it favorably against the alternatives, it then becomes an instance of knowledge for the agent or agents who accept both the validation criteria, and the factual claims about the results of the testing process.

Validation criteria for EM's and other rule networks will vary across enterprises. Even within the scientific community there is no commonly agreed upon, precisely specified, and prioritized set of validation criteria [10]. So, clearly there will generally be no consensus across enterprises on validation criteria. As a result, there will also be no consensus on knowledge claims. What falls into the mere "information," and what falls into the "knowledge" categories is likely to differ across similar enterprises, and even across groups within the same enterprise.

Enterprise models are produced by the knowledge production process. In turn, the knowledge in EMs, as well as additional knowledge produced by the knowledge production process, is continuously used as the basis for action in implementing business processes other than knowledge processes, such as Sales, Marketing, Financial Management, Customer Care, etc. Knowledge use is not a knowledge process itself. Instead, it is an activity that is part of every knowledge process and every other business process as well.

There are three high-level knowledge processes that may be modeled in EMs and that also may be decomposed further [11]. These are: Knowledge Production; Knowledge Acquisition; and Knowledge Transmission. Before discussing them though, it's time to provide a definition of enterprise level knowledge.

Enterprise-level Knowledge

The previous definition of an EM goes a long way toward providing a definition of an enterprise's knowledge. The hierarchical network of the enterprise's validated rules is the knowledge base of the enterprise. Such knowledge enables it to explain, anticipate, and predict events and interaction patterns in the enterprise and in its environment. The knowledge base formed by this rule network of the enterprise, contains: its set of remembered data; its validated propositions and models (along with metadata related to their testing); its refuted propositions and models (along with metadata related to their refutation); its metamodels; and (if the system produces such an artifact) the software it uses for manipulating these.

The enterprise's knowledge base is an abstract phenomenon. And it is one that emerges from the cas-style interaction of the various agents comprising the enterprise. Measures of an enterprise's knowledge base may be found in its cultural artifacts [12], including its linguistic products, its electronic artifacts, and its artistic expressions, if any.

The enterprise knowledge base is frequently viewed as being composed of explicit knowledge and tacit knowledge. In analogy to individuals, explicit knowledge is often thought of as knowledge that is verbally communicated, sharable, and a matter of public record, while tacit knowledge is seen as hidden, non-verbal, and tightly held. This distinction will not quite hold for the enterprise. Enterprise's don't keep secrets in quite the same way as individuals. Barring security classification of knowledge, all other knowledge is reflected in some way by the enterprise's artifacts, because the knowledge could not emerge without producing it through communication that leaves a trail of artifacts.

Some knowledge is highly explicit in that it is stated in documents or linguistic formulations that are identified as enterprise knowledge sources whose contents has been previously validated. Formal, automated knowledge bases are examples of this type of explicit knowledge, as is the organization chart of the enterprise, the enterprise logo, etc. Other types of knowledge though, are not gleaned or measured so easily from cultural artifacts, and may not be explicitly acknowledged by the enterprise. Nevertheless, such "tacit" knowledge is not hidden, and non-verbal as is the case for the individual, it just requires more careful measurement modeling and inference from cultural artifacts to tease it out of them.

This distinction between explicit and tacit enterprise level knowledge talks past the currently important issue in KM circles of safeguarding or adding to enterprise knowledge assets by capturing the tacit knowledge of employees. This is an understandable continuing concern of KM. But the conceptual distinction implicit in this issue is that between the tacit knowledge (non-verbal and hidden) of individuals and the explicit knowledge of the enterprise. It has nothing to do with the distinction between the explicit and tacit knowledge components of the enterprise knowledge base.

Knowledge Production

The process of producing knowledge is depicted in Figure Two. The core of knowledge production is the activity of formulating knowledge. I use the term "formulating" in a general sense. It encompasses (a) formulating new knowledge, (b) revising and refining previously produced knowledge, and (c) reformulating previously produced knowledge.

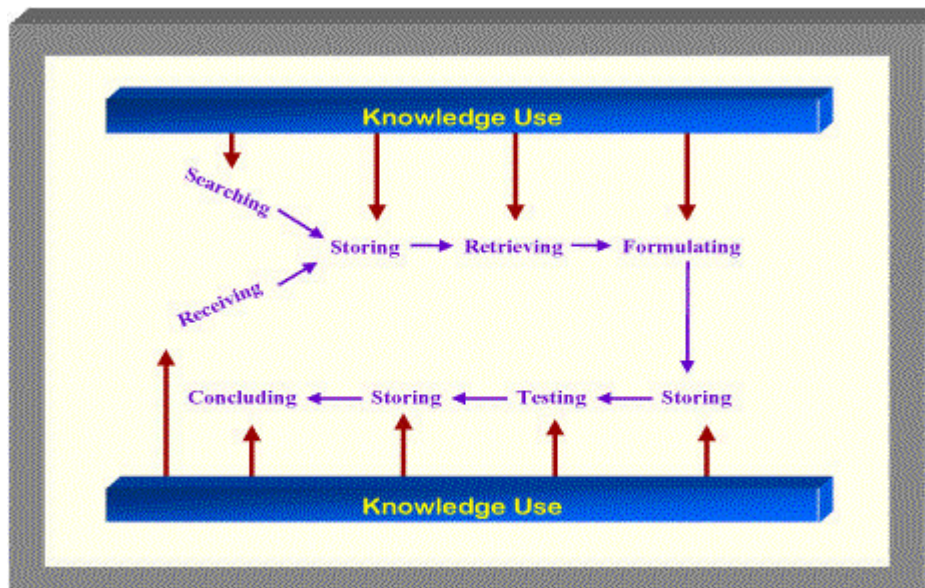


Figure Two -- Knowledge Production Process

In order to formulate knowledge we need to use previous knowledge about how to formulate knowledge. So knowledge use is a necessary requirement for formulating knowledge.

Formulating new knowledge is preceded by retrieving knowledge previously stored as the result of searching and receiving. Once knowledge is formulated, it is again stored pending testing of the knowledge claims produced by the activity of formulating knowledge. And following testing, knowledge may again be stored pending assessment of the results of testing and the activity of arriving at a conclusion rating competing knowledge claims against one another. This notion of rating competing knowledge claims does not, in general, imply rigorous rating or comparison activities. Rigorous validation methodology is not excluded as either an empirical possibility or a normative preference. But in the real world of enterprises, and even in scientific activity, the activity of concluding or validating is most often carried out with fuzzy comparisons and ratings.

In knowledge production, the activity of concluding is again followed by the activity of storing. In fact, each stage of activity within the knowledge production process is followed by knowledge storing activity. This reflects the difficulty of storing any appreciable amount of knowledge in human memory.

The knowledge production process is highly dependent for its effectiveness on knowledge storing. It is also highly dependent on using previous knowledge to implement all of the activities comprising the knowledge

production process. And from this it is clear that both knowledge storing, and knowledge use, are not independent knowledge processes, but broad ranging activities that occur within knowledge production, knowledge acquisition and knowledge transmission as well.

Part of the activity of concluding is selling the knowledge that has been formulated and validated by groups and teams within an enterprise. By "selling," in this context, I mean persuading others that the knowledge claims that have been formulated and validated by one's team or group have, in fact, been justified. Selling, in other words, is persuading the knowledge production political system in an enterprise, that the products of the knowledge formulation process in teams or groups, their validated knowledge claims, are indeed valid, relevant, and useful at the level of the enterprise.

I distinguish five types of knowledge production according to differences in the linguistic form of the outcome of knowledge production. These are: Planning Knowledge, Descriptive Knowledge of Fact, Measurement and Non-causal Modeling, Causal Modeling Knowledge, Predictive Knowledge, and Assessment (cost/benefit) Knowledge. The general outlines of the knowledge production process are not different among these types, but there are differences in the details of formulating and testing knowledge of different types, because the different types of knowledge exhibit linguistic differences in the form and semantics of their characteristic rules.

Knowledge Acquisition

Knowledge Acquisition is illustrated in Figure Three. It begins with searching for data, information, and information validated by sources external to the enterprise (knowledge from the viewpoint of these external sources). The search uses previously produced descriptive knowledge about how best to classify or map external sources. Search activity in knowledge acquisition is therefore related to classification schema development in descriptive knowledge production, and vice versa.

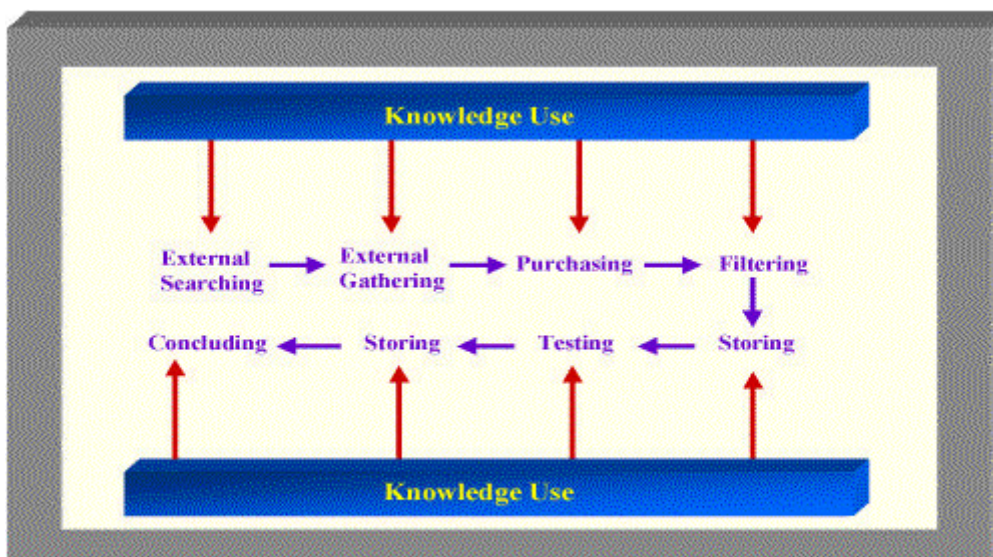


Figure Three -- Knowledge Acquisition Process

Search activity is followed by the activities of data, information and external "knowledge" gathering. The activity of gathering may or may not be accompanied by purchase activity, depending on whether the external content carries a price. The last activity in knowledge acquisition is filtering and integrating the new acquisition into the enterprise's knowledge base. Filtering includes cleaning and transforming data, information, and external knowledge, and staging it for loading into the enterprise's own stores [13]. All external knowledge is initially stored as information, unless filtering is supplemented by using the knowledge production activities of testing and validating to validate external knowledge as knowledge from the viewpoint of the enterprise.

Of course, gathering, purchasing, and filtering data, information, and knowledge, presupposes using previously produced knowledge to gather, purchase, and filter. You need to know how to get data from external sources, whether gathering requires writing and mailing a letter, faxing a document, or downloading a data set from the Internet.

Knowledge Transmission

I distinguish the following types of knowledge transmission in the enterprise: (a) "pushing" data, information, and knowledge using an electronic network, (b) knowledge sharing, (c) searching/retrieving, and (d) face-to-face knowledge transfer. "Pushing" means transmitting knowledge automatically to prospective consumers. The knowledge could be transmitted in small chunks, or lengthier documents might be transmitted. In the near future when technology makes it practical, whole Computer-based Training Courses may be distributed through "push" technology.

Knowledge sharing means making knowledge available for retrieval by consumers. This can be done by placing documents in a library, or by placing them on the enterprise Intranet. Knowledge sharing is often preceded by "pushing" information or knowledge about the availability of knowledge that may be shared.

Searching/retrieving refers to the activities of searching the enterprise knowledge base, and retrieving certain knowledge from it. These activities can occur through using an electronic or a personal network to do the searching and/or the retrieving. While searching/retrieving through the enterprise electronic network is very powerful, and becoming more so as technology advances, one's personal network will remain a primary source of knowledge that is unobtainable from more formal sources.

Face-to-face knowledge transfer refers to both casual face-to-face knowledge transfer within informal groups, and also formal education and training contexts in which knowledge is transferred from teacher to student. The first provides the platform for transferring tacit knowledge by making it explicit. The second provides the means of transferring explicit and enterprise sanctioned information and knowledge in a highly organized and disciplined way.

All of the above knowledge transmission activities involve using previously produced knowledge. To "push" knowledge you need to know how to use techniques for pushing it. Those receiving it need to have minimal knowledge to use what they have received. To share knowledge you need to know how to transfer a document to the enterprise library, or how to get your document posted on the enterprise's web site, and so on. Similar examples could be given for searching/retrieving, and knowledge transfer. Knowledge use, again, is an inextricable part of knowledge transmission.

Keeping Levels Straight

To understand EMs it is important to keep levels of interaction and analysis straight. An enterprise is a complex adaptive system composed of intelligent agents. The lowest level intelligent agent is the individual participant in the enterprise. Individuals though, cluster together to form higher level agents. Examples of such agents include groups, teams, organizations, and enterprises.

Each intelligent agent above the level of the individual has its own knowledge production, knowledge acquisition and knowledge transmission processes. These need to be distinguished from the processes of every other agent. In particular, what is knowledge for one agent, may be only information for another. Knowledge validation for one agent doesn't automatically carry over to lower level, higher level, or agents at the same level of analysis. What is knowledge transmission for one may be only information transmission for another, and so on. To keep straight what is data, what is information, and what is knowledge, we need to keep straight the level of our current discourse, and be constantly aware of when we are shifting levels. If we do not, we will be constantly confusing enterprise knowledge processes with the knowledge processes of lower level agents, and

the portion of our EM dealing with knowledge processes and their impact on other business processes will become confused and unworkable.

Enterprise Knowledge Management Models

KM is handling, directing, governing, or controlling knowledge *processes* within an organization in order to achieve the goals and objectives set by the organization for these knowledge processes. An Enterprise Knowledge Management Model (EKM) has the same general form as an EM model, but it enables an agent to explain, anticipate and predict events and interaction patterns either in the enterprise's knowledge processes, or in its NKMS.

The Knowledge Management Process (KMP) is an on-going persistent interaction among human-based agents within the NKMS who aim at integrating all of the various agents, components, and activities participating in the three knowledge processes into a planned, directed, unified whole, producing, maintaining, enhancing, acquiring, and transmitting the enterprise's knowledge base. Knowledge Management is human activity that is part of the interaction constituting the KMP. In modeling the NKMS, EKMs model KM activity and its consequences. But what kind of activity is it, and what is the subject matter of such EKM Models? The next two sections on levels of knowledge management, and knowledge management activities will address these questions.

Levels of Knowledge Management

The first step in answering this question is to step back and note that there are multiple levels of KM processes arranged in a hierarchy that, in principle, and with respect to knowledge production, has an infinite number of levels [14]. The hierarchy is generated by considerations similar to those specified by Bertrand Russell [15] in his theory of types, and Gregory Bateson [16] in his theory of learning and communication.

Knowledge processes occur at the same level of agent interaction as other business processes. Let's call this business process level of interaction level zero of enterprise cas interaction. At this level pre-existing knowledge is used by business processes and by knowledge processes to implement activity. And, in addition, knowledge processes produce, acquire and transmit knowledge about business processes, using (a) previously produced knowledge about how to implement these knowledge processes, (b) infrastructure, (c) staff, and (d) technology, whose purpose is to provide the foundation for knowledge production, knowledge acquisition, and knowledge transmission at level zero. But where does this infrastructure, staff, knowledge, and technology come from, who manages it, and how is it changed?

They don't come from, by and through the level zero knowledge processes. These knowledge processes only produce, transfer, and acquire knowledge about business processes. So, this is where level one of cas interaction, the lowest level of knowledge management comes in. This level one KM process interaction is responsible for producing, acquiring, and transmitting knowledge *about* level zero knowledge production, acquisition, and transmission processes to knowledge workers at level zero. It is this knowledge, developed in a level one EKM model, which is used at level zero to implement its knowledge processes.

The KM process and EKM model at level one are also responsible for providing the knowledge infrastructure, staff, and technology necessary for implementing knowledge processes at level zero. In turn, knowledge processes at level zero use this infrastructure, staff, and technology to produce, acquire, and transmit the knowledge used by the business processes. The relationships between level one KM and level zero knowledge and business processes are illustrated in Figure Four.

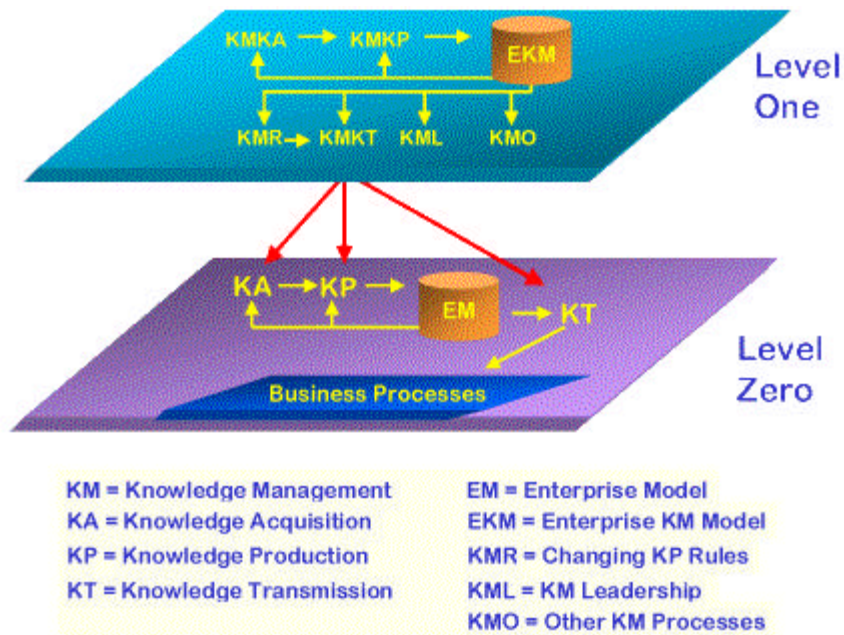


Figure Four -- Level Zero/Level One KM Process Relationships

Knowledge about level zero knowledge processes, as well as infrastructure, staff, and technology change when first level KMP interactions introduce changes. That is changes occur: when the level one KMP produces, acquires, and transmits new knowledge about how to implement level zero knowledge processes; and when it adds or subtracts from the existing infrastructure, staff, and technology based on new knowledge it produces. There are two possible sources of these changes.

First, knowledge production or acquisition at level one can change the EKM model, which, in turn, impacts on (a) knowledge about how to produce, acquire, or transmit knowledge about (level zero) business processes, (b) knowledge about how to acquire or transmit knowledge about level one knowledge acquisition or transmission processes (c) staffing, (d) infrastructure, and (e) technology. This type of change then, originates in the level one KM process interaction, itself.

Second, knowledge about how to produce the level one knowledge in the EKM model may change. This knowledge however, is only *used* in arriving at the level one EKM model. It is not explained or accounted for by it. It is determined, instead by a level two KM interaction process and is accounted for in a level two EKM model produced by this interaction. Figure Five adds the level two KM process to the process relationships previously shown in Figure Four.

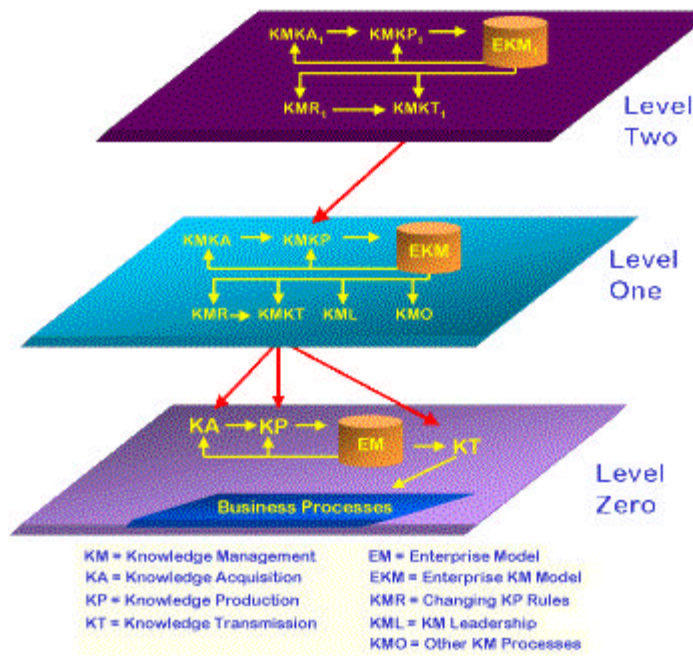


Figure Five -- Level Zero -- Level Two KM Process Relationships

Instead of labeling the three levels of processes discussed so far as level zero, level one, and level two, it is more descriptive to think of them as the knowledge process level, the KM level and the meta-KM level of process interaction. There is no end, in principle, to the hierarchy of levels of process interaction and accompanying EKM models. The number of levels we choose to model and to describe, will be determined by how complete an explanation of knowledge management activity we need to accomplish our purposes.

The knowledge process level gives us knowledge about business processes. The KM level gives us knowledge about how to produce knowledge about business processes. The meta-KM level gives us knowledge about how to produce knowledge about knowledge processes. Level Three, the meta-meta-KM process level of interaction would give us knowledge about how to arrive at knowledge about the KM process. Level Three then, seems to be the minimum number of levels needed for a fairly complete view of KM. And in some situations, where we need an explanation of our knowledge about how to produce knowledge about the KM process we may even need to go to a fourth, meta-meta-meta-KM level.

Enterprise Knowledge Management Activities

Business process activities may be viewed as sequentially linked and as governed by validated rule sets, or knowledge. Such a linked sequence of activities performed by one or more agents sharing at least one objective is a Task. A linked sequence of tasks governed by validated rule sets, producing results of measurable value to the agent or agents performing the tasks is a Task Pattern. A cluster of task patterns, not necessarily performed sequentially, often performed iteratively and incrementally is a Task Cluster. Finally, a hierarchical network of interrelated, purposive, activities of intelligent agents that transforms inputs into valued outcomes, a cluster of task clusters, is a business process.

This hierarchy, ranging from activities to processes, applies to knowledge and KM processes as well as to operational business processes. Enterprise KM activities may be usefully categorized according to a scheme of task clusters which, with some additions and changes, generally follows Mintzberg [17]. There are three types of KM task clusters: interpersonal behavior, information (and knowledge) processing behavior, and decision making. Each type of task cluster is broken down further into more specific types of task pattern activities below.

Interpersonal Behavior

- Interpersonal Behavior includes *figurehead* or ceremonial KM task patterns and tasks. This activity focuses on performing formal KM acts such as signing contracts, attending public functions on behalf of the enterprise's KM process, and representing the KM process to dignitaries visiting the enterprise.
- A second type of interpersonal task cluster activity is *leadership*. This includes hiring, training, motivating, monitoring, and evaluating staff. It also includes persuading non-KM agents within the enterprise of the validity of KM process activities. That is, a KM task pattern includes building political support for KM and knowledge processes within the enterprise.
- A third type of interpersonal KM task pattern is *building relationships with individuals and organizations external to the enterprise*. This is another type of political activity designed to build status for KM and to cultivate external sources of support for KM.

Knowledge and Information Processing

- *Knowledge Production* is a KM Task Cluster as well as a knowledge process. KM knowledge production is different in that it is here that the rules for knowledge production that are used at the level of knowledge processes are specified. Keep in mind that knowledge production at this level involves planning, descriptive, cause-and-effect, predictive, and assessment knowledge about all three level zero knowledge processes, as well as these categories of knowledge about level one interpersonal, knowledge acquisition, knowledge transfer, and decision making KM activities. The only knowledge not produced by level one knowledge production, is knowledge about how to accomplish level one knowledge production. Once again, the rules constituting this last type of knowledge are produced at level two.
- *KM Knowledge Acquisition* is another KM task cluster. At any KM level of interaction, knowledge acquisition is a source for knowledge production and also an effect of knowledge production (through knowledge transfer) at that level. The relationship is one of reciprocal causation over time.
- *KM Knowledge Transfer* is affected by KM knowledge production, and also affects knowledge production and knowledge acquisition activities by stimulating new ones. KM knowledge transfer at any KM level also plays the critical role of diffusing "how-to" knowledge to lower KM and knowledge process levels.

Decision Making Task Clusters

- *Changing knowledge process rules* at lower KM and knowledge process levels. Essentially this involves making the decision to change such rules and causing both the new rules and the mandate to use them to be transferred to the lower level.
- *Crisis Handling* would involve such things as meeting CEO requests for new competitive intelligence in an area of high strategic interest for an enterprise, and directing rapid development of a KM support infrastructure in response to requests from high level executives,
- *Allocating Resources* for KM support infrastructures, training, professional conferences, salaries for KM staff, funds for new KM programs, etc.
- *Negotiating* agreements with representatives of business processes over levels of effort for KM, the shape of KM programs, the ROI expected of KM activities, etc,

The DKMS

Two ways to look at the DKMS are in terms of its architecture, and its use cases. Let's proceed to examine its architecture, and then its use cases.

Architecture

DKM architecture is the characteristic architectural pattern of the DKMS. It is an evolving O-O/Component-based architecture applicable to enterprise wide systems incorporating multiple processing styles including DSS, OLTP, and Batch processing. Comparing it to contemporary data warehousing architectures will help in describing it.

Top - Down and Bottom-Up data warehousing architectures may be viewed as two-tier architectures utilizing clients and local or remote databases [18]. Enterprise Data Mart Architecture (EDMA), Data Stage/Data Mart Architecture (DS/DMA), and Distributed Data Warehouse/Data Mart Architecture (DDW/DMA) may be viewed as adding middleware and tuple layers to earlier architectures to provide the capability to manage data warehouse systems integration through unified logical views, monitoring, reporting, and intentional DBA maintenance activity [19]. But tuple-layer based management still doesn't provide automatic feedback of changes in one component of a data warehousing system to others.

DKM architecture may be viewed as adding an object layer to EDMA or to DDW/DMA to provide integration through automated change capture and management. Figure Six depicts DKM architecture. The object layer contains process distribution services, an in-memory object model, and connectivity to a variety of data store and application types. The layer requires an architectural component called an Active Knowledge Manager (AKM) [20].

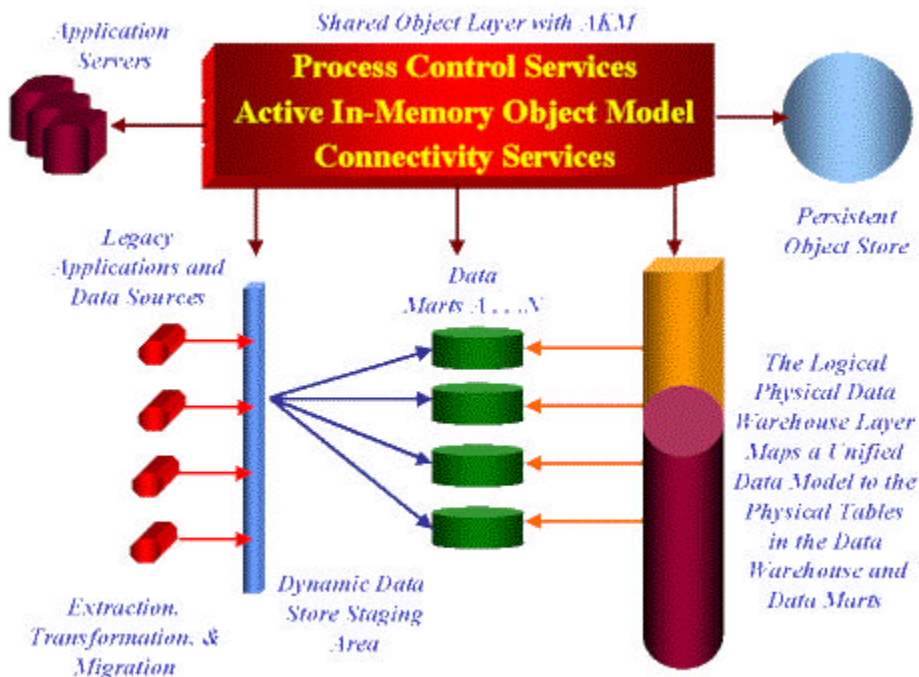


Figure Six -- DKM Architecture

The Active Knowledge Manager

An AKM provides process control and distribution services, an object model of the DKMS, and connectivity to all enterprise information, data stores, and applications.

Process Control and Distribution Services include:

- in - memory proactive object state management and synchronization across distributed objects;
- component management;
- workflow management;
- transactional multithreading;

The in-memory Active Object Model and Persistent Object Store Model components of the AKM include:

- Event-driven behavior;
- DKMS-wide model with shared representation;
- Declarative business rules;
- Caching through partial instantiation; and
- A Persistent Object Store for the AKM.

Connectivity Services of the AKM include:

- Language APIs: C, C++, Java, CORBA, COM
- Databases: Relational, ODBC, OODBMS, hierarchical, network, flat file, etc.
- Wrapper connectivity for application software: custom, CORBA, or COM-based.
- Applications including all categories mentioned in Figure Seven below.

Only the DKMA among the preceding architectures, supports distributed, proactive monitoring and management of change in the web of data warehouse, data mart, web information servers, component transaction servers, data mining servers, ETML servers, other application servers, and front-end applications comprising today's Enterprise DSS/Data Warehousing System. Figure Seven shows the relationship of the AKM to front-end tools, application servers, and data stores.



Figure Seven -- The AKM, Data Stores, Application Servers, and Clients

Use Cases

Knowledge Management and knowledge process activities can be supported, but not automatically performed, by information system use cases: one or more of which constitutes an application. In the Unified Modeling Language (UML) a use case is defined as "a set of sequences of actions a system performs that yield an observable result of value to a particular actor." When a DKMS is viewed functionally as an application, it performs a set of use cases supporting various tasks within the main activities of the knowledge and KM processes. Figure Eight illustrates this partial support relationship.

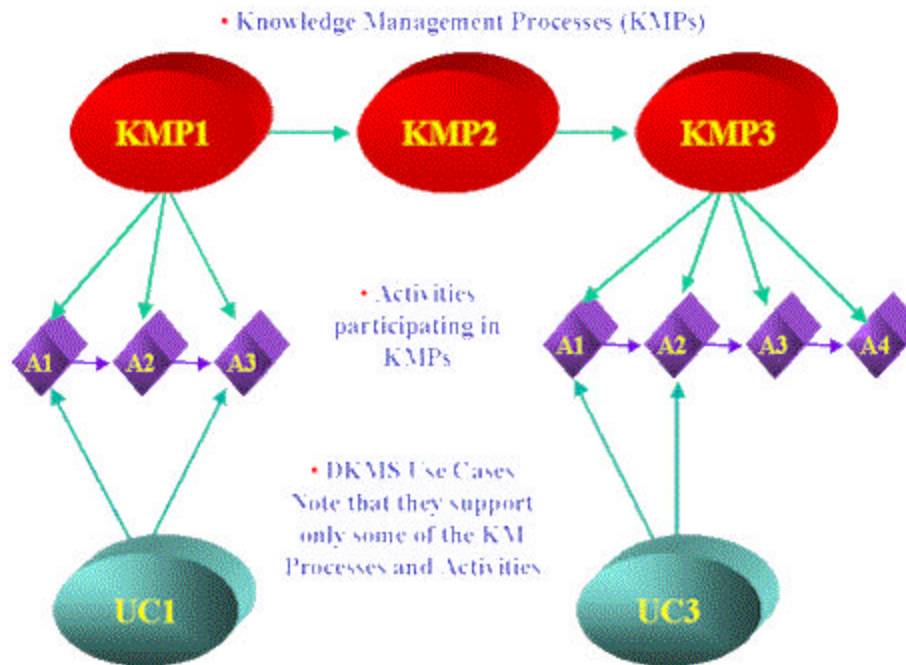


Figure Eight – Relationships of KM Processes and Activities to Information System Use cases

Here are three side-by-side lists. A list of knowledge processes, one of associated Kn and KM activities, and a list of DKMS use cases that might be implemented in a comprehensive KM enterprise wide application. These also illustrate the point of partial support of the activities and the processes by the DKMS use cases.

Table One Kn and KM Processes and DKMS Use Cases

Knowledge & KM Processes	Activities Within Processes	DKMS Use Cases
Knowledge Production	Searching (within the enterprise for data, information, or knowledge)	<ul style="list-style-type: none"> Perform cataloging, and tracking of previously acquired enterprise data, information, and knowledge bases related to business processes
	Receiving (transmitted data, information, or knowledge)	<ul style="list-style-type: none"> Receiving transmitted data,

		information, or knowledge through e-mail, automated alerts, and data, information, and knowledge base updates
	Storing (and loading data, information and knowledge)	<ul style="list-style-type: none"> • Storing the outcomes of searching, receiving, and other knowledge production activities into a data, information or knowledge store accessible through electronic queries
	Retrieving (data, information or knowledge)	<ul style="list-style-type: none"> • Retrieve through computer-based querying data, information, and knowledge of the following types: <ul style="list-style-type: none"> • Planning • Descriptive • Cause-effect • Predictive and time-series forecasting • Assessment
	Formulating new knowledge claims	<ul style="list-style-type: none"> • Prepare data, information, and knowledge for analytical modeling • Perform Modeling including revising, reformulating, and formulating models
	Testing knowledge models and claims	<ul style="list-style-type: none"> • Testing competing knowledge models and claims using

		appropriate analytical techniques, data, and validation criteria
	Concluding (about knowledge models and claims)	<ul style="list-style-type: none"> Assessing test results and comparing (rating) competing knowledge models and claims
	Using Previously available Knowledge	
Knowledge Acquisition	Searching (for data, information, or claimed knowledge external to the enterprise)	<ul style="list-style-type: none"> Perform cataloging, and tracking of external data, information, and knowledge bases related to enterprise business processes
	Gathering (externally located data, information or claimed knowledge)	<ul style="list-style-type: none"> Order data, information, or external claimed knowledge and have it shipped from external source
	Purchasing (data, information, or claimed knowledge)	<ul style="list-style-type: none"> Purchase data, information, or external claimed knowledge
	Filtering (including cleaning, transforming and staging data, information, or knowledge claims)	<ul style="list-style-type: none"> Extract, Reformat, Scrub, Transform, Stage, and Load, data, information, and knowledge claims acquired from external sources
	Testing knowledge models and claims from external sources	<ul style="list-style-type: none"> Testing competing knowledge models and claims using appropriate analytical techniques, data, and validation criteria
	Concluding (about knowledge models and claims from external sources)	<ul style="list-style-type: none"> Assessing test results and comparing (rating) competing knowledge models and claims

	Storing (and loading data, information, and knowledge)	<ul style="list-style-type: none"> Storing the outcomes of Filtering, Concluding, and other knowledge production activities into a data, information or knowledge store accessible through electronic queries
	Using Previously available Knowledge	
Knowledge Transmission	"Pushing," data, information and knowledge	<ul style="list-style-type: none"> Publish, disseminate data, information, and Knowledge using the enterprise intranet Update all data, information, and knowledge stores to maintain consistency with changes introduced into the DKMS
	Sharing knowledge (by making it available)	<ul style="list-style-type: none"> Load data, information, or knowledge and updates into enterprise stores and provide access to enterprise query and reporting tools
	Searching/retrieving data, information, and knowledge using an electronic network	<ul style="list-style-type: none"> Search/retrieve from enterprise stores through computer-based querying, data, information, and knowledge of the following types: <ul style="list-style-type: none"> Planning Descriptive Cause-effect Predictive and time-series forecasting Assessment

	Searching/retrieving data, information, and knowledge using personal networks	<ul style="list-style-type: none"> • Use e-mail to request assistance from personal networks
	Face-to-face knowledge transmission within small groups	
	Face-to-face knowledge transmission in formal training and education	<ul style="list-style-type: none"> • Present knowledge using computer-aided displays
	Storing (and loading data, information, and knowledge)	<ul style="list-style-type: none"> • Storing the outcomes of knowledge transmission activities into a data, information or knowledge store accessible through electronic queries
	Using Previously available Knowledge	
Representing (at ceremonies)	Signing Contracts	
	Attending Public Functions for KM	
	Meeting and relating to dignitaries	
Leadership	Hiring KM Staff	<ul style="list-style-type: none"> • Identify Knowledge Management responsibilities based on some

		<p>segmentation or decomposition of the KM Process</p> <ul style="list-style-type: none"> • Retrieve available qualification information on knowledge management candidates for appointment • Evaluate available candidates according to rules relating qualifications to predicted performance • Communicate Appointments to Knowledge Management constituency
	Providing for KM Staff Training	<ul style="list-style-type: none"> • Plan or select training program(s) • Purchase or create training vehicles and materials (seminars, CBT products, manuals, etc.)
	Motivating KM Staff	<ul style="list-style-type: none"> • Plan and Schedule motivational events
	Monitoring KM Staff	<ul style="list-style-type: none"> • Querying and Reporting using data, information, and knowledge about: • KM staff plans • KM staff performance description • KM staff performance cause/effect analysis • KM staff performance prediction and forecasting
	Evaluating KM Staff	<ul style="list-style-type: none"> • Querying and Reporting using data, information, and knowledge about assessing KM staff performance in terms of costs and benefits

	Building relationships with individuals and organizations external to the enterprise	<ul style="list-style-type: none"> • Communicate with external individuals through e-mail and online conferencing technology
KM Knowledge Production	Activities are the same as those specified for Knowledge Production	<ul style="list-style-type: none"> • DKMS use cases are analogous
KM Knowledge Acquisition	Activities are the same as those specified for Knowledge Acquisition	<ul style="list-style-type: none"> • DKMS use cases are analogous
KM Knowledge Transmission	Activities are the same as those specified for Knowledge Transmission	<ul style="list-style-type: none"> • DKMS use cases are analogous
Changing Knowledge Process Rules	Deciding to change Knowledge Process Rules	<ul style="list-style-type: none"> • Search/retrieve from enterprise stores through computer-based querying, data, information, and knowledge of the following types about knowledge process rules: <ul style="list-style-type: none"> • Planning • Descriptive • Cause-effect • Predictive and time-series forecasting • Assessment
	Directing use of KM Knowledge Transmission to transmit new rules and mandate for using them	<ul style="list-style-type: none"> • Communicate directives through e-mail
Crisis Handling		<ul style="list-style-type: none"> • Uses DKMS use cases associated with those activities

	Various activities associated with other processes implemented in a "time box" mode	
	Forecasting developing crises or crisis potential	<ul style="list-style-type: none"> • Search/retrieve from enterprise stores through computer-based querying and reporting, data, information, and knowledge of the following types about crisis potential: • Cause-effect, and • Predictive and time-series forecasting
	Monitoring developing crises	<ul style="list-style-type: none"> • Search/retrieve from enterprise stores through computer-based querying, data, information, and knowledge of the following types about crisis potential: • Descriptive • Cause-effect
	Evaluating developing crises	<ul style="list-style-type: none"> • Search/retrieve from enterprise stores through computer-based querying, data, information, and knowledge about crisis potential of the following types: • Descriptive • Cause-effect • Predictive and time-series forecasting • Assessment
	Contingency Planning for crisis	<ul style="list-style-type: none"> • Search/retrieve from enterprise stores through computer-based querying, data, information, and knowledge of the following types about crisis potential:

		<ul style="list-style-type: none"> • Planning • Descriptive • Cause-effect • Predictive and time-series forecasting • Assessment
	Evaluating crisis contingency plans against crisis management performance	<ul style="list-style-type: none"> • Search/retrieve from enterprise stores through computer-based querying, data, information, and knowledge of the following types about crisis potential: • Planning • Descriptive • Cause-effect • Predictive and time-series forecasting • Assessment
Allocating KM Resources and mandating implementation for:	KM infrastructure	<ul style="list-style-type: none"> • Specify (either alone or using a work group) and compare alternative KM infrastructure options in terms of anticipated costs and benefits • Communicate directives through e-mail
	Training	<ul style="list-style-type: none"> • Specify (either alone or using a work group) and compare alternative KM training options in terms of anticipated costs and benefits • Communicate directives through e-mail
	Professional Conferences	<ul style="list-style-type: none"> • Specify (either alone or using a work group) and compare

		<p>alternative KM professional conference options in terms of anticipated costs and benefits</p> <ul style="list-style-type: none"> • Communicate directives through e-mail
	Compensation for KM staff	<ul style="list-style-type: none"> • Specify (either alone or using a work group) and compare alternative KM compensation options in terms of anticipated costs and benefits • Communicate directives through e-mail
	Funds for new KM programs	<ul style="list-style-type: none"> • Specify (either alone or using a work group) and compare alternative KM budget options in terms of anticipated costs and benefits • Communicate directives through e-mail
Negotiating with business process representatives about:	Levels of effort for KM	<ul style="list-style-type: none"> • Specify (either alone or using a work group) and compare alternative KM level of effort options in terms of anticipated costs and benefits • Communicate options, proposals, and responses through e-mail and online conferencing and collaboration application
	The scope and content of KM programs	<ul style="list-style-type: none"> • Specify (either alone or using a work group) and compare alternative KM scope and content options in terms of anticipated costs and benefits • Communicate options, proposals, and responses through e-mail and online conferencing and collaboration application

	<p>KM ROI targets</p>	<ul style="list-style-type: none"> • Specify (either alone or using a work group) and compare alternative KM ROI targeting options in terms of anticipated costs and benefits • Communicate options, proposals, and responses through e-mail and online conferencing and collaboration application
	<p>KM infrastructure support for business processes</p>	<ul style="list-style-type: none"> • Specify (either alone or using a work group) and compare alternative KM infrastructure support options in terms of anticipated costs and benefits • Communicate options, proposals, and responses through e-mail and online conferencing and collaboration application
	<p>KM staff support for business processes</p>	<ul style="list-style-type: none"> • Specify (either alone or using a work group) and compare alternative KM staff support options in terms of anticipated costs and benefits • Communicate options, proposals, and responses through e-mail and online conferencing and collaboration application

The breadth of DKM architecture discussed earlier, and the range of identifiable DKMS use cases just presented, illustrate the comprehensiveness of the DKMS as an integrative enterprise application supporting knowledge processes and KM across the board regardless of whether the necessary support requires batch, OLTP, or DSS processing. The comprehensiveness of the DKMS, and its integrative capability, far exceed that of either Data Warehousing solutions or Enterprise Resource Planning (ERP) solutions. The data warehouse as a conceptual construct provides only limited decision support capability in the form of querying and reporting against integrated relational data, while ERP solutions are focused on OLTP processing and fall far short in the DSS area.

Both classes of enterprise solutions are broadening in scope as time goes on, and as the demands of the market place force extensions of conventional data warehousing and ERP solutions. But, increasingly, extended data warehousing and ERP solutions are beginning to require the kind of functionality available from the DKMS. Thus both types of enterprise wide solutions are beginning to converge on DKMS architecture and use case functionality.

EKM Models and the DKMS

The relationship of the DKMS to an EKM model is a complex one of mutual feedback and virtuous circularity over time. The EKM model and the DKMS such an extensive and complex relationship because both operate at different hierarchical levels and impact each other both within and across levels. Figure Nine illustrates this relationship for levels zero to four of the Kn/KM levels hierarchy.

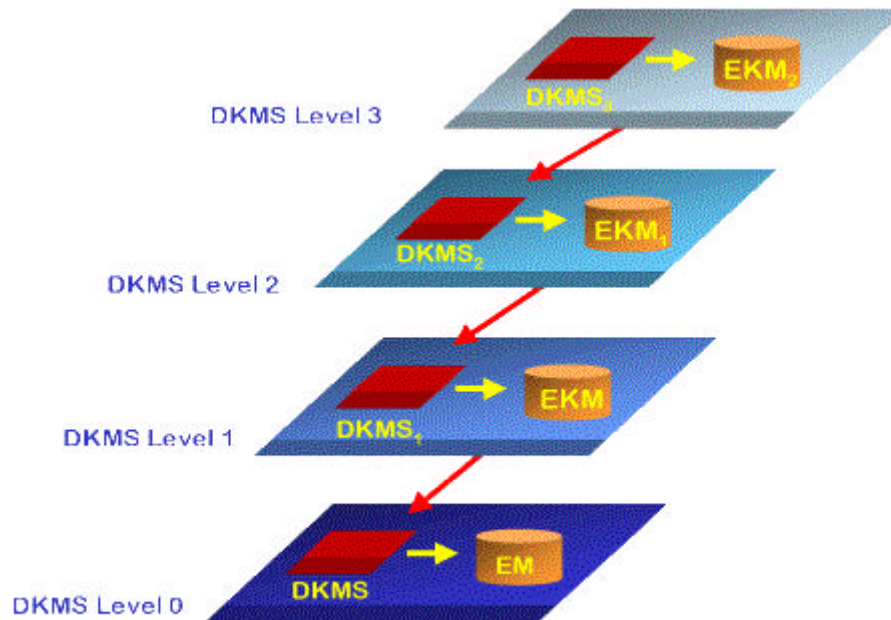


Figure Nine – DKMS and EKM Levels

- Level zero knowledge processes are supported through the DKMS, but the knowledge used by the DKMS is transferred from the EKM model of KM level one.
- At level one however, the DKMS must support knowledge production involving adaptation and change of the level one EKM model, while at the same time, in order to do this, it must rely on EKM₁ model formulated at level two and governing change in the original EKM model.
- At level two however, the DKMS must support knowledge production involving adaptation of the level two EKM₁ model accounting for change in the original EKM model. While at the same time in order to do this, it must rely on an EKM₂ model, formulated at level three, about change in the level two EKM model, and so on.

Conclusion

The EKM model is one of the continuously improved outcomes of the DKMS. Yet, the DKMS is also, at any level of analysis (n), both an outcome of a higher level EKM model at level (n+1), and partly an outcome of the EKM model at level (n). This means, that if the EKM model at a specific level is to be developed, it must be done hand-in-hand with the DKMS, and similarly development of an effective DKMS is equally reliant on development of an effective EKM model at the level above the specific DKMS level in question. An EKM model is thus the intelligence behind the DKMS. But the DKMS, in turn, is the tool for developing the

intelligence behind an EKM model.

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- [11] My thinking on knowledge processes was developed in extensive conversational and written exchanges with Edward Swanstrom, Executive Director of the Knowledge Management Consortium (KMC) to whom I am very grateful. Of course, the views expressed here are solely my own, and may not agree either wholly or in part with those currently being developed by Mr. Swanstrom, or by the KMC.
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Biography

Joseph M. Firestone is an independent Information Technology consultant working in the areas of Decision Support (especially Data Marts and Data Mining), Business Process Reengineering and Database Marketing. He is developing an integrated data mining approach incorporating a fair comparison methodology for evaluating data mining results. In addition, he is formulating the concept of Distributed Knowledge Management Systems (DKMS) as an organizing framework for the next business "killer app." Dr. Firestone is one of the founding members of the Knowledge Management Consortium (KMC), a collaborator in its Enterprise Knowledge Management Modeling Project, and the Chairperson of KMC's Artificial Knowledge Management System Committee. You can e-mail Joe at eisai@home.com.

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