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THESE

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Par M. Mahmoud MORADI

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Gestion des connaissances et modélisation d'entreprise ; Contribution à un cadre méthodologique unifié

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Après avis de MM. **Jean-Louis ERMINE** Rapporteur
Professeur à Télécom Ecole de Management
Xavier BOUCHER Rapporteur
Maître de Conférences, HDR à l'Ecole des Mines de St Etienne

Devant la commission d'examen formée de :

MM. **Eric BONJOUR** Président de jury
Maître de Conférences, HDR à l'Université de Franche-Comté
Jean-Louis ERMINE Rapporteur
Professeur à Télécom Ecole de Management
Xavier BOUCHER Rapporteur
Maître de Conférences, HDR à l'Ecole Nationale Supérieure des Mines de St Etienne
Bruno VALLESPIR Directeur de thèse
Professeur à l'Université Bordeaux 1
Yves DUCQ Examinateur
Professeur à l'Université Bordeaux 1
Benoît LE BLANC Examinateur
Maître de Conférences, HDR à l'Université Bordeaux 2
Freidoon SHAMS ALIEE Professeur invité
Associate Professeur à L'Université Shahid Beheshti, Téhéran, Iran

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Introduction générale

Contexte de recherche

La mondialisation représente sans doute l'une des principales caractéristiques de l'environnement extérieur des systèmes d'entreprise aujourd'hui. La mondialisation en tant que résultat du développement rapide des technologies de l'information et de la communication permet également la fusion des marchés locaux et nationaux dans un caractère mondial (Kalpic et Bernus, 2002).

L'imprévisibilité et la variabilité dans l'environnement interne et externe, sont considérées par les entreprises comme des turbulences (Warnecke et al, 1993) et nécessitent une réactivité et une flexibilité dans l'organisation et dans l'exécution des processus.

L'information et la connaissance deviennent des ressources stratégiques des entreprises en plus de celles traditionnelles telles que les matières premières ou les énergies (Warnecke et al, 1993). Par conséquent, les technologies de l'information et de communication peuvent être considérées aujourd'hui comme des technologies stratégiques, et la connaissance est considérée comme une clé capitale et stratégique des entreprises.

Survivre dans le monde hautement concurrentiel et en constante expansion nécessite une gestion habile, au sens de réactive, capable de surveiller et de contrôler les situations problématiques extrêmement complexes et les systèmes impliquant un nombre croissant de paramètres interdépendants et variables les uns des autres. Ce phénomène peut être observé dans un large éventail d'organisations, d’institutions et d’industries ; allant de la fabrication traditionnelle pour les sociétés informatiques, des installations médicales aux organismes gouvernementaux. La complexité croissante des systèmes d'entreprise a stimulé le développement de méthodes sophistiquées et d’outils pour la modélisation d'entreprise. (Lim et al, 1997).

Dans ce contexte complexe, nous pensons que les deux domaines de la modélisation d'entreprise (EM) et la gestion des connaissances (KM) sont des solutions mutuellement complémentaires qui, ensemble, fourniront des orientations utiles pour les entreprises en traitant de la connaissance et de son partage. L'intégration est une question essentielle au regard de la finalité principale de la modélisation d'entreprise qui vise à fournir rapidement la bonne information au bon endroit au bon moment sous le bon format. Ici, nous pouvons trouver l'intersection de EM et KM : leur objectif est de fournir des connaissances et des informations pour apprendre et pour prendre la bonne décision.

Contributions

Nous nous référons au principe global du cadre et des méthodes dans le contexte de la modélisation d'entreprise (Vallespir et al., 1993; Doumeingts et al, 1998). Dans cette approche, un cadre, pour être global, doit avoir trois aspects principaux. Un modèle de référence décrit les fondements théoriques et les blocs de construction d'un cadre. Le modèle conceptuel décrit et explique le paradigme dans lequel le cadre existe. Le deuxième aspect est sur les outils et techniques de modélisation. En général, ce niveau comprend les points de vue dans la modélisation et utilise les formalismes pour capturer des informations et des connaissances.

La troisième couche est une méthode pour la mise en œuvre. Cette méthodologie permet de poser la ligne directrice et le cycle de vie de l'ensemble du projet avec les rôles et les responsabilités et la structure du groupe de travail. De plus la méthodologie dans cette perspective implique un cycle de « analyse-conception » qui dans le contexte d'ingénierie peut être décrit comme la courbe AS-IS et To-Be avec des niveaux d'abstractions différents.

Dans ce document, après l'analyse de littérature et une étude comparative sur les complémentarités d'EM et de KM, nous proposons trois contributions. La référence et le modèle conceptuel seront clarifiés en deux parties : l'une se concentre sur les concepts communs et l’autre se concentre sur un cadre générique. Les outils pour la modélisation de la connaissance dans tous ses aspects font l'objet de l'ingénierie de l'entreprise basée sur la connaissance. A cette phase de nos investigations, nous n'avons pas encore de propositions pour une méthodologie de mise en œuvre. C’est pour cela que cet aspect fera l'objet de poursuites et de propositions dans les perspectives.

Les concepts communs (VCKC)

Première étape pour étudier la nature complémentaire d'EM et de KM est définir la taxinomie des ressources et terminologies des connaissances utilisées dans le domaine. Pour ce faire, dans le chapitre quatre, nous proposerons un modèle basé sur la valeur ajoutée pour décrire les activités de création des connaissances.

Nous proposons une chaîne de valeur épistémologique pour le processus de création de connaissances ; Value Chain of Knowledge Création (VCKC). Cette chaîne part de la réalité à la capabilité et met tous les concepts importants comme les données, informations, connaissances, jusqu'aux compétences et ainsi de suite, dans une valeur ajoutée présentée en ligne.

L'un des résultats de ce travail est d'ouvrir une fenêtre pour les chercheurs pour examiner les concepts épistémologiques de KM basé sur une vision processus. Comme nous sommes dans la communauté de la modélisation d'entreprise, cette approche proposée sera le point de départ pour la modélisation d'entreprise en collaboration avec l'activité de gestion des connaissances, parce que par la distinction entre différents concepts utilisés dans ce domaine, il est important de concevoir un cadre dans lequel les techniques de modélisation d'entreprise et modélisation de processus ont été appliquées. VCKC est également un vocabulaire commun pour le contexte des connaissances dans les entreprises.

Cadre générique (I2CE)

Le cadre de gestion des connaissances est très important pour les organisations qui entendent mettre en œuvre le KM dans leur organisation. De nombreux chercheurs ont proposé des cadres de KM. Beaucoup de ces cadres sont normatifs, en fournissant des orientations sur le type de procédure KM sans fournir de détails précis sur la manière dont ces procédures doivent être accomplies.

Ils diffèrent par leur accent et leur but. Ces représentations servent à fournir une base pour la compréhension de KM et d'éventuelles initiatives qui peuvent aboutir à un état amélioré de KM dans une organisation, mais ils fournissent généralement peu d'aides pour les études normatives, de prévision et d'évaluation. KM au regard de multiples disciplines est, par nature, à l'origine d'une complexité accrue des cadres. C'est un des premiers résultats.

Un modèle conceptuel de référence de KM dans l'organisation est nécessaire. En outre, il est nécessaire d'avoir une vue évolutive pour KM, soit comme un projet ou en tant que poursuite d'un processus. Nous recommanderons un cadre générique pour être en mesure de couvrir presque tous les aspects du KM dans les entreprises. Ce cadre est I2CE (Intention-Content-Context-Evolution) et se fonde sur notre compréhension du KM dans le contexte des entreprises, en particulier pour le domaine de la gestion de la production. Ce cadre est fondé sur certaines hypothèses et considérations qui sont décrites dans le document.

Modélisation des connaissances en organisation (KBEE)

L'objectif principal de cette thèse est d'étudier la nature complémentaire de la modélisation d'entreprise et de la gestion des connaissances. Puisque la connaissance existe dans des documents, dans des procédures, dans des organisations, dans des processus, des activités, et dans l'esprit des employés, il est très important de considérer la connaissance de plusieurs points de vue pour se représenter correctement une approche globale de la connaissance.

Avec un regard large sur les méthodes de la modélisation à la fois en KM et EM on peut trouver plusieurs vues. Voire, certaines d'entre elles sont communes dans toutes les méthodes comme l'activité et la tâche. Certaines visions sont uniques à chaque méthode. Nous proposons une classification générique pour intégrer les vues de modélisation et développer les blocs de construction de KBEE (Knowledge Based Enterprise Engineering).

Pour la comparaison des méthodes nous proposons un cadre permettant de classer tous les points de vue en quatre catégories. Dans la même règle que dans I2CE ces catégories sont une modélisation du contexte, la modélisation de l'intentionnalité, la modélisation du contenu, et la modélisation de l'évolution. Ces composants sont ensemble le fondement des méthodes examinées. L'Activité est le premier niveau d'analyse dans la modélisation d'entreprise. D'un autre côté l'acteur est l'élément central des méthodes de modélisation des connaissances.

KBEE intègre l'activité et l'acteur avec une entité comme le résultat ou la finalité de l'action faite par l'acteur sur la tâche. KBEE est un cadre de l'ingénierie d'entreprise basé sur le modèle visant à la modélisation des connaissances sous toutes ces formes et de toutes ces sources dans les entreprises dans la perspective de fournir une base de données intégrée et multiforme de la connaissance.

Résumé de la thèse

La thèse sera organisée en cinq chapitres

Chapitre un : problématique

Ce chapitre est une introduction à la recherche. Elle fournit des informations décrivant le vaste domaine d'étude. Son objectif est d'orienter le lecteur par une introduction à la structure de la thèse. Dans ce chapitre, nous montrons les objectifs de la thèse. Les deux premières sections observent le contexte économique et l'importance des connaissances dans les

organisations contemporaines et pourquoi la gestion des connaissances est une compétence organisationnelle.
La troisième partie décrit le contexte industriel concerné par le contexte économique dans son ensemble. Les sections quatre et cinq explique les objectifs et les principes de la modélisation d'entreprise et de la gestion des connaissances, respectivement, au sein des organisations ainsi que les problèmes et les limites de chacune au regard d'une approche intégrée. La section six exprime la motivation et les objectifs, l'orientation, et l'importance de notre étude. De plus, il souligne l'organisation de la thèse.

Chapitre deux : état de l'art

Le deuxième chapitre vise à examiner les fondements théoriques de ce travail de recherche au travers d'une revue de la littérature existante. Cet examen permettra de déterminer les questions de recherche pertinentes en explorant les disciplines parentes de la gestion des connaissances et de la modélisation d'entreprise. L'examen de ces disciplines placera la recherche dans son contexte et permettra d'établir des limites.

Chapitre Trois : étude comparative

Selon le problématique du premier chapitre, il y a une nécessité d'étudier la nature multidimensionnelle de deux concepts. Au cours de la première étape, nous allons examiner, d'une manière analytique, les travaux dans la littérature, les recherches ou les documents qui traitent soit du KM ou de l'EM de façon à illustrer un point de vue commun. Certains auteurs trouvent l'intersection et la complémentarité du point de vue des « processus business » ou certains cherchent à mettre l'EM dans le cadre du cycle de vie des connaissances. L'ingénierie des connaissances se présente comme un outil important pour le KM et utilise les vues de modélisation dans les organisations. Avec CommonKADS et MASK, on peut constater que ces méthodes utilisent largement les formalismes pour modéliser plusieurs aspects. Ensuite, nous allons comparer KM et EM situés par rapport à un certain critère comme la conception, l'organisation et le projet. La section deux fournira les matières communes que le KM et EM pourraient être en mesure de traiter. Enfin, les trois contributions de cette thèse seront montrées à la fin de ce chapitre.

Chapitre Quatre : le modèle de référence fondamental pour le cadre intégré

Nous définissons un fondement conceptuel qui, dans ce chapitre, est divisé en trois sections. Au début, nous proposerons un cadre à valeur ajoutée de cette approche à la terminologie de base (VCKC). Ensuite, fondé sur un examen exhaustif des cadres et des approches en gestion des connaissances, nous allons construire le fondement théorique de notre modèle générique et la troisième section décrit l'ensemble du cadre (I2CE) en détail.

Chapitre Cinq : Ingénierie de l'entreprise basée sur la connaissance (KBEE)

L'objectif principal de ce chapitre est d'étudier la nature complémentaire de la modélisation d'entreprise et de la gestion des connaissances. Pour ce faire, nous évaluons certaines méthodologies importantes dans chaque domaine, puis plusieurs points de vue de la modélisation sont expliqués. En passant en revue CommonKADS, MASK, CIMOSA et GRAI/GIM et leur point de vue modélisation, nous proposons un cadre générique pour la modélisation de la connaissance dans tous ses aspects. Ce cadre comporte quatre points de vue à savoir : la modélisation de l'intention, la modélisation du contexte, la modélisation du contenu et la modélisation de l'évolution. Ces vues sont classées en plusieurs sous éléments réunis pour le développement du méta modèle dans les diagrammes de classes UML. KBEE pourrait potentiellement être utile tant pour les spécialistes et scientifiques. Les différents modèles montrent des solutions relatives aux connaissances et leurs modélisations dans les entreprises.

Chapter 1

Problem Setting

Introduction

This chapter introduces the subject matters and the goals of the thesis. The first two sections look at the economic context and the importance of knowledge in contemporary organizations and why knowledge management is an organizational competency. Section three describes the industrial context affected by the whole economic context. Sections four and five explain the objectives and principles of enterprise modeling and knowledge management respectively within organizations plus the problems and limits of each other in regarding to an integrated approach. Section six expresses the motivation and goals, focus, and significance of our study. Adding up, it also points out the organization of the thesis.

1.1 Economic context

The age, we are passing through, is called as ‘information age’, and the prevailing economic structure of this era is defined with the term of ‘knowledge economy’ or ‘knowledge–based economy’. Knowledge–based economy rationale is based on the argument that in our globalizing world, knowledge is the most strategic source for competition (Asheim and Coenen, 2005).

A keen interest in the subject of knowledge has been developing in the west. An explosion of sorts has occurred in the business press in the 90 decades, with prominent authors such as Peter Drucker, Alvin Toffler, James Brian Quinn, and Robert Reich leading the field (Nonaka and Takuchi, 1995). In their own ways, they all herald the arrival of a new economy or society, referred to as the “knowledge society” by Drucker, which distinguishes itself from the past in the key role knowledge plays within society. Drucker (1993) argues in his latest book that in the new economy, knowledge is not just another resource alongside the traditional factors of production- labor, capital, and land- but the only meaningful resource today. The fact that knowledge has become the resource, rather than a resource, is what makes the new society unique, he contends.

Toffler (1990) echoes Drucker’s contention, proclaiming that knowledge is the source of the highest-quality power and the key to the power shift that lies ahead. Toffler observes that knowledge has gone from being an adjunct of money power and muscle power to being their very essence, and that is why the battle for control of knowledge and the means of communication is heating up all over the world. He believes that knowledge is the ultimate replacement of other resources.

Quinn (1992) shares with Drucker and Toffler the similar view that the economic and producing power of Modern Corporation lies more in its intellectual and service capabilities than in its hard assets, such as land, plant, and equipment. He goes a step further by pointing out that the value of must products and services depends primarily on how “knowledge-based intangibles” –like technological know-how, product design, marketing presentation, understanding of customer, personal creativity, and innovation- can be developed.

These authors also agree that the future belongs to people endowed with knowledge. In a society based on knowledge, says Drucker, the “knowledge worker” is the single greatest asset. Included in his definition of a knowledge worker

1.2 Knowledge as a strategic resource

The knowledge-based view of the firm argues that the products and services produced by tangible resources depend on how they are combined and applied, which is a function of the firm’s know-how. This knowledge is embedded in and carried through individual employees as well as entities such as organization culture and identity, routines, policies, systems, and documents. The knowledge-based view of the firm posits that these knowledge assets may produce long-term sustainable competitive advantage for the organization because knowledge-based resources are socially complex to understand and difficult to imitate by another organization (Alavi & Leidner, 2001).

According to Alavi and Leidner (2001), it is less the knowledge existing at any given time per se than the firm’s ability to effectively apply the existing knowledge to create new knowledge and to take action that forms the basis for achieving competitive advantage from knowledge-based assets. It is here that information technologies may play an important role in effectuating the knowledge-based view of the firm. Advanced information technologies (e.g., the Internet, intranets, extranets, browsers, data warehouses, data mining techniques, and software agents) can be used to systematize, enhance, and expedite large-scale intra- and inter-firm knowledge management. While having unique access to valuable resources is one way to create competitive advantage, in some cases either this may not be possible, or competitors may imitate or develop substitutes for those resources. Companies having superior knowledge, however, are able to coordinate and combine their traditional resources and capabilities in new and distinctive ways, providing more value for their customers than can their competitors. That is, by having superior intellectual resources, an organization can understand how to exploit and develop their traditional resources better than competitors, even if some or all of those traditional resources are not unique. Therefore, knowledge can be considered the most important strategic resource, and the ability to acquire, integrate, store, share, and apply it the most important capability for building and sustaining competitive advantage. The broadest value proposition, then, for engaging in knowledge management is that it can enhance the organization's fundamental ability to compete (Zack, 1999).

Alavi and Leidner (2001) suggest that the long-term sustainable competitive advantage comes from the firm's ability to effectively apply the existing knowledge to create new knowledge and to take action that forms the basis for achieving competitive advantage from knowledge-based assets. The knowledge existing at any given time per se is not sufficient to form such a basis for long- term sustainable competitive advantage.

The special capabilities of organizations for creating and transferring knowledge are being identified as a central element of organizational advantage. Knowledge is a renewable, reusable and accumulating asset of value to firms that increases in value with employee experience and organizational life. Knowledge is intangible, dynamic and without boundaries. If it is not used at a specific time in a specific place, it is of no value.

Human capital has long been argued as a critical resource in most firms. Recent research suggests that human capital attributes (including education, experience, and skills) affect firm outcomes (Hitt et al., 2001).

What is it about knowledge that makes the advantage sustainable? Knowledge — especially context-specific, tacit knowledge embedded in complex organizational routines and developed from experience — tends to be unique and difficult to imitate. Unlike many traditional resources, it is not easily purchased in the marketplace in a ready-to-use form. To acquire similar knowledge, competitors have to engage in similar experiences. However, acquiring knowledge through experience takes time, and competitors are limited in how much they can accelerate their learning merely through greater investment (Zack, 1999).

Knowledge-based competitive advantage is also sustainable because the more a firm already knows, the more it can learn. Learning opportunities for an organization that already has a knowledge advantage may be more valuable than for competitors having similar learning opportunities but starting off knowing less. Sustainability may also come from an organization already knowing something that uniquely complements newly acquired knowledge, which provides an opportunity for knowledge synergy not available to its competitors. New knowledge is integrated with existing knowledge to develop unique insights and create even more valuable knowledge. Organizations should therefore seek areas of learning and experimentation that can potentially add value to their existing knowledge via synergistic combination (Zack, 1999).

Sustainability of knowledge advantage, then, comes from knowing more about some things than competitors, combined with the time constraints faced by competitors in acquiring similar knowledge, regardless of how much they invest to catch up. This represents what economists call increasing returns. Unlike traditional physical goods that are consumed as they are used (providing decreasing returns over time), knowledge provides increasing returns as it is used. The more it is used, the more valuable it becomes, creating a self- reinforcing cycle. If an organization can identify areas where its knowledge leads the competition, and if that unique knowledge can be applied profitably in the marketplace, it can represent a powerful and sustainable competitive advantage (Zack, 1999).

Information sensing, collection, organization, communication, and use are critical to the knowledge-based organization. According to Kettinger and Grover (1995), information can be a source of power, justify ideologically based decisions, as well as symbolize adherence to norms. Knowledge, the combination of experience and information, applied to a context, has a dynamic quality and is defined by individuals in shared and coordinated interaction. The strength and characteristics of individual and group ties impact knowledge transmission. Knowledge-sharing capability can determine an organization's processes and structural form. The capability of an organization to share and leverage knowledge as a whole facilitates its ability to change.

Organizations should strive to use their learning experiences to build on or complement knowledge positions that provide a current or future competitive advantage. Systematically mapping, categorizing, and benchmarking organizational knowledge not only can help make knowledge more accessible throughout an organization, but by using a knowledge map to prioritize and focus its learning experiences, an organization can create greater leverage for its learning efforts. It can combine its learning experiences into a critical learning mass around particular strategic areas of knowledge (Zack, 1999).

The knowledge-based view of the firm stems from theorization of why firms have performance differences. According to Grover and Davenport (2001), debate on the "theory of the firm" originates from two viewpoints, one based in transaction cost economics, and the other in resource-based theory. While transaction cost economics posits that firms exist in lieu of markets due to their reduced potential for opportunism, resource-based theory asserts that long-run superior performance is associated with the possession of scarce, valuable, and inimitable firm-specific resources. The tenet is that knowledge as a focal resource creates unique advantages for governing economic activities through a logic that is very different from a market.

The knowledge-based view argues that the success of firms is not only based on the economics of the contracts it implements (property rights, incentives), but also on its heterogeneous stocks and flows of knowledge. Further work from this perspective has examined different models of organizational design and development of organizational capabilities. The latter view conceptualizes the firm as an institution for integrating knowledge and examines how the mechanisms for integration establish flexible response capabilities in hyper- competitive markets (Grover & Davenport, 2001).

While a knowledge advantage may be sustainable, building a defensible competitive knowledge position internally is a long-term effort, requiring fore- sight and planning as well as luck. Long lead-time explains the attraction of strategic alliances and other forms of external ventures as potentially quicker means for gaining access to knowledge. It also explains why the strategic threat from technological discontinuity tends to come from firms outside of or peripheral to an industry. New entrants often enjoy a knowledge base different than that of incumbents, one that can be applied to the products and services of the industry under attack. This has been especially evident in industries in which analog products are giving way to digital equivalents (Zack, 1999).

Knowledge has a strategic role if unique firm knowledge can successfully be applied to value-creating tasks and if it can be used to capitalize on existing business opportunities. Since competitors, in developing their own survival strategies, are likely to benchmark themselves against the industry leader to level out performance, knowledge must be difficult to imitate (Von Krogh et al., 2000).

1.3 Industrial context

The broad range of knowledge management related articles, papers, books, authors, disciplines, conferences and, lately, training is evidence that KM is a discipline which needs to be considered in any modern business strategy and planning.

As Leonard-Barton (1995) states, “Firms are knowledge as well as financial institutions. They are repositories and wellsprings of knowledge”. Effectively implementing a sound knowledge management strategy and becoming a knowledge-based company is seen as a mandatory condition of success for organizations as they enter the era of the knowledge economy. Becoming a knowledge based company need not be pure happenstance, as Edvinsson and Malone (1997) observe “Companies can plan to increase their `knowledge value'; this increase can be forecast and modeled”.

An industrial organization is not only a production unit or a service provider trying to produce new products and services in best conditions concerning costs, delays and quality, but also a knowledge production unit (Grundstein, 2000). We distinguish therefore between industrial processes producing products and services, and knowledge production processes.

Industrial processes assemble different resources in order to produce the products and services. The industrial processes involve people and machines which are responsible to assemble the resources. During the execution of industrial processes, the people can produce new knowledge. However, the human agents need also a certain level of knowledge in order to execute the industrial processes. Therefore, the knowledge produced supports the industrial processes (Grundstein, 2000).

One objective of industrial organizations is to optimize their industrial processes and resource consumption. This can be achieved by optimizing knowledge flows and the knowledge production process (Sveiby, 1997). Knowledge management can be one possibility to support the organization of knowledge and the knowledge production processes (Barthes, 2000).

The different possible motivating facets for knowledge management in an industrial organization can be diverse (Dieng, 2000):

1. Avoid the loss of knowledge of an expert being near to his pension age or move to another organization.
2. Exploit the experience of past projects and keep past lessons in order to avoid reproducing some errors.
3. Improve the circulation of information and the communication.
4. Improve learning processes of the employees.

5. Integrate new possible information and knowledge existing outside the firm and exploit it to improve existing processes.

Ermine (Ermine, 1998) highlights that knowledge management in an industrial organization concerns several organizational levels: the research and development, the management (service, quality, etc.), the production (data management, document management, know-how) and the human resource management (competence management). Knowledge management can therefore be a support for various industrial processes.

Global markets for goods and services and the world-wide availability of know-how, technologies and capital are the main characteristics of today's industrial environment. These markets are very dynamic and highly competitive. They are driven by customer demands and technology evolution, and long range predictability is becoming the exception rather than the rule. Product innovation, quality and cost become major items of competition. (Kosanke et al. 1999).

1.4 Enterprise Modeling

1.4.1 Objectives and principles

The question is how to know what is relevant information and where and how to get it in time? Even the business processes in the home organization are not transparent enough to allow real time access to the relevant data. A systematic definition, collection and provision of external data are even more difficult. External services may be helpful in collecting and providing information, but it is still necessary to decide which information is needed where and when (Kosanke et al. 1999). In this view several benefits of Enterprise Modeling (EM) can be cited for example:

1. Enterprise knowledge and business processes become much more transparent with an explicit, commonly understood representation and documentation.
2. Intra and inter enterprise communication is based on easily accessible real-time information and common understanding and thereby greatly increased.
3. Decision support for the evaluation of operational alternatives, business process re-engineering projects, exception handling and problem solving on all levels of the decision hierarchy can be easily based on real time information and thereby enhances significantly the decision quality.

4. Management of change becomes possible through the ease of access to information, the ease of adaptation of the decision support base, i.e., the business process model and the visibility of impact of proposed changes prior to their implementation.
5. Capitalize enterprise knowledge and know-how to build an enterprise memory, which becomes part of the enterprise assets.

1.4.2 Problems and limits

The major problems of EM are of two types (Goranson et al. 2002). First, EM assumes that one knows what should be made or done, who will do it, and a precise notion about how each element of work will be done. Because the primary leverage from the approach is the system view, some substantial part of the system must be included in the model. But those enterprises desiring a system view might wish to include strategic marketing and product design elements, if applicable. Such processes aren't as easily captured as process models however: they have "soft" elements like unknown futures, tacit knowledge, and poorly understood cultural and collaborative dynamics.

Second, EM usually deals with the normative, stable, deterministic case. In other words, managers expect their world to remain as it is because they are going to great lengths to engineer an operational enterprise. Dynamic environments, evolving processes, shifting partnerships and changing products are a way of life for many enterprises. So if Enterprise Integration (EI) is employed, it must be more federated than unified. That means the EI system must ideally be cheap to assemble, must change the source models and process in little or no way, be responsive to change, even indicate change, and be to some extent self-organizing and adapting.

Adding Knowledge Management (KM) techniques to the mix can possibly mitigate these two problems.

1.5 Knowledge Management

1.5.1 Objectives and principles

In the last few years, with sudden and unexpected strength, Knowledge Management (KM) has emerged as a major challenge in many enterprises. A set of strategic elements has contributed to this emergence; for example (Ermine, 2006):

1. Knowledge is a fundamental economical asset;
2. Knowledge is a strategic resource;
3. Knowledge is a factor in the stability of the enterprise;

4. Knowledge brings a decisive competitive advantage.

KM is henceforth part of the real life of the firm. But to understand what the management of knowledge in an organization concerns in reality is not easy, because nearly all components of the firm are involved.

KM involves strategy, because it is a new type of management responding to a new socio-economic environment and a new vision of the organization. It involves the structure of the organization because the knowledge is created through complex networks, connected to the environment that can challenge the classic structures. It concerns many processes that have already been put in place in organizations, but that have to be reviewed from new perspectives, optimized or developed. It concerns the staff of the organization, the human resources, which are the heart of the issue, because knowledge is created, is shared and evolves only through people, who must mobilize themselves personally and collectively for this objective. It concerns information and communication technologies (ICT), which are powerful vectors for KM if they are used efficiently.

The strategic vision that leaders of an enterprise can have concerning their knowledge capital is leading them to define some global objectives for managing and optimizing this resource. These objectives are always articulated around three key points:

1. Capitalize: know from where we come, so that we know where we are, to know better where we are going;
2. Share: switch from individual intelligence to collective intelligence;
3. Create: create and innovate to survive.

1.5.2 Problems and limits

The general problems with KM are of two types. First KM field are "soft," almost by definition. They deal with intellectual property for which no good value metrics exist; they deal with collaborative contexts that are not well modeled; and they implicitly address the slippery reality of "tacit" knowledge. Many KM systems deal with strategic planning, which means they address uncertain futures, but without extrapolating from the current situation. The current situation is often described only by an EI or other operational system, whether or not formalized and automated.

Second, KM deal with both "know-what" and "know-how," but with little emphasis on the "how." In other words, the knowledge is not sufficiently bound to the work of the enterprise, or what that work might become. One part of this problem is the age-old lack of linkages between strategic planning and operational management — it is not just an impedance mismatch between functions, but between methods and basic representations as well. This mismatch frequently produces strategic decisions that make little sense.

1.6 Discussion

The increasing importance of Enterprise Integration and Architecture and Knowledge Management within economic reality as well as their common epistemological problem is good reason to look for an integrative approach to both disciplines.

Lack of integration into everyday work practice is a reported shortcoming of knowledge management (KM), enterprise modeling and process improvement (Davenport & Prusak, 1998b). KM too often becomes the domain of outside experts that lack a full understanding of the complexities of work and the local language of the work community (Senge 1990,Wenger, 1998). Work performers become sources of information to KM activities, not active participants and contributors. Standardization and codification, rather than local innovation, organizational and social learning, become the focal points of KM. Failure rates above 50% are common (Lawton, 2001).

The gap between what people say and what they do, makes it difficult to use enterprise models and other official accounts of work as input to KM. This is further explained by the horizons and layers of knowledge acquisition, encoding and representation and the proximity to the action of the encoder (Lillehagen, 2002). Still some knowledge cannot be articulated and will remain tacit, such as alternative actions, feelings and possible experimentation. Most descriptive views in industry are just for the presently needed solution while they are used, subject to an ongoing elaboration and interpretation.

1.6.1 KM and EM: toward a common response

Although the importance of knowledge has been highlighted in the last decade by both academics and practitioners, the result has been an incomprehensible and confusing body of knowledge. On the one hand, from the academic perspective, diversity of intellectual antecedents of KM field as economics, sociology, psychology and philosophy (Prusak, 2001) has led to a set of contributions featured by a lack of integration. On the other hand, from the practice perspective, many companies everywhere are paying attention to knowledge and are beginning to actively manage their knowledge and intellectual capital – exploring what it is and how to create, transfer, and use it more effectively all over the world (Davenport et al., 1998a).

A consequence of the situation is that most industries are not aware of the implications, opportunities, and the potential benefits of using a holistic and integrated EM approach based on an integrated modeling and knowledge work execution platform.

The idea of managing knowledge is closely tied to other approaches for strengthening the competitiveness of the organization, such as Total Quality Management (TQM), Lean Management, Kaizen or Continuous Improvement and above all Business Process Reengineering (BPR). Different authors regard Knowledge Management as a supplement to Business Process Reengineering. The fact that John Wiley's Journal "Business Change and Reengineering" was renamed as "Knowledge and Process Management" in March 1997 supports this thesis (Barclay and Murray 2000).

A function of Knowledge Management can be seen in the management of knowledge that is necessary for the execution of the processes and generated at the time of execution (in reference to these business processes). However this interpretation of process oriented Knowledge Management is not particularly new. Numerous IT projects executed in the context of BPR already had goals such as the improvement of communication, co-operation, co-ordination and the information supply on their respective process functions. At that time, the focus was on "information supply", whereas today it is called "knowledge transfer".

The term "explicit modeling" can already serve as a starting point for an analogy. In Knowledge Management, a differentiation is made between implicit and explicit knowledge (Nonaka and Takeuchi 1995). Explicit knowledge is thereby understood as externalized knowledge. If we regard externalized knowledge as what it is, a knowledge representation, then the connection between explicit business process models (model representations) and the term of explicit knowledge becomes evident. Explicit knowledge (as understood by Nonaka and Takeuchi), can be distributed, internalized or combined, everything that can be done using representations of models. However, yet another aspect refers to a possible connection between Business Process Modeling and Knowledge Management. For both, 'externalization' by means of a language is necessary, regardless of whether natural or formal.

1.6.2 Motivations

A closer look reveals a number of correspondences between Enterprise Modeling (EM) and Knowledge Management (KM), which motivates an integrated treatment of both areas:

1. (Externalized) Models as knowledge representations are used in EM as a basis for communication about certain issues, similar to externalized 'knowledge' in KM.

2. (Externalized) Models serve as a storage medium for ‘knowledge’ on an issue, again similar to knowledge representations in KM.
3. Given the ability to store knowledge, there is a possibility of reuse that is commonly described by the term “best practice” in KM (O’Leary and Selefridge 1999). In EM, this case is referred to as “reference models” which allow for reuse in similar cases due to their genericity (for example, customizable standard software) (Scheer 1994).
4. The externalization of models allows for the integration of model representations from different model builders. In KM, this is regarded as ‘knowledge’ combination (which is in fact not the case, since it is not knowledge that is combined, but knowledge representations).
5. Modeling may be seen as an intentional mapping (ignoring unimportant details) of knowledge about certain facts. This requires knowledge about these facts, and modeling can therefore be interpreted as creation of knowledge representations regarding the facts, which in KM is seen as the elicitation of knowledge.
6. Learning as a process for knowledge generation is not satisfactorily considered in both EM and KM as due to their techno-centric points of view.

The goal in this thesis is how the strengths of one approach could strengthen the weaknesses of the other. KM needs formalisms (which might help with metrics) and anchoring in the enterprise’s actual work; EM needs ways of dealing with knowledge about context and other soft elements, specifically including tacit knowledge. Broadly speaking, the role of EM for KM and KM for EM (Fig. 1)

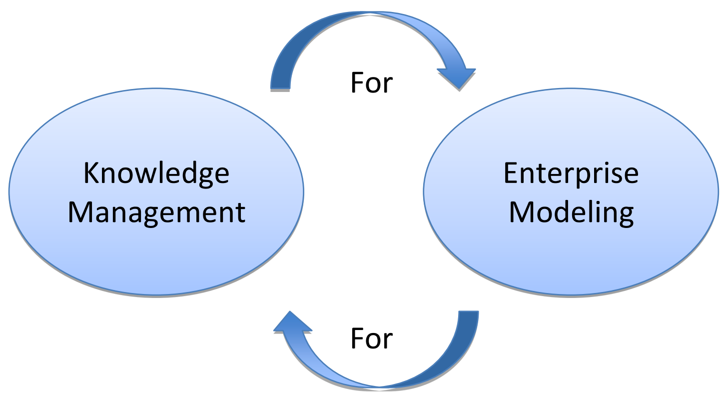

Fig. 1. Global Framework of this research

1.6.3 Questions

Several questions rise from the problem setting being explained above; These questions could help to clarify the intersection and complementarities of these notions. For example:

- Is there any relationship between EM and KM? If yes of which?
- How are the relationship, mutual effects, and role of EM and KM?
- Can we enhance EM by applying the principles of KM?
- Is there possible to apply EM tools in the field of KM to ameliorate efficiency of KM?
- Is there possible to define a common base for EM and KM?

In this thesis we will try to respond in a methodological way some of these questions.

1.6.4 Structure of the thesis

Focusing on an integration of Enterprise Modeling and Knowledge Management, we begin our observations with an analysis of the prevailing understanding of the notions in the literature both EM in the field of Enterprise architecture and knowledge and KM in the concerned disciplines. In the field of Enterprise Modeling, we start by analyzing common definitions and the purposes of models and modeling from the literature. Similarly, we look at the common views on KM. literature reviewing in the next chapter show how knowledge could be the subject of several distinct theories and the result is the multidisciplinary nature of KM.

Then, to explain the complementary nature of these two notions and consistent with our goals, we will compare in a comprehensive way the concepts. This comparison illustrate a tough relation of EM and KM demonstrate how and in which area we can keep track the benefits of utilization of EM and KM in a complementary way. Moreover, this comparison will define the foundation and shared road of studying EM and KM.

First common subject to treat is defining a common conceptual ontology for the concepts being use in the domain. We will develop a descriptive value chain model for the creation of knowledge entitled VCKC (Value Chain of Knowledge Creation). We will explain the transformation of concepts like data, information, knowledge, competence etc. The classification of the terminology could be considered as a basic platform or reference model of unified methodology in EM and KM domain.

Subsequently, socio-technical guides us to have a comprehensive view toward the organization. The management and modeling of knowledge require a well defined approach to the Intent, Content, Context, and Evolution and other components that affect knowledge in the organization. This is why we wish to propose a descriptive and generic framework for implementing KM in the enterprises entitled I2CE (Intent-Content-Context-Evolution). This framework allows us to select and compare KM solution in the organizations.

Finally, from the hypothesis that modeling of knowledge and enterprise are imperative tools to manage knowledge in the organizations especially in externalization and integration of knowledge and also for the engineering context, we will propose in the fifth chapter a method for engineering the enterprise based on knowledge. This method is a result of synthesis of four main frameworks in EM and KM. This method put in a shared context all of the aspects concerning knowledge in the enterprises and look at the knowledge from several point of views and entitled KBEE (Knowledge Based Enterprise Engineering). Fig. 2 illustrates the structure of the research.

We should add a point that because this thesis was held in production community and in this domain, enterprise modeling tools, techniques and frameworks are well-known and illustrated in several scientific works, we prefer to pass rapidly EM and devote the majority of the contributions to develop common language for knowledge management in the production community.

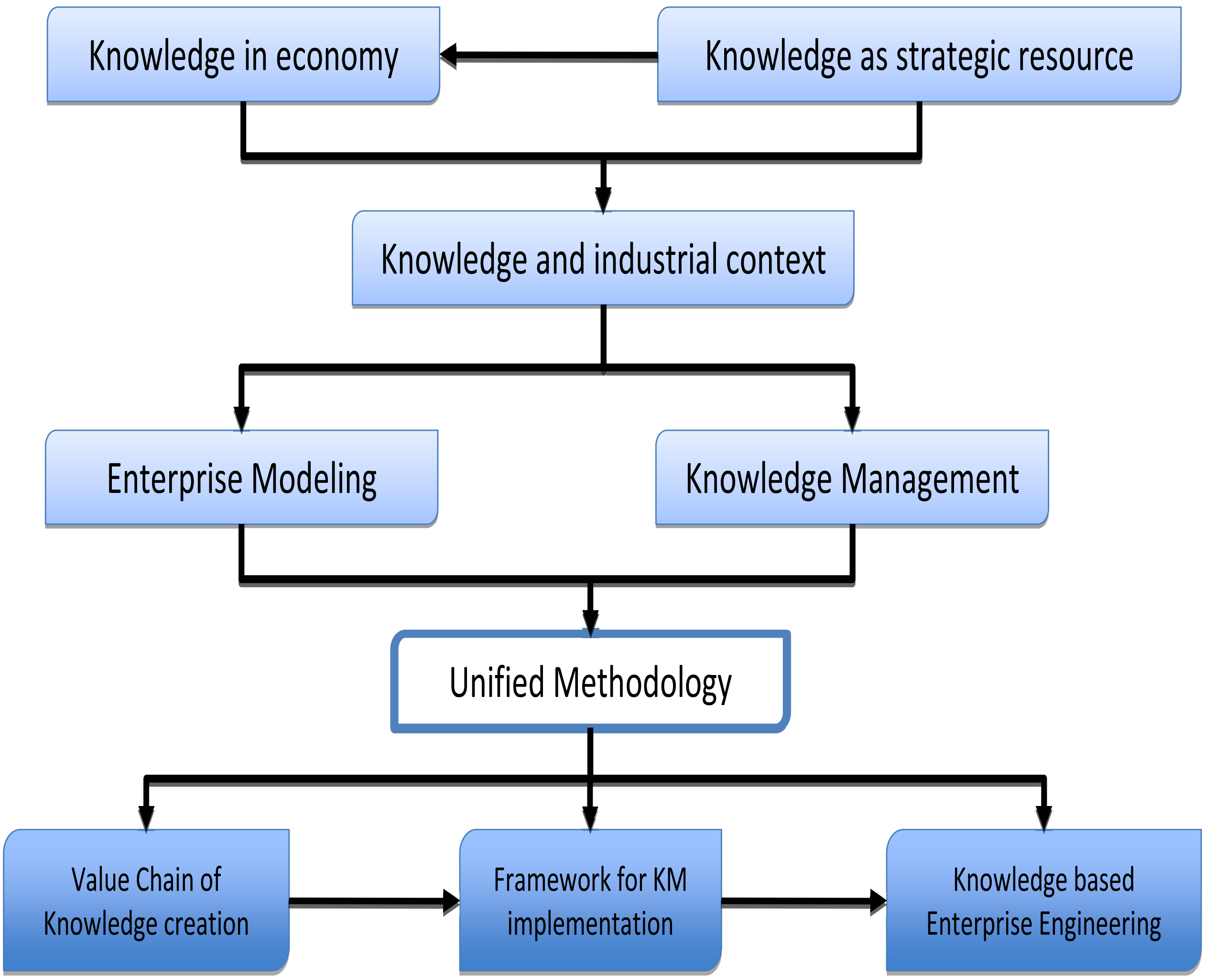

Fig. 2. Thesis Structure

Chapter 2

State of Art

2.1 Enterprise Modeling

2.1.1 Introduction

A model may represent a system (e.g., a manufacturing system), an object (e.g., designed artifact) or a problem (e.g., designing a shaft) and is typically constructed for the purpose of analysis. Models are used to describe existing systems, as well as to evaluate the feasibility and anticipated performance of proposed systems. Although models must capture enough details to facilitate reliable experimentation, the purpose of modeling must not be violated. Such a violation may be caused by including unnecessary information at a cost exceeding the cost of building and/or experimenting with the actual system. The motivation and potential drawbacks of modeling efforts vary considerably between applications and methods. A thorough understanding of functions, data, resources, and the organizational structure is essential in modeling processes. A model can provide a sufficient understanding of the system being modeled without disturbing the actual environment. For example, in manufacturing, models can be used to analyze the manufacturing system ability to respond to the market changes. This enables rapid and accurate reconfiguration when new products are demanded. Ultimately, an executable version of the model can simulate and even control the actual process. Once a process model has been developed, one should be able to perform various analyses, e.g., time (temporal), quality of the underlying processes by presenting a user with different perspectives.

2.1.2 Enterprise Integration and Enterprise Modeling

Today's "business trends are clearly towards the need for managing organizational and operational changes within companies in order to face global competition and fluctuating market conditions"(Vernadat, 1996). This situation poses a number of integration problems that enterprises have to tackle: integration of markets, integration between several development and manufacturing sites, integration between suppliers and manufacturers, integration of design and manufacturing, integration of multi-vendor hardware and software components. Enterprise Integration is therefore, not anymore only a problem of interconnecting physical and software applications but also requires global business integration, aiming at the use of the existing or new enterprise resources in order to better achieve the overall business objectives.

“Things to be integrated and coordinated need to be modeled. Thus, enterprise modeling (EM) is clearly a prerequisite for enterprise integration”. According to Vernadat (1996), *enterprise modeling* is the set of activities or process used to develop the various parts of an enterprise model to address some desired modeling finality. It can also be defined as the art of “externalizing” enterprise knowledge, i.e. representing the enterprise in terms of its organization and operations (e.g. processes, behavior, activities, information, object and material flows, resources and organization units, and system infrastructure and architectures). The finality is to make explicit facts and knowledge that add value to the enterprise or can be shared by business applications and users for the sake of improving the performance of the enterprise. The prime goal of enterprise modeling is not only to be applied for better enterprise integration but also to support analysis of an enterprise, and more specifically, to represent and understand how the enterprise works, to capitalize acquired knowledge and know-how for later reuse, to design (or redesign) a part of the enterprise, to analyze some aspects of the enterprise (by e.g. economic analysis, organization analysis, qualitative or quantitative analysis,. . .), to simulate the behavior of (some part of) the enterprise, to make better decisions about enterprise operations and organization, or to control, coordinate and monitor some parts of the enterprise.

Enterprise Modeling techniques and associated visual languages are very important and useful to support new approaches to enterprise business transformation and improvement, developing smart organizations and new networked organizations.

Within the initiative on Computer Integrated Manufacturing (CIM), Enterprise Modeling was born in the United States at the beginning of the 80’s and emerged through large CIM projects, e.g. ICAM (Integrated Computer Aided Manufacturing) led by the US Air Force or CAM-I (Computer Aided Manufacturing - International) via the project ”Factory Management”. In the mid-80’s, Europe launched several projects on Enterprise Modeling giving birth to several enterprise modeling languages (including notably GRAI and CIMOSA). As a result, in the 90’s many commercial tools dealing with EM or business process modeling appeared on the marketplace, e.g. ARIS ToolSet, FirstSTEP, METIS, Enterprise Modeler, KBSI tools, CimTool, MOOGO, IMAGIM and many others as well as a myriad of workflow systems, each one with its own modeling environment (Action Workflow, COSA, FlowMark, Lotus Notes, Teamware Flow, Ensemble, WorkParty, . . .). This intensive production of tools has led to a Tower of Babel situation in which the many tools, while offering powerful but different functionalities and semantics, are unable to interoperate and can hardly or not at all communicate and exchange models. This is a serious drawback for awareness, acceptance and wide use of the EM technology in industry which cannot capitalize from previous modeling efforts. This situation hinders true enterprise integration, interoperability, and sharable enterprise knowledge.

The evolution in this field has gone through several phases: the initial objectives aimed to build the physical level integration; then the focus was on the integration of applications; the integration of the business level and finally of the full enterprise operations were addressed (Fig. 3).

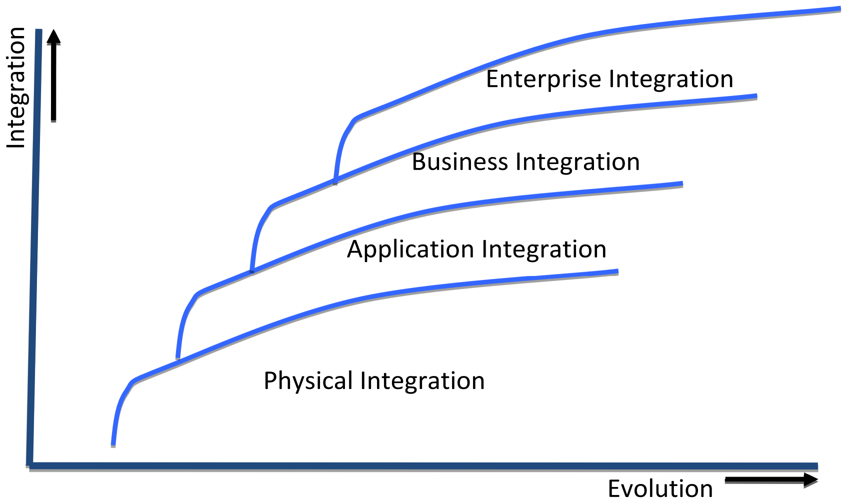

Fig. 3. Enterprise Integration evolution (Kosanke, 1997)

To reach these objectives, all levels of enterprises must be considered, from the most strategic to the most operative ones. They must evolve in a coherent frame, which enables that actions and decisions made at each of the levels of the enterprise are taken into account.

2.1.3 Enterprise reality and process models

Models are abstract representations of reality. Therefore, the modeler has to decide on what and how to model. However, a common representation of the model contents should be used to allow for common understanding by the people using the models. Also guidance has to be provided on how to model. This is especially important if the models are to be used in decision support and by people not deeply involved in business process modeling (Kosanke and Zelm, 1999).

Creating a model usually starts with the identification of the entity to be modeled. This may be a part of the operation or the complete operational process. It may be entirely intra-organizational or could be inter-organizational—crossing company boundaries and including parts of customer, vendor or partner operations. Very important is the identification of the relations to the environment. This will allow the extensions of the model at a later point in time or for linking the model with parts of the environment which may have also been modeled as business processes.

Fig. 4 shows this situation in a schematic way, identifying both the process functionalities and dynamics (the plants) and the process links (the order and parts flow) of the inter-organizational enterprise. Methods and tools are used to describe and represent the reality. Functionality and dynamics are described using the modeling language and its graphical representation for the human oriented representation.

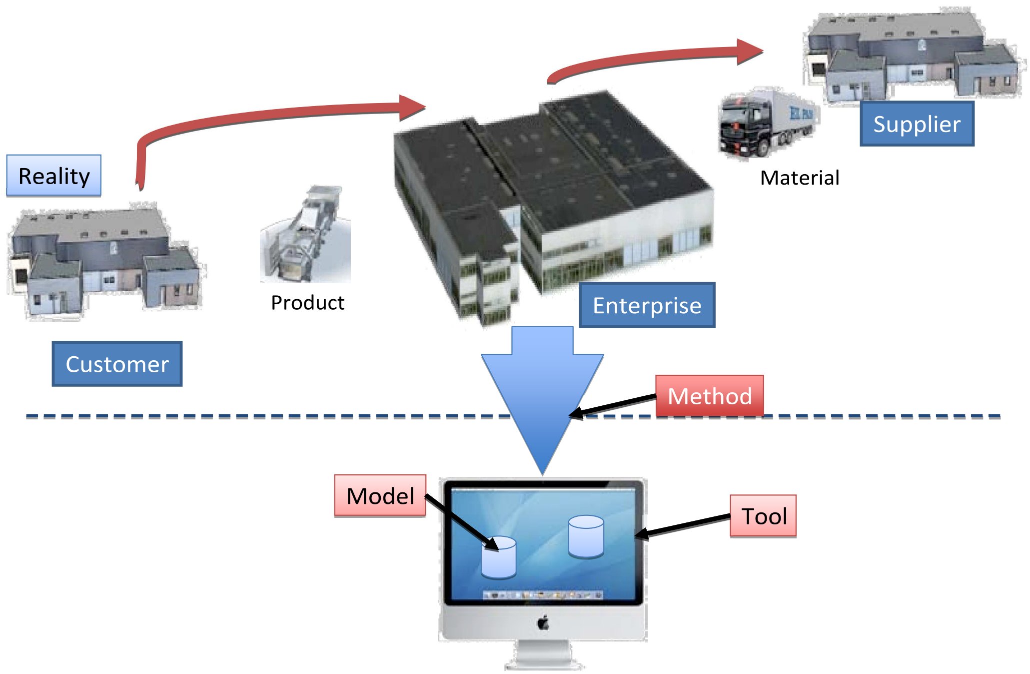

Fig. 4. Enterprise reality and process models (Adopted from Kosanke and Zelm, 1999)

2.1.4 Enterprise Frameworks and Architectures

A framework is defined as a fundamental structure which allows defining the main sets of concepts to model and to build an enterprise. The dominant Enterprise Modeling Frameworks and Architectures that are being pursued by industry and interest organizations are:

The Zachman Framework (Zachman, 1987) has with some success been used by the Canadian Government to design their EA approach, and as a reference categorization structure for enterprise knowledge repositories.
The GERAM framework (IFAC-IFIP, 1999) give a very good overview of the different EM modeling aspects and domains, but lacks some very important aspects such as meta-modeling capabilities, knowledge spaces and modeling platforms with repositories.
The GRAI/GIM Framework (Doumeingts et.al, 1992) has strong support for performance indicator management and supporting decision making, but has limited expressiveness and platform integration.
ARIS (Architecture of Integrated Information Systems) has strong top-down process modeling and integration capabilities (Scheer and Schneider, 2005), but lacks expressiveness for other aspects and the "big picture" created by a holistic approach.
The CIMOSA Framework is a good reference framework (Kosanke, 1995), but lacks expressiveness for multiple dependencies of types of view, for evolving concepts, contents and capabilities and for capturing context.
The DoDAF Architecture Methodology (DoD, 2004) is a comprehensive framework and methodology targeted specifically at systems engineering in the military forces, and cover all kinds of systems not just software systems. It has a strong categorization of enterprise knowledge contents.
TOGAF Architecture Methodology (TOGAF, 2005) has a good methodology for developing an approach (the Architecture Development Methodology – ADM), but again it is just a framework of descriptive fairly abstract views.
The TEAF Methodology (TEAF, 2000) is specifically tuned to deliver a methodology to the US Government agencies and all administrative legislative and financial systems, so this architecture is very rich for those application domains.

PERA stands for Purdue Enterprise Reference Architecture (Williams, 92). It integrates all phases of the enterprise, from Concept, through Engineering, Construction and Operations and adds the human role to the enterprise model. Furthermore, it provides a formal way to identify optimum levels of automation, and the effects on the rest of the enterprise. It addresses both continuous processes and discrete parts manufacturing. Together with GRAI/GIM and CIMOSA it constructs GERAM framework.

Common to all of these is that they are descriptive frameworks, defining enterprise domains and their views and contents, but they are today all architecting methodologies for producing descriptive architectures detached from the operational platforms and systems out there.

2.1.5 Existing Modeling Tools

The development of tools for modeling and analysis of processes has been motivated by the need to increase productivity and improve communications and structure of design and manufacturing systems. Representing models as process graphs, performing observational and structure model analyses are important issues. Table. 1 shows a synthesis of business modeling techniques (Aguilar-Savén, 2004)

Table. 1. Business process modeling techniques (adopted from Aguilar-Savén, 2004)

Technique	Description	Attributes	Characteristics	Strengths and Weakness			
				User perspective		Modeller perspective	
				Strength	Weakness	Strength	Weakness
Flow Chart	Graphic representation	Flow of actions	Not sub-layers Great details No overview	Communication ability	Can be too large	Flexibility quick, simple	No method available Different notations
DFD	Descriptive diagrams for structured analysis	Flow of data	Explains logical level sub-layers	Easy to understand	Only flow of data is shown	Easy to verify and draw	
RAD	Graphic view object state transition diagrams	Flow of individual roles	Detailed view Degree of empowerment No overview	Supports communication Intuitive to read	Not possible to be decomposed	Include business objects	Different notations
RID	Matrix representation of processes for co-ordination of activities	Flows of activities and roles	Inputs to and outputs from are not modelled Performers are included	Intuitive to understand	Important information is not included	Rigid notation Complex processes can be displayed	Difficult to edit an existing diagram Hard to construct
Gantt Chart	Matrix representation	Flow of activities and duration	Relate activities to time	Easy overview representation and control of performance	Not aid for analysis or design	Simple	No clear representation of dependencies
IDEF0	Structural graphical representation, text and glossary	Flows of activities, inputs, outputs, control and mechanisms	Based on SADT Sub-layers The most popular	Shows inputs, outputs, control and mechanisms overview and details	Trend to be interpreted only as a sequence of activities Roles are not represented	Strict rules Possible to build a software Quick mapping	
IDEF3	Behavioural aspects of a system	Precedence and causality relationships between activities	Allows different views Process flow descriptions and object state transition description diagrams Sub-layers	Easy to understand dynamic aspects in a static way	Many partial diagrams to describe a process	Strict rules and notation Possible to build a software	Need lot of data Time consuming when modelling complex systems
Coloured Petri Nets	Graphical oriented language to design, specify, simulate and verify systems	Network of places, transitions and arcs	Extended Petri nets Token are differentiated by colours Hierarchical decomposition	Easy to understand how individual processes interact with each other	Models are excessively large	Formal mathematical representation Well defined syntax and semantics Possible to build a software Data concepts	Time consuming when modelling
Object Oriented Methods	Describe a system with different type of objects	Object's structure and behaviour	Three concepts: objects, classes and messages There are many modelling techniques based on OO	Enactable model to control and monitor processes	Model are excessively large and detailed Fragmented information	Internal consistency across design, analysis and programming Possible to build a software	Need lot of data Time consuming when modelling Complexity
Workflow	Computerised facilitation or automation of a business process	Flow of information, tasks and procedural rules	Flow of tasks between computers and people Decentralised	Easy to analyse Shorter learning time		Possible build a software Data transfer Easy to make changes	Lack of a particular notation Many languages
Rich Pictures	Contextual representation of things	Represent process human problematic	Represent some of the richness of the process being examined	Support communication and understanding of the process	It is not structured approach	Easy to illustrate components as clients, people, tasks and environment	Lack of a particular notation
GRAI grid and GRAI nets	Descriptive diagrams of the process focused on decisions	Decision making process and flow of activities	Sub-layers Distinction between period and event driven activities	Shows inputs, outputs, control and mechanisms, overview and details	Many partial diagrams to describe a process	Strict rules and notation Possible to build a software	Need lot of data Time consuming when modelling Complexity

2.1.6 The view dimension

According to GERAM, views are used “to decrease the apparent complexity of the resulting enterprise models”. It “allows the operational processes to be described as an integrated model, but to be presented to the user in different subsets (model views) of an integrated model.” Views allow “the user to concentrate on relevant questions that the respective stakeholders may wish to consider using enterprise modeling. Different views may be made available highlighting certain aspects of the model and hiding all others.”

Among the different set of views proposed by GERAM, “model contents” view describes different aspects of the enterprise that EM approach might or not allow to deal with. However, these views are only a set of commonly addressed “model contents” views and others could be defined. For this reason, an approach is characterized as addressing another view, not defined in GERAM. Consequently, the following contents views is obtained:

The Process/Function View “represents the functionalities (activities) and the behavior (flow of control) of the business processes of the enterprise. Decisional activities of the management related operations are represented, as well as transformational and support activities. The functional view of the management- and control system of an enterprise or entity is indeed the functional model of its decision system. The function view includes functional models, process models, decisional models, which [...] all talk about some aspect of the enterprise function. As a result, the ”function view“ is a holding place for a host of possible models, such as CIMOSA (Vernadat, 96;2002) function view models, GRAI Grid (Vallespir, 93) and GRAI Net representations of decision centers, Petri nets, Event Driven Process Chains, Generalized Process Networks, QGERT or GPSS models, ... and so on.”

The Information View “collects the knowledge about objects of the enterprise (material and information) as they are used and produced in the course of the enterprise operations. The information is identified from the relevant activities and is structured into an enterprise information model in the information view for information management and the control of the material and information flow.”

The Resource View “represents the resources (humans and technical agents as well as technological components) of the enterprise as they are used in the course of the enterprise operations. Resources will be assigned to activities according to their capabilities and will be structured into resource models e.g. for asset management.”

The Organization View “represents the responsibilities and authorities on all entities identified in the other views (processes, information, and resources). It caters for the structure of the enterprise organization by organizing the identified organizational units into larger units such as departments, divisions, sections, etc."

Each view tries to externalize some dimensions and aspects of knowledge in the enterprises. These views correspond to global framework for enterprise modeling. Shen et.al (2004) classified the views in accordance with most popular framework in EM (see Fig. 5)

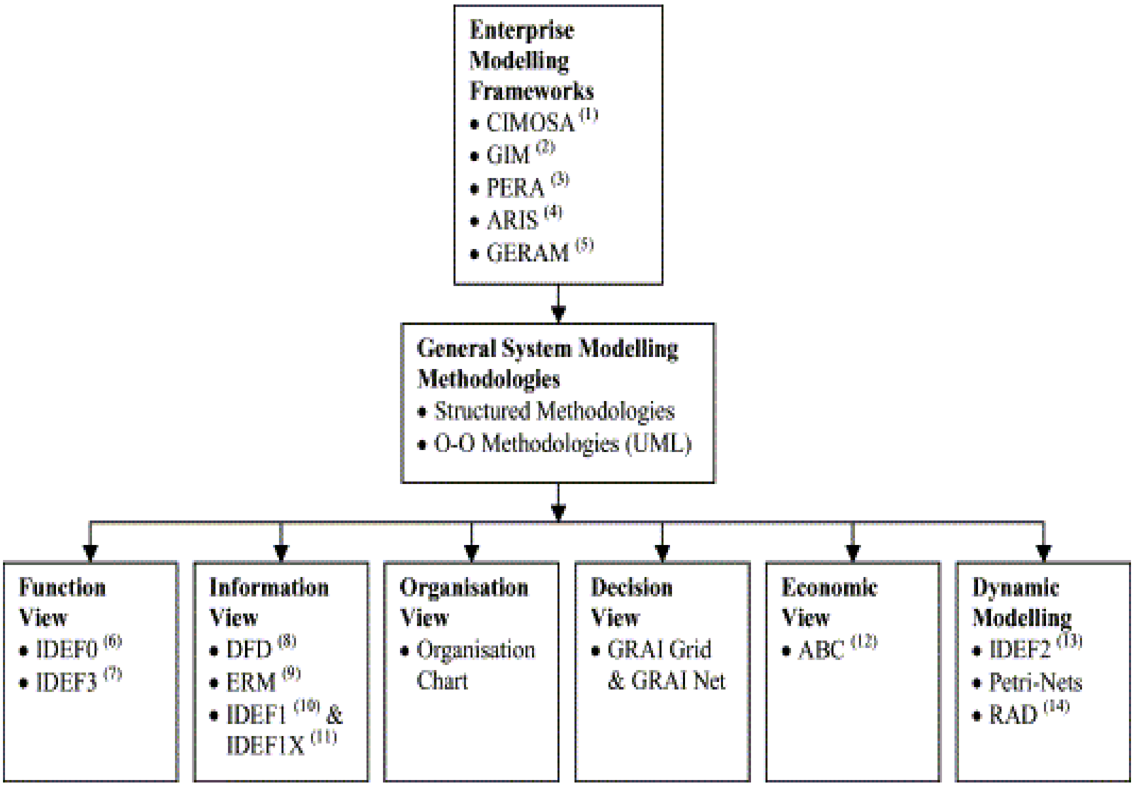

Fig. 5. A classification of modeling methods and techniques (Adopted from Shen et. al, 2004)

2.1.7 Application domains of EM

According to (ATHENA, 2004) there are four main current application domains of EM. These application domains are:

1. Enterprise engineering and reengineering
2. Product life cycle management
3. Choice and implementation of IT systems and solution
4. General enterprise architecture and operations support

In Fig. 6, POPS dimensions (Product, Organization, Process and System) and the application domains are related to show how frequently EM is applied to each type of domain. As described, there are several overlaps between the main application domains from having common sub domains.