Knowledge-Based Management System and Dearth of Flexible Framework for Software Development

[1] Wemembu U.R., [2] Okonta O.E., [3] Imiere E.E., [4] Ajani D, [5] Owolabi A.A

[1] Department of Mathematics, Federal College of Education (T), Asaba,
[2,4,5] Department of Computer Science, Federal College of Education (T), Asaba,
[3] Department of Physics, Federal College of Education (T), Asaba
Wemembuuchenna@gmail.com, okeyokonta@yahoo.com, emmaedekinimiere@gmail.com, ajanidele@gmail.com,
abudulhakimowolabi@gmail.com, lawrenceuzomah@rocketmail.com

Abstract

This paper discussed the dearth of definite framework to design knowledge based management system model that can be deployed to design a knowledge structure capable of stipulating general format for software development that will meet the yearnings of the consumers who want products that meet their need and are not too costly. This paper examined the recent evolution of the software engineering industry to show why new approach should be adopted while increasing attention is paid to conceptual modelling. It went further to outline the current state of knowledge modelling techniques and supporting tools. The paper looked at several works carried out in an attempt to create unique model. Most of the designs involved complex and iterative processes based on methodologies and technologies for capture and reuse of knowledge. Most the products proposed to support knowledge development for the last two decade havel falenl short of what they contemplated. The objective of this paper is to find the missing link and make important contributions to knowledge.

Key Words: *Knowledge-based management, knowledge modelling, cognitive programming KB-software assistant, knowledge model.*

1.0 Introduction

Human brain can store several thousand of critical information and yet we still feel that human brain is underutilized, but advances in human knowledge are directly linked to the ability to analyze in order to form information, which is processed into knowledge and in turn communicated to others. The human brain has approximately 1011 nerve cells called neurons. It is probably the most complex and least understood part of the human anatomy. It has continuously worked in declarative and procedural way for problem solving that till today it is still a mystery how the human mind functions. Advance in modern technology with the help of new knowledge, new tools and new resources and development of systems that make use of knowledge, wisdom and intelligence had open new avenues to provide more insights and fashion ways to tackle such arduous challenge. The ability of the intelligent systems to capture and redistribute expertise has significant implications on development of a nation, community or population. Such systems allow documentation of one or more expert knowledge and utilize the knowledge for problem solving in cost effective way. It allows for, in a controlled manner, the import of expertise in various areas that the nation lacks, the export of knowledge relating to domestic areas of expertise, and the duplication and redistribution of scarce knowledge in a cost effective manner[1]. (Darek et al). Thus areas of expertise that the selected nation is deficient in or possesses exclusively are potential candidates of the knowledge-based systems. Though synthesized information is a key element for success in all ventures but in many businesses this is still lacking. A significant amount of energy is deployed in transferring knowledge through education and training, but if properly designed and harnessed Artificial Intelligence systems can effectively distribute the scarce resources for the development process while the Knowledge-Based Systems (KBS), which are steps towards an intelligent system, can be justified when a few individuals are the custodians of the majority of the knowledge.

What Is Knowledge?

The definition of knowledge is imprecisely understood. Data, information, knowledge and wisdom are the fundamental elements of human thinking and reasoning process. There are distinctive differences between data, information, knowledge and wisdom. Data is concerned with collection of raw facts showing people, object, events concepts and ideas. They are useless without structure so they must be some processing in form of arranging, comparing, inferring, filtering, and sorting. The processed data is what is known as information. Furthermore we can garner knowledge as a result of processes like synthesis, filtration, comparison and analysis of available information to generate meaningful outcome. Over the time, the experiences acquired, judgments, values, laws are all summed up to form wisdom

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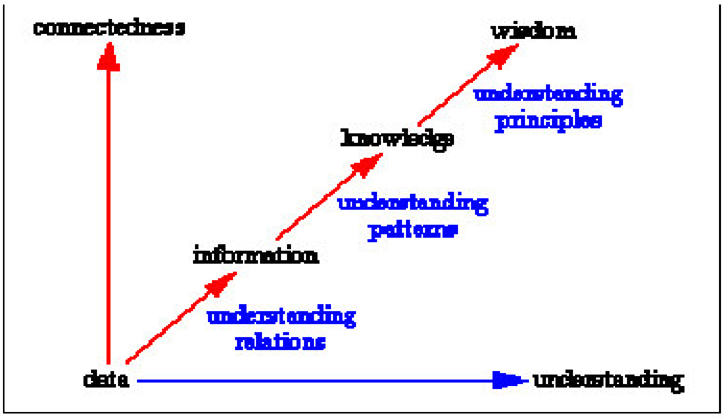

Figure 1 Bellinger's Knowledge Model

What is a Knowledge-Based System?

Symbolically, it incorporates knowledge that is symbolic as well as numeric. Heuristically it reasons with judgmental, imprecise, and qualitative knowledge as well as with formal knowledge of established theories. Transparently its knowledge is simply and explicitly represented in terms familiar to specialists, and is separate from its inference procedures. It provides explanations of its line of reasoning and answers to queries about its knowledge. Flexibly it is incrementally extensible and can be also refined. More details can be specified to refine its performance; more concepts and links among concepts can be specified to broaden its range of applicability. It is an expert system if it provides expert-level solutions. The power lies in task-specific knowledge. It does not tell the program what to do, it tells it what to know. It keeps the knowledge in the knowledge base. Choose a representation that is as high-level transparent as possible. And its main task is elucidating and debugging knowledge, not writing and debugging a program. Some example of knowledge-based system in the areas can be outlined as follows:

Physical development
KBS for infrastructural planning
Small scale industries like agribusiness and co-operatives
Energy planning and reuse
E-Governance
Irrigation management and supervision
Communication and transportation
Public distribution services
Special programmers like drought prone area planning
Forestry
KBS for natural resource management
Knowledge-based planning for land use and land reform
Network monitoring systems
KBS for resource sand material management
KBS for river and land use management
KBS for soil health card for villagers
KBS for intelligent manufacturing and new product development
KBS for geographic property identification and measuring
Robotics and fly/drive by wire vehicle system
Pilot training and space training through virtual reality
Publication and printing media KBSs
Loan passing system
Fault diagnostic System

Economic Development
Employment exchange services
Market reforms/information systems
New product development advisory
Business selection advisory
Tax planning system
Knowledge-based planning of agricultural products
Knowledge-based planning for agricultural inputs
Knowledge-based diagnosis for plants and animal diseases
Crop land pattern matching system for agriculture
Intelligent manufacturing
Matching buyers and sellers agent in e-commerce
Embedded KBS in the devises like fuzzy washing machine
Robotic and intelligent sensors in manufacturing
KBS for potential risk identification in investments
Software/product quality management
Intelligent ERP based systems

Social Development
Cultural information
Tourism portal
Identity/ration card
Voters' identification and election related systems
Intelligent system to identify suitable beneficiaries for Government/NGO schemes
Awareness systems
Child and women health/nutrition systems
Community health
E-learning
Education and training systems
Knowledge-based examination planning system
Games and entertainment KBS
Language translation and tutoring

Health Improvement
Government schemes information system
Diet planning system
Disease diagnostic system
Disease diagnostic system for cattle and live stock
Patient monitoring system
Medical insurance
KBS monitoring in surgical process
KBS for guided neuro-surgery

Review of Related works and Ideas

The term "knowledge-based systems" is often construed to mean expert systems but this paper will expands the concept of knowledge-based systems to include taxonomies and empirical and process or simulation models as well. Knowledge-based systems are discussed in the context of encompassing knowledge management issues since knowledge-based systems represent but one component of the knowledge issue, and knowledge-based systems will ultimately have to be integrated into an overall corporate knowledge management program. The field of knowledge management is both new and highly volatile. While we were able to find many popular articles on knowledge management and some overviews, all dealt with relatively small subsets of the range of work we found referred to as knowledge management. Unfortunately, we were unable to find a comprehensive overview of the current state and direction of knowledge management. Therefore, much of the effort was placed on understanding the status and direction of knowledge management development under the assumption that knowledge-based systems will ultimately need to be integrated into a larger knowledge management system. This will include such things as patents, documents, manuals, operating procedures, standard practices, and a corporation's informal knowledge of how things are done. The ultimate goal was to identify issues that would increase or mitigate the integration of knowledge-based systems into a corporate knowledge management structure that can be put to more effective use.

Route to Knowledge Based Software Assistant

In the early 1980s the United States Air Force realized that they had received significant benefits from applying artificial intelligence technologies to solving expert problems such as the diagnosis of faults in aircraft. The air force commissioned a group of researchers from the *artificial intelligence and formal methods* communities to develop a report on how such technologies might be used to aid in the more general problem of software development. The report described a vision for a new approach to software development. Rather than define specifications with diagrams and manually transform them to code as was the current process, the Knowledge Based Software Assistant vision was to define specifications in very high level languages and then to use transformation rules to gradually refine the specification into efficient code on heterogeneous platforms.

Each step in the design and refinement of the system would be recorded as part of an integrated repository. In addition to the artifacts of software development the processes, the various definitions and transformations, would also be recorded in a way that they could be analyzed and also replayed later as needed. The idea was that each step would be a transformation that took into account various non-functional requirements for the implemented system. For example, requirements to use specific programming language such as Ada or to harden code for real time mission critical fault tolerance [2]. (Green Cordel et al)

The use of knowledge based systems has been limited to an area of very specific applications where special methodologies and tools are used quite different from the techniques applied for software engineering model. The Software Engineering field has been mainly focused in information systems development improving the reliability and efficiency of data services. However, the current users of these services are being increasingly interested in deeper functions integrated in the information systems supported by the knowledge related with the data conceptual domains. The relationship between both approaches has been produced only in the area of knowledge based support to software engineering tasks. Lowry, Duran, [3] summarize this recent evolution in two main trends: (1) improvement of automatic program synthesis techniques aiming to transform in operative programs high level specifications using set theory and logic such as the commercial system ***REFINE*** or the experimental system ***KIDS*** Smith [47] built on top of ***REFINE,*** and (2) broadening the automatic programming scope to the entire software life cycle by building knowledge based assistants for acquiring validating and maintaining specifications. [3] These capacities have been embedded in CASE tools. However, three circumstances are creating a different situation:

- The need for a more open architecture in applications to ensure an adequate human-machine interaction according to the recent approaches for design that follows a user-centered view.
- The need of software reuse which requires an open structure: (1) to easily understand the contents of any software component and (2) to be capable of accepting changes in its contents according to the specific needs of the application where the component is going to be reused.
- The improvements on reliability and capacity of representation produced in the last fifteen years in the field of knowledge representation and knowledge acquisition methods, giving birth to a collection of mature technologies supported by experimental tools, yet, but providing levels of services very close to the industrial requirements.

Therefore, now it is possible to formulate and to build an application by using directly the knowledge modelling concepts supported by adequate tools instead of formulating the application using information structuring concepts and data processing algorithms as in the usual software environments. This is a very important feature because it approaches the design phase to the conceptual specification phases, that usually in the traditional software world are separated by a bigger gap and, hence, subject to more errors than the errors possible between the conceptual model and the knowledge model which is closer to the conceptual abstractions. However, not many attempts have been made by the Artificial Intelligence community to produce something like cognitive programming environments in an operational way where reasoning steps using domain models are applicable to describe and to explain the answers of the application. Artificial Intelligence has to invade with practical views this area of applications. Although the paradigm modelling efforts must continue as focus of research, an additional focus should be the advanced modelling of complex applications using the available paradigms.

In recent years, engineering systems have moved from being information-intensive towards knowledge intensive systems [4, 5]. The information is thus constantly refined by clarifications, discussions and evaluations, until an optimized or compromised solution is agreed. In the framework of Product design and manufacturing, Weber [6] argue that today's systems provide infrastructures to store and move data, but not retain knowledge about the content and the interrelationships of the data they handle. But, decisions are based upon the designers' intellectual assets and vary from one expert to another. It becomes crucial to develop a method that harnesses the benefit of this intellectual capital. The Knowledge Based Systems (KBS) are just one stop solution. Their development relies on the transformation of human informal knowledge into formal knowledge with some support from knowledge engineering techniques [7].

Knowledge-based methods and tools

A knowledge-based system can be defined as an automated system that uses knowledge about some domain in order to deliver a solution concerning a problem [8]. The first generation of knowledge-based systems was expert systems using a set of facts and rules [9]. This kind of systems is composed of essentially two components: a knowledge base (KB) and an inference engine. It applies specific domain or domain-specific knowledge to problem-specific data to generate problem-specific conclusions [10]. The next KBS generation was the case-based systems. These systems use previous solutions to problems as a guide to solving new problems. Knowledge-based systems are widely acknowledged to be the key for enhancing productivity in industry, but the major bottleneck of their construction is knowledge acquisition, i.e. the process of capturing expertise before implementation in a system [11].

Some methodologies assist the developers in defining and modelling the problem in question, such as Structured Analysis and Generation of Expert Systems (***STAGES***) and Knowledge Acquisition Documentation System (***KADS***) (an acronym that has been redefined many times, e.g. Knowledge Acquisition Documentation System and Knowledge-based system Analysis and Design Support). Moreover, these approaches get enriched in order to take into account the project management, organizational analysis, knowledge acquisition, conceptual modelling, user interaction, system integration and design [12,13]. Consequently, knowledge modelling in engineering must be based on a rich and structured representation of this knowledge, and an adequate way of user interaction for modelling and using this knowledge [14]. Due to the complexity of engineering knowledge, knowledge modelling in engineering is a complex task and so quality function should be properly deployed.

Parametric Modelling with KBE

With the pioneering work of Requicha and Voelcker the Parametric modelling laid its solid foundation in 1970s [15]. Since then, the researchers turned their focus on developing the modelling techniques. In this process, advanced parametric modelling was first introduced in 1980s and it has become the new paradigm for mechanical CAD designs. But Robert Stiles [16] argues that the real origin of parametric modelling was a few decades earlier. The modelling and designing of a product in parametric modelling approach is dimension driven and which is built on set of mathematical equations to facilitate automatic re-use of existing design process based on the results of engineering analysis [17] and that makes the adoption of this modelling in our suggested frame very pertinent. In parametric modelling approach, the parameters can be changed by the operator as needed to generate the preferred part by making use of history-based method which keeps the record of how the model was generated [18]. When the operator changes parameters in the model and regenerates the part, the program repeats the operations from the history, using the new parameters, to create the new solid design. Parametric design can be treated as a powerful, easy, proficient expert method for consistent product design [19].

Parametric Modeling Fully by Program

This is a complete program control approach where the user can straightaway develop the program to produce the parametric model based on the needs. This is the flexible and suitable approach for modelling without the support of model library. However, as the approach demands high level of programming skills it may be suitable where the model is simple but consists of high number of variables.

The early ***CAD*** systems are often criticized for their static modelling technique such as constructive solid geometry (***CSG***), boundary representations (***BREPS***), or a hybrid of the two [20]. However, parametric design systems such as variants programming, history-based constraint modelling, variation design, rule-based variants, and parametric feature-based design substituted the deficit of the conventional ***CAD*** systems by enabling dynamic modelling and modification [21, 22]. In 1988, the first commercially successful parametric software, ***Pro/ENGINEER*** with 3D geometry capabilities was released into market by the former mathematics Professor Samuel Geisberg, the founder of

PTC (Parametric Technology Corporation). During the releasing press meet, Samuel Geisberg expected that parametric modelling approach not only enable the designer to a variety of designs but also allows a choice to be made later in the design [23]. In 1993, French software Dassault Systèmes S.A. released its first CAD software ***CATIA V4*** with parametric features. Later, Autodesk Inc. released Auto CAD2010 with parametric functionality, and announced in the press release as "a ground breaking new capability". Later, on parametric modelling approach went through the scripting interfaces of CAD software packages allowing the designers to write code to automate parts of the software. Currently, parametric modelling is no long the exclusive domain of overtly parametric tools like ***CATIA*** and ***Pro/ENGINEER.*** Parametric modelling capability has also drive into other CAD software such as, ***CREO*** Parametric, ***NX, CATIA V5, SOLIDWORKS***, ***SOLID EDGE***, ***INVENTOR*** and ***IRONCAD.***

Based on the review, the observations of parametric modelling system are: Parametric modelling not only provides appreciated experience about the final product's proportions and form but also presents how the design is modified. With the involvement of KBE, parametric modelling approach proposes enhanced integration with manufacturing practice and assists to reduce the product development time. Parametric modelling offers better details of the model for analysis and prototyping. However, when developing the parametric model as the design factors are not fully considered, it is unrealistic that this approach can replace people. On the other side, parameterization is possible on the standards, common and series products.

Function Based Modelling through KBE

In general the reason for designing a product is to meet a certain function but the objective can be attained easily with some additional support. Unfortunately, this extra additional support is making the design process more complex [24]. The conventional CAD systems cannot carry out automatic modelling based on the given specifications as they are not built with AI to perform reasoning and to make decisions by itself. In practice, these activities are performed by the designers to fulfil the requirements. Recent advances in the field of CAD systems have greatly increased the influence of AI on the modelling phase of the design of the product by encompass human knowledge [25, 26]. Function oriented design has become an active area of research for the past decade. The intention of functional design is to present computer aided tools to connect design functions with the physical embodiments used to recognize the function [27]. In the early stage of the development of functional design approach, Chakrabarti et al. [28] pointed that knowledge of functionality is required for design, modification, comparison, evaluation of the process.

In reality the definition of function given by many researchers is observed to be diverse and contradictory. However, designers agree that there is tight coupling between function and behaviour. Function is what the design is going to do while the behaviour is how the expected result is attained from design. The most common form of knowledge representation in functional design is rules, frames, objects and constraints. In 1996, Li et al. [29] applied rule based paradigm for automating the computational synthesis of conceptual design of mechanism. A frame based structure was used to model the kitchen appliances by Tong and Gomory [30]. Gelsey et al. [31] developed a conceptual design of supersonic aircraft using constraint based model in 1998. An easily modify and highly flexible object oriented architecture was proposed by Akagi et al. [32] for developing a sustainable functional design process by considering the objects as elements. Zhang et al. [33] proposed an integrated knowledge method that unites rule-based and object-oriented representation methods to stand for functions and functional related design characteristics in an intelligent design environment.

Andrews et al. [34] proposed the concept of design reuse in CAD systems to facilitate quick design by using already-available product's design process. Tor et al. [35, 36] has drastically reduced the time and effort needed in configuring industrial robot by make using of behaviour-driven, function-environment-structure (B-FES) modelling framework. Xu et al. [37] proposed a function-based design synthesis approach to support design reuse framework by using functional-based product information model and multiple objective optimization model for developing intelligent product structure**.**

From KBSA to KBSE

The Kestrel Institute in United States focused primarily on the provably correct transformation of logical models to efficient code. Information Science Institute focused primarily on the front end of the process on defining specifications that could map to logical formalisms but were in formats that were intuitive and familiar to systems analysts. In addition, Raytheon did a project to investigate informal requirements gathering and Honeywell and Harvard University did work on underlying frameworks, integration, and activity coordination. Although not primarily funded by the KBSA program the MIT Programmer's Apprentice project also had many of the same goals and used the same techniques as KBSA. In the later stages of the KBSA program researchers developed prototypes that were used on medium to large scale software development problems.

By 1991 the emphasis shifted from a pure KBSA approach to more general questions of how to use knowledge-based technology to supplement and augment existing and future Computer Aided Software Engineering (CASE) tools. In these later stages there was significant interaction between the KBSA community and the object-oriented and software engineering communities. For example, KBSA concepts and researchers played an important role in the mega-programming and user centered software engineering programs sponsored by the Defense Advanced Research Project Agency (DARPA). In these later stages the program changed its name to Knowledge-Based Software Engineering (KBSE). The name change reflected the different research goal, no longer to create a totally new all-encompassing tool that would cover the complete software life cycle but to gradually work knowledge-based technology into existing tools. Companies such as Andersen Consulting (one of the largest system integrators and at the time vendor of their own CASE tool) played a major role in the program in these later stages.

Our Suggested Framework Design for KBMS

The engineering of knowledge-based systems is a discipline which is closely related with Software Engineering. The term Knowledge Engineering is often associated with the development of expert-systems, involving methodologies as well as knowledge representation techniques. Since its early days the notion of "ontology" in computer science has emerged from that discipline, giving rise to Ontology Engineering.

Despite sharing the same roots, Knowledge Engineering is often regarded as a spin-off from Artificial Intelligence research. Its main goal is to structure the development and use of knowledge models. For that purpose, the most widely known Knowledge Engineering approaches (such as Common- KADS are based on the paradigm that knowledge should be represented in formal and explicit specifications (often called ontologies. Ontologies capture the semantics of the knowledge in a format that is intended to be both easy to maintain and efficient to process by reasoning algorithms (often called Problem-Solving Methods. The construction of both ontologies and Problem-Solvers is supported by various modelling methods, the phases and models of which resemble traditional Software Engineering approaches. By separating ontologies from methods it is hoped to enable reuse of both domain and reasoning knowledge. However, practice has to date not produced much evidence that this reuse is feasible on a large scale. Especially the formalization of knowledge without having an application domain in mind has shown to be hard (an issue often called the interaction problem [38]). Furthermore, the transitions between high-level conceptual models and the implementation platform are insufficiently supported [40]. Therefore, professional knowledge modelling tools are missing. For these reasons, methods from Knowledge Engineering are often too expensive to apply and – in contrast to approaches from Software Engineering –virtually not used in industry, even for the construction of knowledge-based systems [41, 39]. It is important to note that a common problem of works on software methodologies have is that it is hard to provide conclusive evidence or "proofs" that any given methodology fulfils its promises. Some of my theories must therefore be based on practical experience.

However, despite these apparent differences, research in both Software and Knowledge Engineering has independently led to many similar results. Both regard the object-oriented paradigm as the most suitable compromise between computational efficiency and human intuition. Furthermore, both have in recent years attempted to find standard languages that can be widely supported by tools. Finally, both agree on the need to iterate during the modelling process. Just like any object-oriented design usually goes through many revisions, knowledge models need to be changed and updated frequently. These observations are the starting points of the approach that we will be adopting. The communities of Software Engineering and Knowledge Engineering share a number of common topics. While Software Engineering research has been continuously striving towards a higher degree of abstraction and emphasizing software modelling during the last decade, the Knowledge Engineering community has been eager to promote several modelling approaches in order to realize the vision of the semantic web. With the advent of web-based software and especially web services, the overlap becomes even more evident. However, both communities mostly live in their own worlds.

A KBMS framework cannot be constructed in isolation. A KBMS should typically functions as a knowledge-intensive component in an IT environment. It is therefore important that clear links exist between KBMS development and other development activities. Over the past years the KBS methodologies have started to make this link by adopting as much as possible techniques and notations from the object-oriented community, in particular the Unified Modelling Language. For example, the Common KADS methodology uses many UML notations. Integration of a KBS is also feasible with the advance of component-based development frameworks. In such an approach a KBS can be integrated as a knowledge intensive component within a larger system.

The conventional system of mass production is not suitable for present turbulent markets as the customer needs are changing rapidly. For achieving this, manufacturing sector has been undergoing a shift from mass production to mass customization. For meeting, these market needs in less time a knowledge base is required to design the required components. If the component is similar, the parametric modelling technique is useful because it can be used where geometrical model changes frequently during the design process. While designing a product, the designer must draw upon different types of information related to the field of customer requirements. The design process must be carefully developed to generate the most suitable design recommendation. The customers around the world are expecting a unique product that combines quality, low price and delivery at right time. For minimizing the cost of the product, it may be sensible to focus on the design phase. The design will be focussing on conventional computer aided solid modelling design tools in order to minimize the time, cost and risk of design mistakes

While aligning completely with the idea of using CASE Tools and Object Oriented Modelling, the new design approach should adopt more of quality function deployment and shift completely to Knowledge Based Engineering as it is used for mass customization and it is one of the best technologies available for rapid design [42-44]. According to Du Yao et al. [19], the objective of KBE is to guide the designer who lacks experience towards the upmost design by declining the repeated design work. The application of Knowledge Engineering Techniques and Artificial Intelligence (AI) in the CAD became known as KBE [45, 41]. It has been observed that KBE produces the efficient output according to the recent research. With the advancement of KBE, the application of computer information technology in the design process is no longer a bottleneck to the designers [46]. Various forms of engineering knowledge are illustrated in Fig. 2.

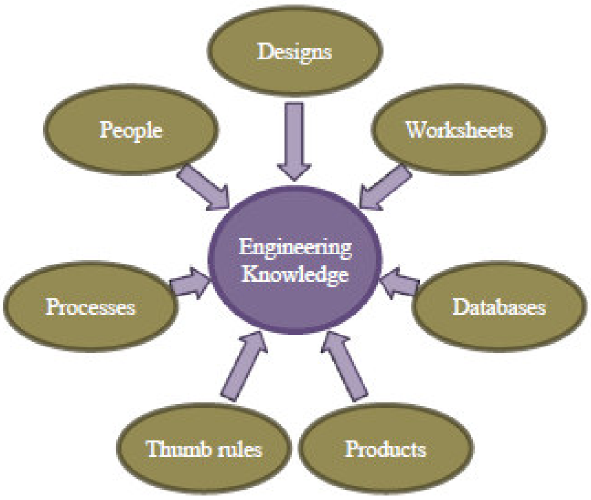

Figure 2 Forms of Engineering Knowledge

If we have to adopt our proposed idea of more quality function to KBE, then certain aspects of KBE needs modification as KBE absorbs wider skill set from modelling to programming and even artificial intelligence. In the recent development of business to business type in electronic commerce KBE attracted the focus light of researchers for further development. The inventor of World Wide Web Sir Tim Berners Lee's vision is to develop the next generation of internet called Semantic Web, enabling the potentiality for KBE for collaborative design to meet the customer requirements [48].

The need of the KBE is because of volatile, insecure, user unfriendly, disorganized present day market. Apart from the need, KBE is speedy, skilled, innovative and error-proof, these features are vital to the today's market. On the other hand, KBE has the ability to improve the collaborative design through knowledge management and as a result automation, maintenance and re-use techniques are further advanced. With these gains, KBE extended the range to Product Lifecycle Management (PLM) and Multidisciplinary design optimization. The scope of KBE comprises design, Computer Aided Engineering (CAE), manufacturing and support fields.

For nearly 20 years, KBE has been used in challenging design and engineering problems, mainly in automotive, civil engineering, aerospace industries. In the beginning, KBE approach has a successful, long running and high productive application for Boeing Company in generating geometry of stringer clips. However, no one realized the early promise of KBE in practice in those 20 years, since fully functioned KBE was missing even in the aerospace world where it has its high impact. Later, the companies such as ICAD, Wisdom systems encouraged the research and developed the special purpose AI hardware such as Symbolic Lisp machines. But extremely high cost hardware became a barrier for widespread of the technology.

Further, these developed systems geared towards expert systems. Later, with the support of independent software vendors KBE came down to approachable cost. With the advancements of fast and inexpensive computer memory KBE systems became as a commodity item. Angelo et al. [49] published the potentialities of knowledge-based engineering (KBE) methods in new product development by estimating the business value produced by a tool which combines the engineering groups of a large aerospace company. In the recent decade, World Wide Web with the association of HTML (Hyper-Text Mark Up Language), XML (Extensible Mark. Up Language), X3D (XML for 3D Models), KBE evolved as complementary to the traditional CAD systems. Finally, once this generic architecture has been built, it can be used as a pattern to construct a particular domain model by creating instances of the generic knowledge areas and writing specific vocabularies and knowledge bases. The proposed approach may be evaluated according to the potential capacities and drawbacks to support applications but engineering it for reuse and advanced user interaction support makes it unique.

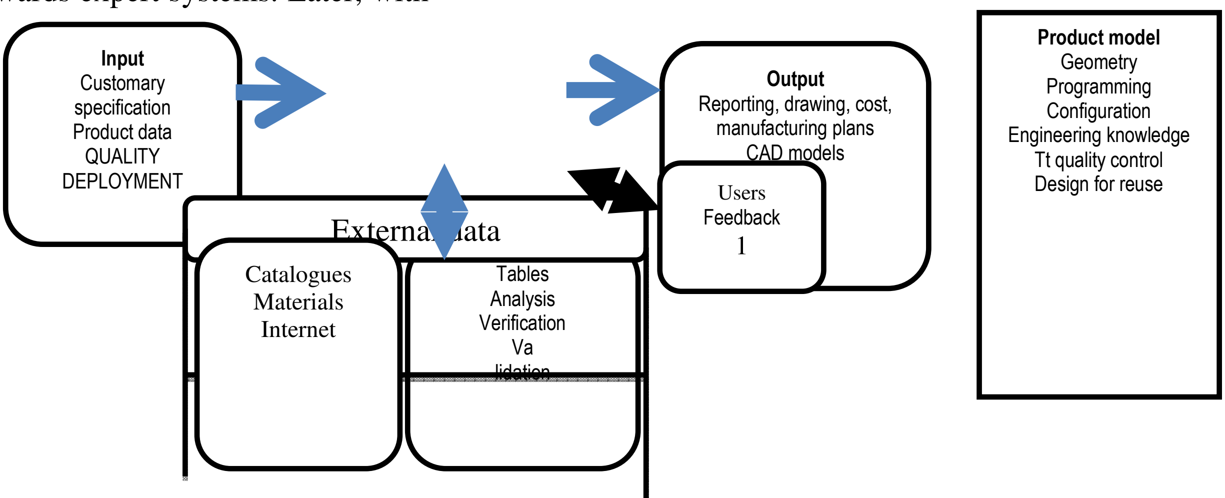

Figure 3 Proposed KBMS Model

Modification and Transformation rules tend towards Object Oriented

The modification rules that the KBMS used were different from the traditional rules for expert systems. The rules stood against specification and implementation languages rather than against facts in the world. It was possible to specify modification using patterns, wildcards, and recursion on both the right and left hand sides of a rule. The left hand expression would specify patterns in the existing knowledge base to search for. The right hand expression could specify a new pattern to modify the left hand side into. For example, restructure a set theoretic data type into code using an Ada set library. —The initial purpose for modification rules was to refine a high level logical specification into well designed code for a specific hardware and software platform. This was inspired by early work on theorem proving and automatic programming.

However, researchers at the Information Sciences Institute (ISI) developed the concept of *evolution transformations*. Rather than modify a specification into code an evolution transformation was meant to automate various stereotypical changes at the specification level, for example developing a new superclass by extracting various capabilities from an existing class that can be shared more generally. Evolution transformations were developed at approximately the same time as the emergence of the software patterns community and the two groups shared concepts and technology. Evolution transformations are essentially what we referred to as refactoring in the object-oriented software patterns community.

Dearth of Ideas

- Building and implementing KBE system takes a great deal of time, hardware, specialized skill and cost.
- KBE is becoming a black box as it produces some output with some input, but nobody knows what happens in between. This situation leads to the problem to transfer the knowledge to a new engineer in the department.
- Localized implementation of KBE has failed to register its impact on complete product development process.

Having said that we know that KBE has been successfully deployed in different disciplines and cross disciplines such as aerospace, automotive, medical devices, dental implants, commercial building systems, electronic enclosures, toys: In ship building domain for example, Ying-Han Wu et al. [50], H.Z. Yang et al. [51], Ryszard Arendt et al. [52] has developed a method for ship design using KBE, Jin-ju Cui et al. [38] applied KBE for optimizing the structural design of ship. In aerospace engineering domain, C.L. Emberey et al. [54] applied KBE to support engineering design application development, Jin-Woo Choi et al. [55, 56, 57], extended KBE approach for weight and cost estimation, Corallo et al. [58] used KBE for low pressure turbine design, La Rocca et al. [59] applied KBE for automating the wing body design, Feng Haocheng et al. [60], used KBE for developing KEACDE (knowledge-based and extensible aircraft conceptual design environment). In automotive engineering domain, Chapman et al. [61] developed rapid car design system using KBE approach. Ren´e Berndt et al. [39], Georgia et al. [53], Y.M. Deng et al. [62], Nicolas Gardan et al. [63], Y.E. Nahm et al. [64] used the KBE approach to design intelligent CAD system. S. Kumar et al. [65] extensively applied KBE for selection, design, and cost reduction of various dies. Bor Tsuen Lin et al. [66] extended the application of KBE by designing the stamping dies using Functional-Based Stack-Up Design System based on CATIA system. S. Kumar et al. [69], S.M. Sapuan [70], Mümtaz İpek et al. [71] has related KBE for material selection. In the research by Dongkon Lee [78] KBE is used as a safety control system, Sameer Kumar [72] applied KBE approach for safety and recall of food based products before they expire. Web-based collaborative design system was developed by Mohanbir Sawhney et al. [73] Chun-Hsien Chen et al. [74], Peijun Wang et al. [75], Dimitris Mourtzis et al. [76] for designing the products using KBE. Robart et al. [77] developed an integrated methodology as a concept for integrating the knowledge base and human-computer

Futuristic Design for KBMS and hope for new ideas

It has been observed that the maturity of KBE application concerns the requirements to identify, capture, structure, formalize and implementing the knowledge. But KBE platforms are supporting only the implementation but not KBE development process. For managing, safeguarding and upgrading the knowledge for development and maintenance of KBE system, a robust methodology needs to be associated. MOKA (Methodology and tools Oriented to Knowledge based Applications) is one of the best example for such concrete methodologies proposes solutions which focuses on capturing, structuring, formalization and implementation [79]. MOKA is a European research project that has been developed to serve as an international standard for KBE system development [80]. MOKA can be treated as a bridge between raw knowledge and KBE platform and it is the widely used methodology in automobile and aerospace industries. MOKA can be used to decompose and stock up the knowledge that can be linked to prearranged network of a problem domain to which users from various perspectives can relate. MOKA can present a framework for capturing and representing the knowledge. Developing lifecycle of KBE according to MOKA is given in Fig. 4.

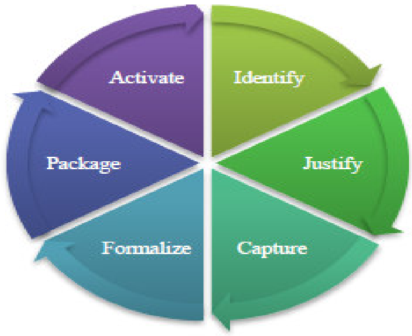

Figure 4 KBE Lifecycle

MOKA framework works at two levels: Informal level and Formal level. Informal level framework is simple and oriented towards representing and formalizing the knowledge in a language that can be understood by person who is not an expert in formalization language. In addition, informal level framework makes the acquired knowledge possible to validate. Further, this level creates a platform to share the views and opinions of the knowledge engineer, expert and software developer. Informal model proposes a realistic approach from human understandable knowledge to formal representation in a formal model. The informal knowledge facilitates to link back the original unrefined knowledge to the text documentation. An informal model is the interrelated collection of ICARE forms: Illustration, Constraints, Activities, Rules, and Entities. Knowledge associated to the composition of designed product and its designing process is collected in the form of forms. Illustration form signifies the general knowledge, description and comments. Constraint forms are used to reproduction interdependencies between entities. Activity forms can express crisis resolving steps in design process.

The modelling of organized knowledge can be allowable by Rules form. Entities forms are used for defining structure, function and behaviour of the product. The formal level framework creates the encoding form for represented and stored the knowledge into a computer [81]. Today, the formal language demonstration is an established area. In the field of engineering knowledge, the conversion of recognized demands in MOKA into ample formal knowledge representation is critical [82]. The transformation of informal model into a formal model can be done with UML (Universal Modelling Language) diagrams according to the rules specified in MOKA formal model [82]. Fig.5. illustrates the formal model framework.

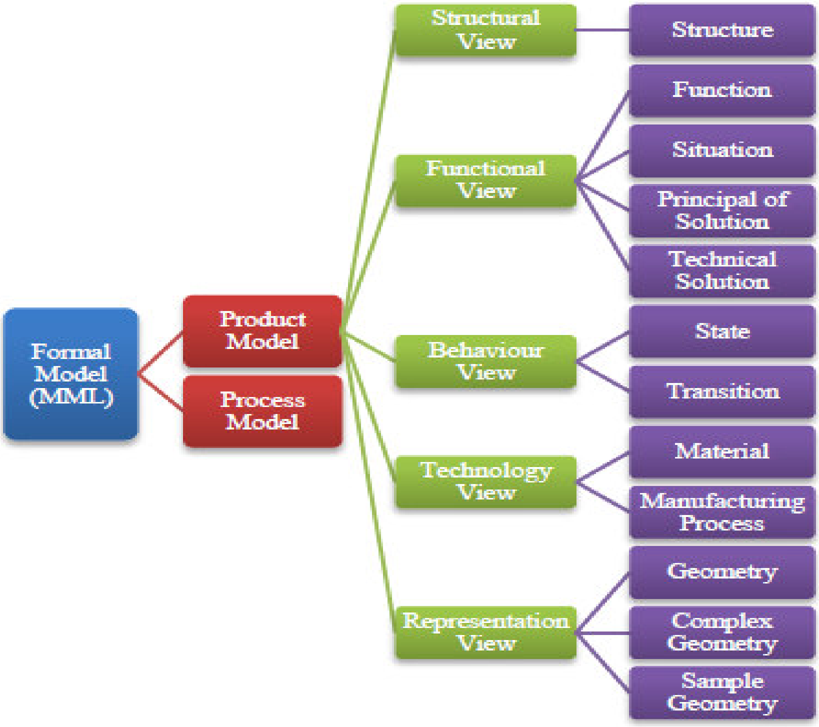

Figure 5 Formal Model

Apart from the above-stated models, MOKA not only illustrates the processes of recognition, acquisition, collection and management of knowledge but also summits the same to the computer program tool for realizing these tasks. PCPACK, a comprehensive tool developed by Epistemics, U.K., is also compatible for the creation of MOKA models. Similarly, some free open source ontology editors such as Protégé are also available for knowledge acquisition [82].

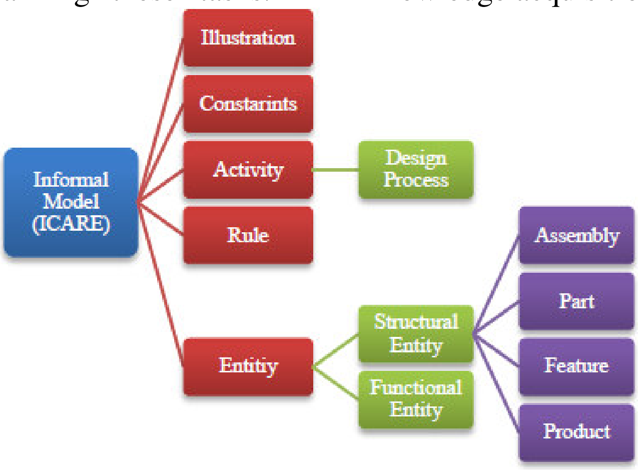

Figure 6: Informal Model

MOKA focuses only on supporting knowledge engineer but not the end user (even though end user is the typical domain expert who holds the knowledge); As MOKA is proposed as a neutral methodology the knowledge represntation mechanism and supporting tools are not completely acknowledged; MOKA is unable to consider the maintenance and re-use of knowledge. Another available KBE methodology is KOMPRESSA (Knowledge Oriented Methodology for the

Planning and Rapid Engineering of Small-Scale Applications) [83]. It focuses to support KBE implementation at Small to Medium Enterprises (SMEs). It covers the whole life cycle development of KBE by maximizing the client involvement based on the experience, and it is well known for its flexibility in application. It provided guidelines, instructions, formats, techniques and hints for analysis, design, modelling, implementation and documentation to represent, manipulate and manage the complex knowledge. DEKLARE (Design Knowledge Acquisition and Redesign Environment) project is a tool similar to MOKA pays attention to SMEs. In response to the missing ingredients of MOKA, the KNOMAD (Knowledge Nurture for Optimal Multidisciplinary Analysis and Design [80], Knowledge Optimized Manufacture and Design [67]) is developed for analytical utilization of multi-disciplinary knowledge within design and production areas. For improving the knowledge retention and application maintenance with the role of end user ***KNOMAD*** has integrated the knowledge representation with design process. Richard Curran et al. [67] acronym the ***KNOMAD*** as (K)nowledge capture (N)ormalisation (O)rganisation (M)odeling (A)nalysis and (D)elivery.

Conclusion

With the advent of the internet and continuous development of software and hardware, KBE approaches are enhancing their capabilities in capturing, reusing the knowledge across time and space. But still, the designers are not able meet the customer's desire because of many reasons. One of them is the knowledge management (KM) problem. KM is developed for capture and reuse of the domain knowledge to integrate the traditional engineering software with knowledge based applications. The reluctance among traditional CAD tool vendors is slowing down the evolution of KAD (knowledge-aided design) because of they fear of losing the market. But recently, few vendors are making the progress towards the development of KAD and that should be encouraged in large scale. Nevertheless, the lack of robust knowledge acquisition system still plague framework design even after the immense research and it has become one more hurdle for the progress of KBE system.

There is also a need in building the automatic knowledge acquisition tool. The mass collaborative product development approach demands faster knowledge accessing system but there is no dependable knowledge base available as the knowledge through the internet is not standardized. But according to recent studies, this can be handled with the rise of wikis. A wiki is a database which allows the users to interact and share the information through web pages. The group of designers can create the standardized knowledge base as global knowledge repository with the help of wiki. It is observed that KBE system became revolutionised with the inclusive of AI. But the compilers and editors for programming the KBE tasks are still complex for the designer as they are not professional programmers. This shortfall demands immense research on easy programming for compiling the KBE system. Additionally, research need to be done to make the software and hardware cheaper for KBE system as the available are affordable for the big companies only. Another shortfall with the present KBE system approach is from its methodologies. Even after the development of advanced MOKA and its enriched approaches, preparing the formal models is a complex task. This should be automated as an application for easy translation. Based on the review, it is observed that this area of research is still underdeveloped. Another shortfall with the present KBE system approach is it is getting developed as black-box application. In black box application, some output with some input will be produced but nobody knows what happens in between. This situation leads to the problem of transferring the knowledge to new engineer in the department as no one knows what exactly is going on in the process. Typical information systems deal with data while knowledge-based systems automate expertise and deal with knowledge. Every business in today's competitive world is full of uncertainty and risk. Managing and satisfying customers with quality product/services have become a real challenge. In this situation the knowledge-based Management system is wise choice for complete intelligent system that is compatible with the natural intelligent system in controlled fashion

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