Knowledge Management Systems Generic Architectures: Enhancing Uniformity and Inter-Operability of Technological Tools for Knowledge Management

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Abstract: Knowledge Management (KM) has come to be regarded as an important activity in today's organizations. Technology plays a crucial role in KM of facilitating knowledge flow through the knowledge life cycle. This role is mostly realized by the implementation of a Knowledge Management System. However, the development of these systems is still haphazard, as organizations implement systems that are not guaranteed to enhance knowledge processing activities, and which may not be knowledge management systems at all. Most of these systems are groups of technologies brought together, with no theoretic and/or conceptual framework to justify the way in which they are integrated. The various forms of knowledge are not handled appropriately, as there is no distinction between the processes involved in managing these knowledge forms in the systems. Hence knowledge distribution and use is not done consistently, efficiently, and effectively. There is therefore a need for a reference point from a technical perspective, emanating from a theoretic and conceptual framework that will guide in developing these systems. This reference point is best provided in the form of a generic knowledge management system architecture, which will guide all technological implementations for KM. This paper seeks to outline the need for a generic knowledge management system and what is to be taken into consideration in terms of technical as well as organizational objectives when developing it. The paper also presents some of the quality attributes to be considered in developing the architecture, and the technologies that can be incorporated.

Keywords: Knowledge management systems, generic architectures, system models, technology models

1. Introduction

Knowledge Management (KM), a discipline viewed by many academics as cross-functional and multi-faceted (Lee H, Choi B, 2003), has come to be regarded as the driving force behind some of the world's largest and most successful organizations. Although it is still a young field (Kumar S, Gupta S, 2012) (G, Kebede, 2010), it is increasingly becoming important to corporate competitiveness (Sucahyo R, Eriyatno, Suroso I A, Affandi M. J, 2013). All these disciplines that make up KM can be classified under the four pillars of KM, namely Leadership, Organization, Learning and Technology (Stankosky M.A., 2005). KM is expected to lead to fundamentally new and never before possible ways of knowledge processing through the Knowledge Life Cycle (KLC) and leveraging knowledge about people and the organization (Galandere-Zile I, Vinogradova V, 2005) while having the ability to move knowledge in all directions throughout an organization (Bixler H. C, 2005). The adoption of KM has been necessitated by drivers that include (Bixler H. C, 2005):

- technological advances which have improved knowledge processing and storage,
- clients' increased expectations for quality products,
- the need for continuous innovation due to increased competition for market share.

Organizational elements such as strategy, culture, processes and measurement are regarded as important for a successful implementation of a KM solution (CEN, 2004). Technology, which is equally important as the other stated factors, makes up a part of a KM initiative (Kumar S, Gupta S, 2012). Technology is primarily viewed as an enabler in KM solutions (Stankosky M. A, 2005), it enables knowledge sharing, integration, and collaboration (Mickey R. V., 2005) through the implementation of an organization-wide knowledge management system (KMS). Combined with organizational processes, it can bring people together for knowledge creation (Lindvall M, Rus I, Sinha S S, 2002). A KMS is an IT system that supports processes and activities encompassed in the knowledge life cycle; these processes are basically dependent on the assistance of IT (Tseng S, 2008). Since they are IT systems, KMSs are thus key enablers for a KM initiative (Huang C, Lin T), which support the codification approach, personalization approach, or a hybrid of the two. The development of these systems has evolved from the initial codification-intensive approach, to including more technologies to support knowledge personalization (Matayong S, Mahmood A K, 2013). Codification approach deals mainly with explicit knowledge and how it can be stored and transferred. The personalization approach is largely concerned with tacit knowledge and enhancing interactions between humans for tacit knowledge transfer. Effective use of a KMS could lead to achieving enhanced effectiveness, facilitate innovation and improve efficiency and competence, as the system will provide a pipeline for the flow of knowledge across the organization (Heejun, P, 2005).

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In like manner, these systems create the bridge between the social structures of an organization and the IT, allowing for a synergistic relationship (Kumar S, Gupta S, 2012). More so, KMSs create an access channel that facilitates human interactions and assists in locating experts for direct transfer of tacit knowledge (CEN, 2004) (Kumar S, Gupta S, 2012) for knowledge production, effective decision making and problem solving (Kebede G, 2010).

Defining a KMS is made difficult by the different interpretations in various scientific communities (Lindner F, Wald A, 2011). A KMS is defined in numerous ways, including but not limited to:

- It as an integrated multifunctional system that can support all main knowledge management and knowledge processing activities found under the knowledge life cycle (Sultan A. O, 2003).
- It can be thought of as a network of contextual data and documents linked to directories of people and skills and providing intelligence to analyze these documents, links, employees' interests and behavior, as well as advanced functions for knowledge sharing and collaboration (Galandere-Zile, Vinogradova V, 2005).

These definitions show that KMSs are interpreted differently from one academic to another, with practitioners also adding in their own voices into the debate. But fundamentally, whatever the definition and/or structure of a specific KMS, they are all responsible for the processing, production and integration of knowledge throughout the knowledge life cycle (Firestone J, 2001). In this regard, a poorly developed KMS leads to poor knowledge processing activities, which inadvertently lead to poor performance by the organization at large. To counter the development of inappropriate KMSs, the study of KMS' architectures has to be undertaken since the latter is the foundation of any software system (Clements P, Kazman R, Klein M, 2001) and this architecture will form the basis upon which most, if not all, KMSs will be developed.

Clements et. al, (Clements P, Bachmann F, et. al, 2011) define software architecture as a "set of structures needed to reason about the system, which comprises of software elements, relations among them, and properties of both". A software architecture is the most abstract depiction of a system (Clements P, Kazman R, Klein M, 2001), which provides the structural foundation of the system, to ascertain that it meets system requirements and has the quality attributes desired to meet organizational goals (Kazman R, Klein M, Clements P, 1999). There are various types of software architectures being implemented today, with the commonly used ones being, among others: Software Oriented Architecture (SOA), client-server, and web services. These modern architectures can be considered in the development of knowledge management system architectures, to increase interoperability of the knowledge management systems with modern systems. In essence, a software architecture is the blue print of the system. KMSs need this blueprint. They have been developed without a main point of reference and the various definitions and lack of theoretic foundation of what a KMS should be like has made it difficult to come up with this reference point. This shows the need for coming up with a reference architecture for KMS, from a technological perspective, to aid both academics and practitioners alike in developing and working with KMSs.

Questions have been raised over the effectiveness of Information Technology (IT) in increasing knowledge transfer between individuals and/or groups (Maryam A, Leidner D E, 2001). It is the opinion of the authors that IT provides a technical foundation that facilities the implementation of KMS. It provides a means by which a strong theoretical foundation for KM can be implemented, as it participates in all stages of the knowledge life cycle. The study and development of a generic KMS architecture can lead to the creation of a tried and tested basis on which information technology can be confidently used for KM.

2. Components of a KMS Architecture

Developing an effective KMS for a comprehensive approach to knowledge processing requires the integration of many technologies (Galandere-Zile I, Vinogradova V, 2005), since no single technology can do it alone. This means that those tasked with developing these systems have a good understanding of how these technologies work together, and appreciate that developing the system is not an easy undertaking (Galandere-Zile I, Vinogradova V, 2005). The dynamics of the market for knowledge management make a classification of KMS preliminary and difficult (Galandere-Zile I, Vinogradova V, 2005), but knowledge management technologies can be described under three levels (Gallupe B, 2001):

- Level 1 is the knowledge management tools, which provide the fundamental building blocks for a knowledge management system.
- Level 2 are knowledge management system generators that can be used to build the KMS' subsystems.
- Level 3 are the specific knowledge management systems that have been built.

The technologies that were found in literature studies that are used in coming up with a KMS include (Bixler H. C, 2005) (Kevin O, 2005):

- enterprise collaboration system,
- knowledge database,
- business development knowledge and information systems,
- the internet, intranet and extranet,
- data warehousing,
- document/content management,
- decision-support systems,
- knowledge agents (people, computers),
- electronic performance support systems,
- artificial intelligence,
- electronic meeting systems,
- groupware to support enterprise collaboration,
- Knowledge-based computer-aided design tools for developing new products.

Knowledge Management Applications (KMAs) can also be developed and used, whose intention would solely be for knowledge processing, with attributes that are tailor made to suit their operating environment, but having a common back-end interface with other KMAs (Personnel, United States Office of, 2011) for easy maintenance as well as for inter-operability of the various KMAs of the KMS.

It is also important to use and experiment with the latest multimedia technologies to capture knowledge, especially tacit knowledge (Schubert D, Romberg O, Kurowski S, Gurtuna , Prévot A), as such technologies have the capabilities of handling knowledge in many forms from various media, which eliminates the need for knowledge conversions. However, it should be noted that a KMS should not be developed on the basis of having the best leading-edge technologies and information systems because this does not guarantee use and effectiveness (Bixler H. C, 2005). Instead, the technologies that are used for a KM initiative should be supported by a KM framework that governs the whole KM initiative in the organization (Bixler H. C, 2005).

The technological tools used for KM are meant to support the interaction and collaboration of knowledge workers (Heejun P, 2005) and to achieve this they should provide a good conceptual basis, go through practical testing and should be well-adapted for the various business environments they operate in (Agreement, CEN Workshop, 2004). Their integration into a KMS should provide value to the organization (Bixler H. C, 2005):

- Through knowledge distribution to those who need it for improved performance and problem solving.
- By enhancing innovation through the improvement of knowledge creation processes and product development support.
- Through continuous improvement of products and processes.
- By protecting knowledge from loss through worker turnover and/or attrition (Heavin C, Frederic A, 2012).

It is difficult to draw the line between information systems' technology and tools for KM as the boundary is fuzzy (Lindvall M, Rus I, Sinha S S, 2002). Information management tools are a subset of knowledge management tools (Kebede G, 2010), as knowledge builds on top of information. However, there is still need to differentiate between knowledge management tools and information management tools, as some of the technologies classified as KM technologies are not necessarily such. For instance, vendors tend to describe search and retrieval functions of their systems as knowledge capabilities, creating the deception of knowledge management, use and retrieval (Firestone J, McElroy M W, 2005). Knowledge management tools are capable of handling the context and richness of the information and not just the information itself (Gallupe B, 2001). If a technology merely handles information without having some form of meta-claim to help in contextualizing it, is incapable of differentiating between information and knowledge and/or does not enhance knowledge sharing, then it is an information management tool (Firestone J, McElroy M W, 2005).

Kebede (Kebede G, 2010) gives a detailed analysis of the knowledge hierarchy, which is a continuum from data to information to knowledge, following each other in that order. Through literature research, Kebede shows the differences among data, information and knowledge as follows (Kebede G, 2010):

- The relationship between the three is hierarchical, with data being elementary and/or crude facts, information being data that has meaning attached to it, and knowledge being information coupled with experiences, insights, beliefs and expertise.
- The manifestations of the three is logically incremental with data becoming information, and information becoming knowledge. The higher level manifestation is also inclusive of the one below it, hence knowledge is inclusive of both data and information.
- Data and information require knowledge for their interpretation and understanding.
- It has to be noted that information and data management are important pillars for KM.

This analysis helps in breaking down the differences and natures of the three elements (data, information, knowledge) that make up the knowledge hierarchy.

3. Managing Different Forms of Knowledge

The content to be managed by a KMS is very important (Galandere-Zile I, Vinogradova V, 2005) and should be taken into consideration when developing such a system. Knowledge, the content of a KMS, is categorized into three types: explicit, tacit, embedded [14]. Explicit knowledge is that which can be codified and stored in databases to become organizational knowledge; tacit knowledge is that knowledge that cannot be stored in repositories, but exists in the brains of knowledge workers (Lindner F, Wald A, 2011) and embedded knowledge is that which is locked in processes, products and structures and is difficult to understand and modify. One can argue that embedded knowledge is simply a subset of tacit knowledge, hence setting tacit and explicit knowledge as the main categories of knowledge. While explicit knowledge has been the main focus of information systems in organizations, KMSs seek to give equal affordance to all types of knowledge. However, a bias towards tacit knowledge management should exist to allow for the creation of a balance in the methods and technologies used in managing the different forms of knowledge.

Many authors view IT's role in KM as being largely related with knowledge combination (Lee H, Choi B, 2003), that is, the conversion of knowledge from explicit to explicit. However, with the advancement in information technology and data processing technologies (Tseng S, 2008), IT can now be involved in the socialization, externalization as well as internalization stages of the SECI model as given by Nonaka and Takeuchi (Haslinda A, Sarinah A, 2009) (Kebede G, 2010). Figure 1 shows a few examples of technologies that can be used for KM at each stage of knowledge transformation in the SECI model, illustrating how technology has gone beyond merely facilitating knowledge combination, to encompassing the whole SECI model. This means that the use of technology for KM can now cut across many forms of communication and knowledge distribution that were once difficult to use and implement from a technological perspective. IT is also an integral part of knowledge codification as it provides fast feedback for explicit knowledge and it is not limited to transfer of explicit knowledge only, but is also integral in knowledge creation (Lee H, Choi B, 2003).

To give a practical view to the management of knowledge, the knowledge should be viewed from its nature, which includes dimensions such as (Supyuenyong V, Islam N, 2006):

- Characteristics - that is, explicit or tacit
- Location – is it individual or collective knowledge
- Source – is it internal or external
- Knowledge Transfer – Whether it can be easily moved from one device or location to another.

Managing tacit knowledge is becoming more and more important because of the following reasons, among others (Nabeth T, Angehrn A, Roda C, 2003):

- Organizations are continuously changing and time for knowledge codification is becoming scant. More so, explicit knowledge is becoming obsolete too rapidly to justify the need for knowledge codification.
- Some of the knowledge is difficult to codify, especially that involving intangible factors such as insights, beliefs, perspectives and emotions.
- Knowledge codification may face resistance from the people themselves, who may consider their knowledge as their asset to guarantee their position in the organization.
- Tacit knowledge is important for the learning organization since it is part of a spiral-type interaction between tacit and codified knowledge.

Due to various barriers in the transfer of tacit knowledge, such as lack of time and resistance from workers to share knowledge (Schubert D, Romberg O, Kurowski S, Gurtuna , Prévot A), there is need to embed the components that make up the KMS directly into the day-to-day activities of the knowledge workers. It has to be noted that some information loss occurs as a result of conversion of tacit knowledge into explicit knowledge in IT systems (Agreement, CEN Workshop, 2004). This is inevitable as some tacit elements of knowledge cannot be made explicit (that is, codified) and conversely.

The differences between information and knowledge have to be well articulated to avoid having KM initiatives that are just but information management solutions. The distinction between the two cannot be obtained by using a purely formal (scientific) approach, as is the case in computer science (Ulrich F, 2001). However, the complete exclusion of information in KM is not possible, as information adds value to knowledge and conversely, therefore a KMS should support the integration of knowledge with information (Ulrich F, 2001).A KMS should also provide various perspectives on the knowledge it stores, with different levels of details and also using corresponding languages and abstractions. This enables it to support different users and tasks (Ulrich F, 2001).

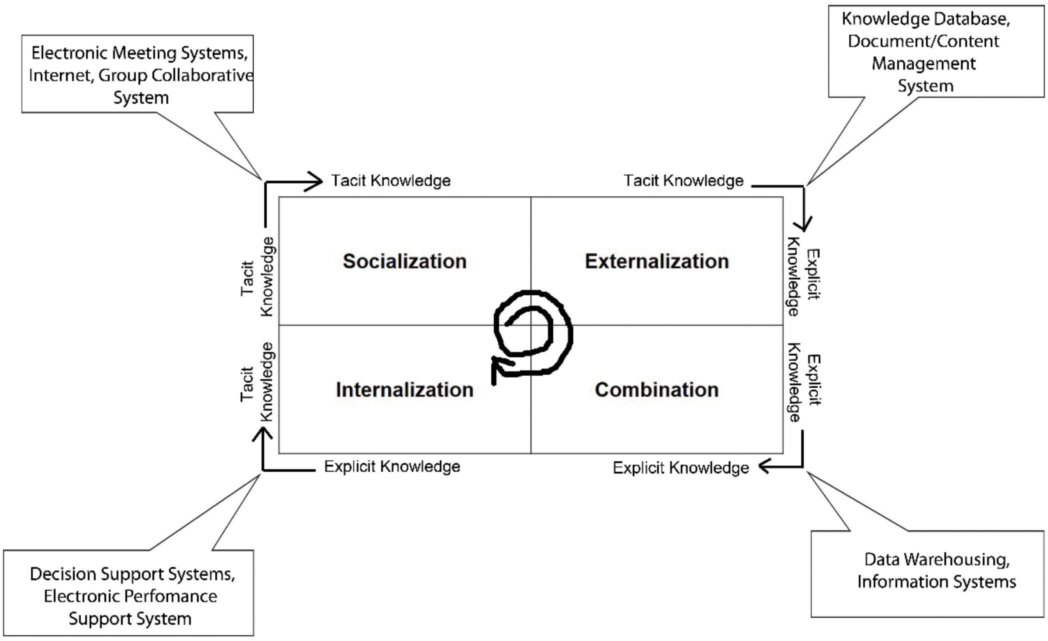

Figure 1 Examples of Technologies used during knowledge transformation in the SECI Model

4. Creating an Environment for KM through a KMS

The creation of an effective environment for knowledge creation and use augments greatly on the success of an organization and the KMS is meant to be part of this enterprise-wide KM framework, which includes the social structure of the organization, tools and processes (Galandere-Zile I, Vinogradova V, 2005). Technology facilitates KM through enhancing knowledge transfer and broadening its reach, and it has to allow for the handling of complex relationships and networks and not limited to individual knowledge elements (Galandere-Zile I, Vinogradova V, 2005). It is thus expected that technology creates networks that connect all the knowledge elements for effective and efficient knowledge distribution and use.

Choosing the right KM technologies for given business contexts and using them effectively are key factors in getting a higher return on investment, and this can be achieved by reviewing the specific roles of each of the technologies (Heejun P, 2005). However, too much emphasis on technology while overlooking other important areas such as leadership, and organizational structure can lead to a failed KM initiative (Heejun P, 2005). This is because other areas such as social structures of an organization have an impact on technology selection and hence should be considered in setting up a KMS (Heejun P, 2005) because technology should enhance knowledge sharing, capture of explicit knowledge within and outside the organization (Vittal A, 2005) and should provide an environment for continuous process and product improvement (Bixler H. C, 2005). KMSs are more successful if mediated by human behavior

(Heejun P, 2005) and also if they are implemented in relation with the size of the organization (Kevin O, 2005), as the latter has a strong bearing on the system's success.
Embedding KM activities and/or processes into the technologies used by workers to do their jobs is an approach that offers the most potential for creating a knowledge productive environment, as KM will no longer be a separate activity, but one that does not require additional time and motivation, other than that already required to do a particular job (Firestone J, McElroy M W, 2005). This in essence suggests that a KMS should be built upon existing job activities and structure while at the same time highlighting to stakeholders the role of knowledge in the processes they are a part of (CEN, 2004).

Technology should not reduce the richness as well as overshadow the role of and need for personal interactions of knowledge workers, as this is one of the best learning methods (CEN, 2004). Instead, it should rather facilitate such interactions and add ancillary services that knowledge workers can use during these and other related interactions.

5. The Knowledge Life Cycle, Processes and the KMS

The main goal of KM is to enhance knowledge processing in an organization by leveraging knowledge production activities already in place through implementing policies and infrastructure (Firestone J, McElroy M W, 2005), which include the use of technologies via a KMS. Through KM, information technology is viewed as of particular importance in controlling processes of change and development in an organization (Allahawiah S, Al-Mobaideen H, Nawaiseh K, 2013). KMSs, through knowledge processing, can enhance organizational processes and activities (Kumara A, Guptab P C, 2012), leading to a trickle-down effect, which would be seen through changes in worker effectiveness, the bottom line, and knowledge workers' relationships (Firestone J, McElroy M W, 2005).

Knowledge processing can be broadly divided into two forms – distributive and collaborative, with each having its own set of objectives in supporting various knowledge processes (Heejun P, 2005), which are in turn encompassed under the knowledge life cycle. Technologies for distributive processing mainly focus on information storage and retrieval of explicit knowledge, while those concerned with collaborative processing facilitate human interactions which involve tacit knowledge (Heejun P, 2005).The knowledge activities to be supported by a KMS include planning, scheduling, product and process design, decision making, product and service optimizations, data interpretation, among others (Bixler H.C, 2005).

The knowledge life cycle (KLC) includes the following knowledge flow paths, namely: (Rahman S A, Bhardwaj A, Pathat M, 2011) (Lindvall M, Rus I, Sinha S S, 2002): creation/acquisition, storage/formalization, organization, transfer, use, and creation/acquisition again. A KMS should support knowledge flow through the KLC (Lindvall M, Rus I, Sinha S S, 2002), as the latter embodies activities that govern knowledge processes. Information technology competency has a direct effect on the processes of knowledge management (Hawajreh K M, Sharabati A A, 2012) hence a KMS should support knowledge work processes and not the other way round. This is because KMSs should help in decision making concerning the work activities of its users (Galandere-Zile I, Vinogradova V, 2005), thus ascertaining the role of IT as an enabler, through the use of a KMS. Figure 2 illustrates how technology, through a KMS, facilitates knowledge processing from an entity (human being, computer system, department etc.) and into and out of the knowledge life cycle. The connection between the entity and the knowledge processes is made possible through the use of technology, allowing for knowledge to be processed at any stage in the knowledge life cycle that the entity so desires.

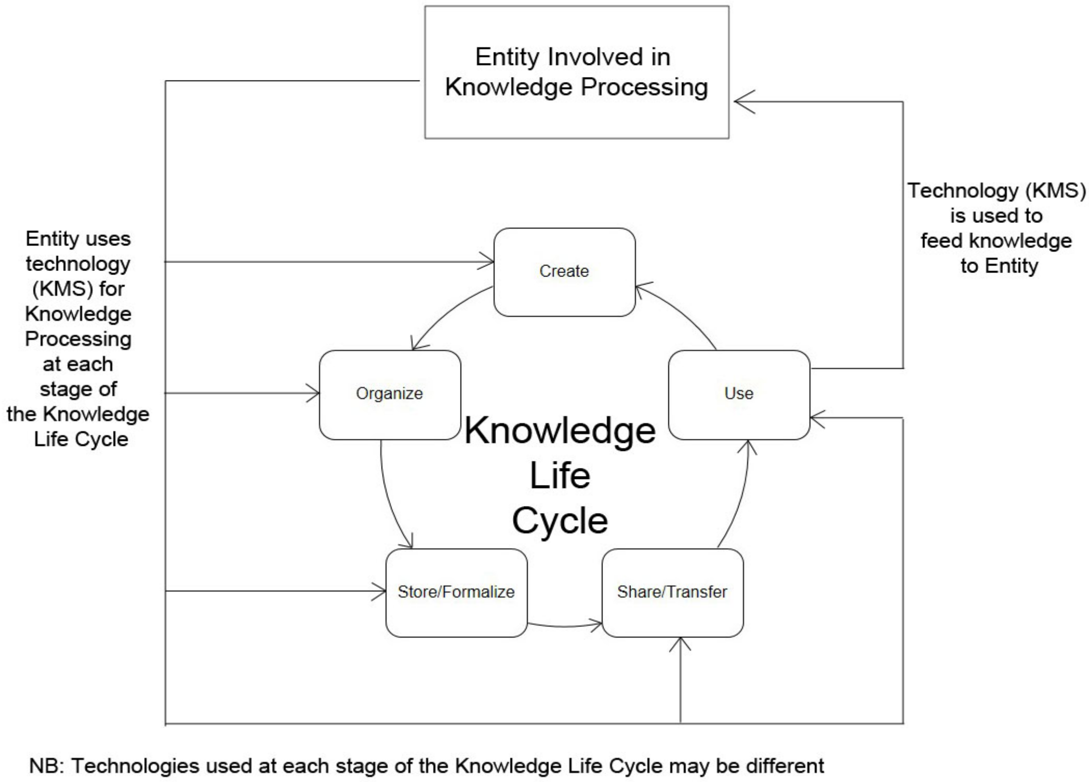

Figure 2 Technology facilitates knowledge flow and processing through the KLC and back to the Entity involved in knowledge processing.

6. Shortcomings of KM Research in Developing KMSs

While most organizations are looking for a well-structured, consistent approach to KM for it to be meaningfully and successfully implemented (Rahman S A, Bhardwaj A, Pathat M, 2011), the discipline still lacks research, study and clarity in some areas, for instance, knowledge creation systems (Gallupe B, 2001), thus hampering the development of effective KMSs that can interact well with the other enablers to produce an effective KM solution for the organization. This highlights the need for a formal approach to KM (Heavin C, Frederic A, 2012). This section outlines some of those areas that are still lagging behind in the study of technologies for KM, how they affect the development of KMSs and how they can be enhanced to assist in coming up with a generic KMS architecture.

The study of generic KMS architectures has been necessitated by a need to come up with a conceptual and theoretical construct for technology's role in KM (Dwivedimy K, Venkitachalam K, Sharif A M, Al-Karaghouli W, Weerakkody V, 2011), to concretize the findings of anecdotal data, case studies and stories (Mickey R.V., 2005), and to eliminate the structural and conceptual vacuum that exists in the field. Despite a number of studies being done on KMSs, there seems to be lack of a structured approach to the growth of the knowledge body in the area of KMSs and a framework guiding KMS research is non-evident; although frameworks, models and theories are being developed but struggling to gain acceptance (Gallupe B, 2001). There is also a lack of research looking directly at the impact of information technology on KM processes (Allahawiah S, Al-Mobaideen H, Nawaiseh K, 2013). This may be due to a deficiency in studies taking a broader view to include the whole process of KM (Matayong S, Mahmood A K, 2013). A lot of research on KMSs focuses on examining predictable factors that are pre-determined, resulting in scant studies on KM issues concerned with exploring how the factors affect the development of theoretical models for KM (Matayong S, Mahmood A K, 2013). There is therefore a need to look into the theoretic aspects that will create the fundamental basis to justify the use of IT for KM in whatever way deemed fit for the organization, as well as to create a method by which technologies for a KM initiative are chosen. The measurement of knowledge itself is still in its infancy, with an expectation to improve as the discipline of KM matures (Kumar S, Gupta S, 2012).

In addition, the dynamics of the market for knowledge management systems have made it difficult to present a typical architecture of KMSs and/or to provide a comprehensive list of its functions (Galandere-Zile I, Vinogradova V, 2005).

To avoid mediocre and inappropriate systems that may not be KMSs at all the scientific community is tasked with producing a framework by which a KMS can be developed, with evidence that it will perform as expected once implemented. The market will then be guided by the framework, which will form a reference point to justify the structure of the KMS, hence increasing the success rate of the system's implementation. This therefore creates an environment where science provides the basis upon which the market's needs in terms of a KMS are met. The generic KMS architecture is meant to be part of this framework, which seeks to eliminate the morass surrounding the suitability and worth of a KMS' implementation.

More so, very few studies that investigate KMSs use quantitative techniques such as surveys or field experiments as most use case studies or conceptual arguments to make their points (Gallupe B, 2001). This has been as a result of lack of a clear cut definition on what a KMS is, hence conducting such empirical studies from a quantitative perspective has been a challenge. Due to a lack of a reference point on which all studies can be evaluated and compared, quantitative research is still not deterministic of success or failure, but merely shows numbers concerned with a KMS implementation. A generic KMS architecture aims to provide this reference point that will form the basis for any study and or development of such a system. However, this does not undermine the value of qualitative analysis of KMSs, which will continue to play a critical role in the development of KMSs. It has been used extensively in measuring KMS' effectiveness in the form of soft measures and will continue to be important as KM is an inter-disciplinary field, with various perspectives requiring varying forms of analysis.

There is also no consensus on how a knowledge management system should look like and how they should be classified or categorized, and there is no clear cut direction in which the corresponding research should be directed (Ulrich F, 2001). This lack of a classification criteria for KMSs has resulted in technological tools being taken as universally applicable to any situation and environment (Birkinshaw J, Sheehan T, 2002), making it difficult to develop contextually appropriate systems using the right technological tools. Little research has also been done on tools and technologies that focus on new or unique problems as there is need for KMS to not only identify and work with existing problems but to identify new problems even before they arise (Gallupe B, 2001).

Current knowledge management systems have also been found to be too narrow as they cater for one type of user using one method of knowledge representation, and they require long learning curves, hence difficult to use (Sultan A. O, 2003). This may have been caused by the large amount of research done on KMSs focusing on knowledge codification and storage (Gallupe B, 2001), leaving the other areas of the knowledge life cycle under studied hence poising a great challenge for the analysis of KMSs. This issue can be addressed through multi-perspective modelling, which enables the modelling of particular aspects of knowledge through the use of a number of techniques that model specific aspects most appropriately, as organizational knowledge is quite complex and no single method can model all of it accurately (Abdullah M S, Benest I, Evans A, Kimble C, 2002).

More so, no system operates independent of others and a KMS is no exception. However, integration with other technological systems in the organization is one area which is still being performed poorly (Durant-Law G, 2003). To improve on integration of technologies in forming a KMS, the architecture by which the system is developed has to be carefully developed, and with no basis upon which such an architecture is developed, there exists the chance for a poorly integrated system to be developed. This necessitates the study of the inter-operability of technologies for a KMS, which is best done from an architectural perspective. In essence, this makes the development of a generic KMS architecture a necessity, as it will demonstrate how technologies should be fundamentally integrated to make a KMS.

To address these issues, there is need for collaborative work among researchers, as there are many non-collaborative efforts with regards to KMS in particular (Dwivedimy K, Venkitachalam K, Sharif A M, Al-Karaghouli W, Weerakkody V, 2011). Figure 3 shows how the generic knowledge management architecture fits into the development hierarchy of a KMS. A complete picture of the KM initiative has to be obtained from research, which leads to the development of a theoretical framework on which the generic knowledge management architecture will be built. The generic knowledge management architecture then becomes the reference point from which KMSs are developed and evaluated, hence creating a common point from which to determine the characteristics as well as the effectiveness of a KMS implementation.

<table>
<tr><td>Development of a KMS Architecture</td><td>Formal Evaluation of the Developed KMS Architecture</td><td>Implementation of KMS</td><td>Evaluation of Effectiveness of Implemented KMS</td></tr>
<tr><td colspan="4">Generic Knowledge Management System Architecture (GKMSA)</td></tr>
<tr><td colspan="4">Theoretic Framework for Knowledge Management Systems</td></tr>
<tr><td colspan="4">Holistic View of Knowledge Management</td></tr>
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Figure 3 A Bottom-up Layered Approach to the development of a KMS and the role of the GKMSA in the development of a KMS.

7. Generic Knowledge Management System Architecture (GKMSA)

The first design artifact that addresses quality attributes of a system is the architecture (Bahsoon R, Emmerich W, 2003). The KMS architecture should exhibit certain qualities that renders it able to deliver its expected objectives. Quality attributes can be in the system realm and/or the software realm and how they will be met has to be well illustrated in the architecture developed. The success of a KMS is partially depended on the extent of use, which itself is tied to the quality of the system, the quality of the information and the usefulness of the system in carrying out knowledge-related activities (Maryam A, Leidner D E, 2001). A system that is of low quality in terms of its construction as well as implementation will not produce optimum performance that can be beneficial to the user. In this case, a set of technical requirements and benchmarks can be produced that will be used in ascertaining the efficiency and effectiveness of the system. By developing a GKMSA, these benchmarks which are the quality attributes and how they are met in a software architecture of a KMS, can then be applied by any organization, in any environment, to aid in implementation of an optimum KMS solution.

8. Characteristics/Quality Attributes of a KMS

KMS requirements can only be gathered if we know how a KMS should be and how the initiative will be implemented (Sultan A. O, 2003). There may be need for a customized KMS for an organization if it fears that the use of a standard market solution threatens the sustainability of its core competences (Galandere-Zile I, Vinogradova V, 2005). The following section details the requirements and /or quality attributes of a KMS that have been found from literature studies. They are all not meant to work together in one system but are provided here together since the goal is to come up with a GKMSA.

A successful knowledge management architecture must have the quality attributes of availability, accuracy (in retrieval), effectiveness (useful and correct) and accessibility (knowledge should always be available) (Rahman S A, Bhardwaj A, Pathat M, 2011). Alkadi (Sultan A. O, 2003) lists the characteristics of an effective KMS as follows:

- Scalable: should manage to support a large number of users;
- Extensible: expands per organizational needs;
- Secure: to protect the organization's intellectual capital;
- Collaborative: should support the interactions of the various organizational units across the organization;
- Complex querying capabilities;
- Flexible: should be able to handle all possible forms of knowledge used and required by the organization, and that include different subjects, structures and media.
- Heuristic: The KMS should learn about its users and the knowledge it possesses as it is used and its abilities to provide users with knowledge should improve (Sultan A. O, 2003).

A KMS should support the dissemination of knowledge by allowing for users to know when information they might be interested in becomes available (Ulrich F, 2001).Lindgren et.al (Lindgren R, Hardless C, Pessi K, Nuldén U, 2002) conducted literature review and a field study research of KMSs and found that KMS evolution is a key quality attribute for a successful KMS implementation and use, and more attention and research should be done into KMS evolution.

Knowledge Management Systems with a deeper understanding of the users through user identity personalization can become virtual companions of users, rather than being mere tools (Nabeth T, Angehrn A, Roda C, 2003). This can be achieved by a system that anticipates user needs, proposes knowledge objects that the user might not be aware of, suggests and provides solutions, advises and creates opportunities for knowledge creation through learning (Nabeth T, Angehrn A, Roda C, 2003).

9. Development Process of the Generic KMS Architecture (GKMSA)

Acceptance of IT implementations for KM plays an important role in ensuring their use and success (CEN, 2004), as IT is only one aspect of a KM initiative (Kumar S, Gupta S, 2012). IT alone is not adequate for a comprehensive and successful KM initiative (Lindner F, Wald A, 2011) as it has to work with other factors such as culture, motivation, and morale. It is therefore important to involve all stakeholders in the development process of the KMS architecture, to engage them in the design so as to have their buy-in as well as their needs catered for from the beginning (Heejun P, 2005) (Allahawiah S, Al-Mobaideen H, Nawaiseh K, 2013). This can be done through software architecture development methods such as the Architecture Trade-Off Analysis Method (ATAM) (Wood M, 2003). ATAM takes the viewpoints of all stakeholders in the development process of an architecture, taking into consideration their needs and concerns. The stakeholders include business management team, system users, customers, consultants among others, depending on the nature of the organization. This method allows for trade-offs to be made when the requirements of different stakeholders conflict, resulting in a system that satisfies the needs of the stakeholders. Since it is not expected that everyone in the organization will adapt to KM initiatives instantaneously, the KMS can be introduced gradually, concentrating on well-focused groups and manageable groups and/or departments, hence necessitating incremental development of the system (Agreement, CEN Workshop, 2004). At each incremental step of development, an iterative development process should be adopted, going through requirements, architecting and validation repeatedly (Bahsoon R, Emmerich W, 2003). This gradual, incremental development of the system is best aided by the adoption of enterprise architecture techniques, which allow for the analysis of the system to be adopted in relation to the business strategy as well as the currently existing systems in the organization. The TOGAF standard, and similar standards can be used to guide this process, as it gives a high level framework for the development of architectures focusing on business, applications, data, and technology. This avoids dissociating the eventual KMS from the overall organizational strategy and from being incompatible with the rest of the systems in production. With enterprise architectural methods, the essential components of the KMS can be deployed first to aid business goals while at the same time, the KMS's architecture is maintained to allow for the growth of the KMS in line with the tailored KMS architecture for the organization, which will also be in tandem with the GKMSA.

Implementing a successful KMS may seem difficult, but some experts believe that most of the infrastructure needed for its implementation is already in place in an organization, for instance, the existing technological infrastructure of networks, computers, servers, information systems, etc. (Galandere-Zile I, Vinogradova V, 2005). Hence a realignment of those technologies may be what is required, saving on cost and time taken to implement the KMS (Galandere-Zile I, Vinogradova V, 2005). Hence the GKMSA to be developed will take into consideration the likely environments in which a KMS will be implemented, enabling the realignment of existing technological infrastructure aforementioned.

10. Evaluating the success of a KMS

Feedback and control aspects of KMSs are those processes that ensure the KMS is performing the knowledge management tasks as intended (Gallupe B, 2001). However, there is lack of an effective formal KM analysis technique, which has led to repeated failures in KM technological implementations (Aoyam K, Ugai T, Arima J, 2007). A GKMSA can be used to create the framework that can lead to the development of an analysis technique that can be used on most if not all KMSs. Measurement is one of the control aspects that can be used but it is among the least developed aspect of knowledge management, given the difficulties in coming up with the conceptual and theoretic framework which clearly define what KM is so as to know what and how to measure it (Andone I, 2009).Having standard metrics to evaluate KM initiatives will help in convincing management and users of the value of a KMS' implementation (Bose R, 2004).To ensure the effectiveness of KMSs, the measurements procedures for KMS requirements should include, among others (Sultan A. O, 2003):

- Precision measurement– retrieval of relevant information.
- Recall measurement – retrieval of all relevant information in response to an inquiry.
- Specificity measurement – express information without limitations.

Heuristic measurement is also important, so as to determine whether the responses from the KMS are improving over time with respect to precision, recall and specificity. The KM impact areas can also be used to provide feedback by measuring the changes that occur to them to have an idea of the KMS' effectiveness. These impact areas include product/service innovation, organizational processes and integration of technologies organization-wide (Bixler H. C, 2005). Defining the quality attributes of the system and how they can be measured and then to apply them onto the generic KMS architecture so as to be applicable is imperative (Owlia S. M, 2010). The definition of these quality attributes can be done according to already set standards, such as the ISO 9126. The ISO 9126 standard creates a baseline on which quality attributes of a system can be determined as it provides an evaluation criteria that includes a focus on Functionality, Reliability, Usability, Efficiency, Maintainability and Portability. The GKMSA can be developed so as to produce KMSs that satisfy these quality attributes. This therefore means that the ISO 9126 standard can be used as a benchmark in the development of the GKMSA which would ensure that whichever KMS that will be developed from this architecture will at the very least provide an acceptable level of service. More so, by adhering to this standard, the KMS would have been developed to cover the aforementioned six quality characteristics that are needed in a well-developed system.

Figure 4 summarizes the factors that have to be taken into consideration when coming up with the proposed GKMSA.

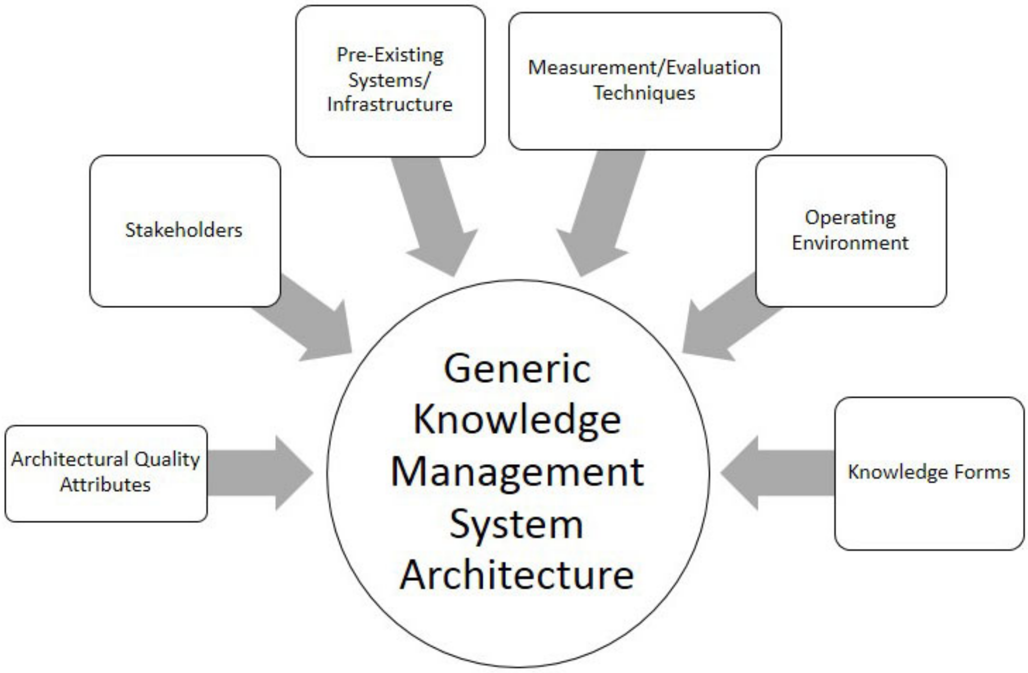

Figure 4 Factors considered in the development of the generic knowledge management system architecture

11. Conclusion

In this paper, the need for a generic KMS architecture was outlined. This is as a result of a lack of a theoretic and/or conceptual basis upon which KMSs are built and implemented. Various technologies can be integrated to form a KMS and this integration has to be managed. The various forms of knowledge have to be carefully handled separately while at the same time supporting effective knowledge conversion. The environment in which the systems operate is important, as it affects implementation. The knowledge processing activities affect the development of a generic architecture for KMSs, hence how they are incorporated into the knowledge life cycle is taken note of. The shortcomings in the research field for KMSs were also looked at and how they can be taken care of to provide a solid foundation upon which research into KMSs can be conducted. Finally, a look at the characteristics and/or quality attributes of the generic KMS architecture was taken, together with the possible ways by which the system's performance can be evaluated. The research into the development of a generic KMS architecture is on-going, and this paper is part of that research.

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