UNIVERSITY OF ZIMBABWE

Knowledge Management System Generic Models and Architectures: Enhancing Uniformity and Interoperability of Knowledge Management Systems

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ABSTRACT

Despite Knowledge Management becoming important in creating a competitive advantage for organizations, the use of technology in the area has been haphazard partly due to a scarcity of technological models and architectures. The available models and architectures are inadequate as they are system specific, sector specific or generally lacking in detail and re-usability. This research sought to address the lack of generic technological models and architectures that function as reference points guiding the process of developing Knowledge Management Systems. It was also aimed at addressing the lack of uniformity in defining knowledge management architecture frameworks to increase understand-ability as well as interoperability of knowledge management systems. The research was qualitative and exploratory, with the traditional literature review as the methodology. An extensive traditional literature review was conducted, based on a research framework developed by the researcher. It consisted of looking at the various disciplines contributing to knowledge management, and then narrowed down to the knowledge management systems. Existing models and architectures were also analyzed and critiqued, and various factors and characteristics leading to the development of generic models and architectures for knowledge management systems, were noted. Thirty-eight themes contributing to the development of Knowledge Management Systems were identified from over eighty-eight publications, and these categories were further aggregated into nine core themes. This culminated in the development of the Knowledge Management System Development Model with three main sections, and the Generic Knowledge Management System Architecture based on a Service-Oriented Architecture. The main contribution of this research to the body of knowledge is coming up with a reference point that can be used as a standard or starting point in the development and implementation of knowledge management systems. This reference point is in the form of the generic architecture developed, supported by the developed model.

Keywords

Knowledge Management, Knowledge Management Architectures, Knowledge Management Systems, Knowledge Management Models, Interoperability, Knowledge Life Cycle.

DECLARATION

I declare that this research project is my own work. It is submitted in partial fulfilment of the requirements for the degree of Master of Philosophy in Computer Science at the University of Zimbabwe. It has not been submitted before for any degree or examination in any other University. I further declare that I have obtained the necessary authorization and consent to carry out this research.

Supervisor

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CHAPTER 1: INTRODUCTION

1.1 Background to the Knowledge Management Research

Knowledge Management (KM) has come to be regarded as an important activity in today's organizations since its ultimate goal is to create value through the use of knowledge to increase operational efficiency as well as profitability (Dwivedimy et al., 2011, Tseng, 2008). As the economies of the world become more knowledge based, and organizations depend more and more on knowledge, the need to manage knowledge has become imperative in order to achieve a competitive advantage (CEN, 2004, Eriyatno et al., 2013). The adoption of KM in organizations has been made easier and necessitated specifically by (Bixler, 2005):

- Clients' growing demand for quality products
- Technological advances that have made knowledge management a possibility, and
- The need for continuous innovation arising from a rapidly changing market and increased competition for market share.

KM is a cross-functional and interdisciplinary field made up of fields such as sociology, psychology, philosophy, management and information technology (Lee and Choi, 2003). A successful KM initiative recognizes these fields, as none of them is easily isolated from the rest. This is achieved by coming up with a KM strategy, KM goals and an organizational design that creates roles for knowledge related tasks and processes, a strong KM culture and an evaluation system for the success and effectiveness of KM (Galandere-Zile and Vinogradova, 2005).These KM goals should be in line with organizational objectives, which are mainly defined by the organization's mission, vision and strategy (CEN, 2004). Being a multi-cultured discipline, KM can take an IT based track, where technology is used for most activities, or a People based track, where it focuses on giving people an environment that allows for knowledge creation and dissemination (Hawajreh and Sharabati, 2012). This research takes an IT based approach to KM to find the best way for technology to be used to harness knowledge.

KM is defined as the activity of organizing knowledge to give it more meaning and context, capturing the knowledge for use by relevant people in relevant fields and distributing knowledge to those who need it in a timely manner. IT's major role in KM has been identified as being to support communication, collaboration and coordination, and most studies have shown that it is key to the success of KM initiatives (Lindner and Wald, 2011, Tseng, 2008). As organizations have come to realize the significance of technology in their processes and in creating a competitive advantage and innovation (Allahawiah et al., 2013, Tseng, 2008), KM tasks and processes have come to be performed more often with information technology, in the form of a Knowledge Management System (KMS) (Hawajreh and Sharabati, 2012). However, there is no consensus on the definitions of knowledge, knowledge management and KMSs due to the field's multi-disciplinary nature which leads to different interpretations of the terms (Lindner and Wald, 2011).

A KMS is a technology based system that assists in the capturing, storage and distribution of knowledge. It supports the codification approach, the personalization approach, or a hybrid of the two. Coming from a codification intensive background, KMSs have evolved to become more and more tacit knowledge oriented, hence increasingly supporting the personalization approach more (Matayong and Mahmood, 2013). However, many definitions of KMSs exist in literature due to the field's multi-disciplinary nature (Ulrich, 2001).Defining a KMS is made difficult by the different interpretations in various scientific communities (Lindner and Wald, 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, 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 and Vinogradova, 2005).

This has created debate and confusion as to what a KMS really is, although there is consensus that a KMS can enhance the effectiveness of KM activities (Tseng, 2008). This research adopted the definition by Sultan (Sultan, 2003) as its basis for defining and eventually building a KMS. This definition was chosen as it encompassed fully the nature of a KMS without prescribing the technologies to be used in its development. This generalization of the definition was important because it allowed for an open-minded approach to the development of a generic model and architecture in this research. This removed bias while enhancing originality in the solutions hence increasing the possibility of a complete representation of the use of technologies for KM through a KMS.

However, regardless of which definition is adopted, the fundamental responsibility of a KMS is to process, produce and integrate knowledge throughout the knowledge life cycle (Firestone, 2001). Hence a poorly developed KMS will result in poor knowledge-related activities as well as a low quality of knowledge itself, which affects an organization's productivity and efficiency.

The studies of KMS from a technological perspective have been sporadic and uncoordinated. This is due to lack of a conceptual framework upon which the study and development of KMSs is based, leading to the development of KMS that appear to be a bunch of systems haphazardly assembled together. Some of the systems presented as KMSs may not be KMSs at all, creating the need for an investigation of what a KM is and how it is constituted. This lack of a clear direction in understanding KMSs has increased the failure rate of KM initiatives that involve KMSs (Yogesh, 2005).

Due to a lack of a conceptual framework, there is no established reference point that can be used in the development of KMS models and architectures. In order for the field to become more and more useful, there is need for the development of KMSs based on models and software architectures that have been developed from a theoretical perspective (Deve and Hapanyengwi, 2014). These models and architectures must fit into a conceptual framework that justifies their need as well as provides a basis that proves their usefulness in developing efficient and effective KMSs. This is all in line with achieving the generally agreed view that a formal approach to KM is needed (Heavin and Frederic, 2012).

There is still a lot of room for research as far as KMSs are concerned since KM as a research field is still a relatively young discipline (Kumar and Gupta, 2012). It is the author's opinion that, in studying KMSs, the need to come up with a reference for the development of such systems is of paramount importance. Advances are slowly being made in this regard; however, there still exists the need for more to be done in terms of technological implementations for KM so as to produce systems that are not determined to be effective based on the practitioner's or developer's word but rather on a reference point that has emanated from a conceptual framework arising from research. The researcher seeks to fill this gap by developing a research framework that can be used to look at KMS Models and Architectures, leading to the development of a generic KM Model and architecture.

1.2 Research Objectives

The objectives of this research were to:

- Critique existing knowledge management systems models and architectures and recommend improvements to the designs of existing knowledge management systems' models and architectures to increase interoperability with other models and/or architectures.
- Determine the factors and characteristics that aid in developing generic knowledge management systems' models and architectures with the aim of increasing uniformity and interoperability.
- Develop a generic knowledge management systems' model and architecture to enhance uniformity and interoperability.

1.3 Key Research Questions

- On what basis and methodologies are current models and architectures for knowledge management systems being developed to increase interoperability with other models and/or architectures?

- What factors determine the characteristics of generic models and architectures for knowledge management systems and how do they relate together towards achieving uniformity and interoperability?
- How are generic models and architectures developed for knowledge management systems to achieve uniformity and interoperability?

1.4 Problem Situation and Justification for the Research

Knowledge Management implementations are being done by more organizations in various sectors (Chang and Chuang, 2009). However, there is a lack of uniformity in defining architecture frameworks to increase understandability as well as interoperability of KMSs. The various definitions of KMSs and the lack of a theoretical foundation of what a KMS should be like has made it difficult to come up with a reference point in the development of KMSs. This has led to a high failure rate in KMS' implementations due to a lack of generic standards, reference models and architectures used in guiding the development of KMS to ensure optimal and acceptable results (Yogesh, 2005). Most architectures developed and used in coming up with KMS are specific to that given system. They also lack details for validating their adoption, as well as general effective formal knowledge management analysis which can be used to judge whether the KMS will work well before introducing it into an organization (Aoyama et al., 2007).

This highlights the need for developing a reference model and architecture for KMS from a technological perspective to aid both academics and practitioners alike in developing and working with KMSs. This will lead to the development of interoperable systems geared towards KM, which will lead to uniformity in system design and implementation across industries.

1.5 Methodology

This research followed a qualitative, non-empirical and exploratory research methodology. Data collection was done through an extensive and comprehensive literature review, which took a holistic approach to KM by studying information which spun across the KM domain. The inclusion and exclusion criteria were thoroughly defined; indicating what was to be used or included into this research and what did not qualify. The existing KM models and architectures were categorized and analyzed. A research framework was also developed, which guided the literature review process, and ultimately the development of the Knowledge Management System Development Model and the Generic Knowledge Management System Architecture was done. Management and organization of the data used in this research was done through a referencing software, which is also outlined in the methodology chapter.

1.6 Outline of the thesis

This thesis is made up of five chapters. The chapters are organized as follows:

- Chapter One – introduces the thesis by giving a background to the research and outlining the research problem. It also highlights the research objectives and key research questions, while also outlining the research methodology used. This chapter sets the tone for the thesis by giving a summary on how the research is formulated.
- Chapter Two – outlines the literature review done, based on the conceptual framework developed. It begins with a holistic approach to the review of literature on KM, then moves to focus specifically on KMS. It then looks at software architectures and models in KM and provides the link between the literature review and the eventual model and architecture to be developed as a product of this research.
- Chapter Three – it focuses on the methodology used in this research, highlighting the parameters under which this methodology was used.
- Chapter Four – it presents the results of the research, by presenting and explaining the Knowledge Management System Development Model as well as the Generic Knowledge Management System Architecture.
- Chapter Five – this chapter provides the conclusion to the research, outlining the value and implications of the results of the research to the KM field and further areas of research within the KMSs domain.

A reference section with all the publications and materials used in this research is the last part to be presented in this thesis.

1.7 Definitions

Knowledge Management – A systematic discipline and set of approaches that enable information and knowledge to grow, flow and create value in an organization (Grimaldi and Rippa, 2011).

Knowledge Management Systems - an IT based system used to manage knowledge in organizations to support the creation, capture, storage and dissemination of information and knowledge. It can make up a part of a Knowledge Management initiative (Kumar and Gupta, 2012).

Knowledge Life Cycle - The stages that knowledge goes through in the form of a cycle made up of the following steps: knowledge creation, organization, distribution, application and finally concludes with creation again (Lindvall et al., 2003).

Knowledge - an individual's perception, skills and experience, which are all dependent on what experiences the individual's worldview contains in the form of meanings (Lindner and Wald, 2011).

KM tools - all those instrument that include anything that serves as a means for performing functions, processes, operations or tasks in KM (Grimaldi and Rippa, 2011).

Tacit Knowledge – knowledge that cannot be stored in repositories, but is owned by workers in the form of experiences, beliefs, insights and expertise, and usually resides in the minds of the knowledge workers (Lindner and Wald, 2011).

Explicit Knowledge – Knowledge which is codified and stored in databases and turned into organizational knowledge (Lindner and Wald, 2011).

1.8 Key Assumptions and Delimitations of Scope

1.8.1 Key Assumptions

- The information obtained from the literature reviews performed is adequate for this research.

- The organizational culture of the organization in which the KMS is to be implemented has been well developed and is suitable for KM activities.

1.8.2 Delimitations of Scope

This research only focuses on KM to aid in the research of KMSs models and architectures.

1.9 Chapter Summary

In this chapter, the background of the research was outlined. The research objectives, key research questions, problem statement and the justification for the research were highlighted as well. The methodology of the research was outlined, as well as key definitions, assumptions and delimitations of the scope of the research. In the following chapter, the literature review will be outlined.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The literature review was an integral part of this research. It provided the content that was central in defining how the model and architecture developed were structured. It was also used to bring all the information together, to show how the KM field is generally structured.

In this chapter, the knowledge management domain is reviewed by first taking a holistic view to KM, which includes looking at the various fields and disciplines contributing to KM and the implications of these disciplines on KMSs. This is followed by a review of the KMSs, by looking at the role of technology in KM, the techno-centric focus area of KM and highlighting the shortcomings and gaps in research pertaining to the use of technology for KM. The knowledge life cycle is also looked at, and the study then looks at the forms of knowledge and the technologies used for KM, followed by a review of existing KMS models and architectures. Finally, a discussion on the generic knowledge management system architecture and the various stakeholders and requirements needed to come up with one is laid out.

2.2 Research Framework

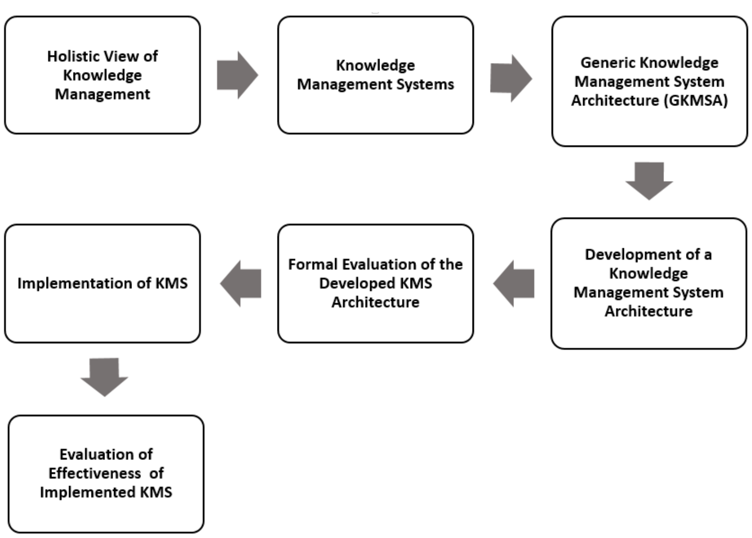


Figure 2.1 Research Framework used in this research

The literature review was conducted in line with the research framework that was developed and used by the researcher for this research. Figure 2.1 shows the flow of the literature review in the direction of the arrows. The research framework is fully outline in Section 3.4 of Chapter 3. The flow of this chapter will be based on this framework, starting with the Holistic View of Knowledge Management.

2.3 Holistic View of Knowledge Management

In the holistic view section of the research framework, as outlined in Section 2.1, the researcher seeks to develop an all-round understanding of knowledge management through an in-depth study of the key disciplines contributing to the field of KM. The researcher aims to relate this information to the development and use of KMS and ultimately the generic knowledge management system architecture.

2.4 Disciplines of Knowledge Management

Knowledge Management is a multi-cultured field, made up of many disciplines that work together for a successful KM initiative. Information technology, sociology, human resource, philosophy, management and psychology are some of the disciplines involved in KM. For KM to be of great value to an organization, it should be shaped around real world issues that need solutions from knowledge workers and should be in alignment with organizational goals in a concrete, measurable and practical way. This alignment is best achieved when all the various aspects of an organization and the forces acting on it are taken into consideration when developing the KM initiative.

All disciplines of KM can be generally categorized under the four pillars of KM, namely (Stankosky, 2005):

- Leadership – deals with the strategy, decision making processes, the values and objectives of the organization and the mapping of the direction for KM and the organization at large.
- Organization – concerns the operating aspects of knowledge assets such as functions and processes, organizational structures, and metrics.

- Learning –deals with principles and practices that ensure maximum collaboration and sharing of knowledge among individuals to create a 'learning organization'.
- Technology– refers to information systems and infrastructure that support or enable KM strategies and functions.

These four pillars work together and are dependent on each other for successful KM. The various players involved in each of the pillars should keep sight with players in the rest of the pillars to have a comprehensive solution that does not lack in certain areas.

The study of the contributions of the various disciplines to KM is important as it not only creates a balanced view towards the KM needs of an organization, but also allows for the development of knowledge management systems that satisfy the needs of the organization. There is a need for an integrative research and/or model that explores the relationships of the disciplines (Lee and Choi, 2003).The value that can be obtained from the various disciplines and their interactions may be financial, innovations, improved and efficient organizational processes, increased customers and better customer relations as well as motivated employees (CEN, 2004a).

Three factors have been identified for managing knowledge: enablers, processes, and organizational performance (Lee and Choi, 2003). Enablers are the influencing factors that create the conducive conditions for knowledge creation, organization and sharing. These include the working environment, culture, organizational structure, technology among others (Lee and Choi, 2003). Knowledge processes assist in the coordination and management of knowledge flow in the organization. They include the Knowledge Life Cycle (KLC) activities (Lee and Choi, 2003). The relationship between the enablers and the processes is that the enablers provide the infrastructure that assists in increasing the efficiency of knowledge processes (Lee and Choi, 2003).

Organizational performance is about whether organizational objectives have been achieved as a result of KM activities (Lee and Choi, 2003).This can be measured in terms such organizational learning and profits made. Through the presentation of measurable results of the effects of the KM initiatives, passion and enthusiasm for KM will increase (Lee and Choi, 2003). The relationship of enablers, processes and organizational performance in KM is important, as it provides a holistic view to be able to describe the various characteristics of KM (Lee and Choi, 2003). KM enablers have a bearing on organizational performance through the development and use of knowledge processes (Lee and Choi, 2003). The following sections will now focus on some of the disciplines that contribute to KM in an organization, and how they affect the development and use of a technology-based KMS.

2.4.1 Measurement

Measuring the effects of a KM initiative on the performance, productiveness and results of an organization's activities is important in order to avoid a failed initiative or to further improve a successful one (Tseng, 2008) (Lindner and Wald, 2011). However, measuring KM is not as straightforward due to a lack of well-established metrics in the field (CEN, 2004a) (Lee and Choi, 2003). Measurement is one of the least developed aspects of KM, largely because of the lack of understanding that still exists in areas of knowledge creation, use and transfer (Andone, 2009), and the lack of a clear conceptual framework that outlines what KM is (Andone, 2009). More so, most of the metrics are soft-measures, which are difficult to quantify since knowledge itself is a soft factor, hence to come up with a proven measurement methodology for KM initiatives is not an easy undertaking (Lindner and Wald, 2011). The metrics may be developed through trial and error and also as the organization evolves, or they can be developed from already existing metrics, which are already accepted and are likely to be measuring what is important to the organization (CEN, 2004b). Having standard measurement metrics is crucial in convincing users and management of the importance of a KMS. More so, the measurements should provide insights into how the organization is developing and using its knowledge assets (CEN, 2004).

In measuring the effectiveness of KM, the organization should recognize what it wants to measure, and why it will measure those specific KM attributes, to avoid measuring just for the sake of getting metrics. This is necessary because organizational needs differ from organization to organization, hence the measuring criteria as well as the metrics used should be determined by the organization concerned.

One of the key attributes to measure is KM's contribution to processes and value addition. KM should aid in improving organizational processes by making them more effective. KM will only have added value to an organization if it contributes in ways that no other initiative could have done. For example, the transfer of tacit knowledge is a process that only knowledge management can achieve, hence if well executed, it can potentially lead to improvements in an organization's performance. This in turn leads to the conclusion that KM will have added value to the organization.

The methods for measuring organizational performance, as a result of implementing a KM initiative, may fall under the categories of (Lee and Choi, 2003):

- Financial Measures: These can be used to note if the bottom line has improved ever since KM was introduced into the organization.
- Intellectual Capital: The amount of intellectual capital in the organizational will increase if the KM initiative makes it possible for knowledge transfer and use among knowledge workers.
- Tangible and Intangible Benefits: tangible benefits include improvement in revenue or operational effectiveness and better innovations. It has been shown that KM is closely related to innovation, as organizations with KM demonstrate a higher capability of enhancing innovation (Liao and Wub, 2010). Intangible benefits include increased collaboration, better culture and improved worker morale.
- Balanced Scorecard: a strategic planning and management system that seeks to give an overall view of business performance by complementing financial measures with non-financial measures. It seeks to create an alignment between organizational goals and its activities.

These categories cater for the qualitative and quantitative measures of KM.

The metrics that are used to measure the success of a KM initiative may focus on production and revenue output. The metrics may also focus on measuring the state of the organization's culture, but this is an issue under debate among academics, as culture is difficult to measure. However, it is generally agreed that the best metrics to use in measuring KM are qualitative, such as increased collaboration, communication, enhanced human resource skills and customer feedback, which are also viewed as KM impact areas (Bixler, 2005). These unquantifiable metrics will give a better picture of the state of KM in the organization, than metrics such as share price and increased market size, which are not directly related to KM. The quantitative metrics that can be used include number of people who have attended a course, number of documents in the knowledge repository, number of workshops held about a certain subject, number of questions being asked in expert systems, user statistics of databases, or intranets' access etc. (CEN, 2004c). The success is also dependent on the quality of the system itself and the quality of information as well (Maryam and Leidner, 2001).

KM's ability to reinforce behaviors, outcomes and standards should also be measured. This is because KM is not only about facilitating the movement of knowledge but is also about making sure that the outcomes that are produced in the organization are repeatable and instilled in the cultures of the teams and individuals in the organizations.

After all the measurements have been done, results obtained and analyzed; there is need for continual reevaluation of the metrics used to measure KM. This is necessitated by the changes that organizations go through, such as change in strategy, size and location, which call for new or different ways of operating. As the organization evolves, so should the KM measurement metrics.

Getting feedback regularly that helps measure user satisfaction helps to avoid failures in KM implementations. Feedback can be obtained through various media such as magazines, newsletters, forums like meetings, discussions and client feedback facilities such as wikis and hotlines. The measurement of a KMS's effectiveness should include (Sultan, 2003):

- Recall measurement – retrieving relevant information in response to a query made on the system.
- Precision measurement – retrieving relevant information.
- Specificity measurement – ability to express information without restrictions.

- Heuristic measurement – the ability to come up with a relevant search result using the most appropriate search method, even though no guarantees are given of this ability at all times.

Heuristic measurement is also key to measure the improvement of retrieved responses to queries with respect to recall, precision and specificity. In addition, when coming up with the quality attributes of the KMS, it is important to define how they are to be evaluated in terms of their impact on the success of the system. This evaluation of quality attributes can be done according to ISO 9126 standard, which is an international standard for the evaluation of software quality. Once the measurable quality attributes are defined, the GKMSA can then be developed with these attributes.

The measurement of knowledge and KM activities is still in the formative stages, and is expected to be more defined as KM becomes mainstream (Kumar and Gupta, 2012).

2.4.2 Organizational Culture

Organizational culture is considered as the most important KM enabler (Lee and Choi, 2003) (CEN, 2004b). Even with a well-constructed IT environment, an inadequate culture will pose challenges in the implementation of KM projects. Culture includes values, beliefs, rewards, language, work orientation, standards and control of an organization. Having the right culture for knowledge sharing, transfer and use can mean the difference between a failed and a successful KM initiative, as it determines not only the knowledge that is valued, but also the knowledge that is retained in the organization for competitive advantage (Lee and Choi, 2003). Therefore, in order to develop an effective KM strategy, understanding of the existing organizational culture is important (CEN, 2004c).

KM is not meant to change the culture of an organization, especially if the organization has been successful with that culture in place (Schutt, 2003). Rather, KM should complement the inter-departmental and enterprise-wide cultures that already exist in an organization, in order to add more value to the productivity and performance of individuals, teams and the organization at large (CEN, 2004b). “Silo-thinking” can exist if the inter-departmental cultures are not compatible, which can lead to lack of interaction and little knowledge sharing or transfer. However, if the need to change the culture does exist, change management actions should be undertaken. More so, it should be taken into cognizance that changing an organization's culture is not an easy and quick process, and does not need to be rushed. It is not an event, rather it is a process which takes time and commitment to achieve the most effective results.

Knowledge workers should not feel threatened by the changes in the work environment and neither should they perceive a loss of personal value through the act of sharing knowledge (Tseng, 2008). They should feel motivated to be part of the change and should see the benefits of the changes to them (CEN, 2004b), if they are to buy in to the new environment and processes. This means that the KM strategy should be aligned to an organization's culture and should maintain the organization's core values while maintaining or increasing morale in order for it to achieve positive outcomes.

A learning culture that facilitates a knowledge creating environment is the hallmark of successful KM, which leads to a learning organization. A learning organization is one that can be defined as creating, obtaining and transferring capabilities. Attributes of a learning culture include (Lee and Choi, 2003):

- **Good individual and inter-departmental relations** -having good communication among individuals and teams allows for knowledge sharing and distribution, leading to faster processes, knowledgeable knowledge workers, increased innovations and improved results. This creates the required social infrastructure for human interaction, which is key to KM.
- **Sharing information freely** -Knowledge workers should not feel that they will lose their power and value in an organization by sharing information with others. They should instead feel empowered and value-adding by partaking in KM activities.
- **Teamwork** - Teamwork breeds dependencies among knowledge workers, which creates the need to share knowledge more for the benefit and success of the team.

- **Fairness** – this is when knowledge workers feel that their value and contribution is not diminished by sharing their expertise through KM, but are rewarded for assisting others, as part of KM.
- **Enthusiasm**–Knowledge workers should be eager to contribute their knowledge and expertise in an environment that benefits others through their contributions.
- **Trust–** there should be trust between knowledge workers and teams in the organization that no one will use the knowledge they gain against others so as to benefit themselves at the expense of those who would have contributed towards a KM initiative.

Knowledge workers should perceive benefits from participating in a KM initiative. For participation to be higher, there should be gains associated with contributing knowledge to others in the organization. More so, knowledge workers should earn respect and feel that they are valued and can retain their intellectual capital even though they would have contributed it to the organization, to prevent knowledge hoarding for power retention and other political reasons (CEN, 2004a). This retention of ownership can be achieved through reward systems linked to KM that recognize those who contribute to the success of KM in the organization. However, even reward systems that would have been set up to incentivize KM activities can lead to negative reactions towards KM in the organization, hence there is need to be wary of counteracting against KM through these reward systems (CEN, 2004a).

2.4.3 Organizational Environment

While information is easier to transfer with IT systems, knowledge is not (Paswan and Wittmann, 2009). This creates the need for an organizational environment that allows for KM to flourish through facilitation of knowledge creation, transfer and use, as well as promoting collaboration and innovation. Such an environment leads to a KM initiative that can support continual improvement of processes and products (Bixler, 2005). It is said that knowledge creation and transfer is more important to an organization than the knowledge itself because knowledge is more about context-specific characteristics than about facts (Lee and Choi, 2003). In creating this environment, stakeholder involvement is important as it assists in coming up with the appropriate KM tools that are likely to be accepted and used by concerned parties in the organization (CEN, 2004b) (Allahawiah et al., 2013). In addition to this, stakeholders can also help in determining the metrics that can be used to evaluate the KM initiative.

While the use of technology is inevitable in assisting the development of a conducive environment for KM in this day and age, personal interactions are still as important as people appear to learn best from them (CEN, 2004c). No amount of technology can replace the human touch in terms of human interactions, hence the environment set up should also enhance human interactions, while using technology as an enabler or a supporting tool for these interactions. This is because the value of knowledge is not mainly in how it is accessed, i.e. by using technology, but is in the human interactions that it facilitates. Technology should aid decision makers to come up with highly informed and timely decisions and provide ancillary services which knowledge workers can use in addition to their personal interactions. This calls for an environment that involves IT as part of the KM framework, which includes social structure, tools and processes (Galandere-Zile and Vinogradova, 2005).

The organizational structure also has a bearing on the effectiveness of KM. A decentralized, cross-hierarchical organizational structure augers well for KM, as it allows for knowledge to flow across all levels of the organization without fear or barriers to communication such as bureaucracy (Lee and Choi, 2003) (Tseng, 2008). This is because it facilitates informal and spontaneous communication between superiors and subordinates, resulting in increased creativity as a result of the flexibility in its structure. This is in comparison with the vertical/centralized organizational structure, which creates a hierarchy that one has to follow in order to communicate with those at the top, which hinders knowledge flow and creates barriers to effective communication of ideas across the organization. This supports the notion that a highly formalized approach to KM inhibits its effectiveness (Lindner and Wald, 2011).

More concentration has to be paid to tacit knowledge as a form of knowledge containing a higher innovation potential (MIKLOšÍK and Hvizdová, 2012). Since more and more knowledge is becoming tacit due to the advent of ubiquitous computing, structures should be put in place to support its use as well as transfer in the organization. Tacit knowledge is only of value if it can be transferred among individuals and teams, hence the need to have facilities and processes that allow for its flow in the organization. This tacit knowledge can become part of the intellectual capital of the organization as it becomes embedded in its processes and culture.

The leadership in the organization should set the tone for KM through the creation and support of processes that support KM and the development of practices and a culture that aids KM (Allahawiah et al., 2013). Enhanced performance, improved effectiveness and innovation can be attained from knowledge use in organizational activities, hence the need for leaders to recognize this and support KM, since it has become strategic to corporate survival (Lindner and Wald, 2011). The leadership also stands to benefit from the adoption of KM, as it can assist them in gaining deeper insights into the issues concerning the organization and assist in decision making (Tseng, 2008). More so, a KMS provides protection against worker attrition, by retaining aspects of the worker's knowledge that would have been stored or shared with others through the KMS (Heavin and Frederic, 2012).

In determining whether an initiative is for KM purposes or otherwise, the following questions can be posed (Firestone and McElroy, 2005):

- Is the initiative aimed at impacting a KM process, the KLC or some aspect of KM?
- If the initiative is aimed at knowledge integration, is there a way of telling whether it impacts knowledge integration or information integration.

Changes may be needed when implementing KM and it becomes the responsibility of management to motivate their teams to withstand the difficulties that arise during the change process and to help them realize the benefits that come with doing their activities in the new ways that involve KM. There is no standard method of introducing KM, but it is generally recommended to introduce the KM program gradually through existing structures, so as to avoid its rejection and encourage adoption on a group by group basis (CEN, 2004). The KMS developers and/or practitioners could start with areas that are key to the organization, such as marketing or research.

Management also has to look at countering barriers to KM such as the organizational culture, lack of ownership of the KM program, non-standardized processes and the organizational structure. These barriers, if not tackled, can disrupt KM negatively. Other barriers to KM include lack of time for knowledge transfer, high expectations by management which hinder the creation of learning opportunities and resistance to knowledge sharing by knowledge workers. There is therefore a need to identify these before and during the implementation of KM, since KM is an on-going activity that evolves with organizational needs.

2.4.4 Human Resources

The people involved in KM are the most important resource in implementing KM (Tseng, 2008). The knowledge and talents of individuals in an organization have a huge impact on its success as most innovations come from them, hence recruiting the people with the required skills and behaviors is key to the success of KM (Galandere-Zile and Vinogradova, 2005). However, these innovations arise as a result of the individual's exposure to already existing knowledge and practices. There is therefore a need for a continuous knowledge life cycle (KLC) from which knowledge is obtained and created, placing people right in the center of the process to allow for them to innovate even more, aided by the KLC.

Most knowledge sharing by individuals is voluntary, hence in order to encourage people to participate in KM processes and activities, there is need for alignment between personal and collective ambitions, so as to eliminate the feeling of knowledge loss to the other (CEN, 2004a). This can assist in the conversion of human resource abilities into intellectual assets of an organization, which allows for easier transfer of knowledge to others.

Developing and using human talents leads to more effective knowledge workers, who are more likely to participate in KM as there will also be developing themselves in the process. Workers with T-shaped skills are more likely to engage in productive conversations with their peers across the organization as they not only have deep knowledge of their discipline, but also know how their discipline interacts with other disciplines (Lee and Choi, 2003). T-shaped skills also allow employees to create knowledge from the integration of the diverse knowledge assets and the combination of theoretical and practical knowledge, making them able to venture into other fields of interests other than their own domains, hence added high value in the KM activities (Lee and Choi, 2003). They also need to be trained regularly to develop skills such as communication, knowledge engineering as well as the use of KM tools to increase their proficiency at KM.

Ultimately, there might be need to have new personnel in the organization or to outsource KM expertise to drive KM forward. These new workers and/or consultants will champion KM and help structure KM so as to accelerate its adoption in the organization. A KMS may also be of great importance to new personnel, as it can serve as the place for knowing and understanding the organization (Sultan, 2003).

2.4.5 Processes

Knowledge Management is not a separate function or department – it should be embedded in organizational processes in order for it to add value (CEN, 2004b).The KMS should interact with the user in a continuous and active manner in order to provide the best value in its use. The work the workers undertake requires knowledge, hence KM should be a part of it through the use of technology, so as to facilitate the creation, storage and transfer of this knowledge as it is produced or demanded (Firestone and McElroy, 2005). Workers are also to be given time for KM activities, because tasks such as documentation may be perceived as important, but not urgent, hence they will not be partaken in a timely fashion, if at all (CEN, 2004c). However, workers will only take this time if only they understand why they are doing it and at times, if rewarded for such activities. KM is not meant to improve worker effectiveness in a direct manner but to improve knowledge creation, processing and access (Firestone and McElroy, 2005). This is best achieved if there is an alignment between KM activities and the processes followed in the organization. In so doing, it is hoped that worker effectiveness is greatly improved.

Stakeholders should be made aware of the role and existence of knowledge in the processes they partake in so as to empower them to partake in and own the KM initiative. More so, the initiative should seek to build on the current activities that have made the organization successful, but should support and enhance the quality and effectiveness of these activities, though it is not an easy undertaking. The organizational processes should also be flexible enough so as not to bog down the creativity of workers in creating and utilizing knowledge (Lee and Choi, 2003).

Knowledge is more contextual than it is factual by its very nature, hence a process-oriented perspective of knowledge will benefit the organization, as it will portray a more accurate picture on how knowledge is used and disseminated in the organization. The KMS can then be used as a tool for continual process and product improvement (Bixler, 2005).

2.4.6 Implications of the Disciplines on Knowledge Management Systems

The various disciplines play a huge part in the development and use of KMSs. No one discipline operates in isolation, but their coherence is what makes a KM initiative successful. Pertaining to KMSs, the use of technology should be in alignment with the rest of the disciplines. This is achieved by aligning technology to the various knowledge components, knowledge management processes, as well as organizational culture and objectives. This alignment will lead to increased interaction of the disciplines for knowledge creation, use and transfer, and the development of an approach that recognizes the continual overlapping of the various disciplines.

IT, being an enabler, should therefore support human interaction, facilitate knowledge processing and the creation of an environment that is conducive for effective knowledge transfer (Heejun, 2005). Culture and the size of the organization affect the selection and use of KM technologies hence the need to consider them when coming up with components for a KMS. This calls for proper setting up of the infrastructure to avoid info glut or info-famine, as both do not create the right conditions for effective knowledge use and transfer.

2.5 Conceptual Framework for Knowledge Management Systems

In the research framework outlined in Section 3.4 in Chapter 3, the Knowledge Management Systems section deals with the review of literature with the aim of understanding the use of technology in KM, and how the various KMSs are developed and how technology relates to the other KM disciplines.

2.5.1 Role of Technology in Knowledge Management

Technology plays a significant role in KM by providing rapid facilitation of the creation, use, storage and transfer of knowledge. It has become an integral component of KM processes, hence the need for a solid IT infrastructure and the adoption of technology in line with organizational goals. This has led to many KM studies being in the computer science and information systems domains, indicating the need to study how technology can be used to effectively contribute to KM (Dwivedimy et al., 2011).

The role of technology in KM initiatives is to broaden the reach of knowledge by integrating geo-spatial locations hence removing the barriers of distance and time, and to enhance the speed of knowledge creation and transfer in organizations (Grimaldi and Rippa, 2011) (Galandere-Zile and Vinogradova, 2005). It can contribute further by integrating knowledge and even stimulating the creation of new knowledge (Tseng, 2008). Technology is also meant to create an environment for knowledge processing from a humanistic perspective of work. The critical role for IT lies thus in its ability to support communication and collaboration, as well as in the transfer of knowledge and information, not merely maintaining static repositories of organizational knowledge.

IT also supports knowledge combination, that is, the conversion of knowledge from one form of explicit knowledge to another (Lee and Choi, 2003). A huge challenge in KM activities is the conversion of tacit knowledge into explicit knowledge (Lindner and Wald, 2011). Due to this, it is generally found to be more effective to externalize the sources of the tacit knowledge, rather than the knowledge itself, as knowledge loss can occur during the conversion process (Kumar and Gupta, 2012). This creates the need for an environment that allows for the interaction of workers with the experts of subject domains as well as the direct sources of knowledge, if need be.

Technology facilitates the KLC and knowledge processes. However, technology works hand in hand with human beings, hence it is their responsibility to use it in a productive manner. Using technology, workers can connect with each other and can be better informed and equipped for knowledge creation and use.

Technology affects culture, just as much as culture affects technology. In fact, cultural issues have a direct impact on the selection of technologies, hence a good mixture of product and people orientation is key for KM (M, Stankosky, 2005). IT alone is not adequate to develop a KM initiative but has to work together with other disciplines, since it is only one aspect of a KM initiative (Kumar and Gupta, 2012).Therefore the actions of the workers towards KM should be shaped through educating and training them on how to use technology effectively to gain maximum benefits from its use.

The size of the organization should be considered when implementing a technological solution for KM as compatibility and performance of the system is affected by the number of people requiring its services at a given time. In choosing the technology, it should be noted that it is not about using the latest cutting edge technologies for a KM initiative. Rather, it is about using IT tools that serve the purpose they are needed for well, and providing the best results for users. This means management should guard against unnecessary use of technology as well as its under-utilization, but should aim to strike a balance between what requires computer and human attention. What this brings to the fore is that IT is not KM, but rather an enabler that facilitates KM work processes and human interactions.

Using a technology-push approach leads to KM failures (Yogesh, 2005). This approach is where the organization first invests in IT for KM and then models the initiative around the IT investment. Instead, a technology-pull approach is recommended, where enablers such as leadership, culture, organizational structure and the ability to learn are prioritized, and then appropriate IT tools are invested in, which will support these enablers.

While the use of technology for KM is greatly encouraged and has tremendous results towards the effectiveness of KM, it should not push people away from each other, by reducing the richness of inter-personal relationships. Technology should in fact bring people together. This means that non-technological tools should work in conjunction with technology-based tools.

This includes facilities such as coaching, communities of practice, expert meetings and social events.

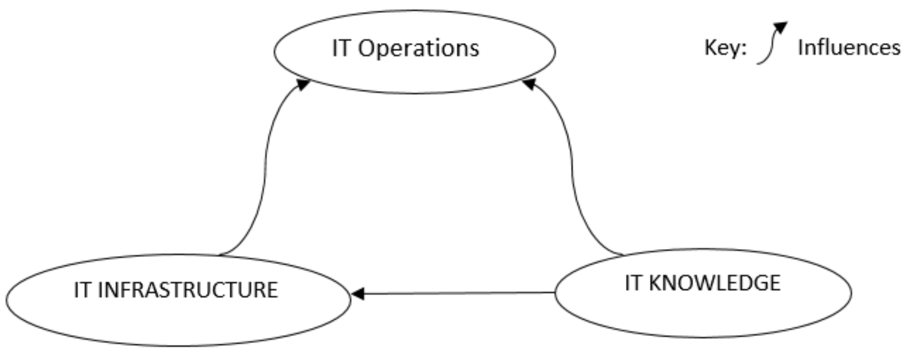
The selection and use of technology for KM should be done based on a framework that governs all the KM activities in the organization (Bixler, 2005). While there have been concerns over the effectiveness of IT as an enabler for KM, researchers believe IT is the technical foundation on which a KMS is built. This KMS caters for all stages of the KLC, and given that IT is an enabler for KM, the KMS will therefore increase the effectiveness of the KM initiative, since it is an IT based initiative.

2.5.2 Techno-centric Focus Area of Knowledge Management

Knowledge Management has three general focus areas: Techno-centric, Organizational and Ecological. The organizational focus area is concerned with how the organization is structured and how it behaves in relation to KM. The ecological focus area dwells upon the environment in which knowledge processing takes place. This means technology is only a part of the KM initiative (Kumar and Gupta, 2012). It is not the KM initiative itself, as IT alone is not adequate to ensure the exchange of knowledge which often times is tacit and personalized (Lindner and Wald, 2011). Rather, IT facilitates KM as an enabler (Galandere-Zile and Vinogradova, 2005). It works together with the other focus areas and their related disciplines to produce the best results possible from KM. In this section, we will focus on the techno-centric focus area.

IT may be considered from 3 dimensions: IT knowledge, IT operations and IT infrastructure. The IT knowledge allows for KM stakeholders to know how to operate and interact with the IT tools as they carry out their KM activities. The IT infrastructure are the components required to deliver the technological services to workers and other stakeholders. This is the equipment and software upon which the knowledge management tools run on and the equipment used by workers in their KM activities. The IT operations involve the functions that the IT personnel engage in to provide IT services to the organization. Since the IT operations are aligned to organizational processes, they need to be supported by the IT knowledge and IT infrastructure, that is, knowledge is required to implement and support IT infrastructure so as to be able to carry out IT operations.

From a KM perspective, this means that, for IT operations to occur, there is need for knowledge from both the IT personnel and the users to be able to understand the KM tools as well as the goal to which they are being used for. From the IT personnel, it is expected that they come up with IT infrastructure that can support the tools required to achieve KM in the way that has been pre-determined by management. The combination of the right knowledge coupled with the right infrastructure will lead to the implementation of IT operations that can support the required KM initiative, in line with organizational goals. Figure 2.2 below illustrates the relationship of these three:



IT Knowledge and Infrastructure influence IT Operations of a KM Initiative.

Figure 2.2 Relationship of IT Operations, IT Knowledge and IT Infrastructure

In developing the IT Infrastructure for KM, it should be noted that most of this infrastructure is already setup in the work environment and it becomes a case of taking advantage of the existing networks and systems to come up with a KMS. The requirements of the KMS will then be obtained by determining common requirements across these systems so as to be able to integrate these systems to make a KMS, if possible. This is because KMS are a class of information systems, hence they can utilize other information sources (Kumar and Gupta, 2012). This may pose a challenge however, as most of these systems would have been developed with other objectives in mind, other than KM (Ulrich, 2001). The following section looks at the shortcomings and gaps in current KM research.

2.5.3 Shortcomings and Gaps in research on the use of technology for KM

There have been issues related to the use of KM in organizations, due to such factors as failure to tap into the tacit knowledge in people's brains where most of the knowledge in an organization is said to be located; searching and retrieving data in repositories, as well as on how to implement a KM initiative. These challenges can still exist even if the benefits are well perceived (Tseng, 2008).The relationship between KM and IT is unclear with regards to how much KM relies on IT for its success in the knowledge era; but in this information era, KM can no longer afford to exist without IT.

There is a general lack of depth when it comes to issues and concepts to do with the use of technology for KM purposes. There is confusion about KM's methodological and theoretical dimensions as well as conceptual foundations and a well-established conceptual framework for the study of technological use for KM does not exist, resulting in unstructured and haphazard approaches in the development, use and implementation of KMSs (Dwivedimy et al., 2011) (Firestone and McElroy, 2005). There is no common understanding of how a KMS should be like as well as to how the research efforts should be directed (Ulrich, 2001). The research effort is not coordinated, with many non-collaborative, and disparate efforts evident in the field (Dwivedimy et al., 2011).

The classification of KMSs is still a challenge due to the lack of a standard or reference point that can be used to assess the nature of a KMS (Ulrich, 2001).This has led to KMSs being developed using technologies that are considered universally applicable without contextual considerations to the use and application of such technologies (Birkinshaw and Sheehan, 2002). In addition, there has been little focus on technologies that focus on the identification of new and unique problems, adding on to the desired heuristic qualities of a KMS. Compounded by the absence of consensus on the definitions of knowledge and KM, the analysis of KMSs is not well developed, making it difficult to categorize them (Galandere-Zile and Vinogradova, 2005). More so, these KM market dynamics make it difficult to come up with a typical architecture for KMSs or to provide a comprehensive list of functions (Galandere-Zile and Vinogradova, 2005).

There are many frameworks, models and checklists for KM. However, these models are undifferentiated and unspecific and are said to work in any and all situations, without providing guidance to management on how to use them (Birkinshaw and Sheehan, 2002). Although there is a huge plethora of tools that can be used for KM, there lacks a framework that also supports the selection of KM tools to be used in a KM initiative. Future research should thus focus on unifying these models and understanding the causes of KM evolution in organizations (Lindgren et al., 2002), to avoid ad-hoc management of KMSs which can lead to unnecessary complexity and project failure (Dwivedimy et al., 2011). More so, the role and impact of information technologies on KM has not been well researched, hence the measurement of the efficacy of the tools is still lagging behind (Allahawiah et al., 2013) (Tseng, 2008).

A methodology for the generation of system and user requirements and involvement of stakeholders in the development of a KMS is needed (Durant-Law, 2003). There seem to be no standard and generally accepted requirements engineering process for KMSs. This creates a need for the development of such a process. KMSs have also been found to be narrow in their focus, as they tend to cater for a specific user, and not numerous types of users (Sultan, 2003). There have been challenges in conducting empirical KM studies due to the lack of a definition of the field, hence classifying an empirical research as a KM one has been difficult (Gallupe, 2001).

There exists the need for experimental studies to determine the impact of different KMS interfaces on the productivity of knowledge workers (Gallupe, 2001). More so, trust levels of knowledge workers on how they approach knowledge in a system whose origins they do not know have to be investigated in order to enhance the credibility of a KMS (Nonaka, 2005).The area of system integration to come up with a KMS is important as no one system acts alone in an operating environment. However, it has not been well researched regardless of its importance (Durant-Law, 2003).

2.5.4 The Knowledge Life Cycle (KLC)

The knowledge life cycle is made up of the following steps: knowledge creation, organization, distribution, application and finally concludes with creation again and a good KMS supports and enhances these stages of the cycle (Lindvall et al., 2003) (Matayong and Mahmood, 2013). In the study of the KLC, knowledge transfer/distribution seems to have been studied extensively compared to other steps such as knowledge creation or use. This is largely attributed to the view that knowledge transfer is more critical towards an organization's long-term success (Lee and Choi, 2003).

The creation and transfer of knowledge is very important because an organization needs to innovate and use its discoveries to gain a competitive advantage over its competitors (Lee and Choi, 2003).

In getting the KMS to support the KLC, it can support the various stages in the following ways:

- Knowledge Definition – through knowledge representation techniques incorporated into the system.
- Knowledge Access – this can be through portals and tailor made applications
- Knowledge Selection – data mining can be used at this stage.
- Knowledge Storage – this can be in the form of knowledge bases hosted in-house, using cloud computing or semantic web technologies.
- Knowledge Sharing – through communities of practice, social networks, expert directory
- Knowledge Creation – through the use of logic, rules, data entry, formatting and collaboration tools
- Knowledge Selling – through commercialization, intellectual property, patents

KM can be:

- Transfer based – focusing on the sharing and dissemination of knowledge in the company
- Storage based – focusing on the retention of knowledge in knowledge bases, or
- Process based – focusing on facilitating organizational processes

The KMS therefore has to support the KLC in ways that supports the basis upon which the KM initiative is based.

2.6 Knowledge Management Systems (KMSs)

IT investment should be made bearing in mind the life-span of the tools being implemented. It would serve no purpose to implement tools that become obsolete far much earlier than the lifespan of the project they are intended for. This will render the KM initiative expensive, which might result in lack of support from management, and ultimately, stopping the KM initiative altogether. Having technologies whose lifespan is exponentially related to the timeframe of the objectives set for KM is always the best case scenario (Figure 2.3) and organizations would do well to aim for such a relationship to get the best return on investment on KM technologies.

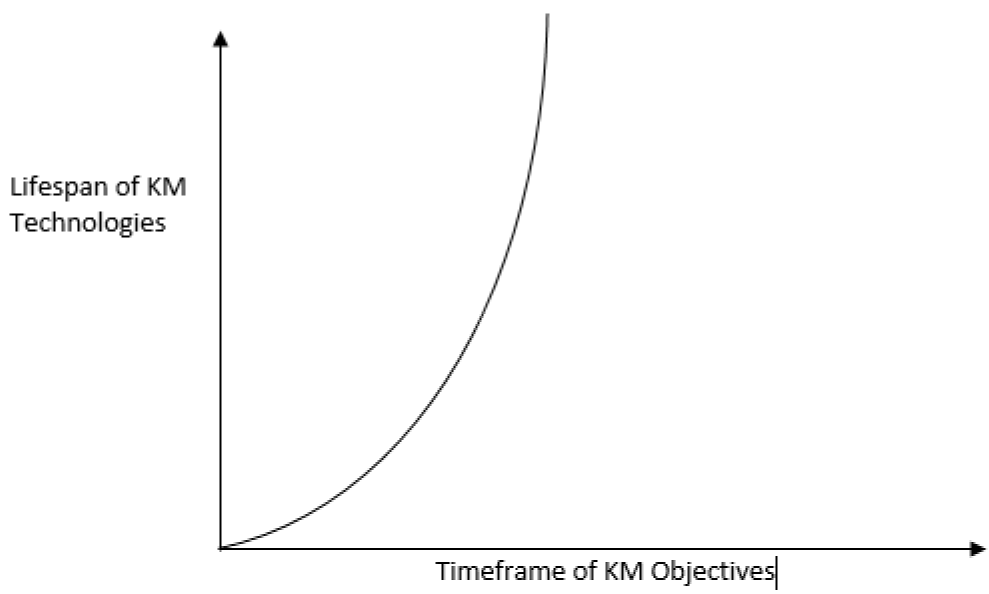


Figure 2.3 Lifespan of KM Technologies in Relation To KM Objectives' Timeframes

Measuring and evaluating the performance of the KMS tools and subsystems is important in order to ascertain if the systems are interacting well as well as producing the required outputs, in relation to organizational goals. This can be achieved by observing the interaction complexity of the technologies, the knowledge life spans in relation with the repositories they are stored in, as well as the nature of the repositories themselves.

However, due to the qualitative nature of most measures in KM, it is a challenge to come up with quantitative metrics for the effectiveness of a KMS. A KMS's effectiveness can be determined by noting how frequently users interact with it and by getting information from the users themselves on whether they are getting value from the use of a KMS or whether more still needs to be done.

Repeated failures in the use of KMSs has been blamed on the lack of a formal analysis (measurement) technique that can be used in determining its effectiveness (Aoyama et al., 2007). In addition to formal analysis of KMS, there is need for similar techniques to compare KMSs as well as KM initiatives at large.

It is important to look at the differences between KMSs and Information Management Systems (IMS) so as to avoid calling one the other. However, doing so is a difficult task. This is because KMSs are mainly built over IMSs, hence the separation of the two is not as straight forward (Galandere-Zile and Vinogradova, 2005) (Lindvall et al., 2003).

A very important characteristic of KM tools is their ability to handle the richness and the context of the information, constituting their difference from information management tools. Without the contextual element and the ability to maintain the nature and manner in which the knowledge is conveyed, the richness is lost and it merely becomes information that can be interpreted anyhow without considering its true meaning or value. They also allow for users to assign meaning, context and content to the data at hand (Matayong and Mahmood, 2013).

IMSs are largely associated with a business process, made up of steps and time, whereas KMSs are focused on the knowledge life cycle and getting the knowledge that has been created to be used, applied and transferred, without really following any set of processes for knowledge acquisition but encouraging elements of innovation and radicalism to exist (Galandere-Zile and Vinogradova, 2005). A KMS should not be perceived as a huge database, but rather as a network of contextualized data and documents linked to various people, taking into consideration their interests, expertise and behaviors (Galandere-Zile and Vinogradova, 2005). Its development is a complex issue, as it involves the integration of heterogeneous information and communication technologies (Galandere-Zile and Vinogradova, 2005), as no one system can achieve knowledge management activities on its own. That is why it is important that those tasked with developing a KMS have enough expertise on integrating the technologies, and an appreciation of the enormity of the undertaking (Galandere-Zile and Vinogradova, 2005).

In summary, the main differences between a KMS and an IMS are that a KMS (Galandere-Zile and Vinogradova, 2005):

- Has an integration of functionality and contextualized combination of information/knowledge.
- Has an organization wide focus, compared to a departmental or sectional view.
- Matches with KM initiatives, and
- Creates the dynamics for organizational learning.

Some organizations prefer to develop their own in-house KMSs as opposed to using commercial-off-the-shelf ones which everyone will be using, as they feel this may give them a competitive advantage over their competitors (Galandere-Zile and Vinogradova, 2005). When developing a KMS attention should be paid to the development of user-friendly tools that encourage use and allow for standardization of the KM environment (Tseng, 2008).A robust back end, in the form of a knowledge repository is also essential for an effective KMS (Lindvall et al., 2003).

2.7 Forms of Knowledge

In developing a KMS, the type of knowledge to be managed should be considered as it affects the tools to be used (Galandere-Zile and Vinogradova, 2005). More so, the end to which the knowledge is being managed is equally important, as it affects the KMS implementation method as well as the nature and type of users to use its various tools (Yogesh, 2005). However, due to the various definitions of knowledge, IT personnel have no firm basis upon which they can justify technological investments for KM and may end up with unstructured KMSs.

Knowledge is generally categorized into three types: explicit, tacit and embedded. Knowledge which is codified and stored in databases and turned into organizational knowledge is explicit, while tacit knowledge is that knowledge that cannot be stored in repositories, but is owned by workers in the form of experiences, beliefs, insights and expertise is tacit knowledge and usually resides in the minds of the knowledge workers (Lindner and Wald, 2011). Embedded knowledge is that which is contained in organizational processes, structures and products and is not easy to commoditize and modify. However, it can be said that embedded knowledge is just a version of tacit knowledge, leaving the main knowledge categories as tacit and explicit.

Explicit knowledge has received wide coverage in research and KMSs, resulting in the view that the IT mainly deals with knowledge combination for KM (Lee and Choi, 2003). This has created a need for more adoption of research and implementation of methods and technologies that manage tacit knowledge to level out the understanding of how to manage both forms of knowledge. In addition, with the advancements made in data and information technologies, IT can play a bigger role in the socialization, externalization as well as internalization stages of the SECI model as given by Nonaka and Takeuchi (Haslinda and Sarinah, 2009). Figure 2.4 shows how technology now plays a role in all the sections of the SECI Model, demonstrating the expansiveness and potential of IT use for KM, which now cuts across forms of communication and knowledge distribution that may have been difficult to achieve before.

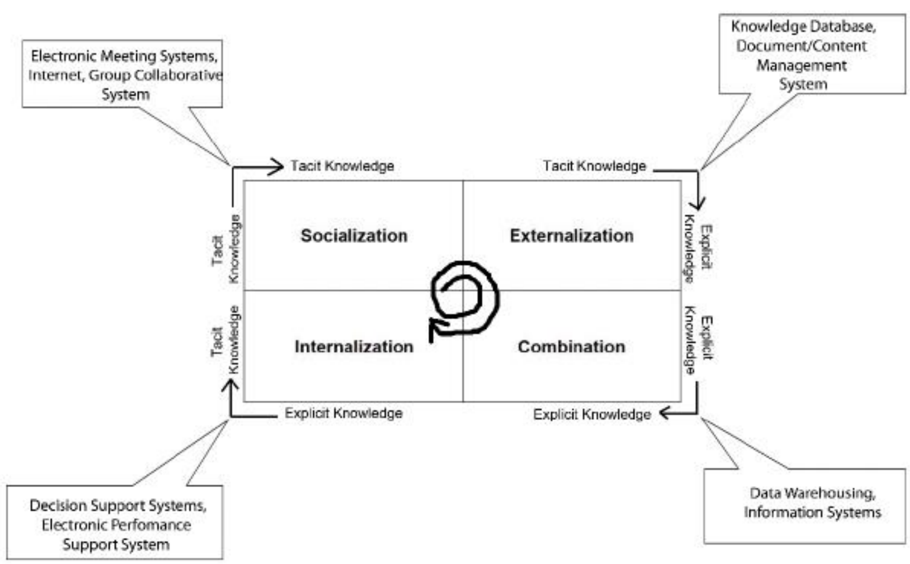


Figure 2.4 The various technologies used to fulfill the sections of the SECI model (Deve and Hapanyengwi, 2014)

The case for a greater focus on the management of tacit knowledge is made stronger due to (Nabeth et al., 2003):

- Continuously changing organizational processes, which make time for knowledge codification inadequate. More so, these changes result in explicit knowledge rapidly becoming obsolete, hence the need to maintain more and more of it as tacit.
- Some knowledge, such as that involving cultures, beliefs and experiences, is difficult to codify.
- Knowledge codification may be resisted by knowledge workers, if they feel their importance in the organization might be eroded by their sharing of knowledge through the KMS, hence the need to increase collaboration, rather than codification.
- Tacit knowledge is important as it forms part of a spiral-type interaction between tacit and codified knowledge.

It is worth noting that the conversion of tacit to explicit knowledge without distorting its meaning is not clear and well understood, and it is a gap that need to be filled in order to be able to interleave the various forms of knowledge. This is because most of tacit knowledge requires conversion to explicit knowledge for it to be captured in knowledge bases (Lindvall et al., 2003).

The management of tacit knowledge can be challenging, as it can be distorted in its conversion or transfer via various media. However, IT can play the role of expert finder, facilitate face-to-face interactions between peers and augment this with some tacit knowledge externalization platforms, such as wikis and discussion forums (Kumar and Gupta, 2012).

Knowledge can also be classified as declarative, procedural or causal. Declarative knowledge describes or explains something, with procedural knowledge dealing with how something occurs, while causal knowledge delves into why something occurs. This classification is equally important, as it can assist in the determination of technologies to use in the management of knowledge based activities.

Understanding the nature of knowledge being used allows for appropriate decisions for its management to be made. The dimensions of this nature include (Supyuenyong and Islam, 2006):

- Knowledge category – whether it is explicit or tacit
- Location – whether the knowledge belongs to an individual or is collectively owned.
- Source – is it internal or external
- Knowledge transfer – whether it can be moved from one location or device to another.

2.8 Technologies for Knowledge Management

KM technologies can be classified in three levels:

Level 1 – knowledge management tools,

Level 2 – subsystems that make up a KMS,

Level 3 – KMSs themselves.

These technologies can also be classified as either:

Integrative Applications, which facilitate the flow of explicit knowledge in and out of knowledge repositories, or

Interactive applications, which allow for the interaction of knowledge workers in their use of tacit knowledge.

Interactive applications support the integrative ones because most of the knowledge that ends up in knowledge repositories starts as tacit knowledge in workers, which is then converted to explicit knowledge, which in turn may be stored in knowledge repositories. However, it is now possible to store tacit knowledge to some extent, if media forms such as video and graphics are stored and used in day to day work.

A broader classification is that KMSs fall under the personalization approach and the codification approach, with personalization emphasizing the linking, networking or communication of people for knowledge exchange purposes, while codification focuses on the storage of information emanating from knowledge to facilitate reuse (Huang and Lin, 2008).

The technologies falling under these categories include

- intranets,
- groupware and workflow systems,
- document management systems,
- brainstorming applications,
- information retrieval engines,
- push technologies and agents,
- help desk applications,
- data warehousing and data mining tools,
- electronic bulletin boards,
- blogs,
- expert systems,
- video conferencing,
- online information sources (Zyngier, 2001), among others.

Tacit knowledge management requires less technologies as compared to explicit knowledge management. This is because tacit knowledge mainly involves human-human interactions, which can be achieved with minimal technology such as video-conferencing or no technology at all if there is no geographical dispersion. On the other hand, explicit knowledge requires a significant amount of technologies to process as the knowledge has to be codified first before being stored. This entails use of technology from the creation of the knowledge, to its codification and then its storage, as well as its retrieval and transfer as knowledge workers interact with it.

It has to be noted that drawing the line between KM and information systems' tools is not easy as the boundary between the two is not well defined (Lindvall et al., 2003). Information management tools constitute a subset of KM tools, since knowledge builds on top of information (Kebede, 2010). There is need to differentiate the two because technologies that may be said to be for KM activities may not be serving that purpose at all. Tools that are capable of maintaining the richness and context of information, while providing meta-methods of accessing and using that data can be classified as KM tools and can be regarded as serving KM purposes (Firestone and McElroy, 2005).

Search and retrieval capabilities are usually characterized as KM capabilities, but that does not clarify if such facilities are being used for KM by supporting and facilitating the KM processes or for other business processes (Firestone and McElroy, 2005). More so, Best Practices boards and Communities of Practices may not qualify as KM initiatives as they can be easily confused with information management activities. Instead, they are more likely to be KM initiatives if they contain some forms of meta- claims in them (Firestone and McElroy, 2005). Therefore technologies that do not differentiate between KM and information management initiatives are highly likely not to be KM tools, unless some way of maintaining the richness and context of the information is incorporated (Firestone and McElroy, 2005) so as to have the element of knowledge in the activities.

It is also important to work with the latest multimedia technologies, as some of them possess the capabilities to deal with various knowledge forms, which removes the need for knowledge conversions.

The knowledge continuum also helps in outlining the differences among data, information and knowledge. Basically, data is made up of crude facts, information is data with meaning attached to it, while knowledge is information with the addition of insights, beliefs, experiences and expertise (Kebede, 2010). It is important to note that they are incrementally related, with data becoming information, and information turning into knowledge, and knowledge assists in the coming up with data. This means that the total exclusion of information from KM is impossible, but nonetheless important to understand their differences. This helps to ascertain the relationship between data, information and KM tools, as data and information tools make a subset of KM tools. From data management to information management, it then becomes a natural development in IS that the next logical step is KM (Kebede, 2010).

2.9 Knowledge Management System Models

KM Models have been developed from the perspective of the issue or discipline it is addressing. These issues include technological use for KM, organizational culture, KM leadership and environment, among others. It is therefore important to study the importance and impact of KM models on the development of a KMS Architecture.

There are numerous KM models. To study them on an individual basis would be duplicative, as they can be generally categorized. In this study, general categories of KM models were adopted. The categories that were developed by the researcher are as follows:

1. Knowledge Transformation Models – focus on how knowledge is transformed from one form to another and how it is disseminated between individuals and groups.
2. Intellectual Capital and KM Measurement Models – focus on KM as intellectual capital and how it can be measured as an asset in an organization.
3. Managerial KM Models – focus on management activities with regards to the adoption and implementation of KM.
4. Knowledge Life Cycle Models – focus on the stages of knowledge use, transfer and storage.
5. Holistic View Models – focus on an overall view of KM, taking into cognizance the contributions of various disciplines to KM.
6. KM Effectiveness/Success Models – focus on what needs to be considered in order to have a successful KM initiative.
7. KMS Models – Focus on the things to be considered in developing a KMS.

KM initiatives can be designed based on specific models. The models that a KM initiative in an organization can follow are:

- Network Model – this focuses on creating connections and fostering interactions among knowledge workers through the creation and transfer of knowledge within the personal relationship created. Video conferencing, expert directories and discussion forums are some of the ways to implement this model.

- Cognitive Model – the focus of this model of KM implementation is on knowledge reuse, repetitive actions, standardization and process improvement. This model favors the storage of knowledge (explicit) in knowledge bases for on-demand access.
- Community Model – this model focuses on informal exchanges within expert domains, to build trust in knowledge shared and create patterns that can be replicated. This could be achieved through wikis, discussion boards and communities of practice.
- Philosophical Model - it is based on questioning and seeking continuous understanding of the market, competitors as well as how internal processes are creating a competitive advantage. The implementation of this model may be done with little technology, although it could be implemented like the network model, but greater focus being placed on personalization over codification.
- The following sections will now expand further on seven categories of KM models mentioned above.

2.9.1 Knowledge Transformation Models

Knowledge Transformation Models focus on how knowledge is transformed from one form to another, and the processes by which it is disseminated from one individual or group to another. These models help understand how technology should be used and built for knowledge sharing and transfer.

Under knowledge transformation models, types of knowledge are determined by its nature and distribution. This is demonstrated by Boisot's Knowledge Category Model in Figure 2.5, which classifies the nature of knowledge as codified (explicit) and uncodified (tacit), and its distribution as diffused and undiffused (Haslinda and Sarinah, 2009).

When it comes to the way in which knowledge is transformed from one form to another, Nonaka's Knowledge Management Model (SECI Model) in Figure 2.5 provides a good description of the environment that has to exist for knowledge transformation to occur

(Haslinda and Sarinah, 2009). Socialization is the personal interactions between human beings, while Externalization is the process by which knowledge that is package for onward distribution. Internalization is the imbedding of knowledge within an individual's or team's ingrained knowledge system and Combination illustrates how knowledge from various sources is merged to form more knowledge.

Hedlund and Nonaka's Knowledge Management Model in Figure 2.5 goes on to give examples of the type of knowledge that exists when the nature of the knowledge (tacit or explicit) is owned by an individual or particular team (McAdam and McCreedy, 1999).

Knowledge transformation Models are important in the development of KMSs because:

- They allow for the determination of the appropriate technologies that can handle the nature of the knowledge as well as those that can distribute it as required (Boisot's Model).
- They help in designing appropriate KMSs that suit the type of interactions that will occur among knowledge workers as well as KM tools (Nonaka's Model).
- They highlight the way knowledge can be organized or displayed for individuals, teams and organizations, based on how these various groups interact with knowledge (Hedlund's Model)

Boisot's Knowledge Category Model

	Undiffused	Diffused
Codified	Propriety Knowledge	Public Knowledge
Uncodified	Personal Knowledge	Common Sense

Nonaka's Knowledge Management Model

from \ to	Tacit	Explicit
Tacit	Socialization	Externalization
Explicit	Internalization	Combination

Hedlund and Nonaka's Knowledge Management Model

	Individual	Group	Organization	Inter-organizational Domain
Articulated knowledge	Knowing calculus	Quality Circle's documented analysis of its performance	Organization chart	Supplier's patents and documented practices
Tacit knowledge	Cross-cultural Negotiation Skills	Team coordination in complex work	Corporate Culture	Customer's attitudes to products and expectations

Figure 2.5 Knowledge Transformation Models (Haslinda and Sarinah, 2009)

2.9.2 Intellectual Capital Models

Intellectual Capital Models illustrate how knowledge can be treated as an intangible asset in the organization, and how it acts as an input to organizational processes and enablers, leading to the production of desired outcomes. As illustrated in the Skandia Intellectual Capital Model of Knowledge Management and the accompanying model in Figure 2.6, intellectual capital can be broken down according to departments and sources of knowledge, which proves that knowledge is a part of all the activities of an organization, hence the need to protect it as well as recognize it as an intangible asset (that should be quantified for valuation where possible) that cannot be disposed of as the organization grows or evolves.

The intellectual capital models highlight that knowledge acts as an input to organizational processes. This highlights that KMSs are enablers to organizational processes and they help bring to the fore the inputs required to kick start the production and performance of the organization. It is therefore important that a KMS highlight all the knowledge available as well as make it available to the relevant players for use and continual improvement of processes.

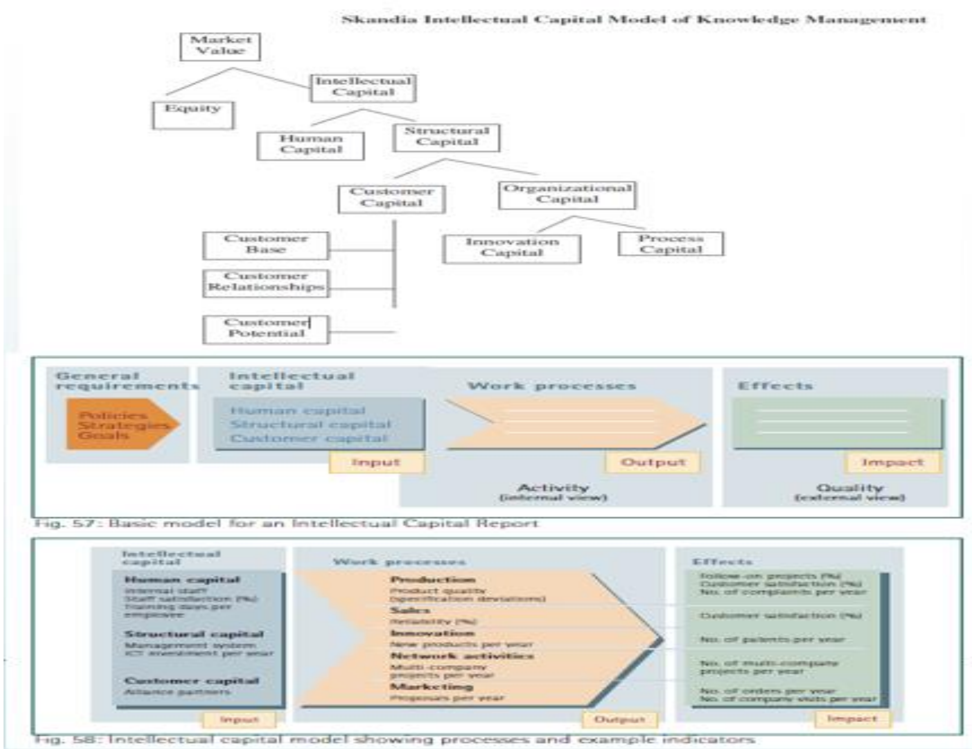


Figure 2.6 Intellectual Capital Models (Haslinda and Sarinah, 2009)

2.9.3 Knowledge Management Managerial Models

KM Managerial Models focus on how to correctly implement, use, maintain and adapt KM processes and activities. As is shown in Frid's Knowledge Management Model (Haslinda and Sarinah, 2009), the adoption and implementation of KM in an organization is a process and not a once off event. Various KM adoption steps are taken based on the level of maturity of KM in the organization, with one level of maturity being reached before the adoption of another. This model bodes well in the implementation of a KMS, as the system may have to be introduced gradually in the organization, either at a departmental level or by introducing the technology-based KM tools in phases, as it leads up to the implementation of the fully-fledged KMS (Tseng, 2008).

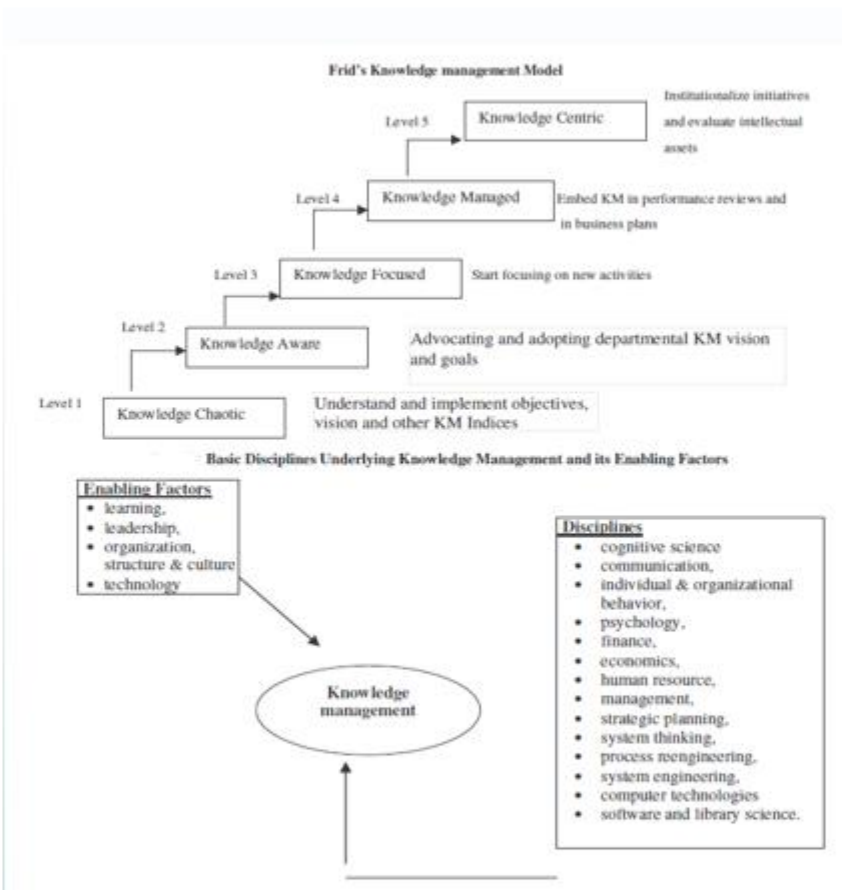


Figure 2.7 Knowledge Management Managerial Models (Haslinda and Sarinah, 2009)

2.9.4 Knowledge Life Cycle Models

These models demonstrate the phases that knowledge goes through as it is used in an organization. The phases that make up the knowledge life cycle are knowledge creation/acquisition, storage/formalization, organization, transfer, use, and creation/acquisition again (Rahman et al., 2011). The models illustrate the relationship between these stages, as shown in Demerest's Knowledge Management Model in Figure 2.8.

The understanding of the relationships of the various stages of the KLC as well as the stages themselves helps determine the stage at which a KM tool or system will be operating. This helps concentrate effort, and in ascertaining the proper structuring of a KMS so that it covers all the stages of the knowledge life cycle.

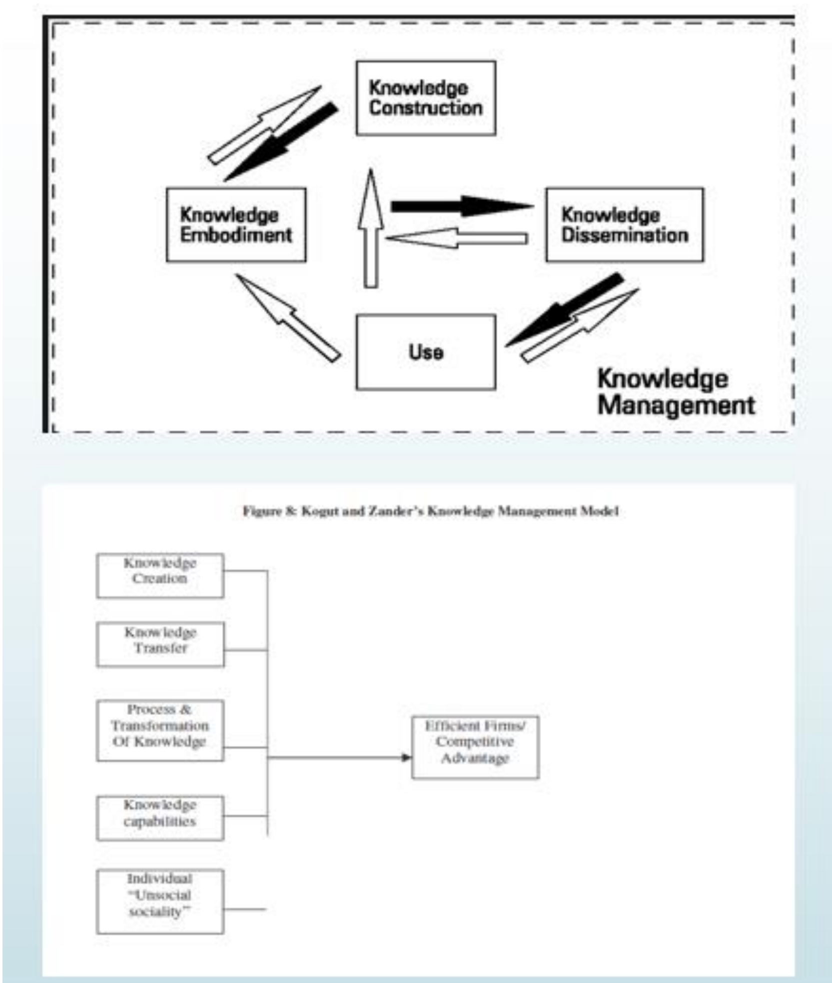
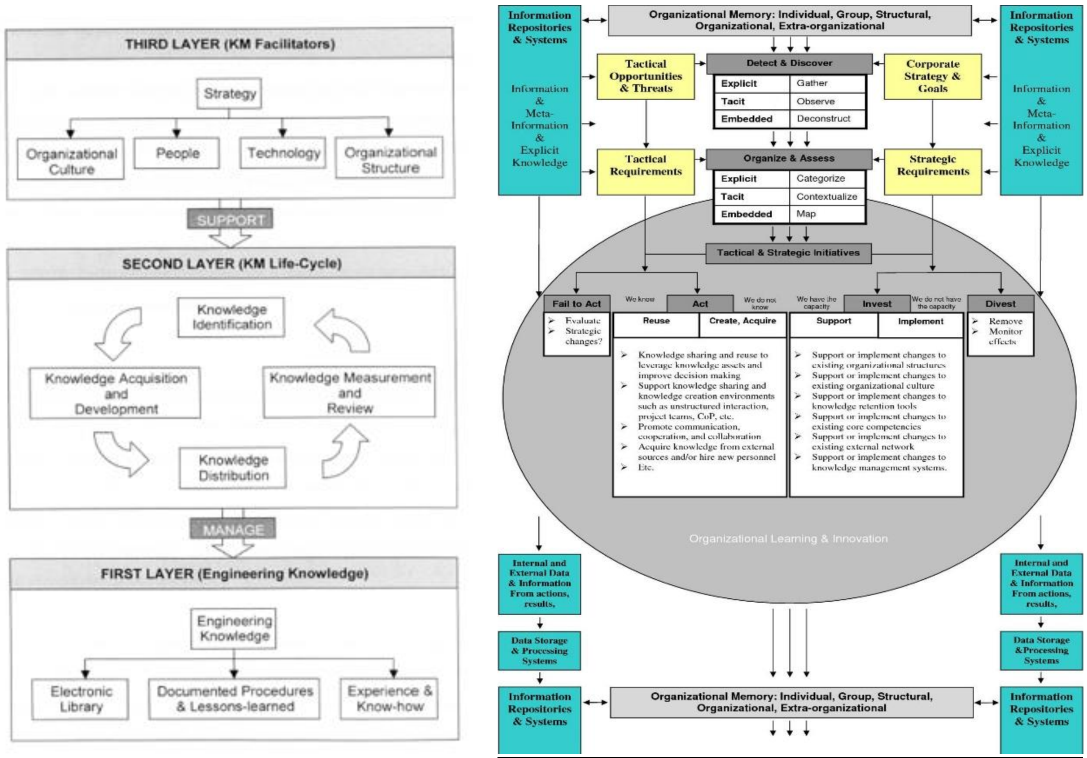


Figure 2.8 Knowledge Life Cycle Models (Haslinda and Sarinah, 2009)

2.9.5 Holistic Knowledge Management Models

Holistic KM Models focus on the entire KM landscape, incorporating all relevant disciplines to KM. They create a complete picture of what is considered and done for a successful KM initiative. However, these models come from various perspectives, therefore whatever they emphasize as being important to KM may differ depending on the discipline the author will be coming from. They are therefore difficult to take as authoritative in the development of a KM initiative since they lack expert input to cover all the disciplines included in the models.

The benefit these models bring to the development of KMSs is that they give a general overview of where IT fits in the KM landscape, allowing for system developers and architects to know the relevant stakeholders to consult, the functionalities to prioritize as well as the types of technologies to consider in coming up with a KMSs. Figure 2.9 shows some of these models. The KM Effectiveness/Success Models are similar to the holistic view models, in that they are tackling the same issues from the same perspective of considering every discipline that contributes to KM. Figure 2.10 is an illustration of such a model, showing how broad and highly abstract they can be, just like holistic KM models.



"SCPTS" three layer KM model

Figure 2.9 Holistic Knowledge Management Models (Alshawi, 2007) (Knowledge Management Tools, 2012)

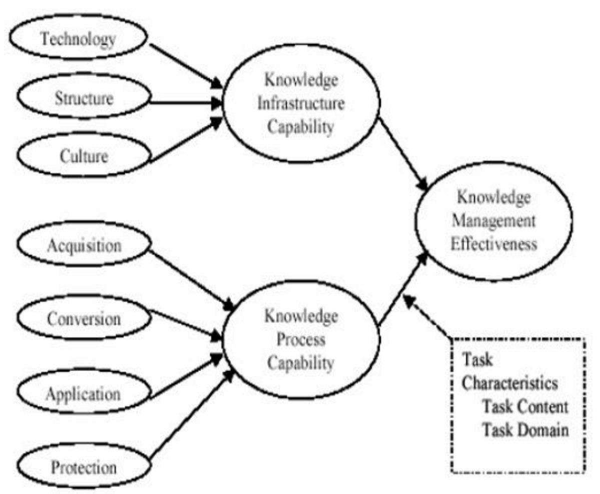


Figure 2.10 Knowledge Management Effectiveness Model

2.9.6 Knowledge Management System Models

KMS models highlight what has to be taken into consideration when developing a KMS, as well as how to measure its outputs to determine its effectiveness. Some of the factors to be considered include system quality, KM strategy, appropriateness of technologies used, and user satisfaction.

These models help in guiding this research as its focus is on developing a generic knowledge management system architecture. This will largely fit in the System Quality section of the first model in Figure 2.11 because this is a technology based system that is being developed. The other sections will assist in the evaluation of the success of the KMS that emanates from the generic architecture that would have been developed.

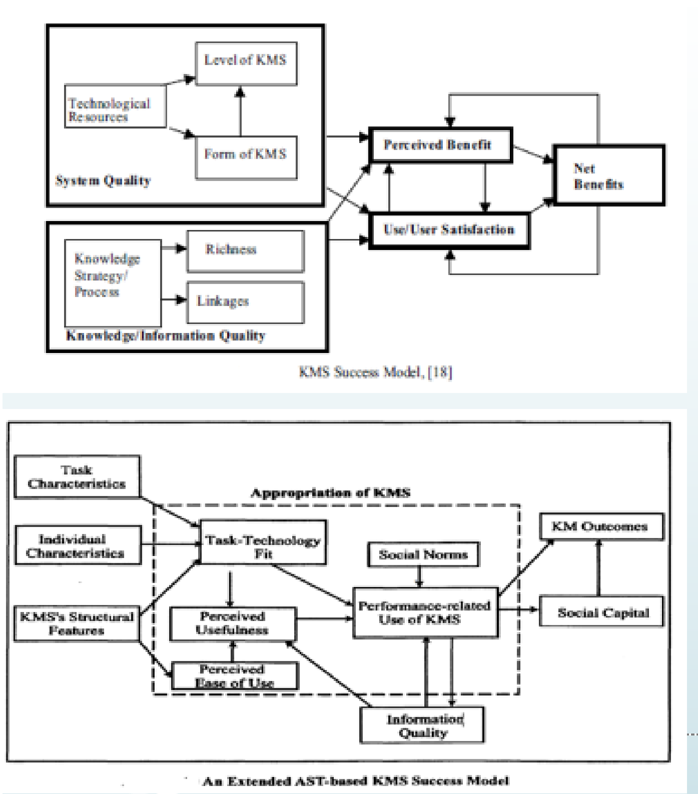


Figure 2.11 Knowledge Management System Models

2.9.7 Towards a Knowledge Management System Development Model

The development of the GKMSA should have a guiding framework that determines how its development will be approached. This framework can be in the form of a model which provides the guidelines without limiting the options of the organization on how to achieve its goals. This model is the Knowledge Management System Development Model. Tiwana developed a ten step approach to the development of a KMS, which will be used as the guide in the development of this model (Tiwana, 2002). Each step, arranged in order of execution, helps to get the KMS that will meet organizational needs, by going through the analysis, implementation and evaluation phases. The ten steps are outlined below:

1. Analyzing existing infrastructure.
2. Aligning knowledge management and business strategy.
3. Designing the knowledge management architecture, and integrating existing infrastructure.
4. Auditing and analyzing existing knowledge.
5. Designing the knowledge management team.
6. Creating the Knowledge Management system blueprint.
7. Developing the knowledge management system.
8. Prototyping and Deployment of KMS
9. Leadership Issues and Reward Structures.
10. Analysis of returns and performance (Knowledge Valuation).

2.10 Knowledge Management System Architectures

KMS Architectures generally follow the conventional architectural styles, hence making their development simple. However, this also introduces challenges in that there might be need to come up with architectures that do not necessarily follow the norm in architectural styles but may have to follow a hybrid approach. The architectures can also be considered from different contexts that include:

- Strategic Context – the architecture is developed such that it helps in achieving organizational goals
- Knowledge Context – the architecture focuses more on the Knowledge Life Cycle.
- Organizational Context–the architecture will help in maintaining and/or bridging the gap in the organizational structure, as well as improving its culture and processes

- Technology Context – the architecture is developed concentrating more on the technical issues to do with, architectural styles and principles, technologies to be used, the technical infrastructure setup and expertise among other technology related issues.

The architectures that are discussed in this section are: Centralized KMS Architecture, Distributed KMS Architecture, Peer-to-Peer Architecture for a Distributed KMS, Context Based Knowledge Flow MS Architecture, Multi Agent Enterprise KMS Architecture, Comprehensive Knowledge Management System Architecture, Health KMS Architecture and KMS Architecture for Industry Cluster.

2.10.1 Centralized Knowledge Management System Architecture

A centralized KMS architecture is one where there is a single knowledge base that is accessed by all knowledge workers using a knowledge portal. This architecture, shown in Figure 2.12 follows a client-server architectural style, with the user being the clients who access the knowledge via the Enterprise Knowledge Portal (EKP) and the service being provided being the knowledge stored in the Knowledge Base (KB). The knowledge base is populated by various knowledge workers and systems using various tools, which helps keep the knowledge base up-to-date.

This design has the following advantages:

- It allows for centralized administration of the system and its knowledge, helping to keep the data current and controlling user access to it.
- The organization has more control over the knowledge in its knowledge base, allowing it to direct its knowledge needs and its use.
- Easy to upgrade and scale to suit growth in users.
- The knowledge is available to all users.

However, the system also has its own pitfalls:

- It can become congested when too many requests are forwarded to the knowledge base for knowledge retrieval and updating.

- It is not very robust, as there can be a single point of failure, such as the server or the network to the system, which would affect all knowledge users.
- Such an architecture can be costly to implement and manage and it requires expertise in technology for its management.
- Difficult to customize to meet needs of specific types of users.

Figure 2.12 A Centralized Client-Server Knowledge Management Architecture

2.10.2 Distributed Knowledge Management System Architecture

The distributed KMS architecture is made up of many nodes (which can be computer systems, servers, applications, etc.) that serve as service providers or provides for redundancy of services. These nodes are located in various locations such as a campus, city, or continent, and communicate together via a data and/or GSM network. The distributed architecture allows for the same service to be located where it is required through the provisioning of redundant services and it also allows for a service to be managed from one area where it is either produced or easily maintained, and provided to other areas that require it.

The advantages of a distributed KMS architecture include:

- It reflects the organizational structure as most organizations have offices in various locations hence the services providing their knowledge needs can be located at the specific offices requiring it.

- There is improved availability, reliability and performance of the system due to redundancy of services and increased processing power because of the multiple nodes providing a single service.
- The system can be expanded easily, allowing for the addition of new sites and systems.
- The cost of implementing the system is less than of a single huge system and it can be easily maintained as the systems are disparate and modularized.

However, these systems also have the following disadvantages:

- The complexity of the system increases as it aims to improve the user experience and as it provides added functionality.
- As complexity also increase, the cost of integrating the systems can become high.
- Implementing the security of the system is difficult because the systems are not centrally managed, hence access control to the system and data is not easily achieved.
- Knowledge base control is difficult, since there exist various knowledge bases, which could be containing various formats and types of data, making the updating and synchronization of data more challenging.
- The distributed system is not easily implemented adhering to prevailing industry standards due to the various systems that can be added to it, which may not be able to suit particular standards or frameworks.

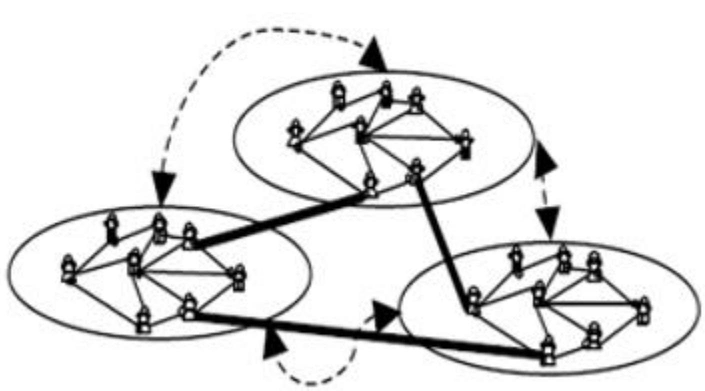


Figure 2.13 Distributed Architecture of Knowledge Management Systems

2.10.3 Peer-to-Peer Architecture for a Distributed KMS

A peer-to-peer architecture is made up of connected workstations, where each workstation has the same capabilities and responsibilities as the others, and resources are shared without going through a mediating server. This means that each workstation functions as both a client and a server, as they can all make service requests to other nodes, while also fulfilling requests from other nodes. This architectural style allows for knowledge workers to share knowledge amongst themselves by giving access to each other to the information they individually own. Therefore a knowledge worker can only access knowledge if they know who has it and if their request for information is accepted by its owner.

This architecture's advantages are as follows:

- It is easy to setup and configure among participating computers.
- All the peers share the content, unlike having a server determining how content is shared.
- It is reliable, as the failure of a single node does not affect the functionality and availability of the rest of the nodes.
- There is no need for a dedicated resource that maintains the system. Each peer is responsible for their IT equipment.
- It is comparatively less costly to setup.

The disadvantages of the architectures are:

- The administration of the network is difficult due to decentralization, hence there's no one person that can manage the access to the network and the content shared.
- Security is very porous in the network, as each peer manages their own security, hence there is a likelihood of malicious attacks and/or data theft occurring in the network.
- Data recovery and back up is challenging, since each peer manages their own data backups, if ever they are available.
- They function well for very small groups of people and are not able to handle the needs of a fully-fledged organization.

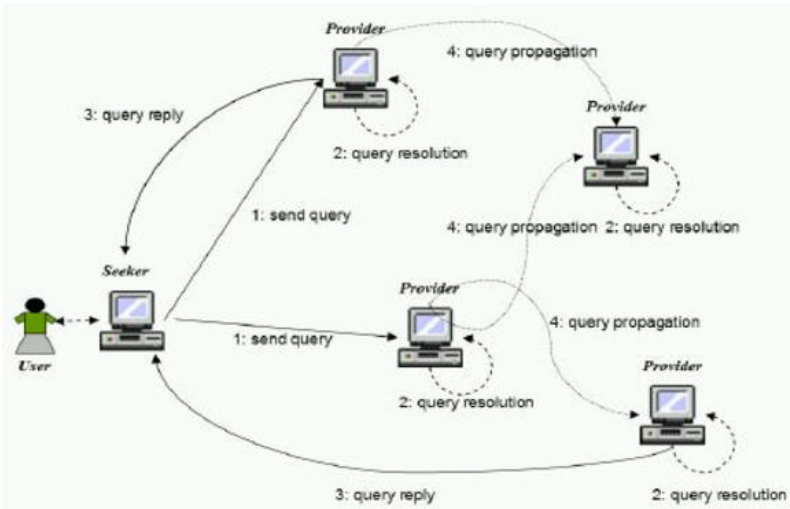


Figure 2.14 Peer-to-Peer Architecture

2.10.4 Context Based Knowledge Flow Management System Architecture

This is a multi-layered client-server architecture which focuses on optimizing the flow of knowledge from the source to the recipient. Some of the activities of the architecture occur on the server side while others are on the client side. It provides modules that have functions such as indexing, search, ontologies, network management and knowledge quality management. The arrows in Figure 2.15 show which module is called during execution.

This model is novel and is yet to be fully implemented in production. However, initial tests show that it improves the flow of knowledge from the source to the right recipient. It uses ontologies to retrieve explicit knowledge and uses quality improvement and knowledge flow algorithms to achieve its objectives.

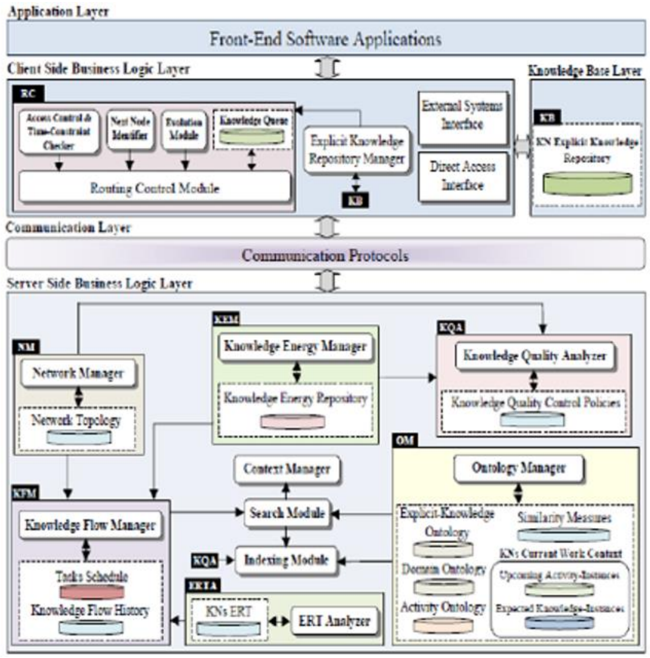


Figure 2.15 Knowledge Flow Management System Architecture (Jarrahi and Kangavari, 2012)

2.10.5 Multi Agent Enterprise KMS Architecture

This architecture uses agents in its communication and execution of KM activities (Rahman et al., 2011). The agents have unique capabilities to each other, allowing for each agent to focus on a specific set of tasks. The knowledge is stored in a repository accessed by the agents, which carry out computations before presenting the results to the user via a graphical user interface

The advantages of this architecture include:

- Its simplicity in implementation
- Reusability of agents due to separation of concerns
- Smooth communication between the agents

It also offers advantages such as redundancy by implementing many agents doing the same things thus achieving robustness and work can be done in parallel by having different agents doing different tasks simultaneously. It is also scalable by adding more agents, which can also aid problem solving.

However, it also poses challenges such as:

- Development effort is required to come up with the agents and the logic of the architecture.
- The complexity of the architecture is not well articulated, which may be a challenge in its implementation.

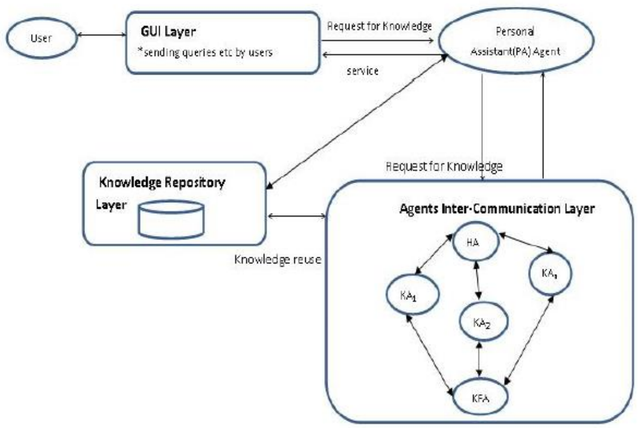


Figure 2.16 Multi Agent Enterprise KMS Architecture (Rahman et al., 2011)

2.10.6 Comprehensive Knowledge Management System Architecture

This type of architecture does not follow a prescribed architectural style. It is a high level illustration of the systems that incorporate a KMS and the roles they play in knowledge activities, as illustrated in Figure 2.17. It has layers that depict various categories of KM tools and the roles they play. However, it cannot be classified as a layered architectural style due to the lack of clear relationships among the layers. It is more of a generic KMS architecture since it acts as a reference to what an architect of a KMS should focus on.

This architecture offers certain benefits:

- It acts as a reference to the functionalities, capabilities and tools that make up a KMS.
- The layered approach of classifying the technology allows for the determination of the kind of tools to be considered when implementing a specific layer of KM tools in an organization.

It also presents the following challenges:

- It is difficult to translate into an actual KM implementation of a KMS as it lacks integration details to get the various systems to work together in facilitating knowledge processes in the KLC.
- It is unlikely that most organizations would want to include all those functionalities in their KMS, as they may not have a need for them.

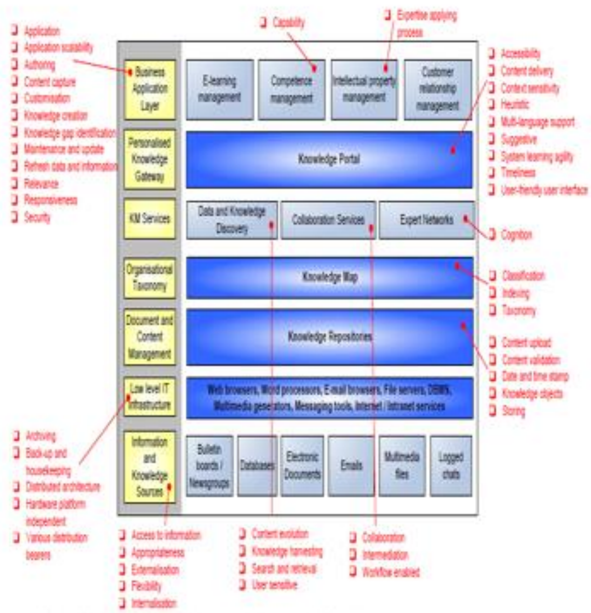


Figure 2.17 Comprehensive KMS Architecture

2.10.7 Health Knowledge Management System Architecture

The Health KMS Architecture was developed with the aim of coming up with a system that helps hospital experts (doctors, nurses, etc.) in decision making when it comes to patient treatment as well retention of knowledge (Barbosa et al., 2009). This architecture follows the client-server design explained above. However, it introduces a layer comprising of a decision support system (DSS) and data mining engine (DM), which help in ascertaining the right actions to take. It also caters for the creation, structuring, transferring and application stages of the KLC. Its advantages and downfalls are similar to the client-server architecture but with the advantage of the DSS and DM that improve knowledge selection and decision making capabilities.

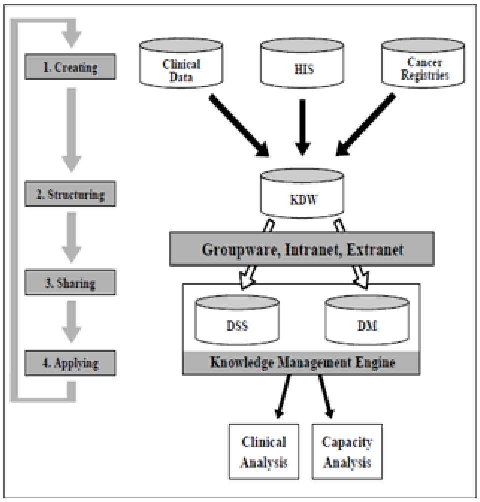


Figure 2.18 Health Knowledge Management System Architecture (Barbosa et al., 2009)

2.10.8 Knowledge Management System Architecture for Industry Cluster

This architecture seeks to achieve an industry specific KMS, catering to the knowledge needs of the concerned industry (Sureephong et al., 2007). It includes a knowledge engineering module that feeds into an ontology that then adds the knowledge to a knowledge base to be accessed by various users of the system. It is similar to the Health KMS Architecture above, in that it also has a client-server architectural style, but has a knowledge engineering module that helps in the acquisition and organization of knowledge.

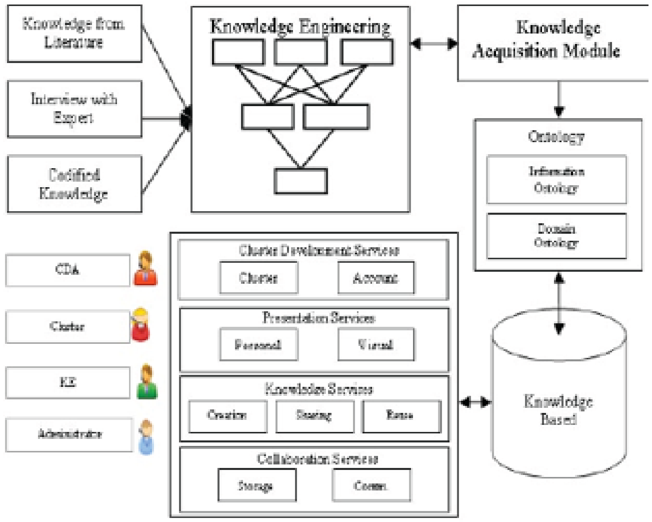


Figure 2.19 Knowledge Management System Architecture for Industry Cluster (Sureephong et al., 2007)

2.10.9 Seven Layer Knowledge Management System Architecture

This is a layered architecture geared at a KMS that is web-based, making use of intranets, extranets and the internet, together with groupware (Tiwana, 2002). The various layers show the path knowledge traverses on its way to the user interface from the knowledge bases. It classifies the various KM tools into the Application Layer and the Collaborative Intelligence and Filtering layer. More so, it also provides the protocols and technologies that can be used in the movement and protection of the knowledge from intruders.

This architecture is good in that it encompasses how the knowledge is transported and protected from intruders. It also makes use of the web, which increases its portability and accessibility from anywhere by merely having a web browser and internet connection.

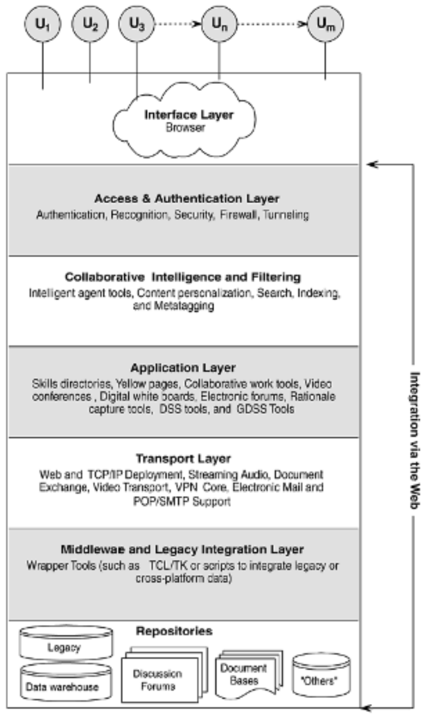


Figure 2.20 Seven Layer KMS Architecture (Tiwana, 2002)

2.11 Generic Knowledge Management System Architecture

In this section, the researcher will focus on generic KMS architectures, with the aim of coming up with a generic KMS architecture and model, as part of the results of this research. This is guided by the research framework outlined in Section 3.4 of Chapter 3, which has generic KMS architectures as one of the parts making up the framework.

2.11.1 Towards a Generic KMS Architecture

The development of KMSs has evolved via two generations; the first concentrating on the development of systems largely for the codification, sharing and distribution of explicit knowledge (Matayong and Mahmood, 2013). The latter has now focused on the use of soft knowledge, leading to the incorporation of tools that can handle tacit knowledge by focusing on its creation as well as the social processes that can be supported by such systems (Matayong and Mahmood, 2013). KMS researchers have inadvertently come up with various types of configurations in their quest to develop relevant KMSs (Matayong and Mahmood, 2013).

It is generally accepted that a 'one size fits all' solution does not work in the use of technology for KM activities due to different needs of various organizations (Grimaldi and Rippa, 2011). However, due to similar capabilities of the technologies in their application in an organization, there can be a foundational basis upon which the use of technology can be coordinated, providing a best practice methodology for the best use of technology towards the use, distribution and transfer of knowledge.

The Generic Knowledge Management System Architecture aims to provide this foundational basis, by being a reference architecture in the development of KMS (Deve and Hapanyengwi, 2014). It can also provide some important quantitative measures in ascertaining the effectiveness of KMS, as there is a gap in coming up with quantitative methods towards determining the success of KM initiatives that use a KMS. Quantitative studies on KMS have been done, but the results are numbers that do not directly show the impact of technology on KM, hence a GKMSA can help in standardizing how technology's impact can be measured. Qualitative measures will remain important as they are most effective in consolidating the outputs of a KM initiative as a result of the interactions of the many disciplines contributing to, as well as meeting the needs of these disciplines to measure some unquantifiable aspects of KM (Deve and Hapanyengwi, 2014).

The GKMSA should provide guidance on the integration of technologies in coming up with a KMS. Lack of a guiding framework on technology integration will continue the haphazard use of technologies for KM, which leads to poor choice in technology investments, poor integration of technologies, and ultimately failed KM initiatives. Therefore the development of this generic architecture is aimed at increasing the interoperability of technologies for a KMS, because architectural studies provide the best foundation and perspective, as they take an overall look at system state, setup and functionality (Deve and Hapanyengwi, 2014).

The development of the architecture requires a set of technical requirements and benchmarks, which will be used in developing and measuring the effectiveness of the KMS. The technical requirements will be in the form of quality attributes and user requirements, while the measurements of the system's success will be guided by the organization's needs. However, the common architectural state of the KMS in various organizations can be of help in also establishing common measures of the success of a KM initiative, hence the importance of such a study.

In coming up with the technical requirements and benchmarks, it is important to involve all stakeholders in the development of a KMS so as to have their cooperation and to cater for their needs from the very beginning of the project (Allahawiah et al., 2013). Software development methods such as Architecture Trade-Off Analysis Method can be used to manage stakeholder involvement. These stakeholders can be system users, customers, business management team, consultants among others.

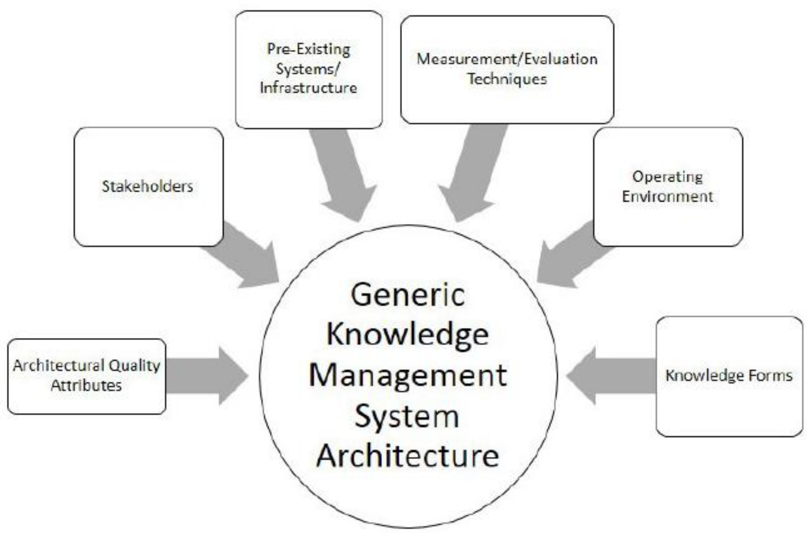


Figure 2.21 Factors considered in the development of the generic knowledge management system architecture (Deve and Hapanyengwi, 2014)

The factors described in Figure 2.21 are briefly described below:

Architectural Quality Attributes – these are the non-functional requirements that will be incorporated in the architecture. These include availability, scalability, extensibility and reliability among others. Quality attributes are important because it's not only the user requirements that are important, but the ability of the system to withstand various stress and operating conditions that it can be subjected to as users operate on it.

Stakeholders –these are the people and/or organizations with interest in the development and use of the system, either from a resource provision or end user perspective, or both. These are the ones who shape how the eventual KMS will look like and how it will be implemented and used within the work environment.

Pre-Existing Systems/Infrastructure – the KMS is more likely to be developed using the already existing IT infrastructure, hence a good understanding of the current systems in use is essential in the development of the GKMSA. While the development of the GKMSA does not necessarily need the consideration of these systems, it is equally important to have a picture of the systems that are likely to be used as KMS tool and subsystems so as to shape it to meet the needs and infrastructure of eventual users.

Measurement/Evaluation Techniques –before, during and after implementation, there is need for quality assurance when it comes to the feasibility and effectiveness of the architecture. Having metrics that determine how well the KMS is performing will help in improving the overall system as well as its use. The measurement techniques will include looking at the system metrics and getting user feedback on the usability, friendliness and appropriateness of the KMS.

Operating Environment – the environment the architecture is to be implemented is also important. Different organizations and industries will require different types of KMSs, hence the GKMSA, which is to be a reference architecture, should be able to accommodate all these differences that will arise in implementation.

Knowledge Forms –the types of knowledge used by knowledge workers is also an important consideration in developing a KMS architecture. How the knowledge is transferred and converted from one form to another is important as it shapes the nature of the architecture hence this has to be looked at.

The following section will discuss the requirements and quality attributes that are considered of importance in the development of a KMS, with the aim of incorporating them in the GKMSA.

2.11.2 Knowledge Management System Requirements

For a KMS to be deemed successful, it is meant to solve problems related to knowledge use and attainment. It has been found that a number of projects fail as a result of inadequate and changing requirements, coupled with lack of user involvement, resources and support as well as unrealistic expectations (Standish Group International, 2013). Therefore careful planning and generation of adequate requirements and the development of a sound methodology for thorough system development is essential for the success of a KMS (Durant-Law, 2003).

Requirements outline the characteristics of a product or service. They are usually broken down into user and system requirements, the latter being called quality attributes. User requirements focus on what the user wants to achieve or obtain from the system, whereas quality attributes focus on how the system will be built in order to achieve the needs of the user. How these quality attributes are met should be well defined in the developed architecture. However, user requirements have a shortcoming of outlining only what the user needs, hence new technologies or capabilities may need to be introduced first even without much user consultation, to gauge their acceptance (Sultan, 2003). Characteristics of good requirements include (Durant-Law, 2003):

- Atomicity – a single need that is clear and unambiguous
- Clarity on who the user is or the results obtained
- Modularity – able to stand alone
- Non-conflicting with other requirements and
- Feasible, verifiable, and traceable.

This section seeks to outline the requirements of a KMS as well as the quality attributes it is expected to meet.

Requirements for a KMS are only assembled if it is understood how the system should be like as well as the objectives of the KM initiative as a whole (Sultan, 2003). To achieve a competitive edge, a KMS tailor-made for an organization maybe what is required, as a standard market solution might erode its competitiveness and innovations (Galandere-Zile and Vinogradova, 2005).

A KMS is a soft system, one with open boundaries, which allows it to interchange with other systems (Durant-Law, 2003). However, this makes it complex and poorly defined, rendering it difficult to develop. This is because due to its open nature, requirements may change or there may be unforeseen outcomes. This therefore means that clear goals for the KMS must be set before its development or implementation and stakeholder requirements should be taken into consideration. It should also bring together the three essential components of KM – people, process and technology (Durant-Law, 2003).

In accommodating the personalization approach in the development of a KMS, two approaches can be taken (Kim and Abbas, 2010):

- An adaptability approach, where the users are enabled to adapt content displayed to suit their preferences,
- An adaptive approach, where the system automatically adapts to the users' needs, such as the recommended products section on e-commerce websites.

One of the reasons why organizations fail to carry out KM activities is because of a lack of tools to do so, hence coming up with the right requirements will allow the sourcing and introduction of relevant technological tools in the workplace (Tow et al., 2012). However, in coming up with the KM technology tools that meet the requirements, technology should have gone through practical tests, reflecting various business environments (CEN, 2004c). Since no system in the real-world operates independent of others, there's need to identify the operating environment (e.g. dispersed or fragmented), the interfaces of other systems, their interactions, among other related issues (Durant-Law, 2003). There may also be restrictions placed on the system, such as corporate policy requirements, occupational health policies and security issues, which influence the design of the system.

The requirements for a KMS are as follows:

- Notifications - the system should allow interested or concerned users to receive timely notifications in the event of changes or availability of knowledge they require.
- Storage of formalized knowledge – explicit knowledge should be kept in a storage engine for referencing. The storage should be done in a way that maintains integrity of the information or knowledge and allows for the generation of meta-data which can be used for extraction and notification purposes. It should also allow for dynamic updating of data in repositories to keep it up to date and relevant (Tseng, 2008).
- Knowledge sharing and transfer capabilities – the system should allow for the sharing and transferring of knowledge to geo-spatial locations, to aid in collaborations and universal access to knowledge (Grimaldi and Rippa, 2011).
- Heuristics – the KMS should have the ability to learn the user's needs, thus directing or providing relevant in-depth knowledge (Sultan, 2003).
- Knowledge Capture Capabilities – knowledge should be captured into the system's data sources as it is created, transferred and used (Ulrich, 2001).
- Organizing and classifying capabilities – it should be able to organize the data in order to filter it to concerned parties or to increase its relevance (Ulrich, 2001).
- Offline Analysis – Caching functionality will help users to access information they frequently use, even when they are not connected to the KMS, or are off-campus (Sultan, 2003).
- Suggestive – It should understand the user's knowledge needs and come up with knowledge associations which the user cannot come up with by themselves (Sultan, 2003).
- Complex Querying – it should be able to execute queries that will allow for the extraction of any type of information and combinations of information required by the user.
- Fast retrieval – Some information requirements might be of a large size, but that should not lead to long extraction time, as the timeous delivery of data is one of the key elements of a KMS.

- Support for various types of users and tasks, regardless of their requirements.

2.11.3 Knowledge Management System Quality Attributes

Quality attributes are the standards that have been defined for the system's intended behavior within the environment for which it was built. They are orthogonal to functional requirements, as their realization does not have a direct effect on the requirements of the user (Bass et al., 2003). A KMS is a system that has open boundaries, allowing it to interact with other systems hence rendering it a soft system. This also means that a knowledge management system can be a collection of systems, hence it can be built by taking advantage of the existing information technology infrastructure in the organization and realigning them to suit its knowledge needs. New systems can then be introduced to add functionality that is already not being provided by the systems integrated in the KMS. Therefore, a key attribute of KMSs is flexibility in the handling of various knowledge forms, while being robust enough to maintain reliability.

Alkadi (Sultan, 2003) and other researchers list the following as KMS quality attributes:

- Scalable – it should be able to support increasing numbers of users as well as an expanding knowledge base.
- Extensible – it should allow for the introduction or removal of capabilities or technologies as the organizational needs evolve.
- Secure – it should be able to protect the knowledge it contains from unauthorized access hence the need for fool-proof system security.
- Relevant and Timely – its technologies should be up to date with the industry's development and should be able to provide knowledge in relevant forms of the day.
- Compliant to industry standards – It should allow the organization to leverage resources of the time and to be able to adapt the KMS without hindrance as a result of compatibility issues.
- Flexible – Should be flexible enough to handle most, if not all forms of knowledge (be it text, graphical or multimedia, and undefined knowledge forms) and situations but robust enough to remain reliable in complex environments (Yates and Paquette, 2011). It should also handle various types of users and their varying needs.

A KMS may also have to approach the knowledge it will be managing from different levels of detail i.e. it may present information in an abstract way in a certain instance and present the same information in a more comprehensive way in another instance, as determined by the needs of the user (Ulrich, 2001). Due to the relationship between data, information and knowledge, it is important that a KMS supports the integration of information with knowledge (Ulrich, 2001).

After the KMS requirements and quality attributes have been gathered, there is need to prioritize certain requirements and quality attributes over others. This is because some requirements, especially user-generated ones, might be conflicting, hence the need to make a trade off by prioritizing others so as to make the realization and implementation of the system feasible, either from a cost analysis or development perspective (Sultan, 2003).

2.12 Chapter Summary – Literature Review

In this chapter, a general to specific approach is taken in the literature review. The various disciplines contributing to KM are addressed. The technology discipline is then addressed and how it contributes to KM, as well as the considerations to be taken in its use for KM. The technologies used for KM, the KM models and the KM system architectures are also highlighted and critiqued, leading to a discussion on developing the GKMSA and the various user requirements and system qualities to be considered therein. Finally, below is a diagram that illustrates how the various concepts discussed link together, following a top-down approach. It starts with the KM focus areas, and then goes down the technology focus area, showing its building blocks.

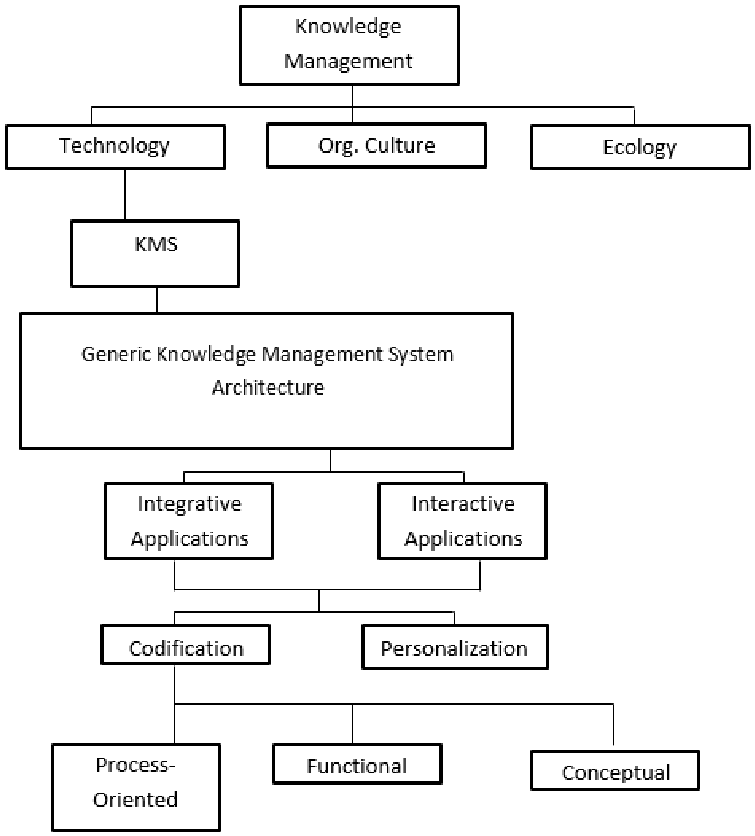


Figure 2.22 A Top-Down Approach to the study of Knowledge Management Systems, in relation to this study

CHAPTER 3: METHODOLOGY

3.1 Introduction

The purpose of this chapter is to outline the methodology used in conducting the research. In this chapter, the research design shall be explained, as well as giving more information on the principles and methods on which it is based. The research framework will also be outlined, and the data analysis process will be highlighted. This will be followed by the outlining of the analysis of findings approach. Finally, the software used in data extraction and management is described.

3.2 Research Objectives and Questions

To understand the context under which this chapter's discussion is based, reference is made to the research questions and objectives stated in Chapter One, section 1.3 and section 1.4. These will guide the selection of the analysis methods used in this research.

3.3 Research Design

The research design provides structure to the research by mapping out the way in which the various parts of the research will work together. It enables the effective use of the information gathered in addressing the research problem in a logical and clear manner. This research's design is qualitative, non-empirical and exploratory, with the research methodology following a traditional literature review approach. A research framework was also developed to guide the research.

Since this research sought to understand knowledge management systems and ultimately develop a framework by which knowledge management systems are built, a qualitative study was the best choice. The research focus was to understand the organization of the KM field at large and the KMS domain specifically. This was in line with the ultimate goal of adding input to the amount of work already done on KMS architectures, through the development of a knowledge management system development model and a generic reference architecture for KMS.

Since the field of Knowledge Management System architectures is not well researched upon, it was fitting to use the exploratory research method so as to understand KM, KMS and KMS architectures and how they all connect together in developing a Generic Knowledge Management System Architecture. While limitations of exploratory research are that the findings cannot be taken as definitive conclusions due to its unstructured nature, it was an appropriate method. This is because this research sought to give recommendations, hence it sufficed as it sought to understand the KM domain by gaining a holistic perspective of the field first before narrowing the study down to KMSs. The research method also sought to participate in advancing research in KMS architectures.

In determining the validity of a qualitative research, four alternative criteria were developed to the more traditional quantitatively-orientated criteria, namely, internal validity, external validity, reliability and objectivity. These alternative criteria are credibility/trustworthiness, dependability, confirmability and transferability. This criteria was fulfilled in this research as follows:

- The researcher used publications from reputable journals and printing presses in addressing the issue of quality of data used. The researcher also compared the data from the these varied sources to identify any information that may not be in tandem with that from other authors and took effort to understand these anomalies so as to know how to deal with them with respect to the study.
- With regards to dependability of this research, as much information as possible has been detailed so as to clarify the methodology and to clearly explain the data collection and analysis stages so that the findings are clearly spelt out.

- On confirmability of data, the researcher based his conclusions on the data he obtained from the various written sources used in this study. This is evident by the references used in support of his opinions and views.
- Since the goal of this research is to develop a generic model and architecture, transferability was of utmost important. The researcher paid attention to how the research and its findings can be adopted and used in various contexts, while guarding the generic model and architecture from distortion during implementation in the different contexts of applications.

3.4 Research Framework

This research was based on a research framework developed by the researcher. Since this is an exploratory research, there was need to cover as much of the KM field as possible, so as to find as much information as possible. Hence, it was designed to fulfill this information need. The framework is in the form of a flow diagram, showing the stages taken in conducting the literature review, as well as in addressing issues related to generic KMS models and architectures. Figure 3.1 illustrates the research framework.

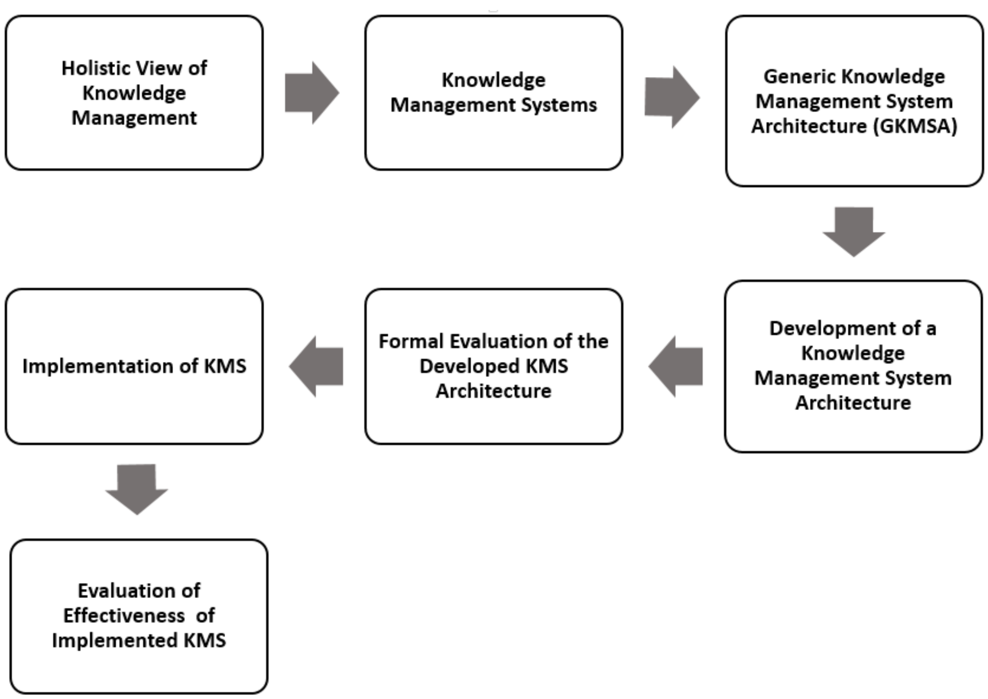


Figure 3.1 Research Framework used in conducting this research

This research framework recognized the need to understand KM from an overall perspective, where all disciplines that are involved in KM were studied to establish their contribution to KM. This established the Holistic View of Knowledge Management as the first stage of the framework. The second stage of the research framework was the study of Knowledge Management Systems. Building on how the various KM disciplines interact and contribute to KM, this stage explored KM models and architectures from the broad spectrum of the multiple disciplines contributing to KM, with the specific goal of coming up with models that can be used in the development as well as implementation of KMSs.

When the ways by which KMSs can be developed had been well outlined, the development of the generic knowledge management system architecture was undertaken. The third stage was the main stage that the research sought to add value to, as the preceding stages were used to develop the case and foundation for the development of a GKMSA. The fourth to the seventh stages contributed to the research by providing insights and details that aid in developing a GKMSA, such as system development processes, architecture evaluation techniques, system implementation methods as well as system use in the production environment. These four stages of the framework were not looked at in this research and are reserved for future studies. They were included in the framework to illustrate the progression of research in the eventual implementation and use of the KMS. They also helped to put in context the relevance and importance of the GKMSA and where it is positioned in the development process of a KMS. Therefore, the last four stages in the research framework contributed to the research by supporting the first stages in the development of a GKMSA.

The study sought to understand KM and KMS as a whole, as the researcher sought to integrate the various perspectives of knowledge management systems in the development of a generic architecture for KMSs. The researcher looked at KM and KMSs with a view to understand what they are and how they work and their impact on organizational effectiveness, leading to the development of generic KM models and architectures.

The research framework helped in conducting the research in the following ways:

- The assumptions of the study were clearly laid out, allowing for the reader to evaluate them.
- It connected the researcher with existing knowledge, which helped in the choice of research methods.
- It helped to identify the limits to the generalizations of the research by identifying key variables that influenced the research.
- It assisted in identifying and outlining research questions, and in identifying ways to come up with and evaluate solutions to the research problems.

Given this research framework, the literature review was structured in line with the stages and the flow of the framework.

3.5 Data Sources

The literature materials used in this research did not necessarily seek to achieve representativeness of the context. This was because the research was exploratory; hence all information found was collected and analyzed for relevance and appropriateness.

The main method of collecting and analyzing data used in this research was the review of documents. This was chosen as the appropriate method for this study over other methods of collecting and analyzing qualitative data such as observations, action research, interviews and focus groups. This is because most of the content relevant to the study of KM was in the form of documents, from which the information used in this research was obtained. These documents comprised of systems documentation, systems description in journal papers, conceptual and empirical reports on KMS implementation, and other related topics to the issue of KMSs' development and implementation.

The data sources used were mainly obtained from the internet, and these were:

- **Journal Websites** – these are websites that publish research papers, usually peer-reviewed.
- **Google Scholar** – this is a web search engine giving access to scholarly literature. It indexes literature from online journals, mostly peer-reviewed, although books and non-peer reviewed publications can also be found.
- **Institutional Websites** – these are websites run by organizations such as universities, research institutes, governmental and non-governmental organizations, among others, that would upload publications or conduct researches that are relevant to this study.

The publications that were used in this research were mainly secondary literature, i.e. publications made up of interpretations and analysis of data which has originated from empirical and/or other theoretical studies. It made data analysis easier and allowed for a broader comparative basis on which to analyze and critic information on KM. More so, the use of secondary data was economical as the researcher did not have to spend money, time, and energy among other resources on primary data collection.

The challenge of the researcher not having control over the quality as well as the appropriateness of the data was overcome through rigorous analysis of the information gathered in relation to its importance to the research, as well as its validity to knowledge management.

The search strategy used in selecting the publications to be used in this research was as follows:

- Search for publications from electronic sources via the internet. These electronic sources included journal websites, academic databases, and conference proceedings. Individual searches were conducted for publications by prominent and authoritative KM researchers, using a go forward approach search to find more publications by reputable authors in KM. The go forward approach looks for more articles written by the same author on the knowledge domain under study to find more information, based on that author's expertise and perspective.

A go backward approach to look for the materials that would have been referenced by other authors was also used to find more publications and sources on the topic under study.

The inclusion criteria for this study considered the following elements:

- **Keywords** – words such as Knowledge Management System, Knowledge Management Architectures, Knowledge Management, Knowledge Management Models, Software Architectures and other related words specific to KM were expected to be a part of the material of a publication.
- **Subject authority** – the authors of the publications used in the research were to have a track record in KM and software architectures, and be considered of good repute and expertise in the field. The source of the publication, for example, a university press or reputable publisher also played a part in increasing the authority of the source, and so did the source and quality of the references in the source itself.
- **References** – publications that were referenced in the key publications studied were also looked at for more information on KM and KMS.
- **Time Frame** – the publications used in this research were published between 2001 and 2016. Some publications that were published before 2001 were looked at, but it was noted that most of the information they provided was adequately covered by publications from 2001 going forward. Choosing a starting date for inclusion which would have been later than 2001 would have also resulted in leaving out some key publications to the study
- **Purpose** – this is objective of the publication from the author's perspective. Also taken into consideration was whether the author was objective, biased or writing facts, opinions or propaganda.

The exclusion criteria for this study considered the following elements:

- **Keywords** – publications that did not contain words such as Knowledge Management System, Knowledge Management Architectures, Knowledge Management, Knowledge Management Models, and Software Architectures were not considered for the study.
- **Subject authority** – authors who did not have a track record of publishing in the KM field and software architecture field were not considered for this research.
- **Time Frame** – the publications outside the period 2001 and 2016 were not used in the study.

3.6 Categorization of Themes

Thematic analysis of data was conducted in order to organize the data according to recurring themes and main issues. The literature provided the information used to come up with the themes that contributed to the development of the generic model and architecture. The criteria upon which the publications used in this research were selected has been carefully laid out in the preceding section. After the exploratory stage was satisfactorily conducted to the standard of the researcher, the main themes and issues were identified and more information was identified from literature where there was inadequate information to clarify pertinent issues.

In coming up with the main themes of this research, the following method was used. The study of various publications related to a specific theme and/or discipline was stopped at each stage only after the issues addressed by the publications started to recur in most publications or became irrelevant to the study. This was determined through the use of the data management software, JabRef, which was used during this study. If the theme and associated points had already been added to the JabRef database, then the theme would not be re-added. If all subsequent publications kept on coming up with the same theme and points, and no new information was added to the database. Data saturation for that theme would have been reached. A new theme or discipline was then studied thereafter. This process was repeated for all the themes identified.

The categorization of the content obtained from the publications led to the development of thirty-eight themes, based on the main issues discussed in the papers. These themes were routinely studied and aggregated according to their similarities and commonalities. This was done continually until only nine core themes remained. This level of saturation was reached after noting that the themes could not be aggregated any further. Table 3.1 shows the themes studied for this research as well as the number of publications studied per each subject area.

THEME	NUMBER OF PUBLICATIONS STUDIED
Architectures in General	8
KM Disciplines	12
KMS and KM Tools	26
KM in General	13
KMS Requirements	4
KM Architectures	11
KM Models and Modelling	9
Books on KM	2
Other	3

Table 3.1 Core themes that were identified from the literature review

3.7 Analysis of Knowledge Management Models and Architectures

Critiquing KM Models and Architectures was one of the stated objectives of this research as espoused in Section 1.3 of Chapter One. It was also one of the key activities in identifying the research gaps that needed to be filled through this research. This was carried out as follows:

- Various models and architectures were identified from the literature review

- From the information that the models and architectures were covering, categories were defined and the models and architectures were categorized accordingly.
- Each category was then explained as to what it was about. The description was based on the models and architectures that were under that category.
- An analysis of the benefits and disadvantages of each category was then done, which brought to the fore the research gaps that this research sought to fill.

3.8 Data Analysis

The process by which data is analysed is critical in determining the credibility of the research's findings.The data analysis of a qualitative research is non-statistical, and its methods are largely guided by the material available. Qualitative analysis involves continually moving between theory and analysis as the researcher seeks to find patterns and relationships between the variables under consideration.

The data analysis for this research included the following strategies:

- **Memoing** – writing notes on the data studied and developing ideas, patterns and relationships. These notes started open-ended and became more focused as the concepts developed. This method was particularly helpful where the researcher had to redesign and reintegrate his conceptual and theoretical notions as he went through the research material.
- **Breaking apart the data**, coding it and rearranging it to identify categories and eventual themes.
- **Integrative diagrams** – these were used to pull all of the detail together so as to aggregate and connect the data with respect to the theory that will be emerging. The diagrams took multiple forms that helped at that stage of the study.
- **Between-study literature analysis** was used, where information from various literature sources was compared, contrasted and aggregated. A within-study literature analysis was also done to gain deeper insights into the subject being addressed in a publication, but this was mainly to support the findings of the between-study literature analysis.

3.9 Use of Software for Data Management and Analysis

Data management software assists in referencing, categorizing and identification of related data and themes. This study used the JabRef Reference Manager Software for the following purposes:

- Memoing
- Data categorization – this was done based on nature of publication and/or on snippets of the actual data found in publications. These snippets were categorized according to the concepts or themes they were addressing.
- Referencing – JabRef assists in automatic importation of references and the selection or changing of the style of reference from the software to the document where the reference is to be used. It has integration capabilities with word processing applications such as Microsoft Word, which was the word processing application that was used in typing and formatting this research document.

3.10 Chapter Summary – Research Methodology

This chapter looked at the research methodology used for the study of KMS and the development of a generic KMS model and architecture. The research design used in this study was discussed. It is a qualitative, non-empirical and exploratory study using traditional literature review for data collection. The research framework developed to guide the study was also outlined. The inclusion and exclusion criteria were also discussed and the methods used for data analysis were highlighted. Finally the software used for data management was explained and the research ethics outlined. The following chapter will discuss the research findings and analysis.

CHAPTER 4 – PRESENTATION AND ANALYSIS OF FINDINGS

4.1 Introduction

In this chapter, the results of the research are presented. The data was collected and analyzed from an extensive literature review that was conducted as outlined in the methodology chapter. The main motivation behind the carrying out of the research was the development of a Generic KMS Architecture which is supposed to guide the structure and functionality of the actual KMS. This was coupled with the development of a KMS Development Model which is meant to help in guiding the steps taken in developing a KMS. The findings in this chapter will demonstrate the need for a model and architecture to help in standardizing the development of KMS

4.2 The KMS Development Model

The KMS Development Model is a model which is meant to help in the development process of a KMS. It encompasses all the steps involved in the development and deployment of a KMS. Figure 4.1 shows a diagram of the model. It is divided into three parts, with the first part involving the interaction of various stakeholders involved or invested in the KMS. The second part mainly concerns the development of the KMS architecture and the determination of the technologies to be used in the system. Part three looks at the implementation and evaluation of the effectiveness of the architecture used. It should be noted that the architecture includes loopback measures to allow for iterative processes so as to revisit areas that will need to be improved in the KMS development process. This helps in continual improvement as well as addition of new features and removal of old ones from the architecture as business requirements and the operating environment change. The following sections will explain the three parts of the model in detail.

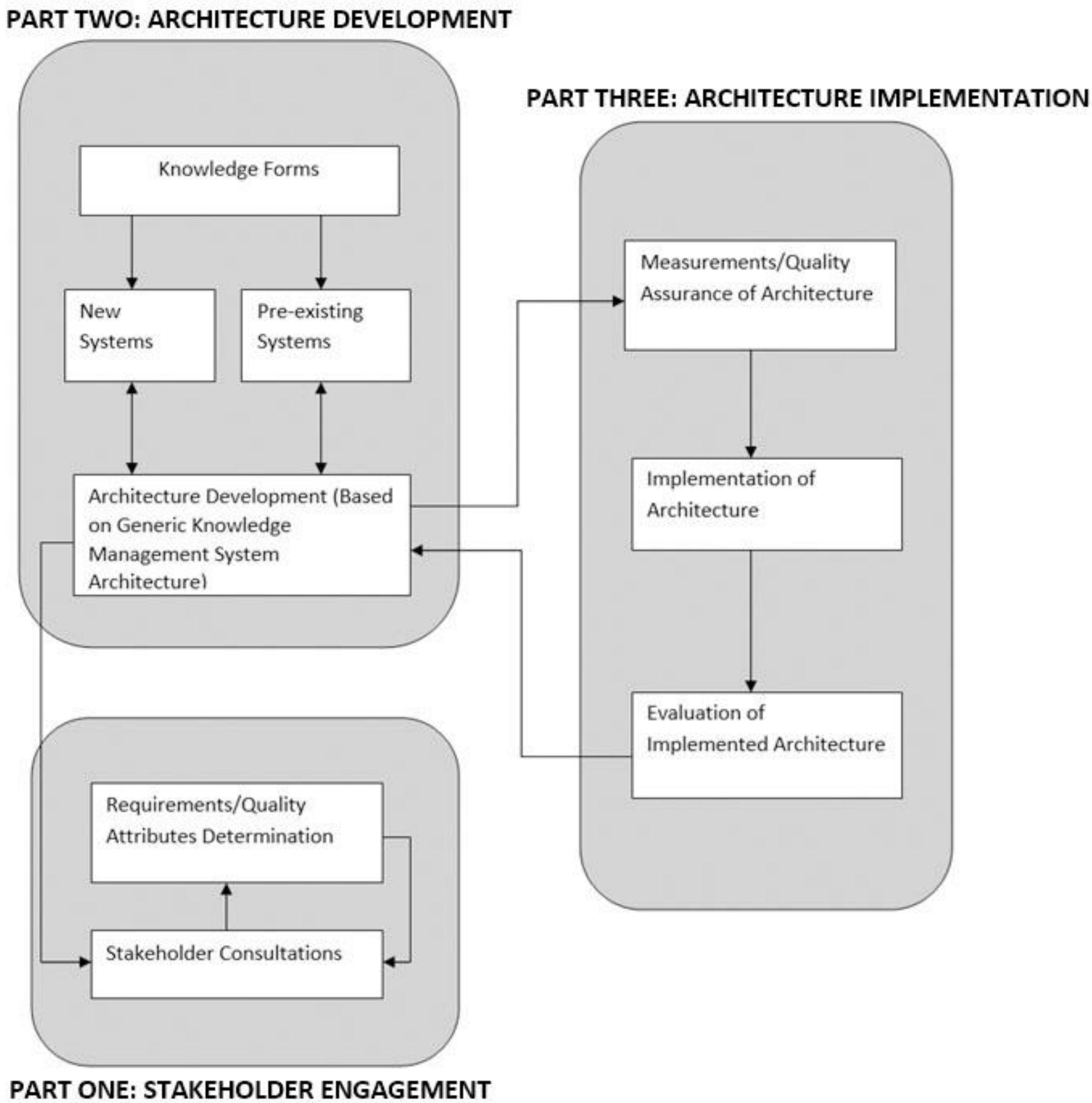


Figure 4.1 Knowledge Management System Development Model

4.2.1 Part One: Stakeholder Engagement

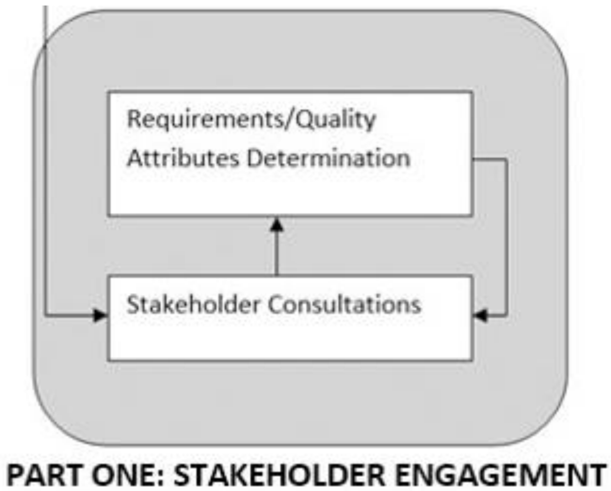


Figure 4.2 Stakeholder Engagement section of the Model

The success of an initiative is largely due to the coordination, relationships and understanding of the people who are involved in it. It is impossible to come up with a successful KMSs without recognizing the various people who have an interest in the use and benefits of the system. This part of the model is concerned with getting the views and objectives of all stakeholders, that is, the people, departments and organizations who are to be involved in the development as well as use of the KMS. These stakeholders can include finance managers, system users, developers, architects, consultants, project managers and company executives.

During stakeholder consultations, the main focus is to understand how the project for the development of the KMS is organized, who is involved and what their role is in the whole project. Consultations may be in the form of meetings, workshops, seminars, brainstorming sessions, online forums and discussion boards, among other related methods. At this stage, the following issues are ironed out:

- Purpose of the KMS – the various stakeholders should come up with a common understanding of what the KMS should be doing, and what the expected results should be from its use. This helps clear up any misunderstandings and unmet expectations, to make sure everyone knows how the KMS will assist in their work and that of their counterparts.

- Financial Investment - There is need to understand the amount of financial investment to be made and whether it tallies with the budget created for the system. Allocation of funds as well as when it will be available and spent is also key to the success of the initiative.
- Timelines- The timeframes have to be clearly worked out, so as to have deliverables and milestones well laid out, and to be able to stick to the set timelines. This allows for accountability, tracking of progress and easier allocation of financial and human resources, according to the stage at which the project will be at.
- Duties and Responsibilities – All the people should know what is expected of them and when they should perform their roles. Lack of clarity on this will lead to project delays as no one will be knowing what to do or who to work with.
- Communication – there is need to work out how the various stakeholders will be communicating so as to avoid discordant acts as well avoiding confusion during the entirety of the project. This involves meetings, electronic communication, decision making trees etc.
- Teams– stakeholders should know who they are working with, who they report to and how they coordinate their activities amongst themselves or with other teams.

The key is to get all this in place before the actual development and implementation of the architecture. As has been said before, this sets the tone for the success of the KM initiative, through the strategy that would have been formulated by the stakeholders to see it to fruition.

Part of stakeholder engagement involves the solicitation of system or architectural requirements. System requirements are those that have to be in place for the software and/or hardware to operate optimally. Architectural requirements include those that have to be incorporated into the architecture, either as functional requirements, or quality attributes. The requirements solicitation is done so as to make sure the system being developed meets the needs and expectations of the stakeholders. The requirements vary from stakeholder to stakeholder hence there is need to coordinate how the functional and non-functional (quality attributes) requirements are gathered.

A method that has been identified as appropriate for the requirements solicitation is the Architectural Trade-Off Analysis Method (ATAM), which was developed by the Software Engineering Institute in Pittsburgh, Pennsylvania, USA (Bass et al., 2003). This method involves all stakeholders in the requirements gathering process by having them discuss their needs and expectations together via the various communication methods mentioned earlier. The key to this method is the trade-off part, where requirements are chosen based on priority and feasibility. This is achieved though such methods as use-case scenarios (where real-life cases are used to determine the feasibility and appropriateness of the quality attributes under discussion). This method assists in finding solutions to situations where two or more conflicting requirements are chosen, and one has to give way to the other. To determine which requirement to keep and which to let go, the priorities of the requirements are determined, after which the most important requirement is chosen to be part of the architecture. However, at times a compromise may be reached, where certain parts of both requirements are incorporated, or a new requirement takes the place of the conflicting ones, so as to satisfy the needs of the concerned stakeholders. Benefits of the ATAM include clarification of quality attributes, improved software architecture and early risk identification in the software development life cycle.

Stakeholder engagement is the first step towards the realization of a KMS in an organization, without which the development process would be marred with lack of organization and coordination, which naturally would lead to a KMS that does not meet the needs of the organization is being developed for.

4.2.2 Part Two: Architecture Development

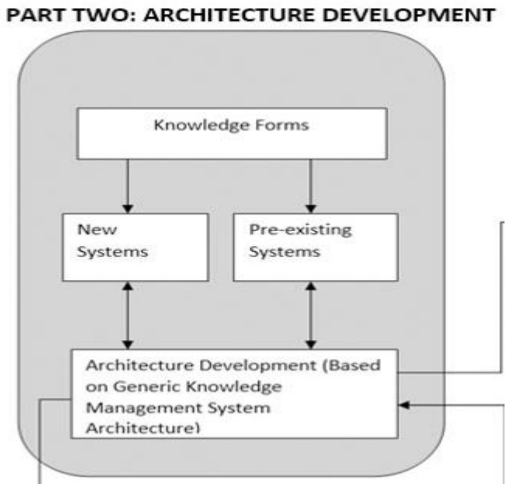


Figure 4.3 Architecture Development section of the Model

When the stakeholder engagements have been done, the next step is to develop the KMS itself. This is the most technical stage where the requirements and quality attributes are then mapped onto an eventual architecture on which the system will be developed. Part two of the KMS Development model focuses on the development of the KMS architecture for the system to be implemented. This architecture is based on the GKMSA. All the requirements of the KMS are mapped onto the GKMSA, from which the specific components and/or structural blocks are then determined. It is important to marry the requirements to the GKMSA because it acts as a reference architecture for the eventual architecture of the system. Various architecture development methods can be used in the development of the architecture, with the GKMSA as the underlying foundation. However, the TOGAF Architecture Development Method stands out as it encompasses all the steps required in the architecture development cycle.

A very important section of this part of the architecture development process is the mapping of pre-existing systems to the architecture. As has been stated before, the KMS is more likely to be built out of the pre-existing IT infrastructure in the organization, since a KMS is made up of various system and it is easier to incorporate systems already in use than trying to bring in new systems. Therefore, the eventual architecture will have to take into consideration how legacy systems can be incorporated. Any features not taken care of by the legacy systems are then handled by the new systems which will be incorporated into the KMS architecture. The legacy systems and the new systems integrate in the GKMSA, to come up with the eventual architecture for the KMS to be incorporated into the organization.

When all has been said and done, the new and the pre-existing systems should be able to handle the knowledge forms that the eventual users prefer and need in executing their duties. Hence the knowledge forms to be handled by the KMS play a crucial role in the selection of the technologies (systems) to be incorporated in the architecture. These knowledge forms are mainly explicit and tacit knowledge, with embedded knowledge forming a subset of tacit knowledge.

The whole concept of a reference architecture is to have the ideal architecture that all related systems can be built upon. This calls for system-neutrality when coming up with the architecture so as not to have an architecture biased towards certain technologies. Therefore, as much as the systems to be incorporated affect the design of the architecture, the architecture should be designed first without considering the systems to be used. Quality attribute and requirements trade-offs can then be made when aligning the systems to the architecture, however bearing in mind that the architecture is the main framework that guides the shape, design and functionality of the eventual KMS.

Turning the views of the stakeholders into an architecture based on the GKMSA is the main purpose of this section of the model. Getting the architecture right is key to a successful KMS which is effective and that will be delivered within the set timeframe. The next part of the Knowledge Management System Development Model is the architecture implementation stage.

4.2.3 Part Three: Architecture Implementation

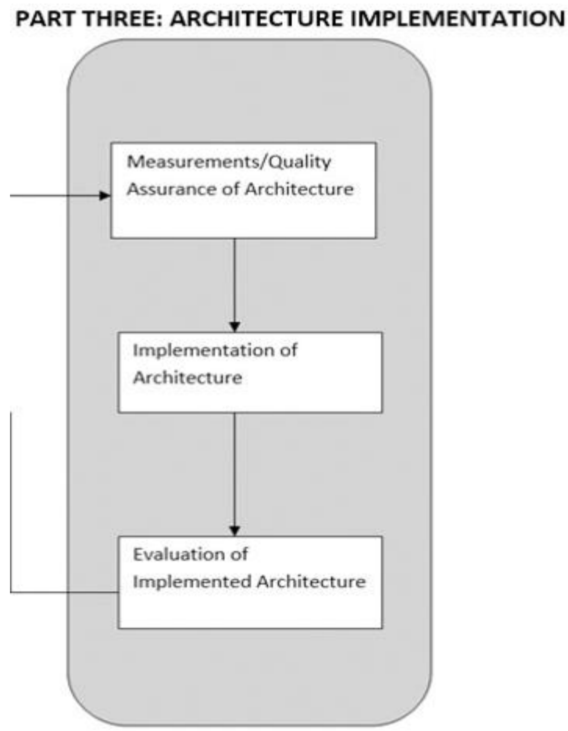


Figure 4.4 Architecture Implementation section of the Model

The third part of the model focuses on the implementation of the architecture into the work environment. It involves three stages;

1. **Measurement/Quality Assurance of Architecture** – this stage is done prior to the implementation of the architecture. This can be achieved through the use of prototypes and use-case scenarios. Prototypes help in ascertaining the feasibility of the suggested solution before it becomes a fully developed solution. This allows for the quick identification of design flaws and inadequacies, which saves on time and financial costs. Use-case scenarios are stories that illustrate how a user will interact with a system and then measured against the capabilities of the system. This method of checking the capabilities of the system before implementation ensures that user needs are met by the architecture and system in general.

   The importance of the quality assurance step is to avoid investing time, human and financial resources into a project before there is a high certainty of success. It also allows for the identification of problems as well as their resolution before the system is put into production.

2. **Implementation of Architecture**–this is when the actual implementation of the architecture in the work environment is done. The implementation can either be gradual, phased or complete (that is, the architecture is implemented all at once), depending on how it affects consistency of business processes. The new and pre-existing systems are introduced and mapped so as to align to the architecture developed.
3. **Evaluation of Implemented Architecture** – after the architecture has been put into use as a KMS in the work environment, there is need to measure and check its effectiveness and suitability for the tasks it is supposed to perform. This stage of evaluating the architecture can be done over a set timeframe, during which feedback is gathered from system metrics as well as from user feedback. The system metrics include availability, resource utilisation and scalability, while user feedback may be based on usability, response times and effectiveness. This feedback is then used during the iterative processes of the model to improve the architecture as well as the KMS.

The implementation of the architecture is the last, but not least, part of the model. It is at this stage that all the planning and design are implemented in the work or production environment, upon which the success of the KM initiative is determined based on the feedback from stakeholders and the metrics and statistics that would have been obtained from the system.

The development of the KMS involves interplay of the KM principles and expertise that arise from the various KM disciplines outlined in Chapter 2. Each discipline contributes at different stages of the model because it is not entirely technical, but involves aspects that would require a holistic perspective from a KM as well as a software architectural perspective.

Firstly, the model is made such that it can meet the requirements of an architecture and secondly, it has to meet the requirements of a KM initiative. The architecture is the foundation of the KMS hence we have to get it right in the quest to have a useful and productive KM initiative that is based on a KMS. The model is therefore a way of striking a balance between developing a software architecture, while at the same time taking into cognizance issues pertaining to KMSs.

4.2.4 Evaluation of the KMS Development Model

This model is developed based on the various disciplines involved in KM, thus having the following benefits:

1. It covers all steps required in the implementation of a KM initiative, which in this case is a KMS. Three stages of the model ensure the adequacy of the model in addressing issues affecting the development, implementation and evaluation of a KMS.
2. It provides a roadmap that helps in developing and implementing a KMS, something that has not been covered before in researches on KM. This assists in delivering the KMS to the workplace according to set timelines. More so, it makes for easier allocation of duties, responsibilities and resources to team members, which increases accountability.
3. It is easier to pin-point the point at which a KM initiative is failing, hence making it easier to get it back on track.

The preceding sections have explained the Knowledge Management System Development Model in detail outlining all the stages of the model. The following section will now discuss the Generic KMS Architecture (GKMSA), which is the reference architecture for KMSs which is used in part two of the Knowledge Management System Development Model.

4.3 The Generic KMS Architecture (GKMSA)

The GKMSA is the main output of this research. This is a reference architecture upon which all KMSs are meant to be built on. A reference architecture can be defined as a document or set of documents that can be referred to for best practices to select the best delivery method for a technological implementation. The GKMSA forms the main part of the Knowledge Management System Development Model, as it central to the development of the eventual KMS. This means this architecture should take into consideration the main factors involved in KM initiatives as well as those that are considered in the development and use of KMSs. The factors taken into consideration during the development of the GKMSA have been described in Chapter 2 Section 2.10.1.

4.3.1 Quality Attributes

Quality attributes are the standards that have been defined for the system's intended behavior within the environment for which it was built. They are more inclined towards non-functional requirements and are orthogonal to functional requirements, as their realization does not have a direct effect on the requirements of the user.

When looking at the quality attributes of a KMS, it has to be noted that a KMS is a system that has open boundaries, allowing it to interact with other systems hence rendering it a soft system. This also means that a knowledge management system can be a collection of systems, hence it can be built by taking advantage of the existing information technology infrastructure in the organization and realigning them to suit its knowledge needs. New systems can then be introduced to add functionality that is already not being provided by the systems integrated in the KMS. Therefore, a key attribute of KMSs is flexibility in the handling of various knowledge forms, while being robust enough to maintain reliability.

The following quality attributes were obtained from the literature that was used in this research and have been chosen to be incorporated into the GKMSA:

- Storage Engine – a robust storage system is needed for storing explicit knowledge as well as referencing it for easy access. The storage system, which can be made up of databases and data warehouse systems, should be able to generate meta-data for the purposes of extracting knowledge and sending notifications to users. More so, it should allow for the dynamic updating of data to maintain its relevance.
- Scalable – able to support the addition of more users and a growing knowledge base.
- Extensible – allow for new capabilities and/or technologies to be introduced as the evolution of organizational needs occurs.
- Secure – should protect the knowledge assets of the organization from unauthorized access and use.

- Compliant to Industry Standards – should be built such that the evolution of the system with time is not hindered by incompatibility issues due to the inability to interface with other or new technologies.
- Flexible – the system must handle all knowledge forms, be they textual, graphical or multimedia, while also handling various types of users with varying needs.
- Complex Querying – there should be the ability to query data from different sources and to provide outcomes from even the most complex of queries.
- Reliable – the system should always be online whenever it is required. It should also be able to provide the quality of service required by the user, as well as come up with acceptably accurate results consistently.

The user requirements and quality attributes outlined need to be identified within the operating environment, as no system works independent of others. Hence issues to do with system interfaces, interaction between systems as well as corporate policies are factors that will have to be considered in coming up with the eventual design of the KMS.

4.3.2 User Requirements

A successful KMS solves problems related to knowledge use and its acquisition. The success of the system is measured by the user's interaction with the system, their level of satisfaction with its functions and capabilities, and improved production as a result of using the system. A number of projects have been found to fail due to incomplete and ever-changing requirements, as well as lack of resources, support, unrealistic expectations and lack of user involvement (Standish Group International, 2013). This makes it important to plan carefully and generate clear and concise user requirements that will be incorporated in the KMS (Durant-Law, 2003), since user requirements focus on what is to be achieved or obtained from the system by the user.

The main requirements found from the literature studies are to be incorporated into the GKMSA as follows:

- Notifications – just-in-time and on-demand notifications are required from the system to inform relevant users of the availability of or any activity on the knowledge they need or use.
- Knowledge sharing and transfer capabilities – the system should allow for the sharing and transferring of knowledge to geo-spatial locations, to aid in collaborations and universal access to knowledge.
- Heuristics – the KMS should have the ability to learn the user's needs, thus directing or providing relevant in-depth knowledge.
- Knowledge Capture Capabilities – knowledge should be captured into the system's data sources as it is created, transferred and used.
- Ability to organize and classify knowledge.
- Offline Analysis – Caching functionality will help users to access information they frequently use, even when they are not connected to the KMS, or are off-campus.

The quality attributes and user requirements obtained were then used in the consideration of the KM tools and KM subsystems to be considered for incorporation into the architecture. This is because KM activities fail due to a lack of proper tools to meet the knowledge requirements, hence having the right requirements from users will allow the sourcing and introduction of relevant technologies for KM.

4.4 The service-oriented generic knowledge management system architecture

The integration of various systems and the ever changing user demands to the KMS justify the use of the Service-Oriented Architecture (SOA). A service-oriented architecture (SOA) is an architectural style in which services are provided via independent application components, which communicate using a protocol over a network. Each service is an independent unit that has a set of functionalities that can be used and updated independently, while being able to interact and collaborate with other services in the architecture. An SOA has the following benefits that make it suitable for a GKMSA:

- Services – these are modules or components that can be reconfigured to create a new functionality that may arise due to changes in business needs or processes, hence increasing flexibility of the system and interoperability of the various systems. The various systems that make up a KMS are the services in the KMS architecture.

- Service Re-use – the services can be reconfigured and used over again, allowing for reconfiguration of the system, as well as lowering development, management and procurement costs.
- Messaging and Message Transformation – an SOA provides a means by which information is relayed from one system to another, while also having the capabilities to transform them into the context and formats that they are required in. For this architecture, an enterprise service bus is incorporated for the communication between systems.
- IT – Business Alignment – due to the flexibility and interoperability of the services in the SOA, aligning IT functionality to business requirements is made easier due to reconfigurable and reusable services. Thus a SOA based KMS is easier to adapt to the needs of the organization. The services can also be incorporated such that they represent a business outcome, hence every service's incorporation can be justified based on how it will be used to the advantage of the business.

From a software development perspective, the SOA also provides the benefits of

- Loose coupling – each service it developed independent of others, reducing dependencies among the services.
- High cohesion – all the components included within a service are heavily dependent on each other, hence each service or service application is only made up of pieces that have a strong relationship/dependency among themselves.
- Parallel development of modules or components – due to loose coupling, the services can be developed simultaneously, so long there is agreement on the nature of interfaces to be included in each module in order to communicate with other service modules.
- Rich testability – since an SOA is made up for independent services, it allows for granular testing for functionality, security and governance, ensuring the robustness of the each service as well as the overall architecture.

These software development benefits are important to a KMS because it is usually made up of various systems in the organization, thus being able to develop and test them separately with the assurance they will work well with the rest of the systems reduces the time to deployment, which leads to added business value in a short space of time.

The various technologies used in KMSs were considered in the development of the GKMSA. The technologies were broken down into their sub-systems or components, with the aim of coming up with the reusable components that will become the services in the architecture. The breakdown of the technologies was done based on the integral units that make up the subsystem. Each integral unit was considered a reusable component, to the extent that it could be broken down. Table 4.1 illustrates this breakdown and the reusable components that were identified.

KM Subsystems	Reusable Component Required
Intranet/Extranet	Network
Help Desk applications	Phone, Email, Fax, Web, Voice Mail
Information Retrieval Engines	Search Engine, KBs, Representation Engine
Push Technologies and Agents	Agents
Data Warehouse	Databases (Data Sources), ETL Tools, Data Marts
Data Mining tools	ETL Tools
Electronic Bulletin Boards	Discussion Forum
Blogs	Web
Experts Systems	Inference Engine, KB
Online Information sources	Internet, Web
Enterprise Collaboration System	Calendaring/scheduling, Project management, workflow system, Document Management System, Wiki
Knowledge Database	Databases
Information Systems	Hardware, Software, Data, Procedures, People
Decision Support Systems	Databases, User Interface, Model Management, Data Management
Electronic Meeting/Conference systems	Data, Video, Voice Conferencing, discussion forum, chat system
Electronic Performance Support Systems	Training module, KB, text retrieval, agents, and communication tools.
Communication Tools	Email, Voice Mail, Faxing, Web, Phone

Table 4.1. KM Subsystems and their KM Tools

This breakdown led to the development of the high level architecture view in Fig. 4.6. This architecture was developed by categorizing the KM Subsystems according to common functions and identifying the main categories, which were then incorporated into the architecture according to the functions they deliver. The arrangement of the architecture follows the standard way in which the identified categories interface with each other.

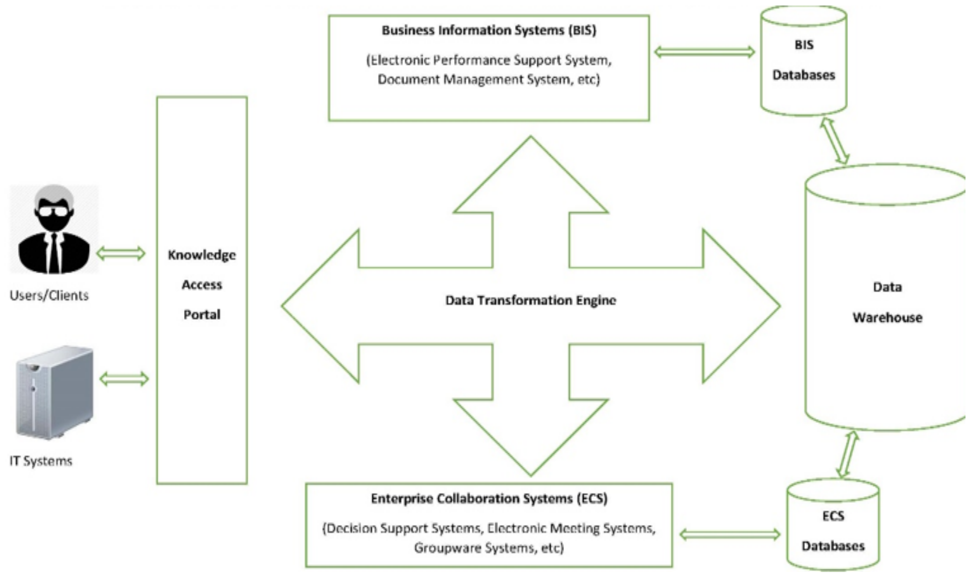


Figure 4.5 High Level View of the Generic Knowledge Management System Architecture

The arrows in Figure 4.6 indicate the direction of data flow. This data can be in any form, including, text, video, graphics, images, among others. The Data Transformation Engine is made up of the KM Subsystems that transform the data and knowledge into what is required, where necessary. The GKMSA will take the place of the Data Transformation Engine, while incorporating the rest of the systems in the diagram. This is because it will introduce the user requirements and qualities that are required of a KMS architecture. To achieve this, the Data Transformation Engine is substituted as shown in Fig. 4.7, where it is replaced with KM tools at the bottom layer, followed by KM sub-systems which are built based on, and using the KM tools.

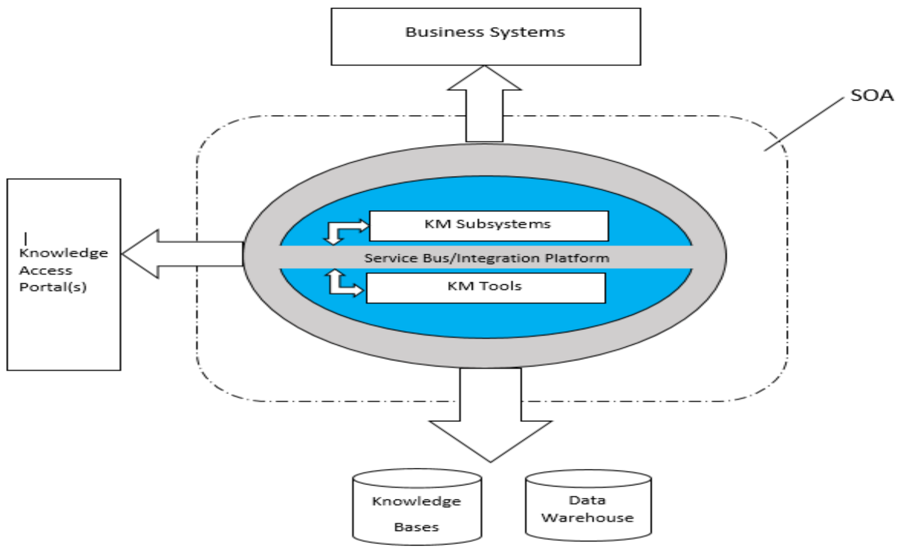


Figure 4.6 High Level View of the Generic Knowledge Management System Architecture with the Data Transformation Engine now substituted with the KM Tools, KM Subsystems and the Service Bus.

The communication between the KM tools and the KM subsystems is achieved through a service bus, which carries all the communication between the components. A service bus is a communication system or method used by software applications which interact together to transmit and receive information. The combination of these three main components will form the SOA based GKMSA.

KM technologies can be classified under three levels (Gallupe, 2001):

- Level 1 being made up of KM tools
- Level 2 being the subsystems making up a KMS
- Level 3 being the KMSs.

This categorization has influenced how the technologies are grouped in coming up with the GKMSA.

The KM tools are the systems that will make up the services of the architecture. These are systems that are usually found in organizations, which are integrated into the KMS. The systems that can be considered as KM tools are listed in Table 4.2, under the Reusable Component Required column. The KM Subsystems are the systems that are made up as a result of integrating the KM tools. Therefore, the functionalities of these systems are dependent on the functionalities of the underlying KM Tools. The link between the KM tools and the KM subsystems is found through the service bus, which provides infrastructure capabilities, implemented by middleware technology, that enable the integration [and communication] of services in an SOA. However, the communication is further coordinated by the introduction of a service registry. The service registry is a database which contains information on how to dispatch requests among the various services. The service registry controls the communication among the service providers and consumers as a broker, promoting location transparency and reuse of services.

Figure 4.7 shows the types of software and applications that can make up the KM Tools as re-usable SOA services, while Figure 4.8 shows examples of KM Subsystems that are built by integrating the KM Tools.

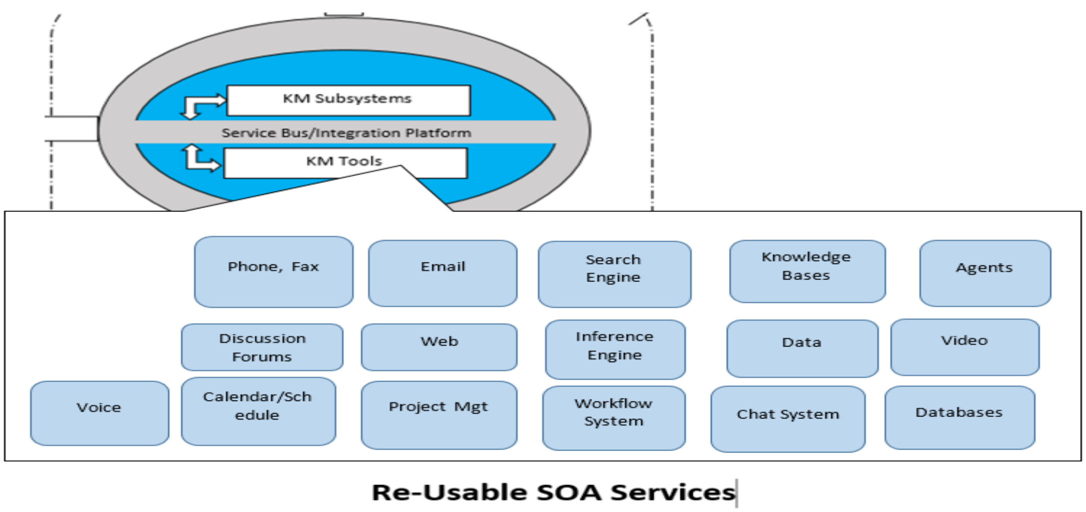


Figure 4.7 Examples of KM Tools

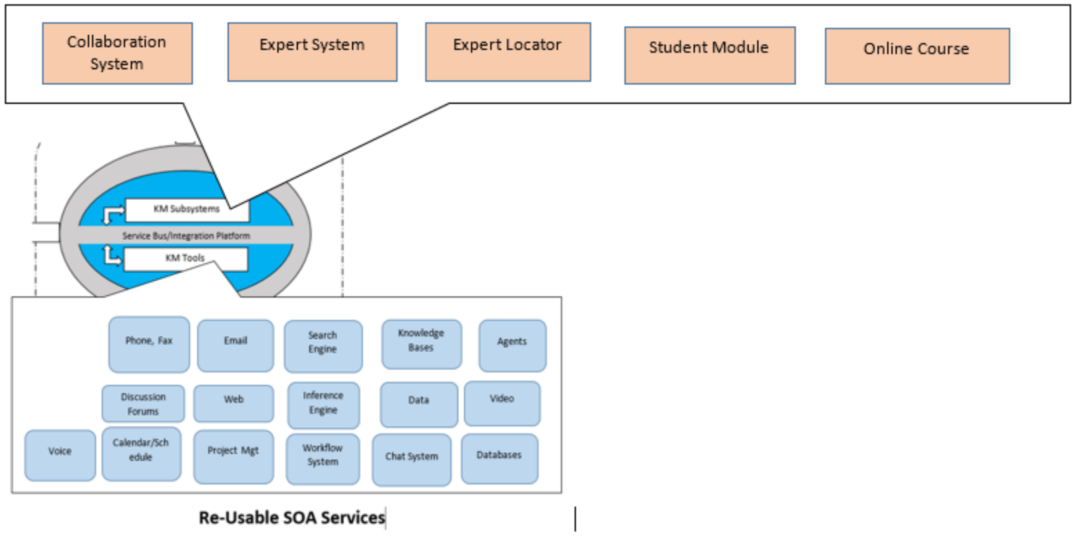


Figure 4.8 Examples of KM Tools and KM Subsystems

The GKMSA is fully illustrated in Fig. 4.9. In this layered architectural view, the knowledge bases form the bottom-most layer. They communicate with the KM tools in the second layer via the service bus. Above the KM tools are the business applications that are created from the KM tools. The layers of business applications can be multiple, depending on the level of complexity of the applications required, as well as their uses. Above the business applications layer come the user portals or presentation tools with which the users of the KMS will communicate with the system. Most importantly, the service registry coordinates the communication between the KM tools, KM subsystems and user portal layers. The layered architecture displays the various layers that the GKMSA is made up of.

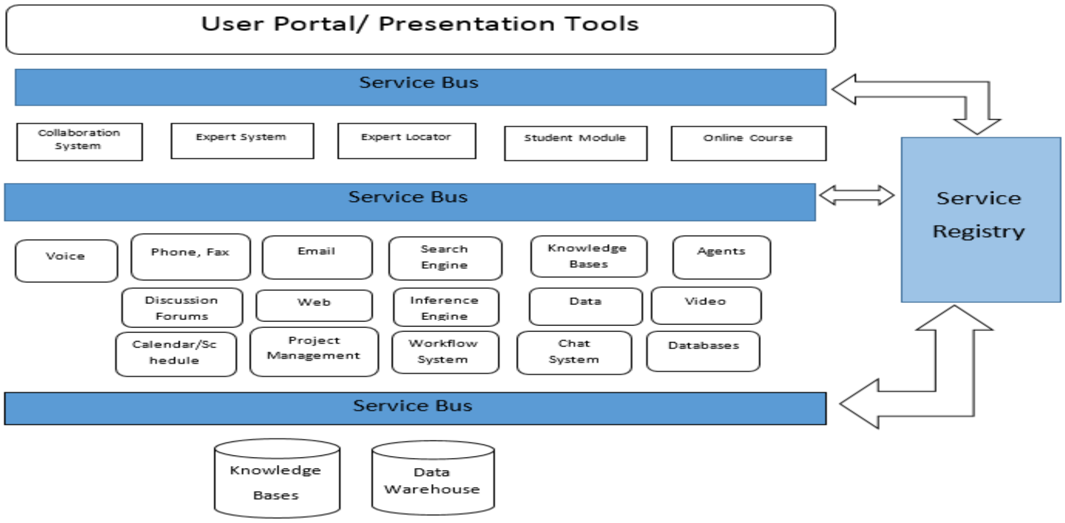


Figure 4.9 A Layered SOA-Based Generic Knowledge Management System Architecture

Finally, the GKMSA architecture is presented in component and connector architectural style in Figure 4.10.

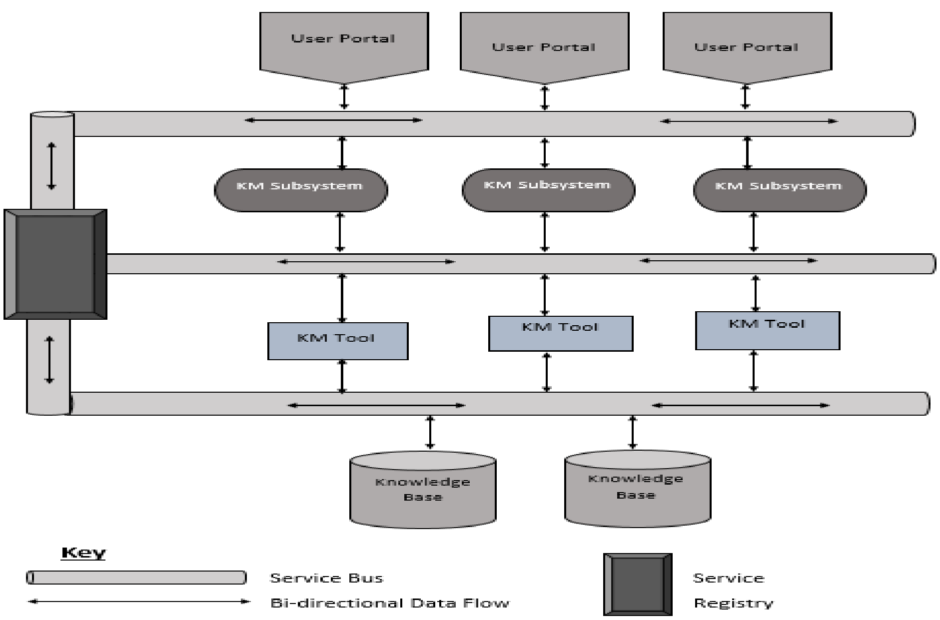


Figure 4.10 Component and Connector Diagram of the SOA-Based Generic Knowledge Management System Architecture

4.5 Theoretical justification for the SOA-based GKMSA

The SOA-Based GKMSA is considered as a good solution for a reference architecture for KMSs due to its ability to incorporate various systems in a reconfigurable manner. This is opposed to the other architectures, which follow a set way of configuring systems for communication, without the flexibility to evolve or incorporate architectural concepts from other architectures.

This ability to integrate various systems allows for organizations to use this architecture for reference purposes, while choosing technologies to use that suit their unique strategies. This creates a competitive advantage in the market, while having the guarantee of an unchanging architectural design that allows for the components to be added and removed without affecting the KMS's core structure.

In addition to flexibility, the SOA-based GKMSA clearly defines the systems that can be defined as services in the architecture and those that are built on top of the services. This removes the uncertainty and facilitates reproduction of the same system across various industries. By having KM subsystems building upon the KM Tools, there is a well laid out technique in which the KMS components build on each other, thus allowing for various levels of application and data processing complexity to be achieved as the layers in the architectures are increased.

Having the service registry as a control mechanism introduces decoupling of the functionality of services from the logic of the overall architecture. This allows for changing of the systems which provide the service, while maintaining the system logic intact, hence maintaining the core functionality of the KMS regardless of the technologies used to achieve them.

Finally, this architecture is more realizable as it can use already existing systems in the organization, and can be tailored around the existing environment, rather than being introduced such that the culture and processes of the organization have to be adapted to suit the system (technology-push model). This allows for better IT-business alignment, as well as for the organization to come up with their KM objectives, irrespective of the functionality of the KMS, as it can be adapted to suit their needs.

4.6 Chapter Summary – Presentation of Results and Analysis

In this chapter, the results and outcomes of the research were discussed. The number of publications used and their categorization was highlighted. This was followed by an in depth look at the Knowledge Management System Development Model, which is meant to be the guiding framework in developing the Generic Knowledge Management System Architecture.

The architecture was then outlined, leading to the discussion on the basis on which it can be justified. The following chapter will provide a conclusion to this research.

CHAPTER 5 CONCLUSION

5.1. Introduction

This research focused on the development of a generic reference software architecture that will guide the development and implementation of KMSs. This architecture was accompanied by a generic KMS development model that lays out the development process of the KMS. There has been a lack of guidance in how KMS should be developed and how they should look like, with academics and practitioners alike coming up with industry or sector specific KMS solutions. This has led to a conceptual conundrum which required the synthesis of the various concepts into a common foundation that can be used in coming up with KMS initiatives, regardless of where the initiative is to be implemented.

Significant research has been done in the field of KM, which has led the discipline to develop more and more interest among researchers and practitioners. But little research has really been done on the integration of the various technologies into a KMS. It is this current development that has led to this study. In this chapter we will discuss the findings from the perspective of the literature review and research questions, we will look at the theoretical implications of the research and also provide recommendations for future research, which will be followed by a conclusion to the thesis.

5.2. Findings

5.2.1 Literature Review

The literature review brought to the fore issues pertaining to the use of technology in KM initiatives, clearly highlighting the synergy that exists between the uses of technology and the rest of the disciplines that contribute to KM. KMSs cannot be studied in isolation, but there is need to look at how the rest of the KM disciplines affect the development and use of KMSs in work environments.

In implementing a KMS, existing infrastructure plays a critical role because a KMS is developed largely by integrating various systems hence the need to be able to use what is already in the work environment to lessen the financial burden and the learning curve for users. However, there will be situations where new technologies and new personnel will have to be brought in. The personnel do not necessarily have to be IT skilled, but can be anyone with the required skills to make the KM initiative a success. This shows the need for T-skilled employees, as well as the importance of other disciplines such as human resources in a successful KM initiative.

Various KM models and architectures exists and they come up with strategies and information from the perspective of the disciplines of the researchers and practitioners who develop them. This contributes to the richness of the KM research domain, allowing for other disciplines to tap into the KM research from others to create a well-knit research effort in KM. Thus there are lots of relationships in the researches that have been conducted. It is upon the contributions of these models and architecture that this research is developed, as they helped guide the thinking process and the gathering of the data that shaped the research.

5.2.2 Research Questions

The findings of this study as well as the resultant model and generic architecture have been outlined in the preceding chapter. The findings in relation to the research questions are as follows:

1. **On what basis and methodologies are current models and architectures for knowledge management systems being developed to increase interoperability with other models and/or architectures?**

   There are a lot of knowledge management models, with the researcher having discussed seven different categories of the models in the literature review chapter. These models cover various aspects of KM from the perspectives of the many disciplines that contribute to the field. Their major contribution to KMSs' development and implementation is how they connect the KM concepts from various disciplines to inform the nature and types of KMSs. The Knowledge Management System Models put the KMS at the center of the model and shape all other activities around it. These models are largely developed by researchers through observation or building upon KM theories and concepts in existent. One of those concepts that have been widely referenced in the development of KM models is the SECI model by Nonaka. The need for guiding principles in KM has always been identified, which has led to the development of these models, which provide frameworks in the various disciplines contributing to KM. More and more models continue to be developed as KM initiatives evolve and this research has contributed its own Knowledge Management System Development Model to guide the development process of KMSs.

In terms of KMS architectures, they have largely been developed from existing architectural styles such as client-server and distributed architectures. Most just focus on having a KMS, without really being tailored towards knowledge management. Some, such as the Context Based Knowledge Flow Management System Architecture have incorporated concepts such as Knowledge Energy Managers and Knowledge Quality Analyzer to cater for the specific needs of KM in the architectures. However, there has largely remained a gap in terms of the foundation upon which the nature of a KMS is determined and how the system should be constructed, leading to this research which sought to come up with such a foundation in the form of a reference architecture for KMSs.

2. **What factors determine the characteristics of generic models and architectures for knowledge management systems and how do they relate together towards achieving uniformity and interoperability?**

   KM being a multi-faceted discipline has many factors contributing to the technological aspects of KM that include requirements solicitation, system development, implementation and evaluation among others. Coming up with the factors that lead to the determination of what to consider in coming up with a generic architecture therefore requires to look at KM from a cross-cutting perspective, taking note of all the factors that may affect the users and developers of the system, the eventual system itself and also those who will evaluate its effectiveness. There is also need to look at the process itself that leads to the development of the KMS. The main factors that were identified in this research that determine the characteristics of generic models and architectures for knowledge management systems are architectural quality attributes, stakeholders, pre-existing systems/infrastructure, measurement/evaluation techniques, the operating environment and knowledge forms. These factors were identified after looking at how the knowledge life cycle is affected by the actions of the system users as well and the functionality of the system.

3. **How are generic models and architectures developed for knowledge management systems to achieve uniformity and interoperability?**

   The researcher developed his own conceptual framework to guide the research. This was necessitated by the lack of a framework to guide the research that could result in the development of a generic software architecture for KMSs, as there were no studies identified that had tried to tackle the issue of interoperability, uniformity and reusability of KMSs. In this regard, the generic models and architecture was developed after a comprehensive holistic study of knowledge management, which was then narrowed down to studying the use of technology in KM and KMSs, then followed by a study of KM Models and architectures, culminating in the development of the generic model and architecture.

5.3 Theoretical Implication

This research did not seek to invalidate or discredit the works done earlier by other researchers, but sought to add on to already existing research. It is a natural step in the progression of KM research as researchers in the field seek to come up with a common understanding and unifying concepts. The research has contributed to the discussion of technology's role in KM by adding an architecture that can be used in developing KMS. The architecture is however theoretical, since there is no empirical evidence of how it performs, but that does not take away from its theoretical contribution to the use of technology in KM. It actually adds a new dimension to the study of knowledge management systems, bringing to focus the actual technical aspects of coming up with a knowledge management system by focusing on the best ways of integrating technologies in a way that allows for the knowledge life cycle to be fully realized in an organization.

5.4 Recommendations for Future Research

The study of KMSs and how they are to be developed, implemented and evaluated is extensive, with more room for broader and/or deeper research to be done. Having looked at how we can come up with a universal framework for KMSs from an architectural perspective, there is still some more work to be done in this regard and related KM facets. The following can be pursued as future research that can contribute further to the field of KM in relation to KMSs:

- Further research can be conducted on the implementation and evaluation of the effectiveness of the Knowledge Management System Development Model and the GKMSA.
- There is need to explore further the relationships of the actual technologies, that is, the KM Tools and KM Subsystems, incorporated into a KMS with regards to how they can be integrated for maximum benefit in terms of knowledge use and dissemination, guided by the knowledge life cycle.
- Research can be conducted on how a KMS can follow the exact stages of the knowledge life cycle in executing its duties, such that the user is easily guided on the potential direction to take based on the flow of the knowledge life cycle.

5.5 Conclusion

In today's knowledge based economies, the use of knowledge management systems will provide a competitive advantage in various sectors. However, the systems need a structure that can be referenced and improved on. The architecture presented in this paper has not yet been implemented, but serves as a good starting point in the discussion for coming up with a technological framework for the development of KMSs. It is hoped that KMS architectural studies will become more prominent among researchers as more and more knowledge is produced, and as the need for its optimal utilization through KMSs grows in organizations.

REFERENCES

[Online]. Available at: http://www.javacodegeeks.com/2013/03/enterprise-benefits-on-service-oriented-architecture-soa.html

[Online]. Available at: https://www.opengroup.org/soa/source-book/soa/soa_features.htm

Allahawiah, S., Al-Mobaideen, H. & Nawaiseh K. 2013. The Impact of Information Technology on Knowledge Management Processes An Empirical Study in the Arab Potash Company. *International Business Research*. **6**(1), pp.235-252.

Alshawi, M. 2007. Rethinking IT in Construction and Engineering: Organizational Readiness, Routledge. London.

Andone, I. 2009. Measuring the Performance of Corporate KMS. *Informatica Economica*. **13**(4), pp.24-31.

Aoyama, K., Ugai, T. & Arima, J. 2007. Design and Evaluation of A Knowledge Management System Using Mathematical model of Knowledge Transfer. *In*: Apolloni, B., Howlett, R. J., and Jain, L. (eds). *KES 2007/WIRN 2007 Part II, LNAI 4693*. Vietri sul Mare, pp.1253-1260.

Barbosa, J., Gonçalves, A., Simonetti, V. & Leitão A. 2009. A Proposed Architecture for Implementing a Knowledge Management System in the Brazilian National Cancer Institute. *Brazilian Administration Review*. **6**(3), pp.247-262.

Bass, L., Clements, P. & Kazman R. 2003. *Software Architecture in Practice, Second Edition*. Boston: Addison Wesley.

Birkinshaw, J. & Sheehan, T. 2002. Managing the Knowledge Life Cycle. *MITSloan Management Review*, pp.75-83.

Bixler, C. 2005. Developing a Foundation for a Successful Knowledge Management System. *In*: Stankosky, M. (ed). 2005. *Creating the Discipline of Knowledge Management The Latest in University Research*, Burlington: Elsevier Butterworth–Heinemann.

CEN. 2004. *European Guide to good Practice in Knowledge Management - Part 1: Knowledge Management Framework*.

CENb. 2004a. *European Guide to good Practice in Knowledge Management - Part 2: Organizational Culture*.

CEN. 2004b. *European Guide to good Practice in Knowledge Management - Part 3: SME Implementation*.

CEN. 2004c. *European Guide to good Practice in Knowledge Management - Part 4: Guidelines for Measuring KM*.

Chang, C.T. & Chuang, S.H. 2009. Performance Effects of Knowledge Management: Corporate Management Characteristics and Competitive Strategy Enablers. *Asian Journal of Management and Humanity Sciences*. **4**(4), pp.181-199.

Clements, P., Bachmann, F., Bass, L., Garlan, D., Ivers, J., Little, R., Merson, P., Nord, R. & Stafford, J. 2011. *Documenting Software Architectures Views and Beyond Second Edition*. Addison-Wesley.

Deve, T., Hapanyengwi, G. 2014. Knowledge Management Systems Generic Architectures: Enhancing Uniformity and Interoperability of Technological Tools for Knowledge Management. *Electronic Jornal of Knowledge Management*. **12**(3), pp.206-218.

Durant-Law, G. 2003. *Specifying a Knowledge Management System*. Unpublished

Dwivedimy, K., Venkitachalam, K., Sharif, A.M., Al-Karaghouli, W. & Weerakkody, V. 2011. Research Trends in Knowledge Management: Analyzing the Past and Predicting the Future. *Information Systems Management*. **28**, pp.43-56.

Eriyatno, Suroso, I.A., Affandi, M. J. & Sucahyo R. 2013. Knowledge Management Strategy To Increase The Innovation Of The Telecommunication Company. *International Journal of Information Technology and Business Management*. **12**(1), pp. 78-89.

Erl, T. 2005. *Service-Oriented Architecture: Concepts, Technology, and Design*. Prentice Hall.

Firestone, J. & McElroy, M.W. 2005. Doing Knowledge Management. *The Learning Organization Journal*. **12**(2), pp. 189 - 212

Firestone, J. 2001. Key Issues in Knowledge Management. *Journal of Knowledge Management Consortium International, Inc*. **1**, pp.8-38.

Frost, A. 2012. 'An Integrated Knowledge Management Model' Available at: http://www.knowledge-management-tools.net/knowledge-management-model.html

Galandere-Zile, I. & Vinogradova, V. 2005. Where is the Border Between an Information System and a Knowledge Management System? *Managing Global Transitions*. **3**(2), pp.179–196.

Gallupe, B. 2001. Knowledge Management Systems: Surveying the Landscape. *International Journal of Management Reviews*. **3**(3), pp.61-77.

Grimaldi, M. & Rippa, P. 2011. An AHP-Based Framework for Selecting Knowledge Management Tools to Sustain Innovation Process. *Knowledge and Process Management*. **18**(1), pp.45-55.

Haslinda, A. and Sarinah, A. 2009. A Review of Knowledge Management Models. *The Journal of International Social Research*. **9**(1) pp. 187-198.

Hawajreh, K. M. & Sharabati, A. A. 2012. The Impact of Information Technology on Knowledge Management Practices. *International Journal of Business, Humanities and Technology*, December, pp.102-107.

Heavin, C. & Frederic, A. 2012. Exploring the Alignment of Organisational Goals with KM: Cases in Four Irish Software SMEs. *Electronic Journal Information Systems Evaluation*. **16**(3), pp.23-34.

Heejun, P. 2005. Knowledge Management Technology and Organizational Culture. *In*: Stankosky, M., (ed). *Creating The Discipline of Knowledge Management The Latest in University Research*, Burlington: Elsevier Butterworth–Heinemann, pp.141-156.

Huang, C. & Lin, T. 2008. Understanding Knowledge Management System Usage Antecedents: An Integration of Social Cognitive Theory and Task Technology Fit. *Information & Management*. **45**(6), pp.410-417.

Jarrahi, A., Kangavari, M. 2012. An Architecture for Context-Aware Knowledge Flow Management Systems. *IJCSI International Journal of Computer Science Issues*. **9**(2), pp.40-51.

Kebede, G. 2010. Knowledge management: An information science perspective. *International Journal of Information Management*. **30**, pp.416-424.

Kim, Y. & Abbas, J. 2010. Adoption of Library 2.0 Functionalities by Academic Libraries and Users: A Knowledge Management Perspective. *The Journal of Academic Librarianship*. **36**(3), pp.211-218.

Kumar, N. 2013. ‘Enterprise Benefits on Service Oriented Architecture – SOA’, *Java Code Geeks.*
Kumar, S. & Gupta, S. 2012. Overview, Role of Knowledge Management Systems (KMS) in Multinational Organization: An. *International Journal of Advanced Research in Computer Science and Software Engineering*. **2**(10), pp.8-16.

Lee, H. & Choi, B. 2003. Knowledge Management Enablers, Processes, and Organizational Performance: An Integrative View and Empirical Examination. *Journal of Management Information Systems*, pp.179-228.

Liao, S. & Wub, C. 2010. System perspective of knowledge management, organizational learning, and organizational innovation. *Expert Systems with Applications*. **37**, pp.1096-1103.

Lindgren, R., Hardless, C., Pessi, K. & Nuldén U. 2002. The Evolution Of Knowledge Management Systems Needs To Be Managed. *Journal of Knowledge Management Practice.* **3**.

Lindner, F. & Wald, A. 2011. Success factors of knowledge management in temporary organizations. *International Journal of Project Management*. **29**, pp.877-888.

Lindvall, M., Rus, I. & Sinha, S. 2003. Technology Support for Knowledge Management. *In*: Scott, H. & Henninger, F. (ed). *Advances in Learning Software Organizations*, Springer Berlin Heidelberg, pp.94-103.

Maryam, A. & Leidner E. 2001. Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues. *MIS Quarterly*. **25**(1), pp.107-136.

Matayong, S. & Mahmood, A. 2013. The review of approaches to knowledge management system studies. *Journal of Knowledge Management*. **17**(3), pp.472-490.

McAdam, R & McCreedy, S. 1999. A critical review of knowledge management models. *The Learning Organization*. **6**(3), pp.91 - 101.

Miklošík, A. & Hvizdová, E. 2012. Knowledge Base Cloud – A New Approach To Knowledge Management Systems Architecture. *Acta Universitatis Agriculturae Et Silviculturae Mendelianae Brunensis*. **28**(4), pp.267-280.

Nabeth, T., Angehrn, A. & Roda C. 2003. Enhancing Knowledge Management Systems with Cognitive Agents (Améliorer les Systemes de Gestion de la Connaissance avec des Agents Cognitifs). *Systèmes d'Information et Management*. **8**(2), pp. 69-91.

Nonaka, I. 2005. *Knowledge Management: Critical Perspectives on Business and Management*. Routledge, London.

Paswan, A.K & Wittmann, C.M. 2009. Knowledge management and franchise systems. *Industrial Marketing Management*. **38**, pp.173-180.

Rahman, A., Bhardwaj, A., Pathak, M. & Rathore, S. 2011. Introduction of Knowledge Management Architecture Using Multi Agent. *International Journal of Computer Science & Information Technology*. **3**(6), pp.229-239.

Schütt, P. 2003. The post-Nonaka Knowledge Management. *Journal of Universal Computer Science*. **9**(6), pp.451-462.

Softwarearchitectures.com. 'Quality Atributes' 2015. [Online]. Available at: http://www.softwarearchitectures.com/qa.html

Standish Group International. 2013. *Chaos Manifesto 2013 Think Big Act Small*. Boston

Stankosky, M. 2005. Advances in Knowledge Management: University Research Toward an Academic Discipline. *In*: Stankosky, M., (ed). *Creating the Discipline of Knowledge Management The Latest in University Research*, Burlington: Elsevier Butterworth–Heinemann, pp.1-14.

Sultan, A. 2003. Knowledge Management Systems Requirements Specifications. *University of Canberra, Unpublished*

Supyuenyong, V. & Islam, N. 2006. Knowledge Management Architecture: Building Blocks and their Relationships. *In*: *Technology Management for the Global Future, 2006. PICMET 2006, Volume: 3*. Portland. pp. 1210-1219.

Sureephong, P., Chakpitak, N., Ouzrout, Y., Neubert, G. & Bouras, A. 2007. Knowledge Management System Architecture for the Industry Cluster. *The International Conference on Industrial Engineering and Engineering Management (IEEM)*. pp. 1970-1975.

The Open Group. 2014. 'Service Oriented Architecture: SOA Features and Benefits'

Tiwana, A. 2002. *The Knowledge Management Toolkit*. Prentice Hall, New Jersey, USA

Tow, W., Venable, J. & Dell, P. 2012. How Organisations Know What They Know: A Survey of Knowledge Identification Methods among Australian Organisations. *In*: *23rd Australasian Conference on Information Systems*. Geelong. pp. 1-10.

Tseng, S. M. 2008. The effects of information technology on knowledge management systems. *Expert Systems with Applications*. **35**, pp.150–160.

Ulrich, F. 2001. Knowledge Management Systems: Essential Requirements and Generic Design Patterns. *In*: *Proceedings of the International Symposium on Information Systems and Engineering, ISE'2001, Las Vegas*. Las vegas, pp.114-121.

Vogel, O., Arnold, I., Chughtai, A., & Kehrer, T. 2011. *Software Architecture A Comprehensive Framework and Guide for Practitioners*. Berlin Heidelberg: Springer-Verlag.

Yates, D. & Paquette S. 2011. Emergency knowledge management and social media technologies: A case study of the 2010 Haitian earthquake. *International Journal of Information Management*. **6**(13), pp.6-13.

Yogesh, M. 2005. Integrating Knowledge Management Technologies in Organizational Business Process: Getting Real Time Enterprises to deliver Real Business Perfomance. *Journal of Knowledge Management*. **9**(1), pp.7-28.

Zyngier, S. 2001. The Role of Technology in Knowledge Management Strategies in Australia: Trends in the Australian Corporate Environment. *In*: *Australian Conference on Knowledge Management and Intelligent Decision Support (ACKMIDS)*. Melbourne.