The Development of Bioinformatics Knowledge Management System with Collaborative Environment

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ABSTRACT

Nowadays, Knowledge Management System (KMS) becomes a common medium to distribute knowledge by using the IT as enabler tools for everyone to reach, share with among the members, and used it from any workplace in the world at any time. In the context of Bioinformatics institution sectors, the collaboration tools of KMS explore the opportunity to create, gather, access, organize, distribute and disseminate the knowledge to their community of practice (CoP) for various purposes such as learning process, Research and Development (R & D) and others. This paper describes on the theoretical concepts and approach of Bioinformatics KM system that could be implemented in institution by showing on how the framework of KM system model is developed using relevance software. The achievement in conducting this framework of the Bioinformatics KMS is an added value for the institution that needs to implement the Bioinformatics KMS, which can help them to achieve their aims and mission statements. The emphasis also will be given to the activities for each stage in the KM life cycle including the critical success factor (CSF) in order to make sure that KMS initiatives will deliver competitive advantage to the institutions.

Keywords

Knowledge, Knowledge Management, Knowledge Management System, Critical Success Factor, and Bioinformatics

1.0 INTRODUCTION

Knowledge Management (KM) has been a buzzword in a range of subject disciplines for many years, and has latterly been applied to higher learning institution. With the growth of this concept, there has also been a need to develop ways of understanding knowledge processes within this domain and to select KM systems that can help in knowledge creation, storage and sharing. In terms of definition, KM is the systematic, explicit, and deliberate building, renewal, and application of knowledge to maximize an enterprise's knowledge-related effectiveness and returns from its knowledge assets (Wiig, *et. al*, 1997).

KM is a discipline that provides strategy, process and technology to share and leverage information and expertise that will increase our level of understanding to more effectively solve problems and make decision (Satyadas, *et. al*, 2001). The objectives of knowledge management are to make the organization act as intelligently as possible to be secured in term of viability and overall process, and to realize the best value of its knowledge assets.

A bioinformatics institution seems to be by its nature especially the suitability for applying the system in KM principles and methodology (Morrow and Wilkins, 2004). The main reasons are, the institution usually posses a modern biological information infrastructure, its knowledge of the community as well as the biologists who generally love to share their knowledge with others. The communities are also desire to acquire knowledge from accessible sources as fast as they could. Therefore, in the bioinformatics industry, KM can be defined as a systematic process that creates, captures, shares, and analyzes knowledge in ways that directly improve performance.

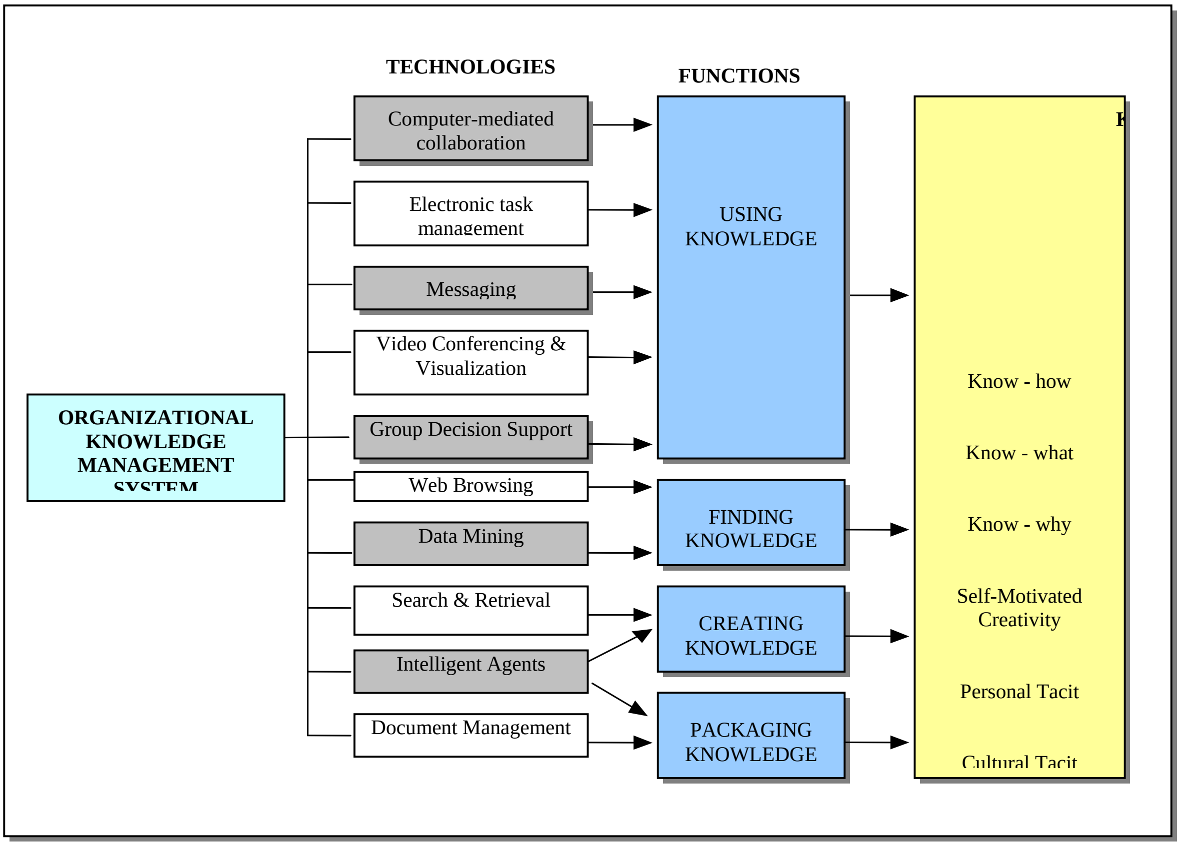

Figure 1: The Technical Perspective of a Knowledge Management System

From a theoretical standpoint, Knowledge Management Systems (KMS) refer to the information systems adopted and designed which efficiently and effectively leverage the collective experience and knowledge of employees to support information processing needs as well as enabling and facilitating sense making activities of knowledge workers (Wickramasinghe, 2002). KMS can include of any type of information, including both quantitative and qualitative. Qualitative information may be in the structured or semi structured text format and often takes the form of reports from prior project leaders on what they have learned during the project. Figure 1 simplifies the technical aspect of a KMS (Meso and Smith, 2000). A well designed of KMS should consider and concern about these four core features so that the system will bring a lot of benefits to the organization. The four core features are:

- Infrastructure, Content and Portal
- Collaboration and Learning
- .
- Social Capital and Expertise
- Communities, Business Intelligence and Integration

The development of KMS involved a number of technologies. The combination of these technologies will produce a system that can collect, sort, store, and share the information throughout the organization. These technologies can be:

- *Intranets* – secure internal networks, to provide an ideal environment for sharing information accessed using a standard browser.
- *Information Retrieval Engines* – search engines are an absolute necessity and are the integral part of KMS.
- *Groupware* – facilitate information sharing via e-mail, online discussions, databases and related tools. Its collaborative features can result in the creation of stores of untapped knowledge

- *Database Management Systems* – computer databases are common repositories of information. KMS can be constructed to incorporate the information that is stored in the organization and accessible by all.
- *Data Warehousing and Data Mining* – data warehouses are centralized repositories of information. Data mining refers to specialized tools that allow the organization to convert increasingly complex sets of data into useful information.
- *Document Management System* – a collection of tools that facilitate electronic document management, including storage, cataloging, search, analysis and routing.
- *Push Technologies* – delivering of appropriate information to individual based on specific criteria.
- *Collaboration* – expert modeling and decision making analysis that lead to more collaboration, information expertise and insight sharing among knowledge workers.
- *Visualization and Navigation System*- relationship between knowledge elements and holders of knowledge.

2.0 THEORETICAL ASPECT OF KM

There are six theoretical aspects that will be discussed in this paper and they are framework, technology, process, development, life cycle, and people.

2.1 Knowledge Management Framework

There are ten KM frameworks that have been identified. Table 1 summarizes and compares these frameworks.

2.2 Knowledge Management Technology

KMS is also defined as the collection of technologies that can collect, sort, store, and share the knowledge throughout the organization. Based on that definition, the technologies that can be used in the development of KMS are:

- *Intranets* – secure internal networks, to provide an ideal environment for sharing information accessed using a standard browser.

- *Information Retrieval Engines* – search engines are an absolute necessity and are the integral part of KMS.

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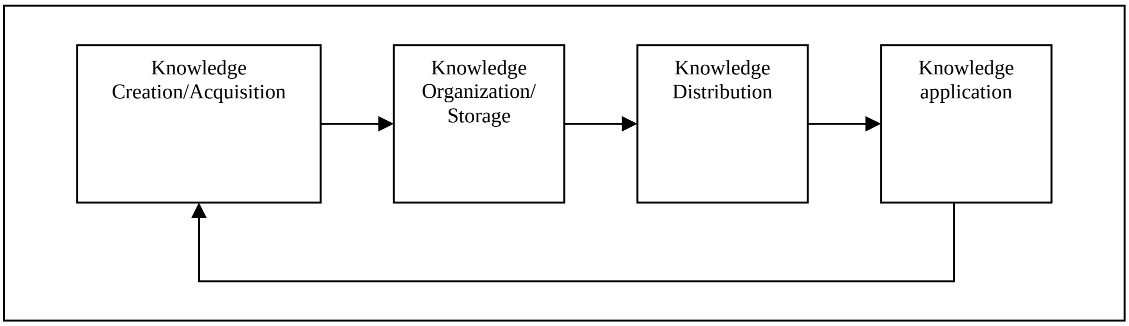
Table 1: Comparative Summary of the Descriptive Framework
(Adapted from Holsapple and Joshi, 1999)

Dimensions / Authors	Focus	Roots/ Origins	Knowledge Resources
Wiig, 1997	Identify management influences on the conduct of KM	Not indicated	
Leonard –Barton, 1998	Manage interaction between organization's technological capabilities and knowledge development activities	Field research	- Employee knowledge - Knowledge embedded in physical systems
Anderson & APQC, 1996	Pride a basis for benchmarking the conduct of KM within and between organization	Consulting experiences	
Choo, 1998	Describe the working of knowing organization	Synthesis of past research	
Van Der Spek and Spijkervet, 1997	Characterize a conceptualize-reflect-act-retrospect cycle for governing the conduct of KM	Not indicated	
Sveiby, 1997	Characterize and measure intangible assets (especially knowledge)	Consulting experiences	- External structures - Internal structures - Employee competencies
Petrash, 1996	Characterize and measure intellectual capital	Practical organizational experiences	- Human capital - Organizational capital - Customer capital
Nonaka and Takeuchi, 1995	Characterize knowledge creation through interaction of tacit & explicit knowledge and among individual, group and organizational entities	Not indicated	
Szulanski, 1996	Identify barriers to transferring best practices within an organization	Synthesis of past research and empirical study	
Alavi, 1997	Using technology to accomplish KM at KPMG Peat Marwick	Case study	

2.3 Knowledge Management Process

Knowledge management (KM) processes comprise of knowledge creation, knowledge storage, knowledge distribution and knowledge application, as illustrated in Figure 2. The act of creating knowledge coincides with the act of working through the learning spiral of conceiving, acting and reflecting. Reflection is key to knowledge creation. Companies must develop the infrastructure to capture, store and disseminate the knowledge created from experience. KM allows organizations to leverage lessons learned to be more effective in the future. In addition, a KM system must help users to get their work done easier and more efficiently.



2.4 Knowledge Management Development

KM development involves four steps (Kotnour, *et. al*, 1997).

- Determine the organization's knowledge needs. The aim of this step is to determine the core competencies or focused knowledge needs of the organization (Drucker, 1993). The knowledge needs, are driven by the nature of the business the organization is in and desires to be in.

At an organizational level, the knowledge needs are a function of the organization's products and services and the processes by which the products are produced. At an individual level, the knowledge needs are a function of the things a worker is responsible and accountable for and the decision to be made and actions to be taken.

- Determine the current state of organizational knowledge base or memory. The aim of this step is to determine where and how the organization's current knowledge is assimilated and disseminated. Using the previously identify knowledge needs, the existing sources of knowledge or organizational memory are identified and evaluated for the ease of use and ability to provide accurate, relevant, and timely knowledge.

- Determine the gaps in knowledge and barriers to organizational learning. The aim of this step is to determine why the organization is not creating and applying knowledge that is accurate, timely and relevant. The output of this step is a list of improvement opportunities for the organization learning process.

- Develop, implement and improve proactive "KM strategies" to support organizational learning. The aim of this step is to develop proactive strategies to support the creation, assimilation, dissemination, and application of the organization's knowledge.

2.5 Knowledge Management Life Cycle

Knowledge evolution cycle consists of five phases (Rus and Lindvall, 2002):

- Originate/create knowledge - members of an organization develop knowledge through learning, problem solving, innovation, creativity, and importation from outside sources.

- Capture/acquire knowledge - members acquire and capture information about knowledge in the explicit forms.

- Transform/organize knowledge — in written material and knowledge bases.

- Deploy/access knowledge – organizations distribute through education, training program, and automated knowledge base system or expert networks.

- Apply knowledge - KM aims to make knowledge available whenever it is needed.

Based on the literature reviewed on KM (Choo, 1998a; Choo, 1998b; Davenport and Prusak, 1998; Davenport, *et al*, 1997; Leonard-Barton, 1998; Myers 1996; Nonaka and Takeuchi, 1995), the consolidation of the research has derived a KM lifecycle as shown in Figure 3.

This knowledge life cycle is depicted in the simplified way, as it suggests a strict sequence of identifying, creating, transferring, storing, (re)-using, and unlearning language (Rosemann and Chan, 2002).

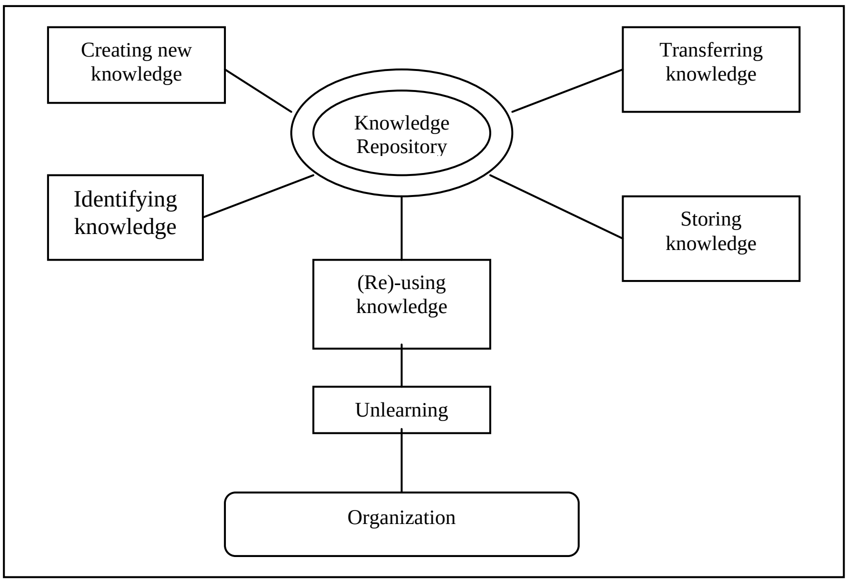


Figure 3: The Knowledge Management Life Cycle

2.6 People in the Knowledge Management Organization

Knowledge won't be well managed until some groups within a firm have clear responsibility for the job. Among the tasks that such a group might perform are collecting and categorizing knowledge, establishing a knowledge-oriented technology infrastructure, and monitoring the use of knowledge.

A task group will comprise of chief knowledge officer (CKO), Chief Researcher Officer (CRO), Chief Information Officer (CIO), Chief Task Officer (CTO), the program manager, and the chief knowledge architect (CKA) (Satyadas, *et. al* 2001).

3.0 A CASE STUDY OF BIOINFORMATICS KMS IMPLEMENTATION IN THE INSTITUTION

There are three basic possibilities of how the bioinformatics institutions could exploit the KM ideas and principles. Firstly is the management of knowledge in term of farmers' success stories and others that related with the farmers' experiences. Secondly is how to manage knowledge for decision support, to improve the internal document management and exploitation, to increase the level of information and knowledge dissemination. Lastly is how to make use the qualitative of change in the educational process itself. Generally, collaboration in bioinformatics institution could involve the following people.

- Academician in bioinformatics - their roles are as teachers and become designers of learning experiences, processes, and environments. They concerned with identifying and then transmitting intellectual content and more focused on inspiring, motivating, and managing an active learning process for students.
- Researchers – process or generate new ideas by doing research.
- Administrators - manage all aspects of the bioinformatics institution tasks such as financial management, security, students' registration and others.
- Biologist – study, accept, and review the knowledge in bioinformatics institution.
- Sponsors - the agent who sponsors the students or researchers in completing their studies or research works.

They are working together, hand in-hand, in their institution to achieve their aims and missions. In this case, there are three important components of the KM system implementation in bioinformatics institution. The components are to serve the community, staff, and administration of the bioinformatics institution. Below is some description about the goal:

- Community

  One of the most important objectives is to support and encourage interaction between the bioinformatics institution and local community. Both individuals and community-based organizations may want to investigate an issue, drawing upon the expertise of bioinformatics institution faculty and staff. Bioinformatics institution involvement includes diverse activities such as public presentations, guidance, research projects, and educational outreach. The use of the Internet is an obvious deployment strategy for the community and any underlying database design should support intuitive browsing and topic-based search capabilities. In fact, the Internet can extend the notion of "local" community to include a geographically dispersed intellectual community interested in the research and educational materials generated by bioinformatics institution.

- Staff

  Bioinformatics institutions' staff has somewhat different set of objectives. The bioinformatics institution is also developing its research presence through graduate education, grants and funding, technology transfer, and scholarly publications. In a very real sense, this mirrors some of the requirements that face organizations such as consulting companies and industrial research laboratories. How can the bioinformatics institution researchers find collaborators, facilities, and grant proposals that might support new projects. The Internet is allowing professional societies and other academic organizations to build online intellectual communities.

- Administration

  From an administrative perspective, the bioinformatics institution would like to promote community involvement and research activity. While these activities are not completely aligned, a KM system could enable key administrators to gain insights with regard to ongoing activities. Administrative capabilities should support the development of policies that encourage new projects and activities in line with the strategic directions set for the university. For example, community contacts and project outcomes could be collected and used to foster new community outreach initiatives.

The need to develop and maintain a knowledge management system (KMS) is common to many knowledge-intensive organizations. While the term "knowledge management" has become overloaded with different meanings, there is a need to develop specific strategies to capture and organize knowledge assets or expertise. Bioinformatics institution is a knowledge-intensive organization that could benefit from KM efforts.

There are seven steps of critical success factors (CSF) to KM process in the bioinformatics institutions. The steps are:

- **The identify stage** determines which core competencies are important to academic success. Every department needs robust knowledge about its pedagogical needs and expectations from its members, services and administration. An understanding needs to be developed to settle its place in the pedagogical world and in other organizational and environmental aspects such as research endeavors and consulting services offered by the department.

- The **collect** stage deals with acquiring the internal and external knowledge, educational skills, fundamental theories and human experience needed to create the selected core responsibilities and knowledge domains.

- The **select** stage takes the continuous stream of collected, formalized knowledge and assesses its value. Initially, one framework should be selected as the basis for organizing and classifying knowledge to be stored in the Knowledge Bank or Repositories.

- Departmental memory resides in three different forms: in human minds, on paper and electronically. The **store** stage takes the nuggets of knowledge and classifies them and adds them to the departmental memory. Much of this knowledge can be represented in electronic form as expert systems. This is where even tacit, intangible knowledge assets are transformed to tangible one.

- The **share** stage retrieves knowledge from the departmental memory and makes it accessible to the users. Individuals, teams and departments often share ideas, opinions, gossip, knowledge & expertise in meetings held in person or through groupware.

- The **apply** stage reclaims and uses the needed knowledge in performing tasks, solving problems, making decisions, researching ideas and learning. To reclaim just the knowledge, requires that the system understand the user's purpose and context. To receive the knowledge at the right time requires a proactive system that monitors the user's actions and behavior and determines his/her purpose.

- The **create** stage uncovers new knowledge through many avenues, such as observing students, student feedback and analysis, research, experimentation, creative thinking and automated knowledge discovery and data mining.

The features and a model of system configuration of KMS are as shown in Figure 5. Among these functionalities at the bioinformatics institution is:

- Electronic on-line document sharing including sharing of files, workflow diagrams, tools, procedures, manuals, best practices, and lessons learned etc. It is how students, lecturers, administrators, researchers and sponsors in the communities can share the ideas or communicate the new knowledge, learn and then use it effectively.

- Correspondence Handling And Tracking System (CHATS) for the management of all correspondence, complaints, enquires etc. Here, students can communicate with their lecturers or sponsors regarding their studies or financial problem and other matters without having to arrange for the meeting and have to wait for a long time to see face to face. Students also can discuss with each other synchronously, and they can grab the result of their discussion as fast as can.

- Extensive collaboration tools such as group and individual calendars, task and resource management, "to-do" lists, emails, discussion boards, and on-line surveys. It is really important for the people in the bioinformatics institution to plan, manage and collaborate with each other. As for example, with the discussion board, the administrators can discuss with the biologists about the structuring of the any related of fileds, and others.

- Various security features to ensure that information is only available to the people who need it. The password and login are only for the authenticated person in the bioinformatics institution. Only those people who have the password can access the databases or the information, such as only the students who registered or in the class of certain lecturer are available and authenticated to access the lecturers' databases and websites.

- Information retrieval through Search And Advanced Search to allow users to find information in an easy and simple way. Here, we can see that most of the bioinformatics institutions have their own websites and that are facilitated with searching tools. By typing words to be searched in the searching box, it will display the information that is needed. It is useful for the students and researchers especially in completing their tasks.
- Flexible views so that each user can tailor the portal to meet their own requirements
- Easily implemented within a company or community due to its Internet architecture. Bioinformatics institution nowadays has their intranet and can link to other information and institutions via the intranet. KM system that will be implemented must make sure that it can link to others.

4.0 RESULTS AND DISCUSSION

Bioinformatics institutions do have a significant level of KM activities, and it is important to recognize these, and use them as foundations for further development, rather than to invent a whole new paradigm. CoP must recognize and respond to their changing role in a knowledge-based society. In order to assess the challenges of bioinformatics institutions face in embedding KM, we use Davenport's four types of KM objectives as lens through which to view bioinformatics institutions: the creation and maintenance of knowledge repositories; improving knowledge access; enhancing knowledge environment; and, valuing knowledge.

The Bioinformatics KM system in the CoP institution, need its own suitable framework. The current frameworks are not suitable to the CoP institution because they do not emphasis on the role of human, technologies and the content development itself (Jones and Lefkowitz, 2000). Bioinformatics institution consists of human who managing it, administrating, doing research, and doing teaching and studying; consists of the technologies which are needed by the human to convey and distribute their content which are ideas and knowledge. It is consists of the content development, which is the KM process.

The proposed model of Bioinformatics KM framework for the communities is shown in Figure 4. In this case, a prototype system by using A relevance software has been developed as shown in Appendix 1. This appendix shows the role of technologies in order to acquire and disseminate knowledge in the CoP. In this case, the system set up was based on bioinformatics CoP in a selected university in Malaysia.

As a general concept or overview of KMS functionality as well its components in bioinformatics environment, it could be viewed as shown in Figure 4 and Figure 5. This KMS development takes the consideration and based on the technical perspectives as stated in the literature review section. Especially that was related to technologies, its functionality and the knowledge (tacit and explicit) or content development and as well as its implementation.

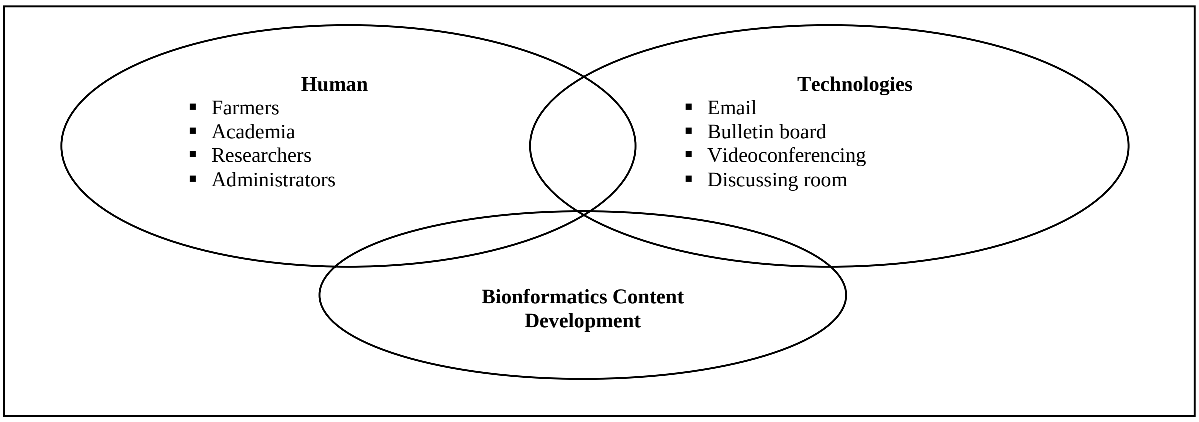


Figure 4: The System Components of Knowledge Management Framework for Bioinformatics Institutions

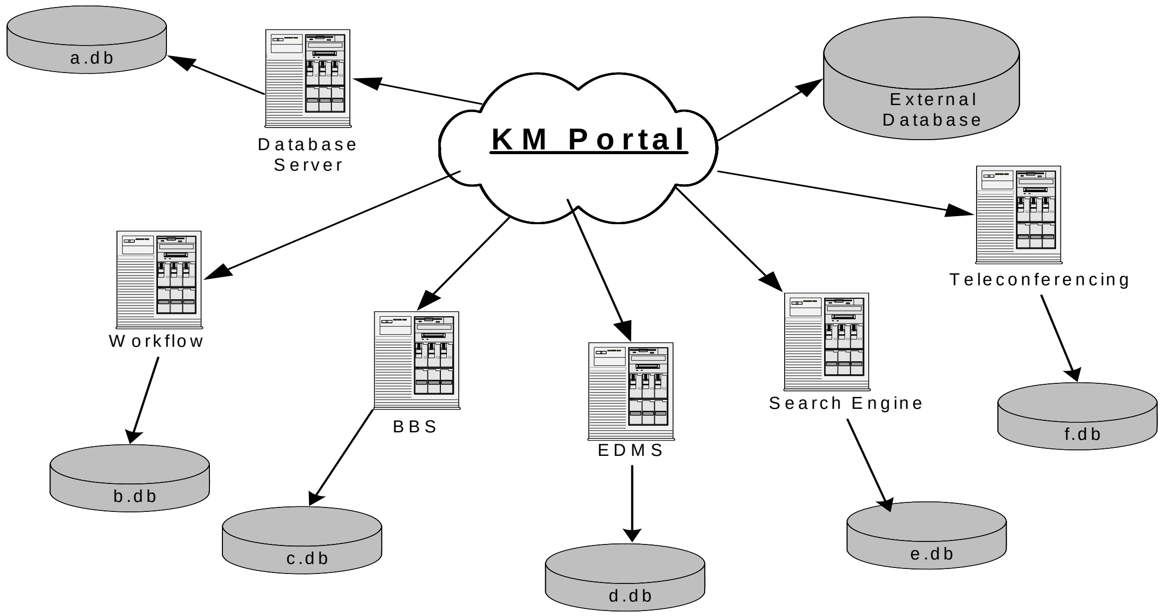


Figure 5: The System Configuration of KMS and Its Functionality for Bioinformatics Institutions

5.0 CONCLUSION

As a conclusion, it seems that Bioinformatics Knowledge Management System could be implemented in the bioinformatics institution with the base of knowledge management framework that has been proposed. In order to develop a successful of KMS, the bioinformatics institution must ensure the proper requirement steps of implementation of KM system is ready and try to adapt as much as possible of the technologies that are suitable for. This is needed to ensure that the bioinformatics institutions can gain the benefit from the implementation so that the organizations will not waste the time and money.

The organizations also must focused on the important of the collaboration environment, whereby the biologists or farmers, academicians, researchers and the administrators can work together, sharing the knowledge and others. Therefore, the organizations also need to find the problem in implementing the knowledge management system in order to make sure that they will always aware of the problem arises and they can try to find the solution to overcome that problem. Here, it is suggested that a proper plan must be adapted along with system implementation in order to maintain the effectiveness of the institution.

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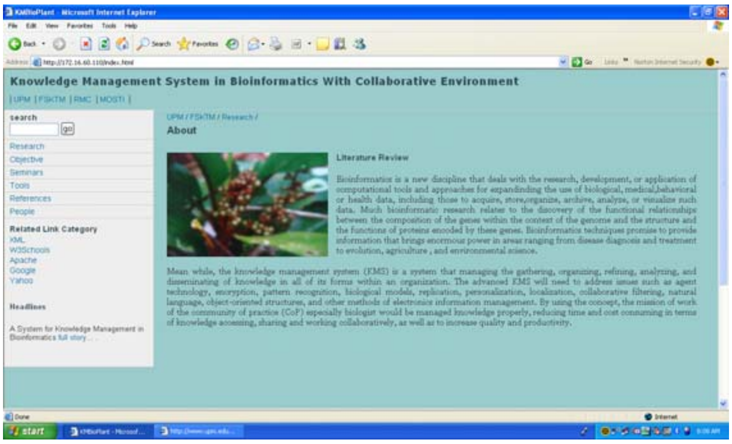
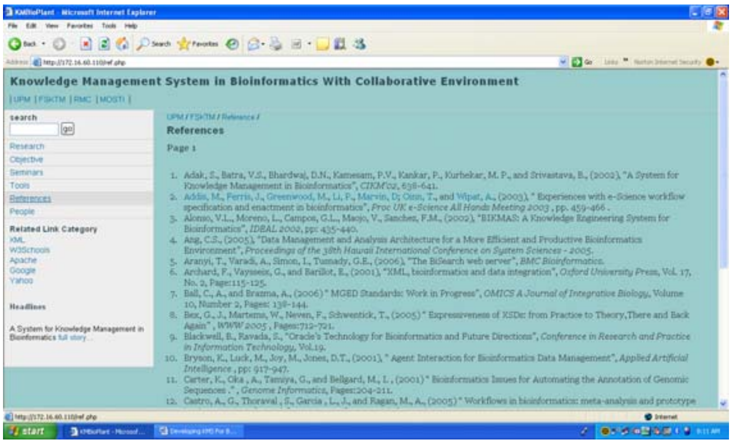
Appendix 1: *The Example Interface Design of a Prototype Bioinformatics KMS*

Example 1: Main menu of Bioinformatics KM System as a central of desktop control



Example 2: An Interface of KMS for a portlet linkage for knowledge dissemination



Example 3: An Interface of KMS for a portlet linkage for community’s communications