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# KNOWLEDGE SERVICES IN CAMPUS: THE APPLICATION OF AXIOMATIC DESIGN

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## ABSTRACT

Knowledge is the intellectual capital of a university. In this knowledge intensive environment, it is very important to consider the knowledge capture and its application to solve practical problems. Knowledge services (KS) is a new concept which comes on the scene to put knowledge management (KM) into practice. KS refers to a boarder concept that covers information and knowledge management. In this paper, we will present the KS in a university setting. KS stimulates information sharing within one university and thus improves university performance. It helps the knowledge producers and receivers to cease working vertically, and collaborate with each other instead. Hereby, we propose a tool namely "Knowledge board" to achieve KS and support the knowledge sharing. The implementation of an efficient tool can assist the decision making process for the three main activities of a university: teaching, research, and cooperation and also the activities in general purpose. It can be used to plan future research activities, support teaching activities and reduce administration costs. This knowledge board is designed and realized based on Axiomatic Design (AD) principles. A case study is conducted to exemplify the process of using AD to design knowledge services within a university environment.

**Keywords**: knowledge services, campus information, Axiomatic Design, touch screen.

## 1 INTRODUCTION

Knowledge is a broad and abstract notion [Alavi and Leidner, 2001]. Knowledge is considered to be a core element in an evolving corporation, and it has become the most precious property of any business or academic institution [Chen and Burstein, 2006]. Knowledge management (KM) principles are also becoming more and more popular in modern organizations, especially in knowledge intensive areas, since knowledge-based activities have the greatest potential to provide a competitive advantage.

Universities are communities of scholars, teachers and students that are known for creating knowledge and spreading knowledge. Such organizations are highly suitable for the introduction of various KM strategies and practices [Mikulecká and Mikulecký, 2000; Loh *et al.*, 2003; Oprea, 2011]. Because the number of knowledge producers and knowledge itself has been increasing, universities are frequently looking into the possibilities of applying KM [Loh *et al.*, 2003]. There are many benefits of KM introduction into universities. For instance, it enables teachers to share their knowledge, improves the level of their teaching and research collaboration, as well as their working relationships [Mikulecká and Mikulecký, 2000]. In summary, it enhances internal and external services and the overall effectiveness of universities [Loh *et al.*, 2003].

KM brings significant benefits to the university, nevertheless, that challenge of achieving goals through KM still remains. It is notable that the higher education is somewhat disconnected from society which it is supposed to serve. It is important to consider and apply some new approaches to support university knowledge sharing activities.

In recent years, the concept of knowledge services (KS) emerged and was soon acknowledged as the practical side of KM. KS provides a suite of services to transform knowledge, share knowledge and store knowledge.

This new research area, KS, brings us research question: *What is the approach to design an effective tool to support knowledge services in the education sector?*

With this research question, the goal of this paper is to develop a tool for KS to ensure that KS is managed as well as to support the knowledge sharing activities. This tool is named the "Knowledge Board". It enables excellence in KS, which in turn improves university research process, enhances university staff decision-making, and accelerates the innovation in education sector.

The design is focused on providing an advanced tool for all university employees, in order to improve their communication, teaching, research, and other administrative

activities. There are two questions to be answered: what kind of knowledge should be included and what new technologies should be adopted to present the knowledge. The design procedure is guided by Axiomatic Design (AD) principles. AD principles can help address these two questions and lead to an optimal solution. This tool can be considered in creating and enhancing the knowledge services in our university.

The contributions of this paper are two-fold. First of all, only limited research has been done on the implementation of KS in university. This paper will provide a potential feasibility study to assess the KS implementation in university. Secondly, this paper will provide an idea of KS tools design based on AD principle.

## 2 KNOWLEDGE SERVICES IN CAMPUS

### 2.1 CONCEPT OF KNOWLEDGE SERVICES

Knowledge and Information are two different but connected concepts. Information has the potential to be used in a way that creates new knowledge. It also can be added to or used to transform existing knowledge [Simard, 2006]. Knowledge always resides in individuals. Efficiently using information and knowledge is critical to organizations' success. More and more organizational managers recognize that business success can be realized when the company's knowledge can be gathered and retrieved for certain business purposes [Clair and Stanley, 2009]. As a consequence, knowledge management (KM) is a strategy to organize an organization's information and knowledge holistically.

According to aforementioned definition [Kidwell *et al.,* 2001], KM is the process of transforming information and intellectual assets into enduring value. People who make decisions or take actions need to be connected when they need knowledge. In the business environment, managing knowledge is a key to achieving breakthrough competitive advantage.

The goal of having KM is to enable organizations to improve the quality of management decision making by ensuring the reliability and availability of information and data. The primary purpose is to improve efficiency by reducing the need to rediscover knowledge. This requires accessible, quality and relevant data and information to be available to staff [Probst, 1998].

In the 21st century, the concept of Knowledge Services (KS) emerged. It was soon acknowledged as the practical side of KM [Clair and Stanley, 2009] and also a natural evolution of KM [Xia *et al.*, 2007]. When there is a need to "put KM to work", KS provides a practical approach to the management of information, knowledge, and strategic learning [Clair and Stanley, 2009]. The organizations can benefit from KS with the advantages of higher-level research, strengthened contextual decision-making, and accelerated innovation [Clair and Stanley, 2009].

KS can also be traced back to the concept of enterprise "Information Management" (IM). The focus of IM is on the management and utilization of information resources for an organization's own purpose while the KM is about internal knowledge resource and expertise. Instead, the purpose of "information services" (IS) is basically on the management and utilization of information resource for serving some external customers. Based on this logic, the KS will be considered as fusion of the fields of KM and IS, in additionally, it includes external knowledge into current states [Xia Wang and Dang, 2007]. Figure 1 shows four research fields rooted from IM and evolved to KS.

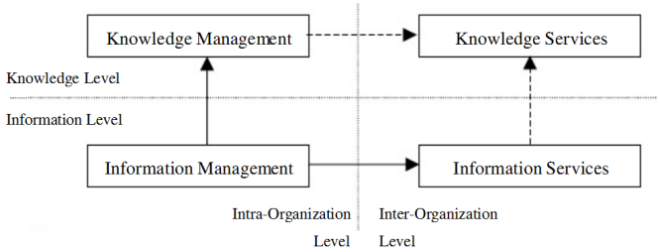


**Figure 1. Evolution Path from IM toward KS [Xia *et al.,* 2007]**

Specifically, all of the knowledge focused elements come together in KS. This service should comprise of IM, KM and IS. The purpose of KS is to create an environment for all enterprise stakeholders to willingly share knowledge [Clair and Stanley, 2009].

### 2.2 KNOWLEDGE SERVICES IN UNIVERSITY

In most of previous research [Brown, 2007], KM is applied in business organizations, and knowledge is defined as value adding activities. Actually, the university is commonly a place where the knowledge base increases and abilities grow continually. Using KM in the higher education sector is as vital as in other business environments [Kidwell *et al.*, 2001]. The researchers, professors, scientists, and other staff work on a daily basis, thence considerable knowledge is gained by individuals.

Due to the appearance of so many knowledge producers in university, more and more universities are looking into the possibility of apply KM [Loh *et al.*, 2003]. Only when the KM is done effectively will it lead to improved decision making capabilities, as well as improved academic and administrative services, and reduced costs, etc.

When creating KM in universities, four key KM objectives must be addressed: 1) creating and maintaining knowledge repositories, 2) improving knowledge access, 3) enhancing the knowledge environment, and 4) valuing knowledge [Loh *et al.*, 2003]. The common problems in most of the universities are the lack of an integrated collection of knowledge in one knowledge repository and also the lack of cross-discipline knowledge support. Knowledge hoarding still remains a challenge.

However, to fully reap the benefits from KM and to counter the challenges mentioned above, it is very necessary to go one step further, and put KM into practical use. Therefore, in this paper, we are focusing on providing a tool to support KS in the university to improve knowledge sharing, communication, and research performance. Two main issues will be addressed in this paper: 1) designing KS to facilitate the central control of knowledge and 2) presenting knowledge across a range of different disciplines to customers (various types of university employees). Transparency of knowledge is understood to be for the common good.

In this research paper, we define knowledge as the valuable information retrieved from different data resources,

which is important and essential in doing research, enhancing teaching activities, and adding value to staff's daily activities. Effective KS can add a tremendous value to the education sector. Nevertheless, KS cannot contribute to organizational success unless effective tools are available to support KS. Therefore, we used Axiomatic Design principle to guide us to design a tool to support KS.

### 2.3 PRINCIPLES OF AXIOMATIC DESIGN

Axiomatic Design Theory was proposed by Nam Pyo Suh. The goal of Axiomatic Design is to establish a scientific basis for design and to improve design activities by providing a theoretical foundation based on logical and rational thought processes and tools [Suh, 2001 p.5]. The Axiomatic Design framework divides the design process into 4 domains [Suh, 2001 p.11]: the customer domain, the functional domain, the physical domain and the process domain. In each domain, there is a characteristic vector. Respectively, they are customer attributes (CAs), functional requirements (FRs), design parameters (DPs) and process variables (PVs).

As shown in Figure 2, the domain on the left relative to the domain on the right represents "what we want to achieve", whereas the domain on the right represents the design solution of "how we choose to satisfy the needs (i.e., the what)" [Suh, 2001 p10]. Therefore, when mapping the right domain to the left domain, "zigzagging" decomposition is used. Designers are requested to create a design hierarchy. FRs and DPs, PVs must be decomposed into a hierarchy respectively until a complete detailed design or until the design is completed [Suh, 2001 p21].

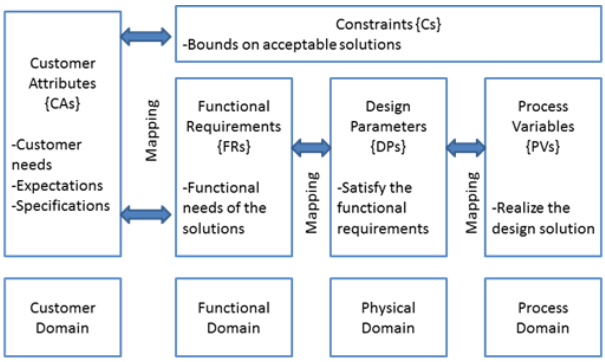


**Figure 2. All design procedures can be represented in four domains. {X} are characteristic vectors of each domain [adapted from Suh, 2001].**

During the mapping processes, the designer is guided by two fundamental axioms to produce a robust design: the Independence Axiom and the Information Axiom [Suh, 2001 p.16].

1. Independence Axiom: Maintain the independence of the functional requirements (FRs).
2. Information Axiom: Minimize the information content of the design.

The axioms offer a basis for evaluating and selecting designs. These two axioms jointly maximize the probability of the design to fulfil its purpose, and thereby achieve the optimal design for a set of functional requirements [Brown, 2007]. In most design tasks, it is necessary to decompose the problem hierarchically. The FRs, DPs, and PVs mapping process can mathematically be described as vectors [Suh, 2001 p18] in the design matrix. A design equation should be written for each transition between domains and at each decomposition level. Detailed information and elaborations on the scientific background of Axiomatic Design are provided by Suh [2001].

## 3 CASE STUDY

Based on the prior considerations and research, we present the conceptual design of a KS tool for use in a university setting.

According to the principles of Axiomatic Design, background research was conducted. The customers (university employees who included professors, lecturers, researchers and administrative staff) were interviewed in order to determine their requirements which were further analysed. We discovered the staff's interests and needs from KS. Moreover, we participated in workshops to gather more ideas from university students. We summarized the functional requirements and design parameters from multiple face-to-face semi-structured interviews.

This resulted in a definite statement of the project goals as well as the means of achieving them.

### 3.1 PROBLEM ANALYSIS

The implemented approach was to look at the studied organization – the University of Vaasa (UVA) - from the perspective of business organization since there are many business activities occurring at the studied university. We stated that KS needs to be better suited to those activities. The interviewees were mainly complaining about issues such as the limited availability of information and the difficulties of locating the right information resource. There are three main reasons for that:

1. Lack of communication: Many employees (researchers, teachers and faculty staff) work in "silos", and they are rarely aware of communication and collaboration opportunities.
2. Lack of support techniques: The employees do not have common standards and tools to communicate and share information with others. It is also possible that much valuable information is wasted before it is stored for long-term preservation.
3. Decentralized Information resources: It is difficult to allocate the information since the information is in various locations. It is time consuming to find the required information.

There are nodal points where knowledge is produced and from where it is distributed. Figure 3 demonstrates the dispersed knowledge in the whole campus. Currently, the information resides in four different buildings. Each building stores different types of knowledge:

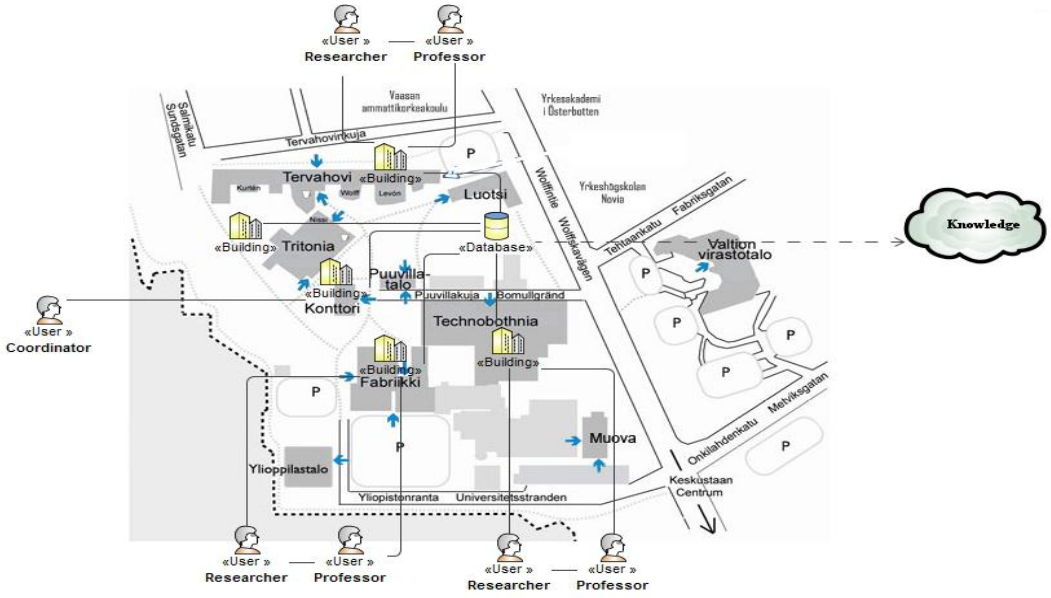


**Figure 3. Distribution of Knowledge in UVA**

- Tervahovi
  - Faculty of Business Studies
  - Faculty of Technology
  - Department of Mathematics and Statistics
  - Computer Centre and Helpdesk
- Konttori
  - University Services
  - Research and Innovation Services
  - Communications and Publications
- Fabriikki
  - Faculty of Philosophy
  - Faculty of Technology
  - University of Helsinki Faculty of Law, Vaasa Unit of Legal Studies
- Technobothnia
  - Research and Teaching Laboratories of Technology
- Tritonia
  - The Academic Library of Vaasa
  - EduLab

The challenge is to manage this information centrally and make it widely and easily available to any employee.

The object is to connect different parties (they are customers of KS) in the university, and to ensure they collaborate. Therefore, it is necessary to collect all the possible information from different databases and locations. We claimed that three aspects should be considered.

1. How to establish a common database that can be accessed by all parties?
2. What information is needed to create the knowledge?
3. How to display the knowledge in an effective way?

## 3.2 CUSTOMER ATTRIBUTES

Based on the preliminary research, we continued to elaborate on the customer attributes. The knowledge requested by customers is classified into four knowledge categories: in general, teaching, cooperation and research. This implies that the university KS incorporates these four categories for the main activities performed by a university. Table 1 presents the categories.

**Table 1. Four categories of Knowledge in UVA**

| IN GENERAL | TEACHING |
|---|---|
| Campus map<br>University press/news<br>Annual Report<br>Department Directory<br>University Evaluation/Ranking<br>Followed policies and practices<br>Job Satisfaction | Ongoing Lectures information and statistics<br>New courses<br>Teacher assessment<br>Teaching Method |
| **COOPERATION** | **RESEARCH** |
| Relationships between departments within university<br>Relationships with other universities<br>Projects with other universities<br>Projects with other industries/companies<br>Workshops organized by university<br>Conferences organized by university<br>Visiting lecturers/Professors<br>Opportunities to visit/teach in other universities | Research interests (vision & strategy impact) in different departments<br>New research projects<br>Research timeline<br>New publications<br>Research archive (Research outcomes)<br>Forum<br>Major Researchers<br>Statistics about department research<br>Research foundations<br>Policy in research<br>Job vacancies<br>Relevant/ potential conferences<br>Department Thesis collection |

## 3.3 DESIGN CONCEPTS

Based on the customer requirements, we summarized 3 main functional requirements to design a KS tool.

The highest level FR0 is to support the knowledge services provided in university. This could be decomposed

into FR1: get the critical knowledge, and FR2: mange the knowledge effectively, FR3: visualize the information in a creative way.

- FR1: Not all knowledge has the potential to add value and is worth capturing within the university. Therefore, it is important to get "Right Information" which is value-adding knowledge.
- FR2: It is important to manage the knowledge we have already captured more effectively. Meanwhile, it is important to re-construct the knowledge so that it is useful and immediately applicable.
- FR3: In order to interpret the knowledge in an easy understandable way, it is very necessary to find an innovative approach to illustrate the knowledge.

| | DP0: Tool of Knowledge Service | DP1: Capture the Knowledge | DP2: Classify the Knowledge | DP3: Display Knowledge on screen |
|---|---|---|---|---|
| FR0: Support Knowledge Service in Campus | x | | | |
| FR1:Get the Critical Knowledge | | x | | |
| FR2: Manage the Knowledge effectively | | S | x | |
| FR3: Visualize the Knowledge | | S | S | x |

**Figure 4. The design matrix for level one.**

In Figure 4, the high level of functional requirements (FRs) and design parameters (DPs) of the knowledge services design are shown. The FRs must be formulated appropriately to provide an effective design environment [Dickinson and Brown, 2009]. The FRs describe the design intent while the DPs describe how to accomplish the intent.

The Xs indicate natural coupling for the indicated DP-FR interactions, and the Ss indicate a sequential coupling (which exists in that the design elements are independent from each other but could not be done without pervious steps.) [Brown, 2007].

Each level one FRs and DPs can be decomposed into the next level. The detailed list of the FRs and DPs is shown in Table 2.

**Table 2. The FRs and DPs in second level**

| 3.4 ***FR0: Support Knowledge Service in Campus*** | 3.5 ***DP0: Tool of Knowledge Services*** |
|---|---|
| **FR1:Get the Critical Knowledge** | **DP1: Capture Knowledge** |
| FR1.1: Sustain Knowledge in the whole university across departments | DP1.1: Synchronize all Information from different databases |
| **FR2: Manage the Knowledge effectively** | **DP2: Classify the Knowledge** |
| FR2.1: organize knowledge in an appropriate way | DP2.1: Make relationship charts of all Knowledge |
| FR2.2: Capture the essence of the Knowledge | DP2.2: Organize Knowledge with certain keywords |
| FR2.3: Simplify the knowledge structure | DP2.3: Show the pattern of knowledge |
| **FR3: Visualize the Knowledge** | **DP3: Display the Knowledge on screen** |
| FR3.1: Easy viewing of information | DP3.1: Use different colors to present different categories |
| FR3.2: Simplify the Knowledge Obtain Action | DP3.2: Display automatically |
| FR3.3: Easily interact with the Knowledge | DP3.3: Touch screen interaction |

Figure 5 shows the design matrix, which is a substantial improvement to the KS solution in the campus.

The formulation of the FRs and DPs and their interactions are considered results of the design process. The DPs are straightforward transformations of the FRs. From this design matrix, we can easily see it is a decoupled design, which means that at least one DP affects more than one FR. In this design, we want to classify all the knowledge by their keywords and simply display in the screen with well-grouped keywords. In this way, it can achieve one of the important requirements from customer's perspective: "to acquire information without complex search for it". Therefore, DP2.2 "how to classify the keywords" impacts FR2.2 but also FR3.2.

## 3.4 RESULT

In this part, we considered how we can put the customers' requirements into practice and build a tool for KS that supports and enables the university knowledge sharing. This tool is called the "Knowledge Board". It consists of the following characteristics as shown in Figure 6:

1. Integration of all the information from different database and locations
2. Categorization of the different types of information
3. Using different colors to present different categories
4. Using keywords to allocate the information (no search needed)
5. Using touch screen to display all the information

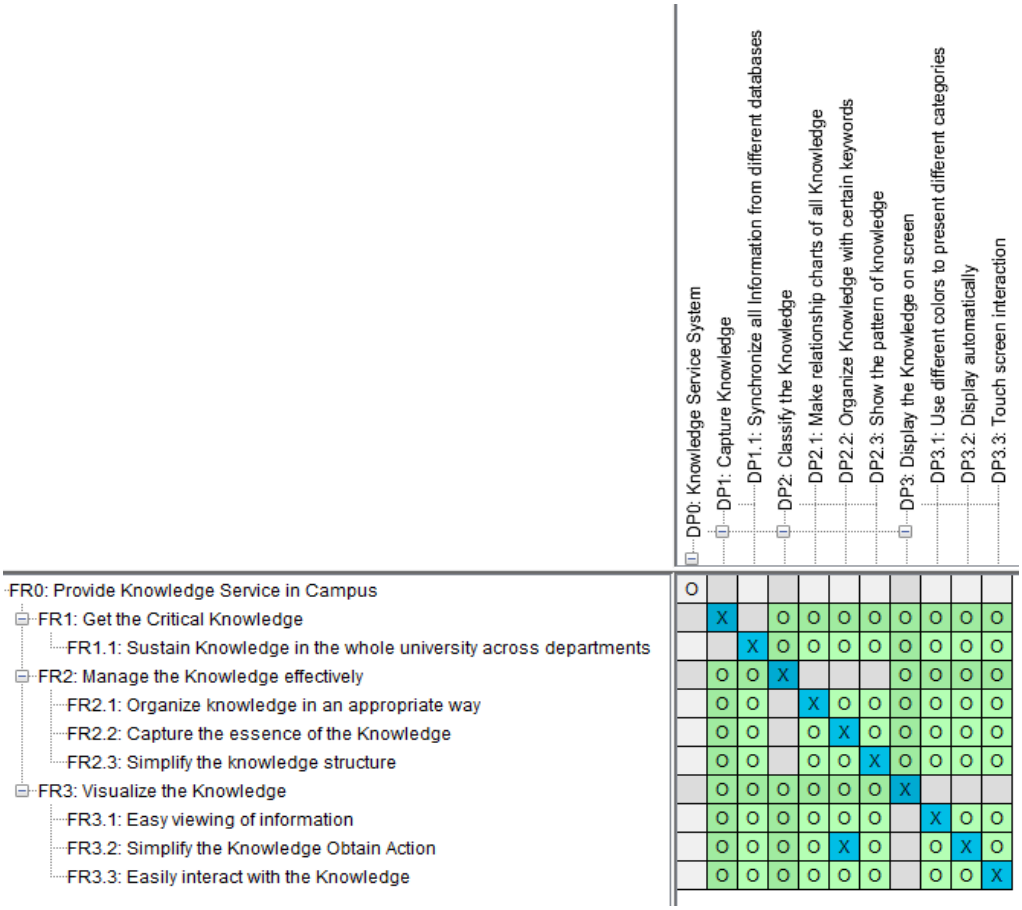


**Figure 5. The Design Matrix for Knowledge Service in Campus.**

There are three organizational levels of a university, namely university, faculties, departments. Each university has one or more faculties and each faculty has one or more departments. Based on this logic, the knowledge is divided into these three levels as shown in this architecture. Each level also represents different data source locations. The four categories (in general, research, collaboration, teaching) are also classified by these three levels.

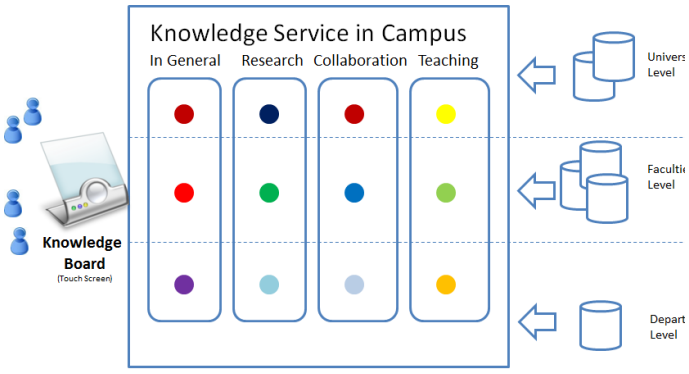


**Figure 6. The Technical Architecture of Knowledge Services Touch screen in Campus**

There are many different possibilities to design the final solution. Nevertheless, by using Axiomatic Design principles, only the best fit solution can be selected. In the end, we decided to use an interactive screen to display our knowledge. This interactive screen will be placed in the different departments and buildings.

The interactive screen technologies are changing constantly and we have found several models that we can use. For example, a Smart-TV would be a solution, but maybe it will be too expensive. Therefore, we use a projector as a simple solution. This projector will work along with a sensor to make sure that this screen is actually capable of interacting with people.

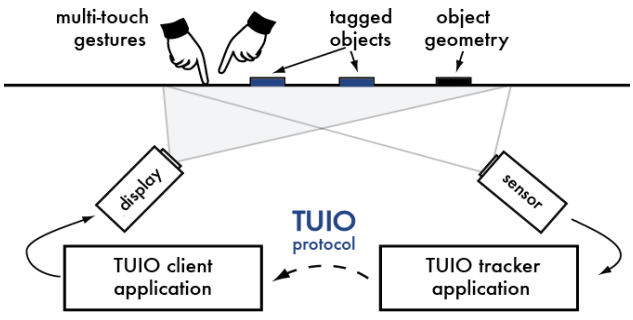


**Figure 7. TUIO.org touchscreen solution [TUIO.Org]**

TUIO.org provides a touch screen solution. It is an optimal solution for our project. The technical solution is presented in Figure 6. TUIO is an open framework that defines a common protocol and API for tangible multiple-touch surfaces. It provides a model that can be changed and

adapted to our needs. The protocol is inexpensive and, according to a programmer, the TUIO reference implementations are available for most common programming languages and media environments. Moreover, this solution is simple because it only requires three sensors.

Figures 8-11 sequentially demonstrate how the screen works. The initial screen is 3 balls (Department, Faculty and University). It is displayed in upper picture in Figure 8. The lower picture demonstrates user interactions with the screen by finger-pressing the category balls.

When users press one ball, it opens the sub categories. The sub categories are in the same colour system as their main category.

For instance, if one user wants to find information about funding opportunities about his/her proposed project, he/she can allocate the information by using the right "keywords". (University-> Research-> Project->National research funding competitions) For instance, in Figure 9 and Figure 10, the "University" is in the colour green, and then all its sub-categories are in a green colour system. Moreover, the other not pressed main categories' balls, such as department or faculty will fade out from the main screen for later use. If users want to change the information in the other categories, it is pending in the background. Also, the sizes of the higher level balls are reduced, and the degree of transparency is increased.

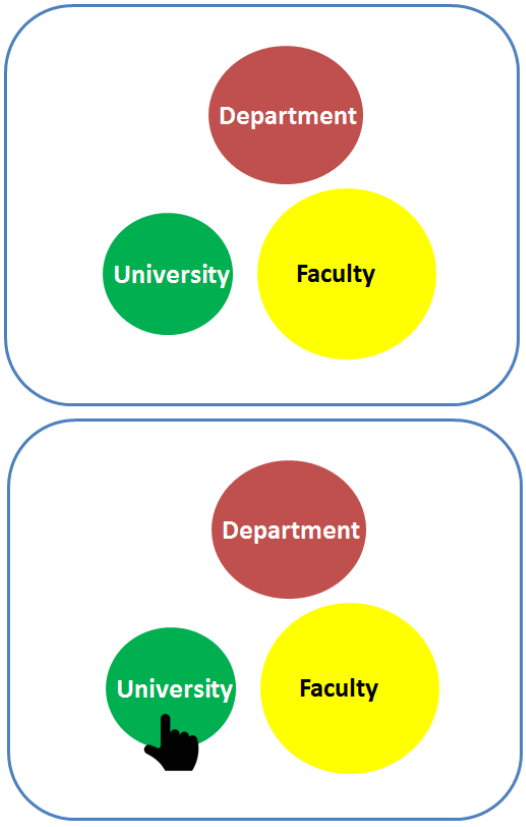


**Figure 8. Screen Status 1**

Moreover, the top-left corner will display the location and categories that have been opened. As a result, users can track and trace the information categories.

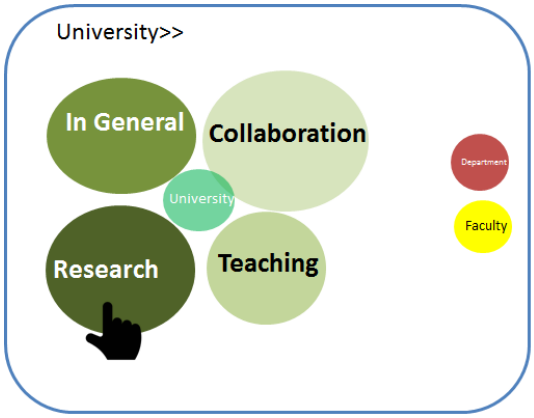


**Figure 9. Screen Status 2**

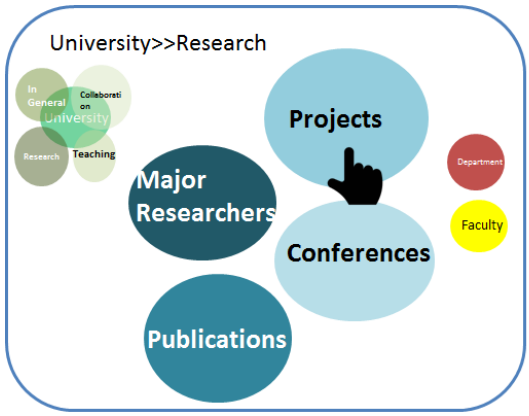


**Figure 10. Screen Status 3**

Ultimately, it is very easily to return to the initial status by pressing anywhere in the background area. For instance, in upper picture of Figure 11, user can press any background space to return to the initial status as shown in the lower picture of Figure 11. In case the user presses the background unexpectedly, the history view can get user's view back immediately.

In summary, we proposed a generic idea of the tool to support university KS in this research paper. This "Knowledge Board" is still under development and needs further study and observation of customers' interaction with this tool. Ultimately, this "Knowledge Board" will be developed and used by every department around the university campus. Certainly, KS is very complex concept and it cannot be implemented by only one tool. There are some other applications and tools of KS will be designed and be used in combination with this "Knowledge Board". For instance, so far, only internal information from university is considered, but in future, external-organization knowledge (from partner universities, from industrial companies, etc.) will be integrated into this board as well. Moreover, this "Knowledge Board" will be able to support two-way interaction with users, which means that users will be able to input knowledge and automatically transform into the knowledge base. Then the knowledge can be classified, sorted and easily retrieved later. Of course, users' search and behaviour analysis are also very important.


**Figure 11. Screen Status 4**

Based on the case of UVA, we argued that this tool of KS can indeed benefit and have the potential to advance the activities in the university. UVA will continue to promote and cultivate a knowledge services so as to enable and support the KS.

## 4 CONCLUSIONS

Universities have significant opportunities to apply knowledge management practices to support research and collaboration among staff. The core activities of universities are knowledge creation and knowledge dissemination. With the appearance of new concept "Knowledge services", we are expecting more from knowledge management. It is interesting to consider improve the performance of the university knowledge management by putting it into practices. Therefore, we proposed a tool to support knowledge services in order to support the knowledge sharing activities in university. The designing process of this effective tool is guided by Axiomatic Design principles.

In this paper, we call this tool of knowledge service a "Knowledge Board". It focuses on collecting the value-adding information as well as presents the information within the university. All the information is classified into different knowledge categories, and then can be used as knowledge. This design benefits from Axiomatic Design principles by transforming customer attributes into design parameters. We are able to optimize the design process and get an optimal idea. Ultimately, the proposed solution offers an opportunity to enhance the teaching activities, research process, and also reduce administrative costs.

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