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An Overview of Industrial Knowledge Management System & A Review of Access Control Methods

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Abstract— **Companies are now realizing the importance of retaining and sharing organizational knowledge, this paper presents the need for a secure and reliable Knowledge Management System (KMS) for manufacturing organisations. Although previous researches have mentioned that KMS security is important, it has not been a focus in previous researches in this area. Previous research in the areas of KMS & Access Control Method (ACM) is summarized in this paper. A literature review was conducted to study the relationship between KMS and ACM, and also to find a research gap in ACM. This paper introduces an ongoing research conducted in a manufacturing company in Malaysia. The aim of the research is to develop and implement a KMS with ACM for security by applying an improved version of Role-Based Access Control (RBAC). The improved RBAC is expected to overcome current RBAC's weakness which is rigidity and requirement for complex management.**

Index Terms— Knowledge Management System, Industry, Security, Access Control Method

I. INTRODUCTION

Knowledge can be defined as the understanding of, or information about a subject that is obtained through experience or study, either known by one person, or generally [1]. Knowledge, in modern philosophy and epistemology is understood as a framework, or an instrument that enables successful behavior. Knowledge, or intellectual capital is said to be the value of a firm's knowledge base and service capabilities [2]. Intellectual capital is an important aspect in ensuring that a company maintains its competitive advantage [3], [4]. Due to this realization, that preserving and sharing knowledge is important within an organization, companies have strived to manage and preserve knowledge [5]. One of the most basic ways to preserve knowledge is by sharing one's knowledge to another, to ensure knowledge continuity. However, even though knowledge sharing between employees is a crucial process, it is something that does not always happen in practice [6].

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This could be due to many factors such as, knowledge sharing is not encouraged in the work place, or even an employee not knowing the value of their knowledge.

When knowledge sharing is not encouraged, or is not a norm in a workplace, the possibility of the organization to lose their knowledge, or intellectual assets will also increase. Organizational knowledge is considered as an asset to an organization because it can contribute to an organization's growth and also helps maintain an organization's competitive advantage, when it is properly managed [3], [4].

The usual method of knowledge sharing between employees is by approaching the person who has the knowledge that is sought after, and then learning from the person. This exchange usually occurs between individuals, or between individuals within small groups. The knowledge itself is not recorded where it may be preserved and spread for others to use, so in cases where an employee retires, his knowledge will be lost by the company.

In order to prevent knowledge lost, and to ensure that intellectual assets within an organization is utilized, knowledge will need to be managed. The process of identifying and leveraging collective knowledge within an organization is known as knowledge management [7], [8]. However, to facilitate knowledge management, a KMS would need to be implemented in an organization.

As a summary, a KMS is a system that facilitates knowledge sharing by enabling storing and sharing of knowledge within an organization. This means that, when used, a KMS is a system that holds an organization's intellectual capital which is integral to an organization's growth. Hence, the system must be secure in order to ensure that access to these knowledge/intellectual capital is controlled: not everyone will be able to access every file/documentation within the system. In order to do this, ACM is applied to KMS. There are different methods in ACM, which will be discussed in Section III.

A. Research Introduction

A preliminary study has been conducted in a car manufacturing company based in Shah Alam, Malaysia for one year in 2018/2019. The study was conducted by focusing on the use of knowledge of employees from the Engineering Group of the company as the organization is more concerned to improve knowledge management for this group. The goal of this study is to identify current knowledge management in the organization and subsequently identify and develop methods on how to improve KM in the organisation.

Preliminary results of this study that was obtained through interviews in which 45 employees were interviewed, surveys, observations, and also through weekly meeting sharing sessions is that:

- Knowledge sharing is not something that is conducted consistently. A number of departments frequently organizes knowledge sharing sessions, while there are other departments that do not. An example of how knowledge sharing is conducted is via weekly sharing sessions. There were also cases where previous experiments were repeated by different departments as they do not have access to finidngs by other departments.
- Although there has been previous attempts in implementing KMS, there is no specific method of document sharing. Specifically there is two other systems meant to be used as repositories, however, it is not fully utilized by employees. Each team/department has their own preferred method of sharing documents. Employees find that their documentations are scattered, as there is no specific system/database used for exchanging and accessing documents.
- Employees are not sure about how access to documentations is determined. Employees were asked for their opinions on current method on determining security levels. 34% of the executives answered that they are unaware of any method, or they are unclear about the method. Another 29% of the executives stated that the current method can be improved.

Kamal et al [9] provides a more detailed report on these findings. Based on the findings above, it can be concluded that KM in the organization needs to be improved in terms of centralization. In this case, it was proposed that a centralized KMS that can be used by all employees, be implemented in the organization. Access control also needs to be improved by implementing a more suitable method. A literature review was then conducted to further support the findings to find out the most suitable ACM to be used, and also to find a research gap for a PhD study. The results of the review is presented herewith.

B. Knowledge Management System

A KMS is a system that supports the process of acquiring, preservation and promotion of organizational knowledge resources [10]. By implementing a system that supports these processes, knowledge sharing and dissemination will be enabled, and an organization's intellectual assets will be preserved. The general steps that should be included in a KMS are identifying the knowledge resources, then collecting, capturing, organizing, storing, sharing, using and creating knowledge [11]. Knowledge termination is also another process that is included in a KMS, as to avoid an overload of documents that is old or not updated. Terminating knowledge means that only updated documents will be stored within the system, ensuring that employees will have access to the latest documents.

There are three major functions, or processes of a KMS, which are, to enable the creation and acquisition of knowledge, the storage of knowledge and the sharing and dissemination of knowledge [12]. This KM processes are illustrated in Fig. 1 below. The processes will then be further explained.

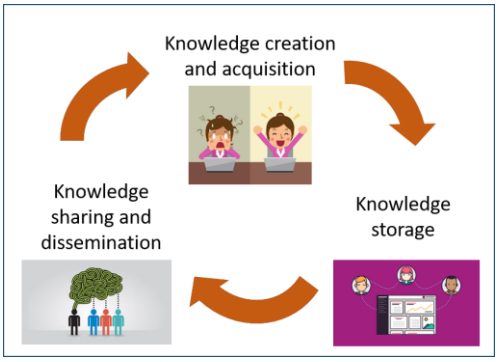

Fig. 1: KM Process

Knowledge creation and acquisition is where new knowledge that is obtained from a research or experiment is obtained. The knowledge is then identified, and then acquired.

Knowledge storage is where knowledge that has been acquired is sorted and organized so that the knowledge is organized in a systematic order to enable easy access to stored knowledge by the employees. In some cases, the acquired knowledge will also need to be translated so that it will be simpler and easier to understand. This knowledge will then be stored in a repository so that it can be accessed when needed.

Knowledge sharing and dissemination is where stored knowledge is accessed, and knowledge is shared and disseminated among employees of the organization. This process is important in KM because there are cases where knowledge that was created was not extracted, stored, and shared with other employees, causing a buildup of tacit knowledge. This, in turn, may mean that if organizational knowledge from employees are not managed properly, the organization may lose the knowledge.

When knowledge is shared and disseminated, said knowledge will be used for other researches or experiments, which, in turn, will create new knowledge. This shows that the KM process is a repeating process, proving that KM is important in organizations as knowledge is constantly being created.

C. Why is a KMS needed?

Wad et al [13] assessed Malaysian automotive industry and reported that this industry has expanded in various aspects: sales, production, and also local content. With the increase of productions, the need to ensure efficiency of production is maintained, is also increased. It is not uncommon to find hundreds of processes in a manufacturing line [14]. These processes are usually in a flow where the first process needs to be done in order for the second process to be executed. If delay was to occur, the whole process will be affected, thus affecting production efficiency. This is one example as to why KMS is needed in an industry.

A KMS is also needed in industries in order to encourage knowledge sharing between employees, especially in large

companies. Examples of large organizations that have successfully implemented KMS are [15], [16]:

- Ford: Initially applied a web-based KMS to maintain its quality standards in the production line.
- Pratt & Whitney: Implemented KMS in order to store tacit knowledge from retiring employees.
- Siemens AG: Due to them being one of the largest organizations, they needed an effective method to share knowledge between its many employees. So they formed a group to study KM, and then implemented KMS.
- Titan Industries: Started to implement KMS when they realized that it was harder for them to replicate past success due to documents being internalized.

This is even more useful for companies that have more than one office branch. By implementing a KMS that can be accessed by employees no matter where they are based at, it can be ensured that all existing documents, and also new findings will be easily accessible.

In industries where a lot of material types are being dealt with, and materials need to be chosen for applications, a KMS is also needed in order to keep track of all the materials that have been used, or have been experimented upon [17]. This is an example that shows a KMS is needed to ease knowledge storing for future access and reference.

A KMS is also needed to ensure that employees will be able to access information that they need, as there could be documentations that is privately kept by an employee, which makes it hard for other employees to access the documents.

The need for a KMS in an organization is as listed below [18], [19].

- Competitiveness
  Increase competitiveness in an organization, as knowledge can be easily accessed.
- Knowledge Sharing
  Encourages knowledge sharing and dissemination by providing a platform to do so.
- Improve Work Quality
  Having access to a KMS can help improve work quality as time needed to complete a task can be reduced, besides improving product quality.
- Identify Experts
  Implementing a KMS in an organization can help ease the identification of experts and their skills.
- Storage
  Ensures that knowledge is stored so that the organization's intellectual assets will not be lost.

D. Factors influencing successful KMS implementation

In order to implement a KMS in an organization, there are factors that need to be considered. These factors are important because they determine whether or not the KMS will be successfully implemented in the organization. Some of the factors include personal barriers [20], failing to make it easy to acquire knowledge, and also failure to integrate the KMS with people's work [21].

Some barriers in implementing a KMS in an organization are listed below [22], [23], [24].

- Organization culture
- User perceptions
- Employees support in creating and implementing KMS
- Infrastructure capabilities
- Knowledge linkage
- Bad time management in solving problems

After implementing a KMS in an organization, a period of time is passed to let the system "mature" before the effect of the KMS implementation is checked. A KMS is considered successful when [25]:

- Resources like people and money attached to a project is increased.
- Increase in volume of knowledge content and usage.
- The project is more likely to succeed even without the help of experts.
- There is some evidence of financial return, either for the knowledge management project, or the organization itself.

II. Current KMS in Industries

Many researches have been conducted on KMS in industries. Some researches were conducted to find out the effects of implementing KMS, some were conducted to develop and implement a KMS in an organization, and various other reasons and objectives. Listed in Table 1 are some of the previous researches conducted on industrial KMS.

Based on the literature review conducted, it can be concluded that organizations are implementing KMS to extract and preserve their explicit and tacit knowledge, besides improving their organizational KM capabilities.

Current researches on KMS have been focusing on producing KMS frameworks that are specific to the applications [4], [26], [27], KMS security [28]–[31], and also exploring different methods to develop KMS [32], [33].

III. KMS Security

When implemented, a KMS holds an organization's gathered knowledge in its repositories. Due to organizational knowledge being an asset [2]–[4], the access to these knowledge needs to be controlled as to prevent the knowledge from being leaked to unwanted individuals. A study conducted by Rose [34], found that there is a research gap in Knowledge Management (KM), KMS, and Security. Previously, researches on KMS has been focusing on the development and implementation of KMS, and also the study on KMS implementation effects within the organization. Due to this, the security of the system is not specified in previous researches, as security is not the main focus of previous researches.

The purpose of a KMS is mainly to store information and knowledge within an organization, so it is important to ensure that these stored items is also secure. KMS security has not always been an essential focus when developing and implementing KMS in an organization. This is because, some might think that it is redundant to apply security which limits access to a system which targets to disseminate information and knowledge within an organization.

A. Access Control Method (ACM)

In order to control employees' abilities to get to knowledge in an organization's database, access control is applied. In

computer systems, access control is controlling a subject's ability to perform an operation on an object based on a policy. In order to decide who gets access to objects within the system, access control policy is applied. In a computer system, access control policy defines a subjects's permissions, which is the

TABLE 1: KMS IN INDUSTRIES

No.	Ref. No.	Paper Title (Year)	Type of Industry	Description	Focus of KMS
1	[35]	Supply chain knowledge management supported by a simple knowledge organization system (2016)	Dairy	A system was proposed to improve and facilitate knowledge management among all supply chain partners. The ontology is used to hierarchically classify data. Then the Simple Knowledge Organization System (SKOS) is used to infer relationships between those data. After implementing system prototype, an evaluation was carried out to determine the most important features that should be present in a KMS.	e-procurement
2	[27]	Implementation of Knowledge Management System in PT Intimas Wisesa (2011)	Printing	An architecture was proposed for a KMS for industrial clusters. MediaWiki was used in developing the KMS. Both tacit and explicit knowledge were gathered and stored for dissemination. Employees could access the KMS in the company's web.	Knowledge acquirement & dissemination
3	[26]	Knowledge Management System for Failure Analysis in Hard Disk Using Case-Based Reasoning (2017)	IT	Case-based reasoning was used as a methodology to build the Knowledge-based systems to solve problems on specific tasks.	Specific task problem solving
4	[36]	A foundational ontology for the modelling of manufacturing systems (2018)	Manufacturing	A KMS for manufacturing systems was designed to manage tacit and explicit knowledge within the company. The developed system is tested in an industrial case study.	Consistent element definitions in manufacturing systems
5	[37]	The Dissemination of Knowledge in Manufacturing Enterprises Using Intranet Based Knowledge Management System: An Example (2008)	Manufacturing	A methodology was developed for a KMS to be implemented in a manufacturing company.The developed methodology supports CI projects on the shop floor of the company.	Using a company's intranet to facilitate knowledge management
6	[38]	An ontology framework towards decentralized information management for eco-industrial parks (2018)	Not specified	A decentralized information management system was proposed, where an ontological knowledge base is created using a top-down conceptual framework. A case study was done in Jurong Park to validate the system, which is used for distributed information management.	Reaching a symbiotic relationship between multiple industries by considering all relations between them.
7	[39]	An Ontology-based Knowledge Management System for Industry Clusters (2008)	Handicraft	A methodology was developed in order to facilitate knowledge management in industry clusters. The methodology was tested in ten firms within two of the biggest handicraft associations in Thailand and Northern Thailand.	Supporting KM between organizations in an industrial partnership
8	[32]	Enhancing knowledge management into systems engineering through new models in SysML (2017)	Not specified	Another methodology was proposed where a decision model that complements the existing methods by using SysML This was done in order to make better the current methods, that do not have enough cooperativeness and KM supports.	Managing industrial environment by integrating cooperative work and KM
9	[40]	A Framework for Ontology-Based Knowledge Management System	Not specified	A methodology was also presented where a KMS was developed in order to match projects to the experts within an organization. The developed system was then tested by collecting experts and projects, and the precision of the system is tested by using different approaches.	KMS framework for semantic similarity
10	[28]	A Congenial Access Control Technique for Knowledge Management Systems (2010)	Education	A congenial access control is proposed for use in large organizations. This researches improves RBAC by creating a fuzzy access control. The results show that implementing this access control method is more accurate in granting/denying access to users.	KMS security

subject's right to perform an operation on an object. Access control policy is employed in order to enforce organization security. In an organization, a user's permissions will be granted based on the access control policy. The policy is often rigid, meaning that if a condition is not met, it is often difficult for permission to be granted to a user.

Some previous researches on knowledge access control that has been done to control access for online systems include proposing an attribute based access control scheme that is integrated with controlled access delegation capabilities [41], applying an extended role-based access control to a KMS [42], and applying access control to a knowledge sharing system using ontology [43].

There are three commonly used access control models: Discretionary Access Control (DAC), Mandatory Access Control (MAC), and Role-based Access Control (RBAC).

These access control models enable users of a system to access securable objects. Each of this models have different ways of defining concepts and the relationship between them in order to Table 2 lists the definitions, pros and cons, and in what types of organizations that the access control model shouldn't be applied, summarized from a paper by Thion [44].

organize access control. In order to decide which access control model to be used within an organization, the organization's structure will need to be studied first.

Table 3 shows a list of industrial ACM in KMS applications.

TABLE 2: ACM

ACM	Definition	Pros & Cons	Should be used by
DAC	The owner of an object controls who can access the object.	Pros: • Owner of data gets to decide who to grant permission to. Cons: • No control over permissions passed from one user to another.	Noncritical structures that are not potential targets of cyber terrorisms.
MAC	Access are controlled based on users' clearance and the object's classification.	Pros: • Solves DAC's weakness: when there is no owner to the object. Cons: • Rigid. Most commercial companies do not prefer this model.	Highly hierarchical organizations or, in cases where a system uses multiple access control models, used in more critical parts of the system.
RBAC	Access are based on the roles each subject plays in an organization.	Pros: • Reduces complexity, cost, and potential error in assigning user's permissions. Cons: • Permissions are granted based on policies that seldom changes [45].	Large organizations

Based on Table 2, it can be concluded that each access control model is suited for different users, depending on the level of security that is needed for the organization. As this research is focused on KMS in industries, which usually involves large organizations, the most suitable ACM to be used according to Table 2 is RBAC. This is because large organization have a large number of employees, in which their responsibilities vary form one another. RBAC is a version of ACM which is more suitable compared to MAC and DAC because it is less rigid in assigning access, and but it is also more consistent in determining access, instead of, for example, in DAC, where the owner of the document decides who gets to access the document. This is also supported by various previous researches conducted to implement access control in industries, where the ACM chosen is RBAC, or an improvement of RBAC.

TABLE 3: EXAMPLES OF ACM APPLICATION IN INDUSTRIAL KMS

No.	Ref. No.	Title	Description	Type of ACM	Pros	Cons
1	[31]	A Secure and Flexible e-Health Access Control System with Provisions for Emergency Access Overrides and Delegation of Access Privileges (2016)	Proposes a flexible and secure access control model, which enables the system to make a decision in emergency situations. A secure mechanism is also developed to manage access delegation in the system.	RBAC + improvements	Tackles the issue of unathourised access and data breaches in healthcare organizations	-
2	[46]	A framework of secure KMS with RBAC implementation (2006)	Proposes a framework for RBAC KMS in a collaborative environment, where security may be compromised in a system that is shared between organizations.	RBAC + improvements	Reduces dependencies on staff for decision making thus reducing management complexity.	Access control on KM process is not part this research.
3	[45]	Ts-RBAC: A RBAC model with transformation (2016)	Introduces "transformation" to RBAC, to help improve system flexibility while not having an adverse effect on RBAC model.	RBAC + improvements	Improves system flexibility by allowing re-assignment of user roles.	Lacking a suitable method to handle more than one administrator.
4	[47]	How to securely break into RBAC: the BTG-RBAC model	A methodology is proposed on allowing users to override existing roles, enabling them to access what they do not have access to, initially.	RBAC + improvements		Users can cause damage to the system as they are able to override access control, and also ignore the system's constraints.
5	[48]	Extended Access Control and Recommendation Methods for Enterprise Knowledge Management System (2014)	Proposes a methodology to improve RBAC with a hybrid model to overcome shortcomings when employing collaborative filtering and RBAC. 3 methods were proposed and tested.	RBAC + improvements	Uses concept of "groups" in organization to improve role assignments in RBAC. This helps improve the accuracy of permission granted to a user.	The consistency of one of the methods is yet to be verified.

Based on Table 3, it can be concluded that most of ACM applied to KMS is RBAC. However, it can also be seen that although these researches uses RBAC, they improve the model by tackling issues like data breaches, or system complexity. This supports the findings in Table 2: RBAC is most suitable in industrial KMS security application, but the model also has its shortcomings, like RBAC being complex to manage, or not having enough flexibility in assigning roles and document access, which prompts for researches on its improvements.

As mentioned in Table 2, RBAC is an ACM where the access is determined by the roles that a person is holding in an organization. An employee may hold more than one role, so that appropriate access can be gained. Fig. 2 shows an example of how roles and access are granted. Permissions are granted based on the roles, which will be processed using the ACM policy.

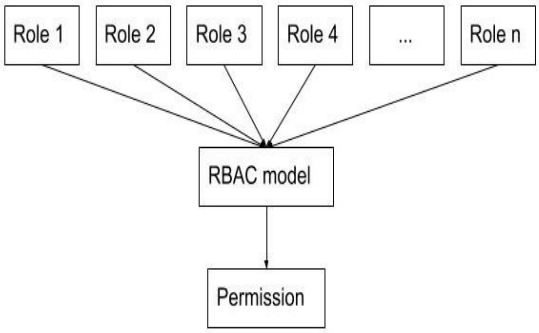

Fig. 2: RBAC Role Delegation

As shown in Fig. 2, an individual within an organization may hold more than one role. This is to help ease the process of controlling access in the KMS. Each role will have their own set of permission, i.e. tasks and document/file that they will be able to assess. Some examples of tasks are shown in Table 4. It can be seen that each role has their own permission, and that not all roles have the same access to perform the same tasks, for eample, to update a document. These permissions will be included within the ACM policy.

TABLE 4: RBAC ACCESS SPECIFICATION

Role	**Permission**		
	Write	Read	Update
Project Leader	√	√	√
Engineer	√	√	
Technician		√	

It is vital to implement ACM with KMS will help improve the system's security. This is because the system contains an organization's intellectual capital, which is knowledge that is valuable to the organization because it can contribute to the organization. According to Jennex et al [49], initially, information security involves education and awareness on how an organization intends to implement security. This means that a formal plan is developed, where policies on security and access control is included.

RBAC is the most suitable to be implemented in large organizations as the employees will already be assigned to their own roles, which includes their job scopes, making the task of assigning their permissions easier.

IV. CONCLUSION

From the literature review, it can be concluded that the awareness of the importance of implementing a KMS in an organization is increasing, due to the importance of preserving their intellectual capital. In addition, KMS security is an important aspect of a KMS that should not be overlooked, due to the importance of protecting the system's content which is the organizational knowledge, that is an important asset. The review also highlighted that each ACM are more suited for different applications. In the case of this ongoing research, it was proposed that RBAC is implemented as a means for KMS security as knowledge in the case study organization is generated, and shared is usually based on the roles or departments of the employees in the company. .

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