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Proposition of a Knowledge Management Approach Based on the Cloud Computing

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***Abstract*—**The significant growth in the use of technologies in all life domains created numerous hurdles that derailed many knowledge management projects. Cloud computing choices are commencement to untangle these obstacles. Linking Cloud computing with knowledge management (KM) is a challenging task. Small amount of researches have been done regarding cloud computing and KM. In this paper, we consider Cloud-based KM as a new KM approach, and study the contribution of Cloud Computing to organizational KM. In fact, KM and cloud computing have many things in common, this similarity allows deriving very interesting features. Our approach is based on these features and focuses on the advantages of Cloud computing in the context of organizational KM. Finally, we highlight some challenges that have to be addressed when adopting a Cloud Computing approach to KM.

***Keywords*—**Knowledge management, cloud computing, knowledge management approaches, cloud-based knowledge management.

I. Introduction

KM is a set of methods and techniques allowing the management of the knowledge and the knowhow of the organization members. This permits to capture and to share experiences in order to improve decision making, to avoid past errors and to create new practices [1]. Reference [2] claims that the aim of KM is to save the organization knowledge, and to transfer it among members and to apply it to create added values, while according to [3], knowledge is not only a resource/asset waiting for mining, it also could be an active service. Knowledge services can be designed and implemented as an IT-enabled process which organizes and transforms knowledge resources into real value, including *increasing human capital*, *improving knowledge worker productivity*, *building of Communities of Practice and learning organizations*, *causing continuous innovation*, etc.

Several studies have focused on KM using Cloud Computing. New concepts and Cloud service models were introduced. A number of frameworks and KM system architectures based on Cloud Computing were proposed. The paper is organized as follows: In the following section we review the various proposals for KM approaches. Section III provides an overview of existing works. Finally, we highlight the characteristics of the Cloud-based KM approach and some challenges that have to be addressed when adopting this approach.

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II. KM Approaches

Various classifications of KM approaches have been proposed in the literature. Based on the *Nonaka Model of Knowledge Management* [4], we group these approaches into two main categories: **socialization approaches**, and **combination and externalization approaches**. In the socialization approaches, organizational Knowledge consists largely of tacit knowledge that remains in the heads of the organization individuals [5]. The approaches belong to this category focus on knowledge exchange between knowledge owners/holders and knowledge users/seekers, while avoiding organizational or professional boundaries [6]. The knowledge exchange is ensured through direct interactions between actors [6], [7] using tools facilitating collaborative work and communication between company employees (groupware tools, for example) [6] or through employee training. Indeed, the training promotes the exchange of ideas [5]. These approaches involve the study of the structure of interactions occurring within a group [5], [8]. This allows to propose structuring tools and methods for ensuring better development of exchanged knowledge and ensuring easier reuse [8]. Thus, in these approaches, knowledge exchange and transmission, and cooperative behavior of organization members are placed at the heart of the KM process [9]. This category includes the *information oriented approach* [6], *personalization approach* [7], *tacit knowledge oriented approach* [5], *social and cooperative approach* [8] and *managerial approach* [10].

In the second category, knowledge must be transformed into the explicit form. The approaches of this category focus on knowledge modeling, once located and identified. The explicit knowledge will be then exploited via the enterprise information system [5] or capitalized in a KM system which includes a knowledge base that can take various forms [11]. This category includes *knowledge oriented approach* [6], *descending/ascending approaches* [8], *codification approach*, *knowledge capitalization approach* [7], *explicit knowledge oriented approach* [5] and *technological approach* [12].

III. KM and Cloud Computing

Several authors have discussed the contribution of Cloud Computing to organizational KM. According to [1], Cloud Computing is known as one of the latest innovations in modern technology. Organizations need to reevaluate and modernize their KM strategies to keep up with technological developments. Technology is one of the most important factors that KM should be kept aligned with, in order to keep itself powerful and useful [2], [13]. Reference [14] stated that conventional approaches proposed for KM system

architectures are lacking to provide desired parameters in *flexibility*, *stability*, *safety*, *consistence*, etc. Other authors support this contribution by presenting various benefits for enterprise when adopting a KM approach based on Cloud Computing [1], [2], [15], [14]. A number of concepts and approaches were introduced for KM using Cloud Computing namely the concepts of *Knowledge Base Cloud* [14], *Enterprise Knowledge Cloud* [16], *Knowledge as a Service* [1], [3], [13], *Knowledge Management as a Service* [13], etc. Other works concern specific areas such as collaborative product design, inter-enterprise collaboration [17], Personal KM [15], Higher Education [18], [19], etc. Frameworks for developing KM Systems using Cloud Computing were proposed. Moreover, new Cloud service models were introduced in the context of organizational KM. Reference [13] presented the relationship between Cloud deployment models (*Private, Public, Community and Hybrid*) and types of knowledge (*tacit and explicit*). They also describe the access level (*low, medium, high*) for these types of knowledge in each deployment model, and the types of knowledge (*Internal, External, Organization, Marketing and Technology*) available in each model of the Cloud. Reference [2] present the benefits of using Cloud Computing in KM systems including decreasing in time, cost and effort for *meeting software development needs*, *providing a great means for gathering and redistributing knowledge*, etc. Also, the authors depict risks of using Cloud Computing in KM systems namely *data leakage*, *IT organizational changes* and *Cloud service provider viability*.

A. Cloud Computing Advantages for Organizational KM

Reference [6] presents the concept of *Enterprise Knowledge Cloud*. It is defined as "collaborative, cooperating, competing mega-structure providing computing, networking and storage services to various 'knowledge producers and consumers' being devices, people and applications". It is a set of interconnected Clouds that are related to business partners, suppliers and customers. Meanwhile, [14] propose a new approach to KM systems architecture called *Knowledge Base Cloud (KBC)*. The authors stated the limits of the subsystems that are playing role in the company KM. The definition of the KBC concept is based on the Cloud Computing concept. It is defined as "knowledge sources, appearances and distribution that do not require end-user knowledge of the physical location of these sources and configuration of the system that delivers the services". Other characteristics of cloud computing can be also adopted to characterize this new term. KBC principles are very similar to the private Cloud model. From the service models of Cloud Computing, the KBC concept can be compared to the *PaaS (Platform as a Service)* model with some characteristics of *SaaS (Software as a Service)*. The major KBC compounds are the existing *Information Systems*, *Relationships and Connectors* defining the position (dominant, balanced or submissive) of each compound regarding the other parts of KBC, *Best Practices*, *Data-Information-Knowledge*, *Know-how*, *Access privileges and rules* which define user rights regarding specific parts of the system and the profoundness of intelligent system resources allocation to the user requests on the system, and *Process architecture* designed as an organized tree of processes regarding the system operation and usage. The authors state also the processes that the company should go through when deciding to implement the KBC concept and rules/recommendations that have to be obeyed. Reference [14] work on Knowledge-based Collaborative Product Design using Cloud Computing Infrastructure, and propose a framework architecture for Cloud-based Knowledge Integration of Collaborative Product Design. The proposed architecture includes four layers. The *Cloud Presentation Layer* from which users (design engineers, manufacturing engineers, knowledge engineers, customers, developers) can access cloud services and other levels. *Cloud Knowledge Integration Service Layer* or *Knowledge Integration as a Service Layer* providing the knowledge based services. *Cloud Physical Layer* includes all physical devices that run on the cloud, halls and corridors with thousands of computers used to store data to process information, etc. Finally, the *Security Layer*, which takes care that all data stored in the Cloud are encrypted and has limited access to authorized users. Reference [15] present the idea of the *Cloud-based Personal Knowledge Management Platform* that takes Cloud Computing benefits to interconnect individuals together to better manage and share their knowledge. According to the authors, the nature of Cloud Computing is perfectly fit for the Personal KM requirement. In fact, Personal KM requires an environment to facilitate personal information management, personal knowledge internalization, interpersonal knowledge transferring, etc. Such environment is known as a Personal Learning Environment that should be accessible at anytime and anywhere, and independent to the client platform or devices. The proposed Cloud-based Personal KM platform can be viewed as Knowledge-as-a-Service which form a Personal Learning Environment. The platform allows cloud user to better manage their personal knowledge (information retrieving, evaluating and organizing), to learn and develop their knowledge, and reflection of their knowledge. The authors have not addressed the platform's technical aspects. Reference [1] proposes a Framework for Cloud Based KM. The proposed framework includes four layers. *Infrastructure as a Service layer* enables organizations to utilize servers, devices, network, and storage disks whenever they require. *Platform as a Service layer* enables organizations to develop and maintain web applications without having specific expertise. *Software as a Service layer* provides applications that do not need to be developed. These applications are cloud based and are accessible to web users or organizations on demand, anywhere and anytime. *Knowledge as a Service layer*, which is used to access specific and necessary knowledge at any time from any location. Reference [3] proposes a five-layer design framework for developing Knowledge as a Service platform. They distinguish the *Knowledge Support Layer*. In this layer it must have the direct or indirect participation of domain experts by applying for example available Body of Knowledge of related domains and

standards as a scientific guide in collecting knowledge resources. The *Knowledge Organization Layer* adopts a Body of Knowledge-based strategy for knowledge organizing. Unorganized and scattered information cannot embody the value of knowledge. The *Knowledge Resource Layer* includes virtual knowledge resources repository**,** in which the resources are located by associated URLs. In the *Knowledge Service layer*, seven value-added service functions have been identified based on available knowledge, organized into seven Service Centers. The *Context Layer* provides more flexible and valuable services for different levels of users (Individuals, Enterprise or Community of practice).

From the various studies cited below, we resume in Table I, the advantages of Cloud Computing in the context of organizational KM.

B. New Cloud Service Models in the Context of Organizational KM

New Cloud service models were introduced, related to organizational KM. Reference [3] extend the *Data in the Cloud* approach to *Knowledge in the Cloud*. They propose a new Cloud service model called **Knowledge as a Service (KaaS)**. KaaS is based on knowledge resources base, from which the user can easily acquire knowledge on demand. Thereafter, the authors present the concept of *Knowledge Cloud* which includes the three service models that can be offered in the Cloud: *SaaS*, *PaaS*, *IaaS (Infrastructure as a Service)*, and the proposed new service model i.e. KaaS. They claim that currently, it must find ways to transfer knowledge not only from person to another but also from Knowledge Cloud to Knowledge Cloud. According to the authors, KaaS is an organizational process covering a whole lifecycle from knowledge generation to dissemination. Indeed, it contains two major areas: collection and organization knowledge resources, and delivery of knowledge services. Meanwhile, [13] define KaaS as "a subtype of SaaS provided by a knowledge service provider, in which, a knowledge provider answers queries presented by some knowledge consumers, via the knowledge services". According to [18], KaaS is a kind of service of which the outcome is that user can share and exchange knowledge. In [1], KaaS is a combination of knowledge based processes and organizational systems which enable KM at organizational level.

Reference [13] introduces the Cloud service model **Knowledge Management as a Service (KMaaS)**. It is defined as "a SaaS, in which, KM services are provided by KMaaS service providers and are consumed by KMaaS service consumers". The authors claim that the difference between KaaS and KMaaS is that the former provides facilities on knowledge itself, while the latter provides management services to the consumers. KaaS is a part of KMaaS.

From existing works on KM based on Cloud Computing, we present in Table II, the KM Cloud services proposed for Cloud-based KM.

IV. Discussion

Cloud-based KM is an approach that combines both KM approaches as shown in Fig. 1.

On the one hand, the company will rely on the Cloud to externalize a part of its knowledge, using Cloud services known as *Knowledge as a Service* and *Knowledge Management as a Service*. These two KM Cloud service models are subtype of SaaS and PaaS, which offerings consist, respectively, of storage spaces for explicit knowledge acquisition, and various services related to KM tasks. These services are implemented by a set of applications hosted in the Cloud or developed in platforms provided by the Cloud. Knowledge users can access these services at any time, regardless of their location. On the other hand, the company could be based on the Cloud resources allowing its employees to connect for communicating and sharing their tacit knowledge. Therefore, Cloud-based KM approach includes the following features:

- It is a distributed KM approach. The distribution relates to the knowledge resources that are deployed on the Cloud and the knowledge users which may be geographically dispersed.
- It is at the same time a socialization approach, and combination and externalization approach. So, it takes advantage of both approaches.
- It is a multidisciplinary approach integrating concepts and techniques from both the organizational KM and Cloud Computing fields. Knowing that KM is itself a multidisciplinary field, integrating concepts and techniques from various areas namely psychology, sociology, artificial intelligence, information systems engineering, economics, human resources management, etc.
- It is a service-oriented approach. KM tasks are insured and provided as services.
- It takes account of both tacit and explicit knowledge.

Cloud computing brings many benefits and presents a number of challenges to organizational KM. The benefits for the company are economic and organizational benefits. Consider Cloud-based KM as a new KM approach involves a number of questions. Including such an approach could cover all the phases of the KM process? Otherwise the company could rely on Cloud Computing to ensure all the phases of the KM process.

In the literature, knowledge acquisition is based on models for capturing, representing and structuring knowledge. The acquired knowledge will be subsequently stored in various forms in order to be reused later as needed. Therefore, knowledge acquisition depends on the knowledge to capitalize and the adopted way to preserve it. However, in a Cloud Computing environment, risks occur at the company. So, it is imperative to provide knowledge acquisition models that take into account the features of this new environment.

Knowledge sharing deployed on the Cloud poses security issues and problems related to the dispersion of shared resources. However, it would be interesting to take advantage of works done in the field of Cloud security. Moreover, in the

KM field, a number of studies have addressed heterogeneous and distributed KM and knowledge access control particularly in virtual and extended organizations.

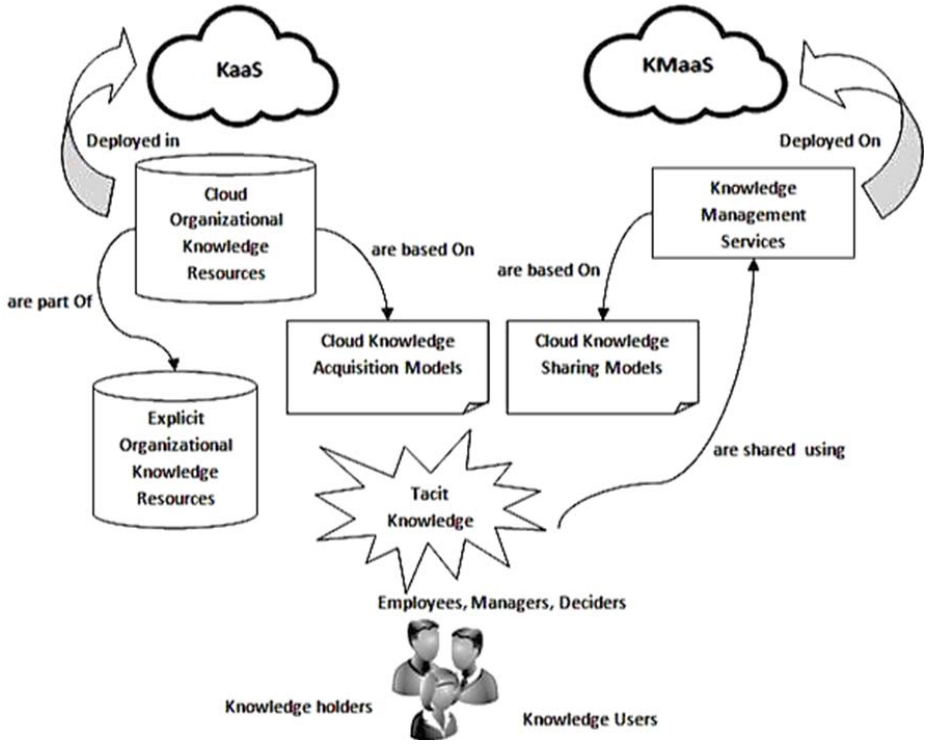

Fig. 1 Cloud-based KM approach

TABLE I
CLOUD COMPUTING ADVANTAGES FOR KM

Cloud Computing advantages for KM	Proposition	Context
- Each of the clouds in the Enterprise Knowledge Cloud is an autonomous entity, existing for its own purpose and capable of collecting, warehousing, managing and serving knowledge to its own group of users. - Furthermore, they should be capable of interconnection, overlap and knowledge-sharing, with appropriate rules and safeguards providing thus the infrastructure for behavioral, structural and strategic adaptation in response to changes in the (business) environment.	Enterprise Knowledge Cloud [16]	Organizational KM
The knowledge resources repository is mainly a virtual repository, rather than a physical. Therefore, it is easily to be dynamically expanded and replicated without demanding large storage.	Five layer design framework for developing Knowledge as a Service platform [3]	Knowledge as a Service platform
- More sophisticated search engines enabling cloud users to search and retrieve necessary information anytime and anywhere. - A cloud-based knowledge repository is not just a storage space for the cloud users to keep the information. It enables the cloud user to internalize their personal knowledge. - Mobility and portability.	Cloud based personal KM platform [15]	Personal KM
- Providing the meta-knowledge model. - Availability of large number of quantities of design knowledge in real-time and from multiple sources. - Increased degree of dependability using replicated copy of data and knowledge all times. - Increased accessibility across many platforms including mobile. - Improved efficiency from high utilization of sharing physical servers. - Improved reliability with replication of data within the system and higher level of fault tolerant.	Architecture for a Framework for cloud-based Knowledge Integration of Collaborative Product Design [17]	Knowledge-based Collaborative Product Design
- Information to be handled is not limited to a specific form. - Users can order, configure and use services without the need to think of the infrastructure on the background. - The sources are accessible from anywhere enabling to dismantle the technical access barriers. - Sharing sources is locality-independent. - Scalability and elasticity through the rapid adaptation of hardware and software sources to the current requirements.	KBC: A new approach to KM systems architecture [14]	KM Systems
- Reduced licensing charges by using a single content management system. - Reduced ownership charges due to transition to cloud. - Enhanced efficiency and cooperation throughout enterprises via a unified system. - Reduced risks due to improved flexibility and scalability. - Worldwide user profiles consolidation and improved security due to centralization. - Navigation and branding consistency by using a single KM tool instead of multiple tools. - Improved induction through centralized training ensuring the system is enhanced to full potential. - Enhanced content accessibility via a central data store. - Reduced the need for organizations to employ expert personnel along with risks originating from human error.	A Framework for Cloud Based KM [1]	Organizational KM

V. Conclusion and Future Work

In this paper, we considered aKM approach. It is a Cloud Computing-based approach, taking advantages of the Cloud Computing paradigm. Cloud Computing brings economic and organizational benefits to KM in organizations. Cloud-based KM approach leads to a KM strategy which is aligned with technological development, as Cloud Computing is one of the latest innovations in modern technology. Cloud-based KM approach is both a socialization approach, and a combination and externalization approach. Therefore, it takes account of both tacit and explicit knowledge. It is a distributed and service-based approach. Cloud-based KM approach is based on Cloud services related to organizational KM known as Knowledge as a Service and KM as a Service. However, some challenges have to be addressed when adopting a Cloud-based KM approach. KM tasks as knowledge storage and sharing in a Cloud Computing environment depicts some risks. In our future work, we intend to provide new knowledge acquisition and sharing models taking into account the characteristics of Cloud Computing environment, and therefore, take in charge risks that have arisen.

TABLE II
KM Cloud Services

KM Cloud Services	Proposition
The knowledge service layer of Knowledge as a Service platform includes seven value-added service functions organized into seven Service Centers which are: - Technology Transfer Center. - E-Learning Center. - Knowledge Resources Center. - Consulting Center. - Community Center. - Wisdom Center. - Innovation Center.	Five layer design framework for developing Knowledge as a Service platform [3]
- Knowledge organizing, storage and internalization services based on cloud-based knowledge repository. - Knowledge search and retrieve services based on Cloud search engine. - Access service of domains knowledge experts.	Cloud based personal KM platform [15]
Cloud knowledge integration service layer provides the knowledge based services: - Knowledge integration service supporting knowledge mapping and merging, and depends on the type of the knowledge (tacit or explicit). - Knowledge search service based on knowledge assessment step which is attaching credibility, value, significance, weight to the explicit knowledge. - Knowledge sharing service based on importance values assigned to knowledge. - Knowledge storage service based on cloud knowledge base.	Architecture for a Framework for cloud-based Knowledge Integration of Collaborative Product Design [17]
KM in Cloud-based environments includes the following services: - Knowledge Finder Services. - Knowledge Services. - Knowledge Access Control Services. - Knowledge Gathering Services. - Knowledge Distribution Services. - Knowledge Inference Services. - Knowledge Storage and Retrieval Services. - Knowledge Integration Services. - Personalization Services. Other services are optional: - Crowd sourcing. - Expert mediation. - Long tail services. - Knowledge pusher services.	KM as a Service: Cloud based architecture for KM

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