Eknoware: A Knowledge as a Service Platform and Application Framework

Rao Yuan¹, Dai Jun¹, Lu Shumin², Lv Yongkang³  

1) College of Software Engineering, Xi’an Jiaotong University, Xi’an 710049, China  
2) College of Social Science, Xi’an Jiaotong University, Xi’an 710049, China  
3) Xi’an Jiaotong University Nation Science and Technique Park, Xi’an 710049, China  

(E-mail: yuanrao@163.com)

An evolution model with requirement, personalization and knowledge solution domain was proposed for providing the creative knowledge services. Based on this model, the different between KAAS and KM from the dimension of the core technique, knowledge target, and knowledge extraction were compared and a BNF definition about KAAS was proposed. In cloud computing environment, a KAAS Cloud Architecture was introduced to make the knowledge available on a self-service, social network-based collective intelligence and on-demand service with three knowledge service layers as follows: knowledge resource layer, service delegate layer, and solution delivery layer. All these three key layers for providing knowledge services are how to improve the access of unstructured and scattered information for the non-specialist users, how to provide adequate information to knowledge workers and how to provide the information in situations requiring highly domain-specific, related and time critical information. Then, a research case about KAAS, Eknoware platform, was developed based on the architecture above-mentioned.

Keywords: Knowledge as a Service, Cloud Computing, Knowledge Cloud

1. INTRODUCTION

With the rapid development of network technology and knowledge economy, social knowledge networking, as a new methodology of network computing, provided many new knowledge sharing patterns, which is based on the Web2.0, cloud computing and some OPEN APIs to communicate with friends in communities of practices (COP) and to share some knowledge resources across different systems over Internet [1~3]. The core competitive capability and knowledge value always embody the process of technical innovation about products and services under the knowledge economy environment. More and more companies [4], such as Proctor and Gamble, Cisco, IBM and Air Products, were beginning to use social knowledge network platform to manage and share their enterprise knowledge and to acquire the competitive advantage by extending and enhancing the effectiveness of intra- and inter-enterprise collaboration. The transition from a loosely structured committee of individual contributors into a collaborative team, such as social networks (MySpace, Facebook…), professional networks (LinkedIn, Plaxo Pulse…), and shared community content development networks (Wikipedia, Del.icio.us, YouTube) and podcasts, blogs, etc., is an important progress in productivity, particularly in organizations operation in the knowledge service economy.

This paper investigated a social knowledge network and knowledge service mechanism from knowledge as a service (KAAS) and Cloud computing architecture perspective. The rest of this paper is organized as follows: Section 2 presented the features and existed problems of knowledge service and proposed knowledge as a service statement space model with requirement content, personalization and the knowledge solution to present the knowledge service economical evolution process with best results to right person in right time. Section 3 illustrated a formalized KAAS definition and architecture with multi-element and analyzed the knowledge services invocation operations to "push" the relevant services together into composited domain information. Section 4 provided a case study, EKNOWARE, which is a new social KAAS platform, to illustrate the merits of knowledge service and KAAS Cloud Architecture. Section 5 presented an overview of knowledge as a service, knowledge service cloud and related works. Finally, the conclusion and future research works were presented in Section 6.
2. KNOWLEDGE as a SERVICE CHARACTERISTICS

2.1 Knowledge service evolution model

Many research papers about knowledge management are investigated into knowledge management elements and relationship or sharing mechanism between knowledge and person [5]. A knowledge management evolution model based on knowledge model is provided as follow:

\[ \text{KM} = (K + P)^{S(t)} \]

Where:
- \( \text{KM} \) denotes a knowledge management tool to classify and manage the domain of knowledge, which created by specially experts in various domains.
- \( K \) denotes the knowledge with some basic elements, such as title, content, UKL (unify knowledge location), tags etc.
- \( P \) denotes the person in the COP, who needs the knowledge to consume or to create new knowledge for consume.
- “\( + \)” denotes a transfer channel. Today, web technique is become the more important channel for knowledge sharing and learning, which can put the fitness knowledge achievement together for different person’s requirements over Internet.
- \( S(t) \) denotes the degree of knowledge sharing with time. It means the method and capability of knowledge sharing and propagating with time.

By this definition, the first value about knowledge management is to provide the best knowledge to right person with the best channel by IT tools. The second one is how to share and propagate the right knowledge to more persons who need it. But, in new era about web 2.0, the relationship between person and knowledge is changing. The person not only can consume and study the knowledge created by others, but also can provide the new knowledge created by himself under the online social network environment. Everyone is owner in social network, which needs more relevance knowledge combined with his personalized requirement and share something to others, including contents, valuation, recommendation, etc. In addition, the sharing mechanism is become from passive reading to active creating by web 2.0 method.

Therefore, the knowledge management is not effective measure, while knowledge service is becoming a new phase for personalization knowledge acquirement to yield the best solutions from e-learning to knowledge as a service for specially question. This paper proposed an evolution model from knowledge management to KAAS perspective, which can be described by a KAAS model as follow:

Definition 1: (Knowledge Service Evolution Model)

The knowledge service evolution model as follow

\[ \Psi_{ks} = \left( \zeta(k) + R(q) \right)^{p} \]

where:
- \( k \) denotes the knowledge, and \( \zeta(k) \) denotes the solution with a set of combined or recommended knowledge. \( k \) is a finite set of knowledge with \( k = \{ k | 1 \leq i \leq n, k \in \phi \} \). It means that the solution is composed of the fusion knowledge by tagging, data mining, aggregation analysis, and knowledge discovery. In addition, some recommended knowledge stems from content filter or collaboration filter based on the person profile model.

\( q \) denotes the list of questions, and \( R(q) \) denotes the user’s knowledge requirement with a set of questions in various domains. \( q \) is a finite set of questions with \( q = \{ q | 1 \leq j \leq m, k \in \phi \} \). It means that the user’s requirement, from keywords searching into context understanding, is becoming the core driving force for knowledge service. All solutions provided by system must be fit to the user’s requirement and questions. Meanwhile, different question brings on different solution or the same question steamed from different person maybe results in different personalization solution, which bases on the person’s profile or favorites’ models strongly.

“\( + \)” also denotes a knowledge transfer channel by IT technique. It means that new social media service platform bridges the different experts and users together to share knowledge each other easily over Internet. By this platform, the KAAS is become the main knowledge sharing service.

\( p \) denotes the degree about personalization. It means that the degree bout the best knowledge for right person in right time to solve the fixed question. With the increasing about \( p \), the best QOS about knowledge service and the best solution will focus on the user’s requirement rightly.

From the definition above-mentioned, Knowledge service, mixing knowledge and personalization service together, is a new method of knowledge sharing and propagating, whose target is to provide the value-added service with the most relevant knowledge and solution by knowledge mining and discovering to the users’ question. So, knowledge service is the context of question-oriented, which the core destination pursues to solve the problem and provides one-by-one attentive service, but knowledge management is specification-oriented, which emphasizes on how to manage the knowledge document and provide unify information retrieve method to user. In general, the evolution process of the knowledge service is leveraged by knowledge service resources from three dimensions of evolution model illustrated in figure 1.

Fig1. Knowledge Service Evolution Model

Knowledge service can evolve and rebuild from three different aspects in figure 1, such as requirement, solution and
degree of personalization, which also provides three knowledge service strategies. On the solution aspect, the knowledge service should support knowledge retrieval from simple knowledge to combined knowledge, and end to certain solution with fusion knowledge under user’s context environment. On the requirement aspect, the knowledge service aims to solve user’s personalization question from simple keywords to complex content of question under user’s scenario and semantic environment. On the degree of personalization aspect, the quality of service (QoS) about knowledge service is greatly related with more personalization solution by person’s profile model to satisfy the user’s questions and requirements.

2.2 The Characteristics of KAAS

Many commercialized KM software have been introduced various version for different users, such as personal knowledge management application, C/S-based or B/S-based enterprise knowledge management version, etc. All these software can excavate out the potentiality of reusing existed knowledge resources to the maximum extent and promote the knowledge reused level greatly in special domain. Whereas it is obviously insufficient to provide knowledge resources for reused to solve cross-domain problem. In particularly, with the digital of information resources and the virtualization about information systems, the method about information retrieve is becoming more convenient and simplify under cloud computing environment, it is important how to acquire the content of knowledge and integrate these knowledge into a solution to form new knowledge products and services.

Knowledge as a Service (KaaS) is an on-demand, where-needed approach [6] to knowledge acquisition, who couples the knowledge and service together and turns the knowledge resources into products and service for value-added. Meanwhile, KAAS also is a process to solve the end-users problems and provide a utilities knowledge application products and knowledge innovation service, based on a series of activities under user’s context environment from knowledge retrieval, cleaning and analysis to knowledge reorganization. S. Xu [6] proposed that KaaS can decouple help, training, and solution customization activities from monolithic projects and makes them available on a self-service, socially-networked basis through the cloud. Therefore, KAAS is next generation of knowledge management paradigm with some new characteristics illustrated in table 1.

Based on the greater change about the thought of KAAS above-mentioned, more and more knowledge service techniques have been proposed in knowledge management and discovering field with more complexity mechanism at service level, such as knowledge cloud computing, semantic-based knowledge mining, content analysis and personalization recommended service etc. In addition, knowledge services not only are simple information collection, but also put the static knowledge to flow [7] from the knowledge service providers to end-users and lessen the distance between them, then, realize how to organize the target of these service activities based on the user’s behaviors.

In currently, three principal problems should be solved in knowledge service process. First principle is the requirement expression, which means that there exists semantic analysis on the user’s question for assembling the new knowledge. Second principle is the degree of personalization, which means that a personalization profile model must be built directed against user’s needs limited by his favorites, location, and time. Third principle is the solution composition, namely, the user can obtain and utilize the combined knowledge that should be solved the user’s requirements in standardized descriptions and operation methods with convenience to use. Although, many technique factors are associated with non-technique factors to realize the knowledge service, the three basic principles above-mentioned are foundation and vital elements to realize Knowledge as a service successfully.

### 3. SOCIAL NETWORK-BASED KNOWLEDGE SERVICE FRAMEWORK

#### 3.1 The Definition of KAAS

Knowledge as a service is an emerging concept that integrates knowledge management, knowledge markets and

<table>
<thead>
<tr>
<th>Target of Knowledge</th>
<th>KM</th>
<th>KAAS</th>
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<tbody>
<tr>
<td>Extraction Method</td>
<td>Provide or transmit the relevant knowledge documents to user</td>
<td>Provide fitness solution to user’s problem</td>
</tr>
<tr>
<td>Method of requirement</td>
<td>Keywords matching</td>
<td>Combined or recommended knowledge</td>
</tr>
<tr>
<td>Service method</td>
<td>Sharing with general knowledge</td>
<td>Sharing with personalization solution</td>
</tr>
<tr>
<td>Value of Service</td>
<td>Information provided</td>
<td>Value-added with integrated knowledge</td>
</tr>
<tr>
<td>Service provider</td>
<td>System or operators</td>
<td>Experts in domain</td>
</tr>
<tr>
<td>IT infrastructure</td>
<td>Knowledge Management system</td>
<td>Social network sharing platform</td>
</tr>
<tr>
<td>Interactive with users</td>
<td>One knowledge document to more users</td>
<td>One knowledge solution to one requirement</td>
</tr>
<tr>
<td>Core technique</td>
<td>MIS and Searching Engine</td>
<td>Could, SNS and Semantic Web</td>
</tr>
</tbody>
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Table 1. The characteristics comparison between KM and KAAS
knowledge organization as cloud computing. Knowledge service, which is openness, on-demand, content-based and where-needed service innovation process, is becoming core elements to propel the knowledge society and the organization unifies forward. Social network expedites the turnover of knowledge and the communication among with different persons, especially, mixed the more experts’ knowledge in community of practice (COP) into the product and service innovation process of enterprise. Therefore, the knowledge as a Service (KaaS), in social network environment, is a service transfer method which contains three major functions: collection and organized knowledge resources created by all users in CoP, aggregation and analysis the requirement of user’s with a knowledge agent, and delivery of the personalized solution for knowledge innovation services. Then, the conception of KAAS is defined as follow:

Therefore, Service delegate has three elements, such as requirement specification, service context and knowledge aggregation, to complete the task of requirement analysis and knowledge aggregation. Requirement specification is an important element which also includes some sub-elements as follow: requirement provider, requirements classify tag, requirements description and some constrains.

Solution delivery is the conclusion of knowledge service, which can successfully invoke the knowledge solution to satisfy the user’s requirements with some different knowledge delivery type. From the viewpoint of marketplace, the KaaS marketplace offers rich opportunities to discover and purchase knowledge solution directly from producers-whether help desk analysts, implementation consultants, developers-as an alternative or precursor to traditional consulting and systems integration engagements. Moving from a knowledge delivery to a knowledge acquisition paradigm provides the end users some new capability to build their own IQs rather than depend exclusively on knowledge consultants. Furthermore, this method decreases the costs about software implementation, customization, and upgrade in enterprise.

3.2 KAAS Cloud Architecture

Based above definition, KAAS, who decouples help, training, and solution customization activities from monolithic projects, is programs that provide content-based organization by data, information and knowledge value-added, which also outputs some advices, answers or

<table>
<thead>
<tr>
<th>Knowledge as a Service</th>
<th>Knowledge Resource, Service Delegate, Solution Delivery</th>
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<tbody>
<tr>
<td>Knowledge Specification, Knowledge Construction</td>
<td>Knowledge as a Service</td>
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<tr>
<td>Atomic Knowledge</td>
<td>Composite Knowledge</td>
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<tr>
<td>Requirement Specification, Service Context, Knowledge Aggregation</td>
<td></td>
</tr>
<tr>
<td>Provider, Requirement Tag, Content, Constrains</td>
<td></td>
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<tr>
<td>Delivery Type, Instance Statement</td>
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Fig2. The BNF definition about Knowledge as a Service

From this definition, the knowledge as a service (KAAS) has three independent parts, such as knowledge resources, service delegate and solution delivery. In addition, Knowledge resources can be divided into two elements, such as knowledge specification and knowledge construction. Knowledge specification defines the elements and relationships about knowledge services with provider information, knowledge classify tag, knowledge content and some constrains to use. We can build a user’s profile model by provider’s information, which can help system provides more personalized and simulated knowledge to user.

Knowledge construction describes the relationship of knowledge composition with atomic or composite knowledge. From knowledge construction perspective, the knowledge is nested hierarchy structure that can assemble the atomic knowledge together to build more complex and practical composed knowledge for reuse. Atomic knowledge includes knowledge name, description and a knowledge access entry point, e.g., URI, which is unique identity of knowledge in network. Composite knowledge can be integrated by some atomic knowledge with instance statement of atomic knowledge and reference, which can connect from atomic knowledge to composition knowledge.

Service delegate introduced a uniform mechanism for knowledge discovered with standard OWL-based description specification from lightweight knowledge service directory register center, which predigest the knowledge discovered process of reusable knowledge resources. Service delegate also is a knowledge agent, which can contact with some knowledge consumers and acquire their requirements.

Figure 3. the KAAS Cloud Architecture
facilities to meet external user’s needs. In cloud computing environment, KaaS makes the knowledge available on a self-service, social network-based collective intelligence, and on-demand service with three knowledge service layers. First is knowledge resources layer, the various knowledge resources can be cleared and normalized by knowledge specification. The knowledge resources specification base, which built by index base, database, media base and knowledge tag cloud, is a basis of knowledge analysis and aggregation. In addition, the knowledge tag cloud can put the different knowledge with same tags into one classification contains for aggregating the knowledge together.

The second layer is service delegate layer, which put various knowledge and data resources into Knowledge Aggregation Engine. This engine can match the right knowledge solution from knowledge resources specification base, by user’s profile model and user’s knowledge requirement specification, which can form the requirement document index and requirement tag. The match method adopts the weighted TF/IDF algorithm, which can weight different style terms to analysis the similarity among the different requirements and knowledge base. In addition, the user’s profile model can be build by an iterated mechanism, which can add the new tags from two methods with different weight mechanism as follow. First is the tags stem from the documents (including: blog, active, group, discussion and so on) created by user himself. Second is that the tags from the documents created by the other users, who are focused on knowledge consumer. Service context engine can utilize the requirement context and semantic to optimize the order list of similarity knowledge and aggregate these knowledge into a whole knowledge service after cleaning.

The third layer is solution delivery layer, which put various aggregated knowledge into knowledge directory center to form the different solution. All these solution can pull the new knowledge to consumer by KaaS cloud with different knowledge client, such as mobile phone, mobile pc and others.

All these three key layers for providing knowledge services are how to improve the access of unstructured and scattered information for the non-specialist users, how to provide adequate information to knowledge workers and how to provide the information in situations requiring highly domain-specific, related and time critical information. Then, this paper introduces a platform of knowledge acquisition and services, namely EKNOWARE, which using social knowledge network as a backbone. Based on the special design about community knowledge sharing and personal knowledge profile model, the system ensures that knowledge service could be improved the user potential business in knowledge consumption.

4. KNOWLEDGE SERVICE CASE RESEARCH

In this section, a KAAS-based application platform, EKNOWARE, with knowledge sharing method and the requirement specification is introduced in the social network environment. The purpose of this application wants to reuse the legacy teaching resources, such as assignments, reference materials, and project resources developed by different teachers and other students in different periods over different departments. The system architecture is illustrated in figure 4. The Knowledge Achievement Resources Unit means that the reusable knowledge resources of the system, such as expert pool, patents pool, research paper Lib and e-training applications, which can be encapsulated to become knowledge service unit with data sources stored in database or Lucene’s index files. The Creative Knowledge Service can be stored in the knowledge service pool that listed all knowledge services and published all these information into private knowledge service register and publisher center (KSRPC) for reuse. When a new knowledge creative service need to be provided, that can pass the process of analyzing the knowledge acquirement and putting the new value add in. KSRPC plays an important actor to aggregate the knowledge

![Diagram](image-url)
and put the direction of knowledge into right method for research and match. By this method, the knowledge-creative service not only reused the knowledge services, but also reused all the data resources which can be merged into a whole knowledge contents located in distributed knowledge database.

The Knowledge Create and Product Unit means that to build some socialization knowledge collaboration communities for sharing and creating new knowledge, which can provide some online knowledge groups and activities to exchange the ideas and knowledge, and then put them into certain project. The knowledge Achievement and Match Unit means that to build some key knowledge matching algorithms, which can put the most similarity knowledge or requirements together for user search. Based on these algorithms and matching service, the user can publish the project’s achievements or requirements with more personalized knowledge pulled by system. In addition, the experts, registered in platform, can provide the knowledge consultation and answer the user’s problems.

The Knowledge Value Transfer Unit means that to provide a knowledge exchange or trade mechanism, which can help all the people in platform to find right knowledge commodity and can pay for it easily. So, how to design an out-of-the-shelf knowledge service and build a reliable online payment, which include many relative knowledge units to output the right value in the right process to user, is a keypoint in KAAS application. Based on this unit, an online knowledge markets will be formed to pay for expert’s intelligence resource, related knowledge resources, and transferred patents resources.

Based on the above-mentioned architecture, a practice knowledge as a service platform, named eknoware (http://eknoware.com), can be build in campus network environment in China. This platform provides some basic functions for knowledge sharing and learning, such as experts blog, online question and answer, discuss in a online knowledge communities, and so on. In specifically, a personal knowledgebase is provided which can not only exchange the knowledge between different persons, but share the knowledge between different knowledge groups. So, the knowledge become a flow from one person to others person with new contents and value-added. The eknoware platform, a best practice of KAAS architecture, is illustrated in figure 5.

5. RELATED WORK

Recently, Murray [8] proposed that the knowledge cloud is “the future of the future”. Many researchers focused on the knowledge as a service and promoted the new “wave” to develop the knowledge service-based application. In generally, the knowledge service strategies [9] can be divided into three aspects: knowledge management service, knowledge value-added flow and creative service and socialized knowledge trade in cloud environment. According to the principles of service science, KAAS service is to allow users “pay-per-use” access to “specialized” provider

![Diagram](http://eknoware.com)
knowledge, on demand, so as to integrate it with their own specific internal knowledge to create value for themselves. Eng K. Chew [10] provided a methodology about KAAS classification scheme based on the business model principles. In parteculate, the knowledge embedded in software as a service (SaaS) will promote the value about software greatly. Ju [11] proposed a public knowledge service platform framework and a practice application about on-the-job learning platform in outsourcing professional development process with knowledge service. Furthermore, the knowledge service and KAAS technology were proposed to resolve the semantic problems for automated knowledge service without much manual intervention, which can put knowledge into all the business process to win huge value-added. The research about the core technique on knowledge as a service is one direction in our future work.

6. CONCLUSION AND FUTURE WORK

The purpose of knowledge service, however, is to reuse knowledge resources and create a new value-added service method more efficiently. This paper proposed a KAAS evolution model with Requirement, Personalization and Solution domain for providing the creative knowledge services. The BNF definition about KAAS is proposed after compared the characteristics between the KM and KAAS with core technique, knowledge target, extraction, and so on. In addition, a KAAS Cloud Architecture is provided in cloud computing environment, which makes the knowledge available on a self-service, social network-based collective intelligence and on-demand service with three knowledge service layers as follows: knowledge resource layer, service delegate layer, and solution delivery layer. All these three key layers for providing knowledge services are how to improve the access of unstructured and scattered information for the non-specialist users, and how to provide adequate information to knowledge workers. Then, a case about KAAS, Eknoware platform, is developed based on the KAAS cloud architecture. The future work of us will design and describe the KAAS-Oriented Architecture with a uniform formulization description language based on the OWL, which can provide the consistency description of system and a mechanism of the semantic of knowledge service at runtime.

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References and Notes