# Service-Oriented Knowledge Acquisition Paradigm and Knowledge Cloud Platform

**Yuan Rao and Shumin Lu**

**Abstract** Cloud computing is an emerging new computing paradigm for delivering some computing services to consumers, which provides scalable and inexpensive service-oriented computing infrastructures with good quality of service levels. In this paper, based on the studies about the characteristic of knowledge service, a feature model of knowledge service is proposed with three features, such as service requirement, knowledge service process, and the quality of knowledge service (QoKS). Furthermore, the architecture about service-oriented knowledge acquisition is built to provide a fundamental for knowledge service, and the lifecycle process about knowledge service is studied under the service-oriented architecture. Then, a best practice about Knowledge Cloud, named Eknoware, is developed based on the architecture above-mentioned, which can provide some knowledge service patterns and reorganize the knowledge clusters to suitable customers.

**Keywords** Service-oriented knowledge acquisition · Knowledge as a service · Cloud computing · Eknoware · Knowledge cloud platform

## 1 Introduction

Cloud Computing is a model for enabling convenient, on-demand access to a shared pool of configurable computing resources (e.g., networks, servers, services, applications, and storage) that can deliver an open platform to integrate knowledge as a kind of cloud service in the next four-to-eight years [1]. Murray [2] thought

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that the knowledge as a service (KaaS) is becoming "the future of the future". Knowledge or semantic-based techniques and technologies combined with conventional IT are promoting a new "wave" to provide the understanding, insight, and experience of knowledge-related services and knowledge innovation products. All these actionable knowledge and services are produced by staff, customers, or suppliers in one enterprise and by cloud computing systems to form a knowledge sharing platform with more opportunities to discover and purchase the service or knowledge, which can be acquired directly from producers by search engine with relevant overwhelmed data [3], by social network with crowd-sourced answers [4] and by online consulting with domain knowledge experts [5]. Therefore, Knowledge service needs new approach from a common knowledge delivery to a personalization acquisition for end users. According to the characteristics of service with intangibility, heterogeneity, and inseparability, a public knowledge service mechanism and application platform are investigated to integrate professional knowledge acquisition process and knowledge service strategies together under cloud computing environment in the paper.

The rest of this paper is organized as follows: Sect. 3 presented an overview of service-oriented knowledge acquisition and related works. Section 3.1 researched on the features and existed problems about knowledge service and proposed a new mechanism of service-oriented knowledge acquisition based on cloud computing environment. Section 3.2 illustrated the architecture about knowledge service cloud platform with multi-element and analyzed the knowledge services invocation operations to "push" the relevant services together into the composited knowledge. Section 4 provided a case study, EKNOWARE platform with a new knowledge service, to illustrate the merits of service-oriented knowledge acquisition. Finally, the conclusion and future works is presented in Sect. 5.

## 2 Related Research Works

Recently, more and more researchers [6, 7] are focusing on the KaaS in cloud computing paradigm to forge a new thinking and powerful methodologies for service innovation and operational improvement. From the definition of knowledge [2], the four viewpoints, such as (1) personal perception (2) output acquired from information (3) organizational resources, and (4) combination of personal perception and output of information, also can build a knowledge management process comprised of knowledge creating, organizing, sharing, and using tacit and explicit knowledge. Wong [8] proposed a knowledge engineering to utilize the repository information and knowledge to inform the future decision and activities with four key activities, i.e., knowledge creation, knowledge mapping, knowledge retrieval, and knowledge use. Therefore, how to bind the viewpoints of knowledge and activities of knowledge engineering together to find a suitable knowledge acquisition mechanism for different users is very important. Moreover, the Intellectual Capital Index (ICI) model [9] is described by the Intellectual Capital

dimension tree and divided intellectual capital into human capital with the sub-elements of competence, attitude, and intellectual property, and structural capital with relationship capital, organizational capital, and the renewal and development value. Furthermore, Some companies, such as RightAnswers, Salesforce, CumulusIQ and NTT utilized these value model of knowledge and tools of knowledge service to manage and share enterprise knowledge capital and gain competitive advantage by extending human capital and enhancing the effectiveness of knowledge service strategies intra- or inter-enterprise. In general, the knowledge service strategies [10] can be divided into three aspects: knowledge management service, knowledge value-added flow and creative service, and socialized knowledge exchange and trade in cloud. In particulate, the service-oriented knowledge acquisition and knowledge cloud platform technology [11] will provide a challenge to resolve the semantic problems for automated knowledge service without much manual intervention, which can put knowledge into all the business process to win more value-added.

## 3 Service-Oriented Knowledge Acquisition Paradigms

### *3.1 Service and Knowledge Service Characteristics*

A service, as an intangible experience performed for a customer to pay the producer for a performance or promise of a performance, is composed of the service providers and service consumers, the service process, and physical fundamental environment. The different services may be selected and organized by different customer to satisfy their certain requirements. The Service Value should be balanced by the quality of process and the costs of acquiring the service. Therefore, a service can be illustrated as follow:

$$\Psi(\mathrm{s}) = (\Omega(\mathrm{person}) + \Phi(\mathrm{process}))^{p(t)} \tag{1}$$

where:

- $\Psi(\mathrm{s})$denotes a provided service, which can be managed and classified in various domains for satisfying the user's service requirement.
- $\Omega(\mathrm{person})$ denotes a limited set of persons, who is related to certain service in one organization, such as staff, customers, or suppliers and needs the service to consume or to create new service for consume. Therefore, all these persons can be divided into two kinds of roles: service provider and service consumer.
- "+" denotes a physical transfer channel. IT technique, today, including service management software system or knowledge service cloud, is becoming the more and more important mechanism for service acquisition and utilization, which can decrease the cost of service acquiring and knowledge clustering for different person's requirements over Internet.

– $\Phi$(process) denotes the process of service, which defines an operational flow of activities with a serial of standard steps in the process.
– $p(t)$ denotes the degree of service's performance with time. It means that the service is time-perishable and the performance of service will change with time and utilization method.

By this definition, we can understand the kernel value about service is to provide the best process to right person with the best satisfaction by suitable channel. The second one is to share and propagate the right knowledge service to certain persons who need it. But, in the era of knowledge economic and cloud computing, especially, knowledge service is focusing on the personalized requirements by suitable mobile devices and more applications, which not only changes the interactive relationship between person and service process, but blurs the border between service provider and service consumer. All users have the same responsibility for coproducing knowledge service, depending exclusively on help desk analysts, developers as an alternative to traditional consulting and systems integration engagements. Everyone is an owner to obtain the more relevant knowledge service combined with his personalized requirement and to share something with others, including contents, valuation, and recommendation. Therefore, knowledge service not only changes the process to satisfy personalization knowledge acquirement and to yield the best results for specially question, but also changes the knowledge sharing mechanism from passive reading to active creating by cloud pattern. A feature model of knowledge service is proposed as follow:

As a new paradigm of resource sharing under cloud computing environment, knowledge service also can be built from three different features in Fig. 1, such as knowledge service requirement, the quality of knowledge service, and the process of knowledge service. From the aspect of service requirement, knowledge service is a process driven by user's knowledge requirement, which aims to solve user's personalized question from simple keywords to semantic understanding under the business scenario. From the aspect of the service lifecycle, the knowledge service lifecycle should be supported from creation and mapping to retrieval from simple knowledge to aggregation knowledge, and end to combination service with complex knowledge under user's context environment. From the aspect of the quality of knowledge service (QoKS), the related personalization solution is provided by the filter of person's profile model and to satisfy the user's questions and requirements.

## *3.2 Service-Oriented Knowledge Acquisition Architecture*

Service-oriented knowledge acquisition is on demand, where approach needed to skill acquisition and knowledge reorganization, which decouples customization activities into helps, training, and solutions from monolithic project. The

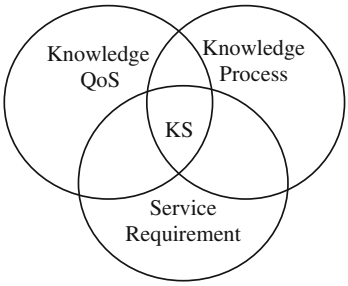


**Fig. 1** The feature model about knowledge service

knowledge service can be acquired on a browser, self-service, and socially-networked basis in the cloud. In general, the strategies about service-oriented knowledge acquisition can be divided into three aspects: knowledge resources, knowledge service objects management, the knowledge service roles in cloud environment. The definition about Services-Oriented Knowledge Acquisition Architecture can be represented by a three tuple:

$$\xi = (\Omega, \Sigma, \Pi) \tag{2}$$

where:

- $\Omega$ is a finite set of knowledge resource objects with $\Omega = \{r_i | 1 \leq i \leq n, r_i \notin \varphi\}$, which includes the vital information, knowledge and experts about program, and process resources of enterprise.
- $\Sigma$ is a finite set of knowledge service objects (e.g., knowledge service) with $\Sigma = \{s_j | 1 \leq j \leq m, s_j \notin \varphi\}$, which encapsulated the knowledge resources into knowledge service index and stored them into the knowledge service base (KS Base) for user's query and acquisition;
- $\Pi$ is a finite set of roles with $\Pi = \{p_f | 1 \leq f \leq k, p_f \notin \varphi\}$, which includes three kinds of role in traditional architecture, such as knowledge service provider (KSP), knowledge service broker center (KSBC), and knowledge service requester (KSR). Each role provides the different functions in whole architecture.

For instance, knowledge service provider, as a knowledge service creator, not only can provide standard service process and value-added trade methods for requester, but also publish the profile information about service and provider to KSBC over Internet. As a limited filtering condition, these profile information are very important for knowledge extracting and filtering. The knowledge service broker center (KSBC) as a catalog of knowledge services and knowledge reorganized center, which introduces a lightweight mechanism to discover the different categories of knowledge services in this architecture, such as content service, experts services and crowed-sources, service by search engine, instant message tools, and social network platform, respectively. All the knowledge services need to build a service index in KSI by Service Agent and can store all information into

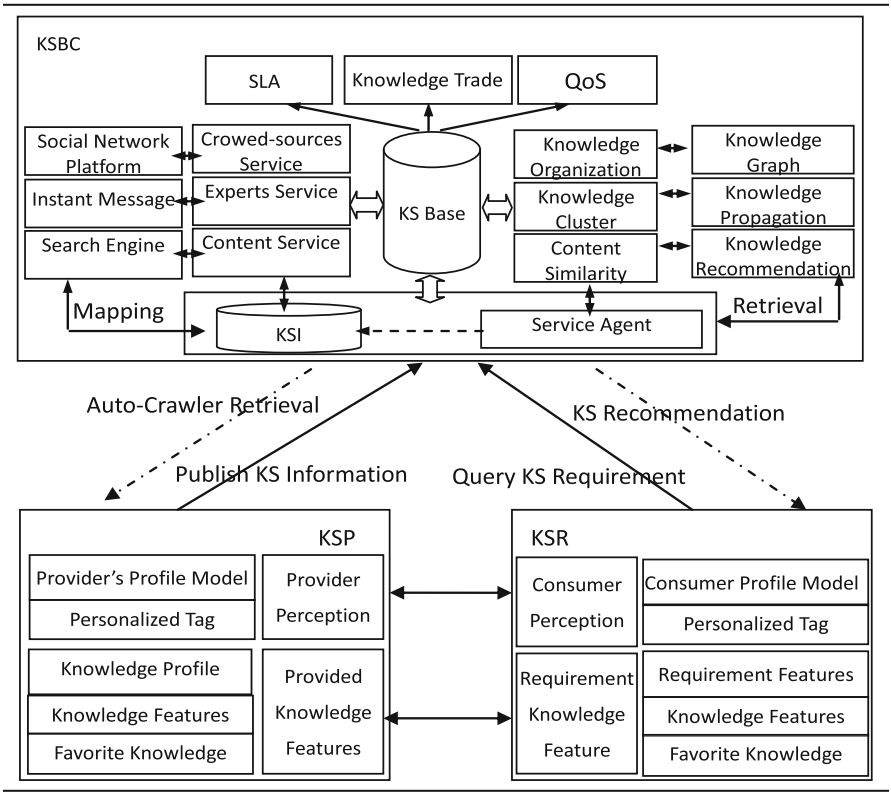


**Fig. 2** The architecture of service-oriented knowledge acquisition

the Knowledge Service Base for query and acquisition. The knowledge service requester (KSR), as knowledge service customer, can acquire the knowledge services filter by the personalization requirements and design specifications.

Based on the definition above-mentioned, the architecture of service-oriented knowledge acquisition is illustrated as Fig. 2. On the one hand, the person in KSR client can query the knowledge service by catalog of service in KSBC to satisfy his personalization requirement in this mechanism. On the other hand, KSBC also can acquire the information of consumer perception and the knowledge requirement features, and then can analyze and organize these relative knowledge services together, and end to recommend some knowledge service package, such as a knowledge graph or knowledge clustering, back to user automatically. Meanwhile, the providers (KSP) have two mechanisms to publish new knowledge service information into KSBC, one is to publish the information about provider's profile model and service features information into KSBC and build a Knowledge service Index, and another is to retrieve the knowledge service by auto-crawler in KSBC to acquire suitable service information automatically.

# 4 The Case Study About Knowledge Cloud Platform

## *4.1 The Process of Service-Oriented Knowledge Cloud*

KaaS, as a service-oriented knowledge cloud platform, can provide the best reorganized knowledge, in the best context, at the best time, with the best experts, in best service mechanism, as needed to satisfy different user's personalization requirement with a standard service process. Moreover, KaaS needs to leverage the cloud to access and make available all sorts of knowledge, provided by knowledge service provider and stored in KS Base, from static repositories to more interesting collective knowledge and to real-time customer contribution. Therefore, based on the architecture of service-oriented knowledge acquisition, the detailed lifecycle of knowledge service acquisition with some main steps should be analyzed from KSBC perspective in this section and shown in Fig. 3.

The first step is to publish the knowledge service and KSP's profile information. The knowledge service or knowledge content and some subsidiary information about KSP, such as profile model and service publish specification, should be published together into KS Resources Bases (KSRB) for increasing the accurate of knowledge filtering and clustering in the KSBC.

The second step is to reorganize and cluster the knowledge and services in KSBC. The service engine, composed by knowledge aggregation engine, service context engine, and profile analysis engine, can retrieve the knowledge service feature and store these service brief index information into Knowledge Directory, which is the global catalog of knowledge service information.

The third step is to map and utilize the knowledge service. When users utilize the KSR Client to access the KaaS Cloud, the requirement and some profile information of KSR should be published into KS Resources Bases firstly. Then, the Knowledge Directory is utilized by KSRs to search and query what knowledge services they want. Meantime, the service engine is used to analyze and aggregate the related knowledge services limited by service QoS and SLA, which can satisfy to the KSR's requirement and can push some valuable knowledge to KSR clients automatically.

## *4.2 The Case Study of Service-Oriented Knowledge Cloud Platform*

Based on the architecture and the lifecycle of service-oriented knowledge acquisition, this paper provides a knowledge cloud platform, named Eknoware (http://eknoware.com, as shown in Fig. 4), to various knowledge consumers and providers, such as personal users and some enterprise or organization users, by social networks for promoting the knowledge propagation and consumption. EKNOWARE

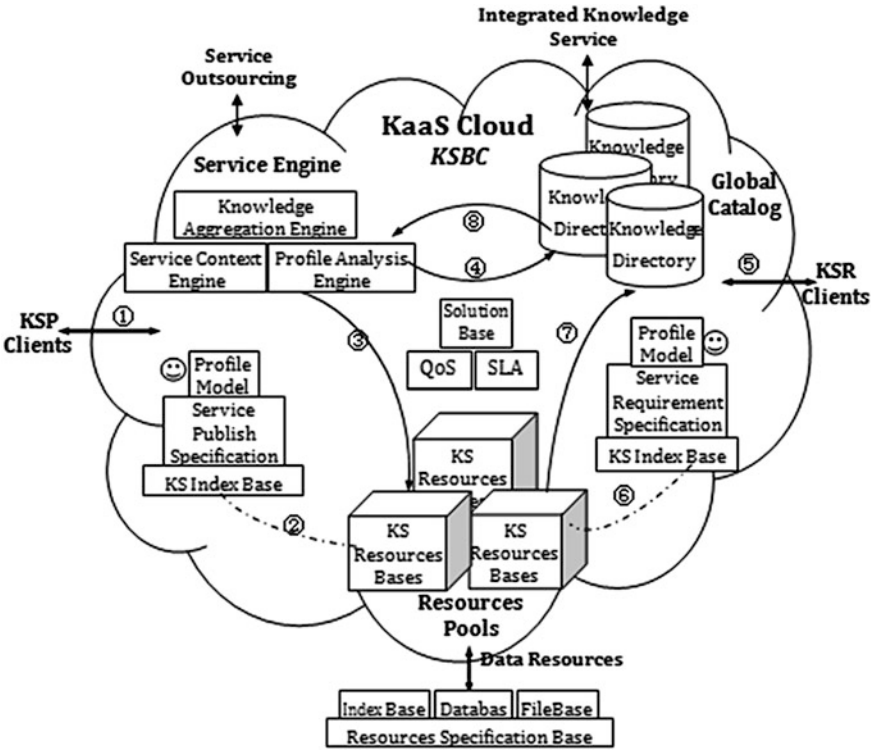


**Fig. 3** The lifecycle and key process of service-oriented knowledge acquisition cloud

platform provides some basic functions for knowledge sharing and learning, such as expert portal, KS activity, KS project management, online questions and answers, discussions forums, and instant messages to communicate with multi-users to construct an online knowledge community. Knowledge Service Resources Base, as a fundamental service, can store and provide various relative knowledge resources for the knowledge engine to classify and aggregate together. A knowledge service dashboard is utilized to select the suitable service functions to provide the best knowledge content to KSR. In addition, in order to reuse these knowledge resources, the Eknoware platform also can provide an OPEN API by Oauth 2.0 to third parts application, which not only can exchange knowledge between different users in inner platform, but also share some knowledge services to different knowledge groups in third part's applications. Some core functions about Eknoware can be illustrated in Fig. 4 with more detailed information.

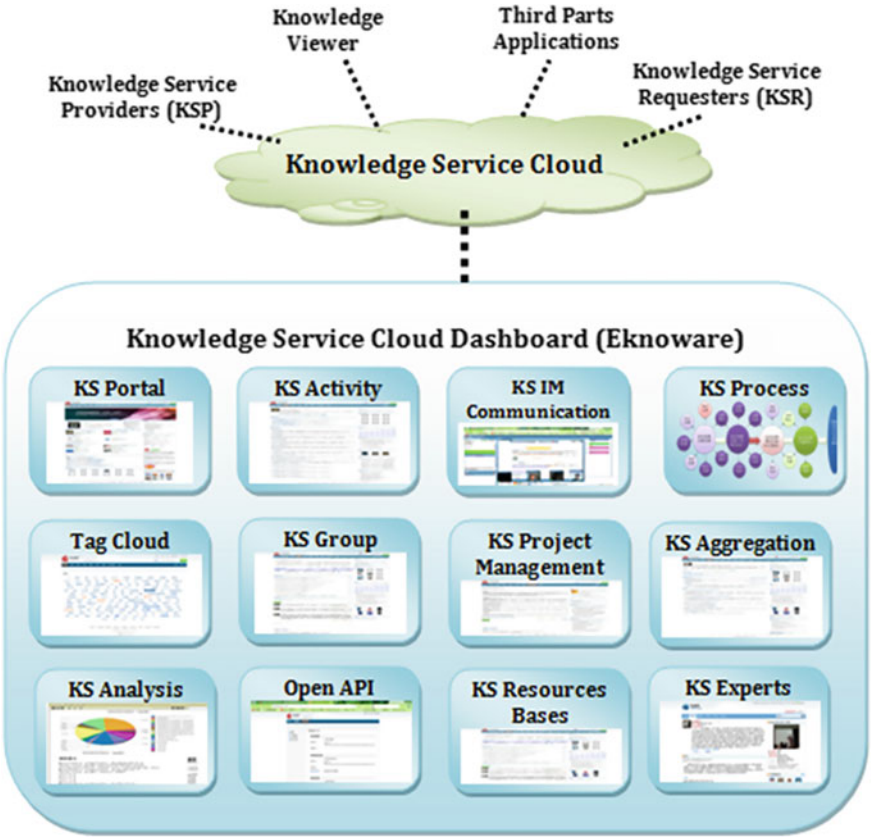


**Fig. 4** Eknoware: the practice platform of service-oriented knowledge acquisition cloud

## 5 Conclusions and Future Work

In cloud environment, the purpose of knowledge service, however, is to reuse knowledge resources and create a new value-added service method with more efficiency. Firstly, the characteristic of knowledge service is studied and the three features, such as service requirement, knowledge service process, and the quality of knowledge service, is analyzed in this paper. Then, a feature model of knowledge service is proposed as an infrastructure for further research. Secondly, the architecture about service-oriented knowledge acquisition is built to provide a fundamental of knowledge service, and the lifecycle process about knowledge service is studied under the service-oriented architecture to promote the implementation of knowledge service. In the end, a best practice about Knowledge Acquisition Cloud, named Eknoware platform, is developed based on the architecture above-mentioned, which can provide some knowledge service patterns and push the best knowledge to suitable customers.

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