MaaS: Model as a Service in Cloud Computing and Cyber-I Space

Guobing Zou[1], Bofeng Zhang[1], Jianxing Zheng[1], Yinsheng Li[2], Jianhua Ma[3]

[1]School of Computer Engineering and Science, Shanghai University, China
[2]Software School, Fudan University, China
[3]Faculty of Computer and Information Sciences, Hosei University, Japan
guobingzou@gmail.com, bfzhang@shu.edu.cn

***Abstract*—In recent years, there has been an increasing interest in user modeling, because of its extremely wide usage in real-world applications, such as recommendation systems and personalized services. However, a large number of researchers have been devoted to focusing on developing a user model that can only facilitate their own applications, which has limited the rapid advances in user modeling research, so that ubiquitous modeling theory and its applications have become an emerging and open issue to solve. To handle this challenging task, this paper investigates the existing user modeling techniques and potentially applicable areas, including cloud computing and Cyber-Individual (Cyber-I), which are on the way of gradually evolving as important computing paradigms. This paper first proposes a novel user modeling conception and profile from Service-Oriented Architecture (SOA) point of view, called Model as a Service (MaaS). Then, based on the widely used three-layer abstraction of cloud computing, a new MaaS-based four-layer new architecture of cloud computing is proposed, allowing users and model developers to participate in cloud activities for the purpose of supporting personalized services. Finally, a novel MaaS-based Cyber-I framework is proposed on the basis of the architecture of Cyber-I oriented platform, where user modeling and MaaS-related operations center on the functionalities, providing the services of creation, evolution and retrieval in Cyber-I space.**

Keywords- model; Model as a Service (MaaS); cloud computing; Cyber-I; Web services;

I. INTRODUCTION

Nowadays, many researchers and engineers have paid more and more attention to user modeling techniques and its applications, such as from e-commerce to e-learning, from housing rent service to search engine, even from tourism and cultural heritage to digital libraries. It is obvious that in order to provide effective recommendation information access on the Internet with large-scale unstructured data, or any kind of personalized services, user model has undoubtedly become a mandatory component and played an important role in these activities. The user model typically involves a user's basic information and also distinguished characteristics from other users, including the user properties of interests, preferences, behaviors, knowledge, goals and other facts that are deemed relevant for provisioning personalized services [1].

Like other knowledge-based approaches, the process of user modeling is concerned with three closely related stages: acquisition, representation and evolution [2]. User modeling acquisition as the first step, many existing recommendation systems have provided personalized behavior history for the extraction of user interests. By monitoring and analyzing user behaviors on the Web, such as copying, saving, printing, and relative browsing time [3], user interests can be extracted based on interest items' weights. The interests extracted from user behavior history approximate users' real preferences [3]. As to the user modeling representation and evolution, many semantic Web combined with psychologically evolutionary algorithms have been taken into account in these two phases. For example, after investigating the existing user modeling methods that only consider the importance of the concepts independently for capturing user's interests, [2] presented an ontological user model for representing all of the semantic relationships among interest concepts. Furthermore, a SAM (Spreading Activation Model) based evolution algorithm is proposed in [2] based on behavioral psychology for adapting to the dynamic changes of user interests. Another interesting work on the evolution of user modeling [4] benefits from the idea of forgetting and reenergizing mechanism of memory in psychology. As a result, it presented an evolution algorithm, called Forgetting and Reenergizing User Preference (FRUP), which overcomes the drawback of dynamic adaption to the user model evolution, thus it can automatically update user models and adapt to the drift of preferences over time.

For the applications of user modeling, the work in [5] concentrates on the application of open user models that allows users to view and edit their interest profiles in the developed YourNews personalized recommendation system. This modeling strategy makes users transparently guide their moves, anticipate results from the system, and control the system by their interactive access process. Without any exception, the YourNews monitors and records a user's news reading behavior history, constructs a corresponding user model representing user interests, and applies this model to recommend the most relevant news articles for the user. User modeling has also been applied to text information filtering system [6]. For example, using user ontology model (UOM) [2, 6], a text filtering system for Chinese text documents has been proposed to denote a user's specific requirements as well as the representation of a text document in the context of semantic relationship. This work avoids the support from plentiful rules and domain knowledge. Moreover, automatic user model identification in [7] has been proposed to mine user interests and apply in personalized search systems.

Although many works have been done on user modeling and its applications, most of the existing research still mainly concentrates on how to develop a user model for a specific

978-0-7695-4858-6/12 $26.00 © 2012 IEEE
DOI 10.1109/CIT.2012.228

application, rather than for a ubiquitous user model to guide the designing and development of recommendation systems. Therefore, it restricts the rapid advances in user modeling research due to lack of the support of ubiquitous modeling theory. To solve this open issue, based on the observations of existing user modeling methods and their applications in personalized services, this paper firstly proposes a new user modeling conception from the Service-Oriented Architecture (SOA) point of view, called Model as a Service (MaaS). Then, along with the cloud computing and Cyber-I oriented platform evolving as two important computing paradigms, a novel four-layer architecture of cloud computing is proposed, by integrating MaaS as an independent service layer into the existing three-layer abstraction of cloud computing. Finally, this paper proposes a novel MaaS-based Cyber-I platform framework based on the Cyber-I oriented platform, where user modeling and advanced MaaS operations dominate the functionalities of the platform, such as the Cyber-Is services of creation, evolution and retrieval in Cyber space.

The rest of the paper is structured as follows. Section 2 reviews cloud computing and Cyber-I space. In Section 3, a novel ubiquitous profile MaaS and its basic components are presented. Section 4 proposes a new four-layer MaaS-based abstraction of cloud computing. A novel MaaS-based Cyber-I oriented platform in Cyber-I space is proposed in Section 5. Section 6 concludes the paper and discusses the future work.

II. CLOUD COMPUTING AND CYBER-I SPACE

Since this work is related to two applicable areas: cloud computing and Cyber-I platform. Here provides an overview of cloud computing and Cyber-I space.

A. *Cloud Computing and its Applications*

With the emergence of representative cloud computing platforms, cloud computing is gradually evolving as a widely used computing paradigm, where dynamically scalable and virtualized resources are provided as services on the Internet. Cloud computing is well defined in [8], where it refers to both the applications delivered as services on the Web and the hardware and system software in large-scale data centers. Compared to other high performance computing paradigm, such as grid computing and sky computing, users can benefit many advantages from cloud computing, such as pay as you go, scalability, efficiency and flexibility.

The widely used abstraction of cloud computing [9] has three layers of cloud services, including Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). These layers are provided by cloud vendors to offer a variety of delivered services for external users.

Cloud computing techniques and system platforms have been applied both in industry and in academic community, including information retrieval, utility provision services, e-commerce and scientific computing. In industry, the leading cloud computing systems contain Google File System (GFS), Windows Azure [10], and Amazon EC2 [11], Amazon S3 [12], and SalesForce [13]. In academia, North Carolina State University designed and implemented a Virtual Computing Laboratory [14], where a variety of of virtualized resources (computational, storage and software resources) are provided by the implementation of a secure production-level utility computing and SOA technology. Those deployed resources are controlled by one or more management nodes that can be either resided in the same cloud or across different clouds. Based on virtualization and SOA, a Cloud Computing Open Architecture (CCOA) [15] has been proposed to facilitate the design and implementation of cloud computing systems.

Although many cloud computing architectures have been proposed and several leading cloud computing platforms have been implemented for use in industrial applications and scientific computing, it is still a challenging task to provide personalized services, because most current cloud computing platforms do not take user model into account. It provides an opportunity to investigate recommendation systems in cloud computing by user modeling techniques.

B. *Cyber-I Space*

With the advent of digital spaces, cyber world has been brought out and it is regarded as another universe to human beings. The physical world and this emerging cyber world are being gradually integrated and merged to form a new space, which is called as the hyper world [16]. Conceptually, a Cyber-Individual (Cyber-I) can be described as a digital counterpart in the cyber world, where each one corresponds to a Real-Individual (Real-I) human in the physical world. All of the Cyber-Is gather together to form a Cyber-I space. In the hyper world, a Real-I is different from other ones in the physical world, by a special Cyber-I in the Cyber-I space, which utilizes multiple factors to represent its corresponding digital descriptions, such as the ways of thinking, emotions, personality, and behaviors.

From the conceptual aspect, a Cyber-I is composed of a three-layer structure, i.e., CI-Mind, CI-Pivot, and CI-Spine, around which many CI-Applications are resided, illustrated in Figure 1 in [16]. As the core of Cyber-I, CI-Mind plays an important role as "brain" in the context of Cyber-I.

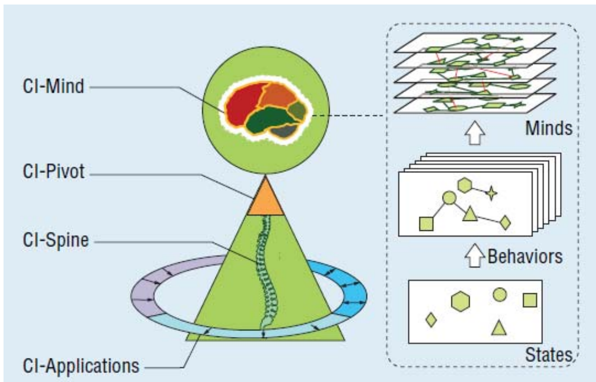

Figure 1. Cyber-I layers and levels. CI-Applications surround the CI-Mind, CI-Pivot, and CI-Spine.

Although Cyber-I is a comprehensive digital description of its Real-I and can be applied to recommendation systems for personalized services, Cyber-I is still far beyond a user model to assist a user. To achieve as accurately as possible, this paper aims at representing the content of a Cyber-I by a ubiquitous user model profile, called the Model as a Service

(MaaS), which can be seamlessly integrated it into Cyber-I platform to approximate the characteristics of Cyber-Is and simulate its evolution from birth, growth, until to death.

III. Model as a Service

In Service-Oriented Architecture (SOA), Web services have been highly recognized as the basic components to dynamically build distributed applications, many individuals and organizations prefer to only keep principal business, but outsource and package other functionalities as services over the Internet. An observation has been drawn that to provide personalized services, a ubiquitous user model profile can be identified as an independent service layer in recommendation systems, called Model as a Service (MaaS). The proposed ubiquitous MaaS profile is illustrated in Figure 2.

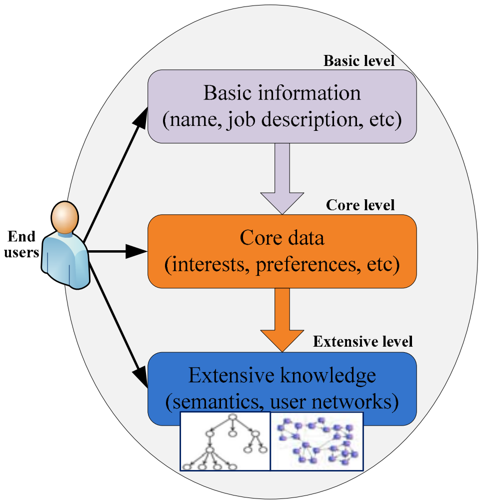

Figure 2. The proposed ubiquitous Model as a Service (MaaS) profile.

Formally, a MaaS profile can be described as a 3-tuple, $MaaS=(B, C, E)$. The top basic level $B=\{b_1, b_2, ...\}$covers a user's identification information, where each element b_i in B represents a basic information such as user name, profession, age, etc. In the middle core level, $C=\{c_1, c_2, ...\}$includes core data of a user, where each element c_i in C depicts one of the vital user features, such as user interests, preferences, goals, etc. By extending middle level, the bottom extensive level $E=\{e_1, e_2, ...\}$ consists of rich knowledge about a user's characteristics, including the semantics of user interests and preferences by semantic relationships analysis and reasoning, as well as model networks by community analysis.

Given a ubiquitous MaaS profile $MaaS=(B, C, E)$, it can be packaged as an independent service layer, which plays an important role and can be easily plugged in cloud computing environment and Cyber-I oriented platform in the subsequent two Sections.

IV. Model as a Service in Cloud Computing

By an observation on a widely used abstraction of cloud computing [9] with three layers, including Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS), this paper argues that in order to provide personalized services, a ubiquitous model plays an equally important role as the other three cloud service layers perform in cloud computing. Thus, it deserves an independent layer, when cloud computing as a large-scale distributed computing paradigm offers a pool of virtualized, dynamically-scalable computing, storage, and platform services on demand.

After the introduction of three-layer abstraction of cloud computing, a MaaS-based four-layer architecture of cloud computing is proposed, where MaaS service layer is located in the position between SaaS and PaaS.

A. Three-Layer Abstraction of Cloud Computing

From the perspective of service layer view, an abstraction of cloud computing can be classified into three layers (IaaS, PaaS and SaaS) [9], which corresponds to three kinds of user roles, including Vendors, Developers and End users. Figure 3 illustrates the widely accepted three-layer abstraction of cloud computing [9].

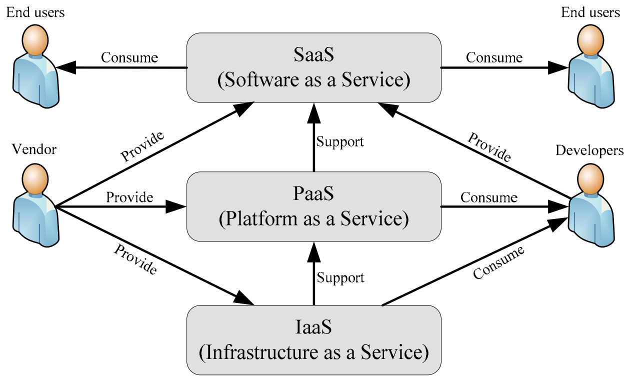

Figure 3. The abstraction of cloud computing with three user roles and three cloud service layers.

In the Infrastructure as a Service (IaaS) layer, different cloud vendors provide developers with a collection of inter-connected and virtualized computers that are dynamically provisioned and delivered as one or more unified computing resources. For example, Nimbus, Amazon EC2, Amazon S3 and Salesforce are IaaS instances for provisioning computing and storage services, which are shown in Figure 4. Since this layer is located at the bottom level, it provides computing power services and large-scale data storage centers based on virtualization technology and Service-Oriented Architecture (SOA). Developers utilize this layer for their deployment of applications and take responsibility to keep sustainable and secure running of virtual machines for end users.

In the Platform as a Service (PaaS) layer, cloud vendors provide application development environments for use, such as Google App Engine and Windows Azure, as shown in Figure 4. This layer abstracts machine instances and other technical details from developers. As a result, the developers only need to concentrate on designing and implementation of those core function modules of their applications, instead of those matters of resources allocation. However, In order to exchange for these benefits, the developers have to handle special constraints that the environment has imposed on their application design [9], e.g., the use of key-value stores.

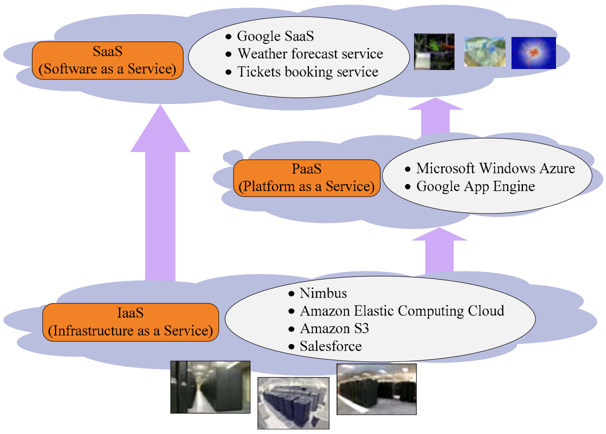

Figure 4. Applications and instances of each cloud service layer (IaaS, PaaS and SaaS) in the three-layer abstraction of cloud computing.

In the Software as a Service (SaaS) layer, developers provide off-the-shelf software applications and instances by their design, deployment and implementation. For example, Google has exploited many SaaS applications for end users to offer different Web-based cloud services, such as Google docs for communication and collaboration, Google earth for directing locations, etc. Many other applications at this layer, such as weather forecast and train tickets booking services, are also shown in Figure 4. This layer provides applications with well-defined interfaces and services for end users.

B. MaaS-based Cloud Computing Architecture

From the abstraction of cloud computing as illustrated in Figure 3, the deficiency can be observed that no matter what kind of end users consume a cloud application, a delivered service is always provisioned to consumers in the same way, after they submit the same request to the application. In other words, if two end users are consuming a cloud application, to which they submit the same request, they would receive the results without any differences.

For the complete functionality of personalized services in cloud applications, a ubiquitous user model component need to be plugged into the existing cloud computing framework. To this end, a new MaaS layer between the SaaS and PaaS is integrated into the abstraction in Figure 3. Figure 5 illustrates the new four-layer cloud computing architecture. In this new layer, model developers are responsible for the creation and management of MaaS, which provides user model for SaaS.

In the Model as a Service (MaaS) layer, the model providers develop ubiquitous MaaS templates for end users, who initiate those MaaS templates and dynamically evolve from initial MaaS instances. In addition, the model providers also analyze user interests and preferences by recoding their behavior actions. By using this, although different end users submit the same request to a cloud application, which returns personalized information based on the user interests or model networks involved in their MaaS instances. However, the design of a ubiquitous MaaS profile and making it plugged into different SaaS applications are still challenging tasks.

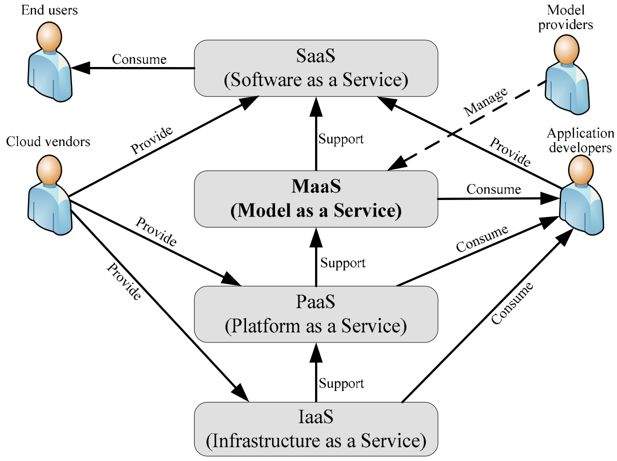

Figure 5. The proposed MaaS-based architecture of cloud computing with four layers (IaaS, PaaS, MaaS and SaaS) and four user roles (Cloud vendors, Model providers, Application developers and End users).

V. MODEL AS A SERVICE IN CYBER-I PLATFORM

Although Cyber-I is beyond a ubiquitous MaaS profile to assist a user, it can still be applied at present to represent a comprehensive digital description of a Cyber-I.

A. Cyber-I Oriented Platform

Based on the group's previous work [16, 17], an overall MaaS-based structure of Cyber-I oriented platform is shown in Figure 6, which consists of five core components: Cyber-Is, MaaS, system applications, third-party applications, and networks and devices.

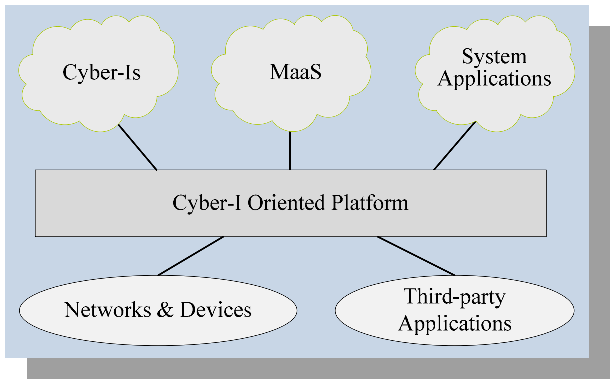

Figure 6. The proposed MaaS-based Cyber-I Oriented Platform

In Figure 6, these five components cooperate to aim at providing personalized services for Cyber-Is. The networks and devices provide essential hardware infrastructure for the other components. A Cyber-I denotes a Real-I whose profile is described by a MaaS instance. The system applications are those CI-applications resided in the Cyber-I platform, and they rely on MaaS instances to offer personalized services. On the contrary, third-party applications are those external CI-applications outside of the platform, but they still need to employ MaaS instances for personalized services.

B. MaaS-based Cyber-I Oriented Platform

In this section, an implementation of MaaS-based Cyber-I oriented platform is proposed and illustrated in Figure 7. It consists of seven layers: Cyber-I infrastructure layer, Cyber-I MaaS layer, Cyber-I MaaS operations layer, Cyber-I system applications layer, Cyber-I third-party applications layer, Cyber-I management layer, and Cyber-I user layer.

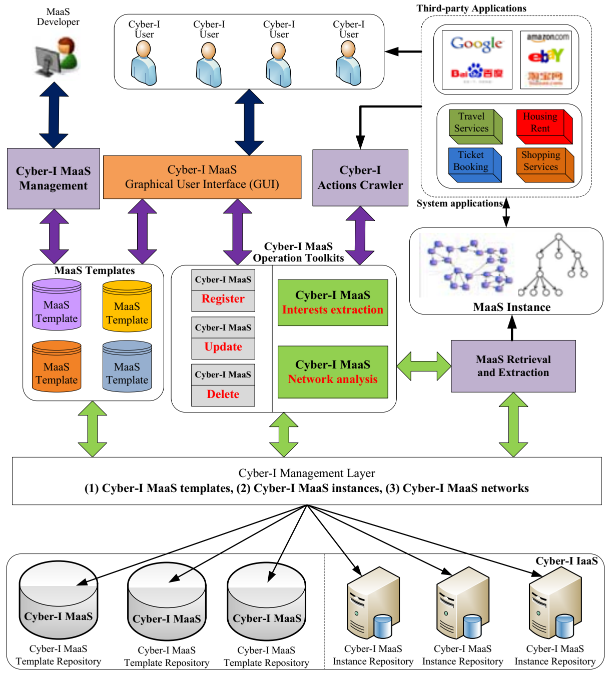

Figure 7. The MaaS-based Cyber-I oriented platform (MaaS-CIP).

- Cyber-I Infrastructure as a Service (IaaS) Layer

The Cyber-I IaaS layer provides hardware utilities and network environment for the sustainable platform running. The Cyber-I infrastructure can be either established by an existing high performance server, or formed by a large-scale data center in a cloud computing system, such as Google File System, Windows Azure, and Amazon EC2 and S3.

Three kinds of structured data are stored and organized in this layer. First, all of the system applications are deployed and resided in the platform. Second, all of the MaaS profile templates designed by MaaS developers are stored in this layer. The third kind of data in this layer are those MaaS instances that correspond to Cyber-I terminal users.

- Cyber-I Model as a Service (MaaS) Layer

In this layer, Cyber-I MaaS developers create ubiquitous MaaS profile templates for the initiation of a new Cyber-I terminal users. On the one hand, Cyber-I terminal users can choose a MaaS profile template from those available samples to initiate their corresponding Cyber-I MaaS instances. On the other hand, the new registered MaaS instances can be dynamically changed and updated, along with the adaption to the needs of those terminal users.

Associated with this layer, a Cyber-I MaaS management component is offered for MaaS developers to maintain their developed MaaS templates, or add new MaaS templates into Cyber-I platform. For the consumption of the available MaaS templates, terminal users are provided with a MaaS GUI to visualize MaaS templates and make a choice.

- Cyber-I MaaS Operations Layer

When terminal users and MaaS developers get involved in Cyber-I oriented platform, this layer offers two kinds of MaaS-related core operations: basic operations and advanced operations. The basic MaaS operations include:

a) Cyber-I MaaS registration

b) Cyber-I MaaS update

c) Cyber-I MaaS deletion

The MaaS registration operation initiates a new created MaaS instance, which corresponds to the birth of a Cyber-I. The Maas update operation changes a MaaS instance for its terminal user, which reflects evolution process of a Cyber-I. The MaaS deletion operation implies the death of a terminal user dies and leaves from the cyber-I space.

For advanced operation functionalities used by the MaaS developers, they are composed of the operations:

a) Cyber-I MaaS interests extraction

b) Cyber-I MaaS network analysis

c) Cyber-I MaaS instance retrieval

The MaaS interests extraction aims to mine user interests and preferences from behavior history of a Cyber-I, collected by Cyber-I actions crawler. The goal of the MaaS network analysis is to find MaaS instances with similar interests by clustering algorithms for personalized services. The MaaS instance retrieval offers system and third-party applications with MaaS instances, when CI-applications submit a MaaS instance request to the Cyber-I platform. The MaaS instances are retrieved by their identification number, which uniquely corresponds to Cyber-I terminal users.

- Cyber-I System Applications Layer

In this layer, Cyber-I system application developers make programming and deploy their applications in the Cyber-I platform, such as travel services, housing rent services, and ticket booking services. The system applications are resided and organized in the Cyber-I IaaS layer. When these system applications are open to Cyber-I terminal users, they require the support of MaaS instances for personalized services. The Cyber-I MaaS layer and MaaS operations layer offer MaaS instances for CI-applications as requested.

Accordingly, an application management component is also provided to allow application developers to deploy and manage their CI-applications in the platform.

- Cyber-I Third-party Applications Layer

Like the system applications layer, all of the third-party applications (e.g., Google, Baidu and Amazon) need to have MaaS instances for personalized services. However, the only difference from the system applications layer is that all of the applications in this layer are external to the Cyber-I platform, rather than resided in the Cyber-I IaaS.

- Cyber-I Management Layer

This layer contains six Cyber-I management components for management and maintenance on the Cyber-I platform. They consist of the management components:

a) Cyber-I MaaS management component

b) Cyber-I scheduling management component

c) Cyber-I security management component

d) Cyber-I backup management component

e) Cyber-I application management component

f) Cyber-I third- party management component

The MaaS management component is designed for those Cyber-I MaaS developers to maintain MaaS templates. The scheduling, security and backup management components are operated together by system managers to ensure correct acquisition of the CI-applications, invoke CI-applications in a secure mode, and store multiple copies of a CI-application in case of its failure at run time. The last two management components are taken by system application developers and third-party developers to manage system applications in the Cyber-I platform and outside third-party applications.

- Cyber-I User Layer

In terms of service provision and consumption, users can be categorized as five roles in the Cyber-I platform.

a) Cyber-I terminal users

b) Cyber-I MaaS developers

c) Cyber-I system application developers

d) Cyber-I third-party application developers

e) Cyber-I system managers

They directly acquire services from the Cyber-I platform (terminal users), help the Cyber-I platform create, manage and operate MaaS instances (MaaS developers), deploy their own applications in the Cyber-I platform (system application developers), use MaaS instances in the Cyber-I platform for their applications (third-party application developers), and sustain running of the Cyber-I platform (system managers).

Typically, these five roles can often be overlapped by an independent Real-I. For example, a user may be responsible for MaaS development, as well as system maintenance.

VI. Conclusions and Future Work

For effective recommendation systems and personalized services, user modeling has been recognized as an essential technique in accessing, retrieving and storing information. In this paper, from the SOA point of view, a new conception, called Model as a Service (MaaS) is firstly proposed. Then, the basic profile of MaaS is elaborated, which can be well integrated into emerging computing paradigms to provision individual interests and preferences. Finally, by using the given MaaS, a novel MaaS-based four-layer abstraction of cloud computing architecture, and a new MaaS-based Cyber-I oriented platform are proposed, respectively.

This work mainly focuses on designing two MaaS-based frameworks in cloud computing and Cyber-I platform. As to the future work, it includes refining MaaS, implementing the proposed frameworks, and validating the effectiveness of the MaaS-based personalized recommendation systems.

Acknowledgment

This work was partially supported by a Shanghai Leading Academic Discipline Project with grant No. J50103 and an Innovation Program of Shanghai Municipal Education Commission with grant No.11ZZ85.

References

[1] F. Carmagnola, F. Cena, and C. Gena, "User model interoperability: a survey," User Modeling and User-Adapted Interaction, vol. 21, no. 3, pp. 285–331, 2011.

[2] J. Pan, B. Zhang, and G. Wu, "A SAM-based evolution model of ontological user model," in Proceedings of the IEEE/ACIS International Conference on Computer and Information Science (ICIS), 2009.

[3] K. Xing, B. Zhang, B. Zhou, and Y. Liu, "Behavior based user interests extraction algorithm," in Proceedings of the IEEE International Conferences on Internet of Things, and Cyber, Physical and Social Computing (iThings/CPSCom), 2011.

[4] B. Zhou, B. Zhang, Y. Liu, and K. Xing, "User model evolution algorithm: forgetting and reenergizing user preference," in Proceedings of the IEEE International Conferences on Internet of Things, and Cyber, Physical and Social Computing (iThings/CPSCom), 2011.

[5] J. Ahn, P. Brusilovsky, J. Grady et al., "Open user profiles for adaptive news systems: help or harm?" in Proceedings of the InternationalConference on World Wide Web (WWW), 2007.

[6] B. Zhang, J. Pan, J. Hu et al., "A case study on Chinese text information filtering method based on user ontology model," in Proceedings of the International Conference for Young Computer Scientist (ICYCS), 2008.

[7] F. Qiu and J. Cho, "Automatic identification of user interest for personalized search," in Proceedings of the International Conference on World Wide Web (WWW), 2006.

[8] M. Armbrust, A. Fox, R. Griffith et al., "A view of cloud computing," Communications of the ACM, vol. 53, no. 4, pp. 50–58, 2010.

[9] A. Marinos and G. Briscoe, "Community cloud computing," in Proceedings of the International Conference on Cloud Computing (CloudCom), 2009.

[10] Windows Azure Platform. Windows Azure cloud service computing platform: http://www.microsoft.com/windowsazure/

[11] Amazon EC2. Amazon Elastic Cloud Computing Platform (EC2): http://aws.amazon.com/ec2/

[12] Amazon S3. Amazon Simple Storage Service cloud computing platform: http://aws.amazon.com/s3/

[13] SalesForce Platform. SalesForce cloud service computing platform (SalesForce): www.salesforce.com/

[14] M. Vouk, "Cloud computing–issues, research and implementations," Journal of Computing and Information Technology, vol. 16, no. 4, pp. 235–246, 2008.

[15] L. Zhang and Q. Zhou, "CCOA: Cloud computing open architecture," in Proceedings of the IEEE International Conference on Web Services (ICWS), 2009.

[16] J. Ma, J. Wen, R. Huang, and B. Huang, "Cyber-Individual meets brain informatics," IEEE Intelligent Systems, vol. 26, no. 5, pp. 30–37, 2011.

[17] J. Wen, K. Ming, F. Wang, B. Huang, and J. Ma, "Cyber-I: Vision of the individual's counterpart on Cyberspace," in Proceedings of the 8th IEEE International Conference on Dependable, Autonomic and Secure Computing (DASC), 2009.