Ontology-Based e-Learning System for Personalized Learning

Bert Chen, Chen-Yu Lee, and I-Chang Tsai

***Abstract*—Ontology has recently gained popularity in building knowledge base because the description, localization and effective reuse of software patterns and systems of patterns can be approached through an ontology-based formalism. This paper designs ontology in the mobile phone domain for the construction of knowledge base, and presents a new method for knowledge assessment in which quizzing questions are drawn using the mobile phone ontology-based knowledge base to assess the sufficiency of professional knowledge of mobile phone salespersons. An automated learning service is then provided to offer users personalized learning contents subject to their knowledge deficiencies.**

***Index Terms*—Ontology, knowledge base, knowledge assessment, e-learning.**

I. Introduction

Today is the age of wireless communication which gives rise to mobile phones [1]. With the advent of new technology, mobile phones have become essential for modern living and have revolutionized the way people communicate, relate and do business [2]. The advancements in business connectivity, social connectivity and personal development mobile phones can offer have contributed to the growing demands and the vast diversity of products in the mobile phone market in recent years [3]. With the rapid development of mobile phones, consumers have to deal with an immense amount of information when selecting the most suitable mobile phone to meet their personal needs. On the other hand, mobile phone salespersons have to learn all the knowledge in regards to the mobile phones they are selling in order to respond to consumer queries. Hence, the level of professional knowledge possessed by mobile phone salespersons is critical in determining the quality of service provided to consumers.

Recently, ontology has had its applications in knowledge representation and modeling, especially in the area of e-learning [4]. There are research works and solutions related to ontology usage for modeling of personalization in an e-learning environment: for modeling of student profile in support of course structure design, for monitoring and evaluating of student behavior [5], and for describing the knowledge about student learning styles, performance and data in the context of personalization in an e-learning system [6].

This paper designs ontology in the mobile phone domain for the construction of knowledge base, and provides a knowledge assessment scheme in the form of an ontology-based quizzing module to measure the level of professional knowledge possessed by mobile phone salespersons. Through the construction of mobile phone ontology-based knowledge base, the information is organized systematically such that knowledge is both sharable and reusable. Then a knowledge assessment scheme in which questions and answers are generated using the mobile phone ontology-based knowledge base is devised to evaluate the level of proficiency of salespersons in regards to knowledge of mobile phones. Finally, an automated learning service is provided to offer users personalized learning contents subject to their knowledge deficiencies.

The rest of the paper is organized as follows. Section 2 describes the mobile phone ontology for the construction of the knowledge base. Following a knowledge assessment scheme that assesses the knowledge level of mobile phone salespersons, Section 3 presents an automated learning service to treat user knowledge deviations via personalized learning contents. Finally, Section 4 gives a conclusion, and outlook of future work.

II. Mobile Phone Ontology

Ontologies are knowledge representation structures particularly useful for the specification of high-level reusable software abstractions [7]. They provide an unambiguous terminology that can be shared and reused by all involved in a development process [8].

An ontology is an explicit specification of objects, concepts and entities of an area of interest, besides relationships between these concept expressed through axioms [9]. On the one hand, the specification is formal which can be processed by a computer system. On the other hand, the specification is explicit in which concepts and constraints are previously and explicitly defined. Furthermore, the specification is sharable that relates to a consensual knowledge accepted by a group and used by more than one individual [10].

For the purpose of our research, mobile phone ontology is divided into two parts: components and style of mobile phone. The components of a mobile phone are further broken down into three groups: hardware, software and pattern. Note that, for example, the software group can be divided into operating system, operation support, protocol, application and so on. Mobile phone style refers to the exterior description, such as shape, color and so on.

Here we present the main terminologies of the ontologies associated with mobile phone components. The concepts of mobile phone will be divided into seven parts, namely, model, hardware, software, standard, brand, shape and color. Figure 1 shows a simple hierarchical graph of mobile phone ontology concepts.

Manuscript received May 2, 2012; revised June 19, 2012.
e-mail: bertchen@iii.org.tw.

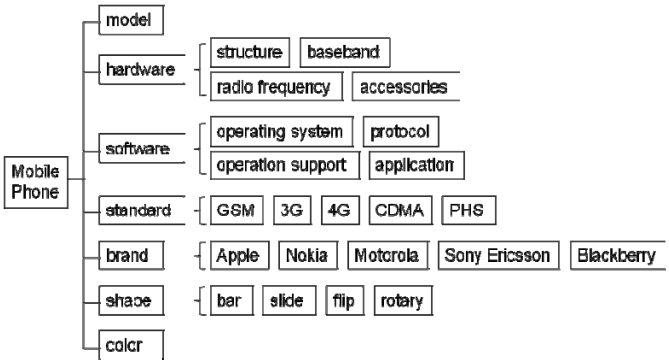

Fig. 1. Hierarchical graph of mobile phone ontology concepts.

The top-down approach is adopted in defining classes under each concept, and sub-classes are continued to be added until further expansion is not possible. For example, the shape of a mobile phone is divided into four sub-classes which are bar, slide, flip and rotary.

Attributes are formed to establish relationships among concepts. Six attributes are formed as shown in Figure 2. “Has brand” implies a relationship between phone and brand, “has shape” implies a relationship between phone and shape, “has color” implies a relationship between phone and color, “has standard” implies a relationship between phone and standard, and “has hardware” and “has software” indicate the respected hardware and software components associated with a phone.

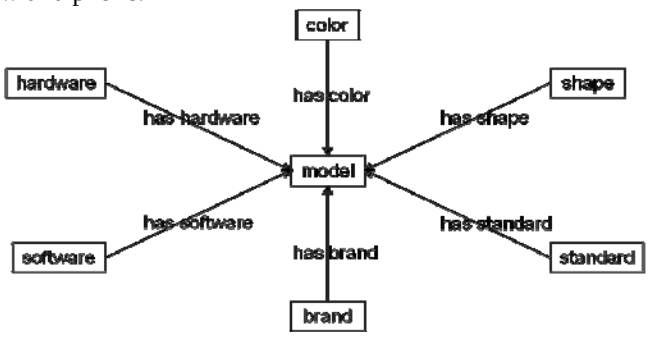

Fig. 2. Relationships among mobile phone ontology concepts.

Table 1 shows examples of mobile phone ontology concepts and instances for the purpose of knowledge base construction. Specifications of existing mobile phone products available in the market are gathered and mobile phone ontology-based knowledge base is constructed using Protégé.

TABLE I: EXAMPLES OF MOBILE PHONE ONTOLOGY CONCEPTS AND INSTANCES.

Concept	model	standard	shape	color
Instance	Apple iPhone 4	GSM	bar	black
	HTC Desire S	3G	slide	white
	Nokia 1800	4G	flip	silver
	MOTO EX300	CDMA	rotary	red
	LG GB106	PHS		orange
	Sony Ericsson C510			pink

III. AUTOMATED MOBILE PHONE KNOWLEDGE LEARNING SERVICE

Here we devise an automated learning service (see Figure 3) that incorporates a knowledge assessment scheme in which an interactive quizzing module can draw questions, using the mobile phone ontology-based knowledge base, to evaluate the capability of mobile phone salespersons on their product knowledge. Specifically, the interactive quizzing module generates quizzing questions using the concepts and instances in the mobile phone ontology-based knowledge base and records quiz performance to create “User Knowledge” profile as shown in Figure 3. The blue nodes in the knowledge tree represent concepts a user is familiar with, whereas the red nodes represent concepts a user has little or no knowledge of. Furthermore, to prevent a user from memorizing quiz answers, the structure of the quizzing questions is designed in such a way that the inference engine in the automated learning service can detect conceptual mistakes made by a user and infer areas of insufficient knowledge as “User Missing Knowledge” after analyzing the quiz results. Finally, the automated learning service provides personalized tuition with learning content tailored for individual users according to their knowledge deficiencies.

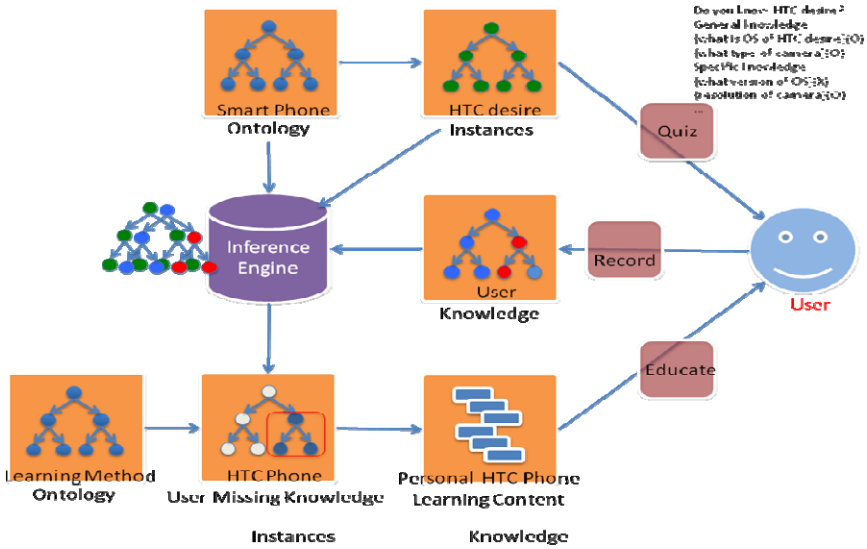

Fig. 3. Automated learning service.

For example, HTC phones are on promotion at a mobile phone shop, the shop manager certainly would like to know if the salespersons have enough knowledge on the phones. Here the mobile phone ontology-based knowledge base would have contained information and knowledge of the HTC phones on promotion as knowledge input instances. The quizzing module would generate questions of increasing difficulty, as shown in Figure 3, to evaluate knowledge capabilities of salespersons. Note that entry level concepts (e.g. {what is OS of HTC desire}, and {what type of camera} etc.) are tested before more advanced concepts ({what version of OS}, {resolution of camera}, and {what's different between android 2.0 and android 2.2} etc.) are examined. If a salesperson knows the version of OS is Android but does not know the difference between versions, and understands all standards of mobile phones (i.e. GSM, 3G, CDMA and PHS) except 4G, the automated learning service would diagnose the deficiencies via the knowledge assessment scheme and offer learning contents related to operating system and 4G standard as personalized tuition specifically tailored for the salesperson.

IV. Conclusion and Future Work

The ontology designed in our research aims at providing a conceptualized description of the mobile phone domain for the construction of knowledge base. The knowledge assessment scheme assesses individual knowledge capability via ontology-based quizzing module and provides personal tuition tailored for mobile phone salespersons subject to their knowledge deficiencies as an automated mobile phone knowledge learning service.

The mobile phone ontology concepts provided at the current stage of this research are by no means exhaustive. For the purpose of providing efficient and effective learning contents, we will attempt to rectify the ontology concepts as we see fit at the next stage of research, and to develop advanced automated personalized learning services such as real time knowledge supplement tools. Furthermore, to broaden areas of learning for our users, domains other than mobile phone will be included in the future.

This research will lay the groundwork for future work in knowledge assessment and computer-based education. Any online lesson with the capability to assess student knowledge level can be augmented with personalized learning contents.

Furthermore, experiments can be designed to compare learning methods and lengths of time students take to master a set of concepts. Future research also might test the effectiveness of different learning methods on individual students, comparing the change in student knowledge level before and after each method is applied.

Automated student knowledge assessment can be applied in future research to understand the changes in student knowledge level as they learn. In this case, student knowledge states are mapped after each question or group of questions to track changes. This could be used in several different ways. Firstly, it could be used to determine the most effective areas of a tutorial, and identify those that are not causing changes in student knowledge level. It could also be used to further understand the process of human learning, assessing whether students are learning in great leaps or with small, gradual changes. Alternatively, this could also be used to redirect a student's learning. Tracking changes in student knowledge level can also alert an automated system to change its strategy.

Acknowledgements

We would like to thank the Industrial Development Bureau, Ministry of Economic Affairs, Taiwan for the funding and their support of this project. This research was supported by the Taiwan e-Learning and Digital Archives Program.

References

[1] R. Godwin-Jones, "Emerging technologies mobile-computing trends: Lighter, faster, smarter," *Language Learning and Technology,* vol.2, no.3, pp. 3-9, 2008.

[2] S. W. Campbell and Y. J. Park, "Social implications of mobile telephony: The rise of personal communication society," *Sociology Compass*.vol.2, no.2, pp.371-387, 2008.

[3] K. Tachikawa, "A perspective on the evolution of mobile communications," *IEEE Communications Magazine*, vol.41, no.10, pp. 66-73, 2003.

[4] N. Henze, P. Dolog, and W. Nejdl, "Reasoning and ontologies for personalized e-learning in the semantic web," *Educational Technology and Society*, vol.7, no.4, pp. 82-97, 2004.

[5] R. Hadj M'tir, L. Jeribi, and B. Rumpler, "Ontology-based modeling for personalized e-Learning," In: *Proc. of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education*, pp. 2601-2609, 2007.

[6] M. Ivanova and M. A. Chatti, "Defining ontology specification for personal learning environment forming," In: *Proc. of the ICL2010.* 2010.

[7] B. Chandrasekaran, J. R. Josephson, and V. R. Benjamins, "What are ontologies, and why do we need them?" *IEEE Intelligent Systems*, vol.14, no.1, pp. 20-26, 1999.

[8] R. Girardi and A. Lindoso, "An ontology-based knowledge base for the representation and reuse of software patterns," *ACM SIGSOFT Software Engineering Notes*, vol.31, no.1, pp.1-6, 2006.

[9] T. R. Gruber, "Toward principles for the design of ontologies used for knowledge sharing," *International Journal of Human-Computer Studies*, vol.43, pp. 907-928, 1995.

[10] F. S. Correa da Silva, W. W. Vasconcelos, D. S. Robertson, V. Brilhante, A. C. V. de Melo, M. Finger, and J. Agusti, "On the insufficiency of ontologies: Problems in knowledge sharing and alternative solutions," *Knowledge-Based Systems*, vol.15, pp. 147-167, 2002.