Mobile Social Software with Context Awareness and Data Uncertainty for Technology-Enhanced Learning

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Abstract. Mobile computing technologies and social software have given new challenges to technology-enhanced learning. Simple e-learning system personalization, adaptation and authoring become only part of problems. Learning activities take place in certain contexts such as at a certain location in a certain period of time within certain communities. Learning content in the Web 2.0 era draws a large audience. There is yet little research work addressed to both context awareness and data uncertainty in mobile learning applications. My research focuses on identifying, analyzing and reducing data uncertainty problems for learning content in context aware technology enhanced learning systems. The concept of mobile social software is realized in the system Virtual Campfire which is a community knowledge management system for context-aware mobile learning. It supports learner communities to create, annotate, search, and share geographic and multimedia knowledge on mobile devices. At the same time, the problems of data uncertainty, data modeling and data semantic are explored.

1 Introduction

Learning is not a kind of activity limited in classroom any more since decades. Situated learning [6], informal learning, life-long learning have been proposed in recent decades. Therefore, context-aware mobile learning platforms play an important role. On the other hand, with the development of social software a great amount of user-generated content has been created on the Internet. Various resources of learning content like Wikipedia, professionals' Weblogs and bookmarks etc. can be easily accessible.

With the great impact of social software, user communities can't help addressing this question. Will the conventional e-learning systems such as course management systems (CMS) meet the community requirements of life-long learning? In the contrary, could learning easily supported by social software? A report shows that data

volume increases all the time at a rate of 60% last year. Social software even creates more and more data in future. With this growth ratio knowledge management and information search and retrieval are getting more and more important. Learning communities want to get the right knowledge at right time. So certain context is crucial for this issue. Future technology-enhanced learning is supposed to support sufficient context awareness that learning communities need.

Web applications especially social software is based on ubiquitous content and communities. Diverse factors lead to data uncertainty and can be categorized in three groups. Firstly, spatial temporal uncertainty is highly relevant to context-aware technology-enhanced learning systems. Secondly, community uncertainty is represented by interests and vocabularies of communities. Among it, a lot of Web uncertainty representation [8] is associated tightly with communities. Thirdly, device uncertainty is resulted from limited capacity of mobile devices. An example of data uncertainty in context-aware technology-enhanced learning could be getting the right knowledge about a monument on site, since there is much uncertain data collected at research histories with historians' different induction and interpretation.

My research focuses on identifying, analyzing and reducing data uncertainty problems for learning content in context-aware learning social software. The research question could be decomposed as the following several sub questions. How is knowledge among various types of social software such as WiKis and Weblogs? What kind of data uncertainty is relevant for context-aware technology-enhanced learning? Consequently, how can it be reduced?

The concept is realized in the mobile social software Virtual Campfire which is a community knowledge management system for context-aware learning. It supports learner communities to create, annotate, search, and share multimedia knowledge with context awareness on mobile devices. At the same times, the problems of data uncertainty, data modeling and data semantic are explored.

The rest of the paper is organized as follows. Section 2 outlines the current knowledge of the problem domain as well as the state of art solutions. My approach to knowledge management with Virtual Campfire is proposed in Section 3. Concrete applications are introduced in Section 4. Section 5 gives discussion about the contribution of the research and open questions.

2 Related work

Data quality is a general problem in data management. Hence, the data quality of e-learning systems is often assumed to be good. A great amount of data is generated by users. Correspondingly, the data quality of Web data for learning is especially crucial. In the real world, data could be incomplete, imprecise, and even maliciously manipulated.

Therefore, information quality is a crucial metric of the evaluation of information systems, together with the system quality metric. With the explosion of information in the Internet nowadays, information quality issues are taken more and more consideration in design, implementation and maintenance of information systems. Accordingly, the cost of improvement of information quality rises all the time.
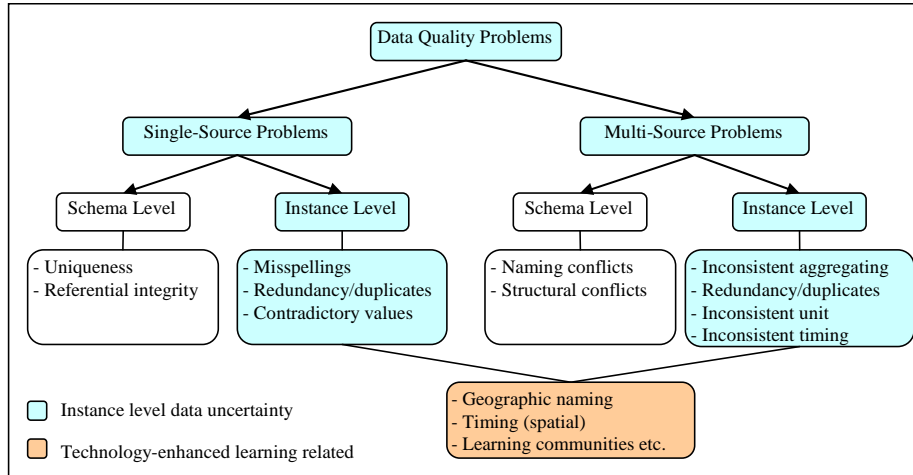
**Fig. 1.** Data quality classification schema (Adapted from [7])

Traditional information systems were applied to process business data, which often consists of exact numbers. There are no approximate or imprecise queries. Knowledge of the real world is almost always imperfect. Thus, how to manage information under uncertainty has been discussed as a challenge for the further development of database managements systems in future at the database Lowell meeting [1]. This problem is typical and acute in context-aware technology-enhanced learning. In most cases, however, data uncertainty problem has been recognized and paid attention in government, commercial and industrial environment. In scientific field, scientists have dealt with data uncertainty by means of mathematical methodology. For example, probabilistic theory and statistics [3] have been applied to handle sensor data and geospatial data. And spatial data uncertainty has been handled with spatial data mining techniques [5]. In conclusion, a data quality classification schema concluded in [7] is extended in Figure 1 for context-aware technology-enhanced learning.

3   Virtual Campfire: mobile knowledge management for context-aware technology-enhanced learning

In the conventional e-learning or course management systems, content has been created according to certain predefined course in school or high education. With the development of mobile technologies, more and more Internet applications will run on mobile devices. It makes context-aware learning anywhere at any time via handheld mobile devices possible. Future technology-enhanced learning will only be successful, if the running applications based on low cost mobile network infrastructure are well developed to meet the requirements of context-aware learning content delivery. Performance, reliability, security and energy-efficiency are meanwhile important measurement.

I propose the concept of a category of mobile social software called Virtual Campfire for knowledge management (cf. Figure 2). It enables professionals to collect, manage and retrieve cultural heritage information and to create and share multimedia stories among wide learning communities with context awareness.

As declared in Web 2.0 motto, data is *the next Intel Inside*. Communities who generate data are in fact the main data creation source. Social network analysis methods are applied to visualize and discover development of communities. Communities enrich learning multimedia repositories in an informal way, for example, through taking videos and pictures as well as writing Weblogs. Furthermore, learning communities can create learning content by tagging existing multimedia content. Hence, a set of services such as location-based services and metadata based multimedia annotation tools can be applied to facilitate these functionalities. Meanwhile, not only multimedia but also spatiotemporal and cultural standards can be applied to organize the multimedia content on mobile devices.
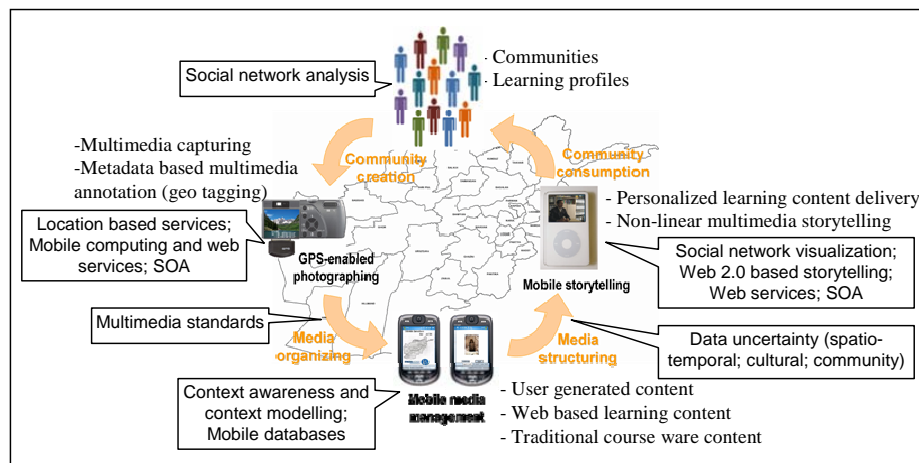
Fig. 2. Concept of Virtual Campfire as an example of mobile social software for technology-enhanced learning

Since context awareness has a wide spectrum of definition. Generally speaking, it is related to different aspects or factors according to the context. It differs quite greatly in business process modelling context and B2C eCommerce. Even in technology-enhanced learning environments, context can refers to distinguishing issues, if the professional communities vary. Physical contexts including spatiotemporal and device hardware and community contexts are to be modelled comprehensively.

Spatial data uncertainty has been an important issue in spatial data mining. Much important hidden uncertain information can be retrieved in the field of cultural heritage management by means of spatial data mining. My aim is to identify and analyze the problems of spatial data uncertainty that the learners encounter in cultural heritage management. In addition, data lineage retrieval [2][4], data modeling and

metadata techniques are discussed to potentially manage and reduces uncertainty and to perform data cleaning in context-aware technology-enhanced learning applications.

Furthermore, storytelling has a great impact on human life. I aim at fostering this tradition with the state-of-the-art information technologies. Exploring digital storytelling with geographic information for learning purpose in the Web 2.0 era, three aspects non-linear storytelling for learning communities, location context, and metadata-driven multimedia integration need to be researched on. The virtual campfire system can be widely used and has its significance especially in communities which face problems at meeting up and storytelling in the real world.

In short, the context-aware learning multimedia life circle comes to a closure via the four main processes: community creation, media organizing, media structuring and community consumption (cf. Figure 2).

4   The UMIC project as a case study for proof of concept

The conceptual approaches for context-aware technology-enhanced learning can be realized within the excellence research cluster UMIC. Functional and non-functional requirements of future mobile web services and applications are analysed and adapted to the mobile contexts. Starting from the requirement analysis results I will design mobile applications to meet future use scenarios, based on context modelling and social network analysis approaches etc.

In mobile computing data uncertainty problems are raised at different layers ranging from devices, network layers to application layers. Varieties of mobile devices make diversity of information perception. Instability and inefficiency of mobile networks lead to further uncertain data. In the application domains especially in context-aware technology-enhanced learning, various user communities often have different data and data sources concerning trust, authorities and standardization factors. So data uncertainty is one of the most universal and typical challenges in mobile data management. In addition, Web 2.0 and social software give rise to new development paradigm in the mobile application area for mobile communities. Reliable infrastructures such as Service Oriented Architectures (SOA) are needed in order to support mobile communities and ubiquitous digital social networks. The research results may provide capabilities for more sophisticated approaches to cultural heritage management, crisis relief work and tourism guide on site.

Detailed research work is divided into mobile data management, mobile application architecture and on site evaluation. At the stage of system design of Virtual Campfire, the mobile social software platform Virtual Campfire is designed based on the pre-designed data model and requirement analysis. A data model for context-aware learning within cultural heritage learning communities has been proposed in Figure 3: left. The learning content consists of cultural heritage object, the related multimedia and events. The learning communities can be managed by the existing Light Application Server (LAS) framework with community hosting services. Data uncertainty problem might happen in each entity in various contexts. The potential minimization approach is the employment of XML based multimedia metadata such as MPEG-7 and the media-centric methodology.

A prototype for mobile data management is designed and implemented for demonstrations (cf. Figure 3: right). The prototype of Virtual Campfire will be evaluated on site for cultural heritage learning communities in Afghanistan. The evaluation result will be used to improve system implementation of Virtual Campfire.
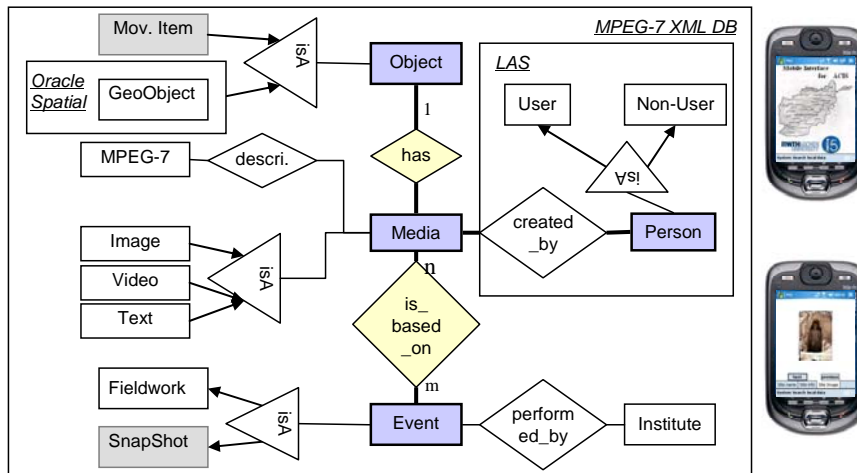
Fig. 3. left: Data modelling of Virtual Campfire; right: the screenshot of the first prototype with the map based search and multimedia search functions.

This sub component of Virtual Campfire can be used as a tool for technology enhanced learning within the professional cultural communities and can be further easily extended, thanks to the service oriented architecture. People who are interested in learning cultural heritage knowledge can use this platform to collect and create cultural heritage content on site with spatiotemporal and community context awareness. At this stage, data uncertainty aspects will be reduced through metadata based social tagging and the other functionalities. At the stage of learning content delivery, user interacted non-linear storytelling will be employed to reuse the learning content via some social ranking. Besides, Wikis, Weblogs and social bookmarking and the other desktop based social software can be integrated to enrich learning content for the cultural heritage learning communities.

5   Contributions and Discussion

In conclusion, my dissertation concentrates on two important questions in mobile computing for technology enhanced learning. One is the data uncertainty problem and the other is the context awareness problem. Hence, this combined starting point is a new view point in this research area. There's little work done in mobile social software for learning, because social software is considered as more a successful market label than research challenge. I consider mobile social software an efficient

context-aware technology-enhanced learning approach to open learning, informal learning and life-long learning. Meanwhile, diverse data uncertainty problems will be dealt with via data lineage tracing etc.

In my ongoing work, I will refine the data quality schema for context-aware technology-enhanced learning applications. Further research will be done to finish a context model for the context awareness, detailed design and implementation of the data lineage tracing method to uncertainty reduction. In addition, mobile technologies enable systems and platforms to be highly integrated and unified. The first mobile prototype has been developed. With the methodology of service oriented architecture, further services will be launched on various mobile devices ranging from iPod, cell phones to Pocket PCs.

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