# Personalized Metadata Mechanism Applied to Adaptive Mobile Learning

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## Abstract

*Most of digital learning content are prepared by publishers; student and teacher use the designed content during class. The teaching experience and learning reflection can not be effective annotated, preserved and managed with the learning content. Under this situation, learning efficiency and teaching quality will be possible limited. Diversity of mobile device are developed, an adaptive content mechanism is needed to provide preferable visual presentation for each different device. In this paper, we develop a personalized metadata mechanism which aim was to implement adaptive mobile learning environment. As preliminary study, the teaching experience and learning reflection can be fully aggregated and managed, and the learning efficiency and teaching quality can be effective improved.*

**Keywords**: *mobile learning, personalized metadata model, Adaptive mobile learning environment*

## 1. Introduction

The spirit of learning is to help student establish personal knowledge from lecturing materials. There are several kinds of information need to be surveyed. The first is the learning materials, which are usually prepared by domain expert or experienced teacher. Lecturing material is the arrangement of series concepts or topics. Process of knowledge formation is the second. Through the learning process, students will know how to organize these topics to form his personal knowledge. During the knowledge formation, students always have many interactions with teacher on his opinion, suggestion, and reflection about lecturing material. Using annotation information, student will be able to make a good use of knowledge which established in his own way.

In tradition education, teacher delivers content of textbook to students in the classroom. This kind of learning is confined by spatial and temporal limitation. With the internet technology fast development, distance learning has been proposed to break the spatial and temporal boundary. There are still some barrier existing, the problems range from inadequate end-user quality of service, to inadequate materials, to shortcomings in learning paradigms, and to missing or inappropriate student assessment and feedback mechanisms. [1] There are several technologies has been proposed, likes using IPv6/ATM to resolve lacking address and the bandwidth of limitation. Quality of service can promote the performance of distance learning. Interactive mechanism can improve the traditional way. [2] Now with mobile technologies, a new type of virtual learning environment is born. User can easily browse and retrieve information by mobile device in any time, any place. There are many scenarios have been imaged likes gamed based learning, intelligent virtual laboratory, collaborative workforce, and etc. [3][4] Although information technology facilitates learning, some problems need to be conquered. Individual learning experience should be preserved for re-used and shared. Learning content should be shown in a preferable visual presentation among different types of device.

## 2. E-learning environment

Many interactive applications have already been developed, likes electronic whiteboard, interactive discussion board, bulletin board, video-conference and etc. These encourage the development of new pedagogy method; likes distance learning, on-line leaning, and collaborated learning. [3][4][5] In general, all of those are called e-learning. In e-learning environment, content management system (CMS) manages variety of resource for users. The main goal of CMS is to achieve resources re-use and re-purpose on the Internet. In reality, a content management system is a concept rather that embraces a set of processes. [6] LCMS (Learning Content Management System) is used to manage learning resource. For e-learning, the major contribution is to exploit the reusable and shareable features of digital content. [7][8] Through a well defined managing mechanism, every user can retrieve desired resource and use rendering tool to generate or reproduce a new content for his need. In this paper, all the mechanism will be implemented in a LCMS environment.

As mentioned, different user has different acknowledge or points to same content. Almost existing LCMS only

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provide a dedicated space or directory for personal storing and easily caused confusion. It is very important to preserve user's personalized annotation which called "extended content", safely and efficiently. How to manage or express these personalized annotation is an important issue which existing LCMS need to be considered.

In order to clearly distinguish the extended content from different user, we proposed a personalized metadata mechanism. Through the proposed mechanism, user can easily annotate his personalized opinion efficiently without mixed up. It is important that these extended contents should be separated from the course content. But the relationship between content and extended content should be careful managed and kept. It is possible that personalized extended content will be revised or updated along with learning progress. In the point of student, in preparation for lessons before class, he may annotate content with "unclearly, need detailed explanation" which remind him must concentrate during class. After class, he may update previous annotation as "basic and important concept" and "review before test". In different temporal environment, the annotated information may be different for same content. How to manage these extended contents would be another important issue need to be considered.

How to efficient describe personal annotation information? Using metadata is the intuitive answer. Couple metadata technology has been proposed. Standards for describing resource or content, especially for multimedia learning content are Extensible Markup Language (XML), Resource Description Framework (RDF), and Dublin core. It is a simply and directly choice to using metadata technology to create, manage, and exchange the personalized annotating information.

The learning resource has been categorized into raw resource, basic metadata, and personalized metadata. Raw resource is the original information which publisher provided or the supplemental material retrieved from internet or exchange from other teacher. These kinds of information will be reposited in original format without any modification and annotation for the reason of integrity and intellectual property right. The corresponding Basic metadata about resource will be established mandatory. Basic metadata is used to represent the resource and also as an index for further querying and reasoning. Through the metadata querying interface, teacher and students can annotate his personal comment with the desired resource. This annotation information is called personalized metadata. By personalized annotation interface, teacher can prepare lecturing materials based on the teaching experience and feedback from students. Student also can use his annotation interface to remind himself where need to review before test or asking question during class. Those are the valuable experience and knowledge for students and teacher during their learning process.

Adaptation is a mechanism of dynamic adjusting content presentation to meet the constraints of network bandwidth, user preference, and devices limitation, thus it is necessary to know network, user, and devices information prior to the content delivering. Ideally, such information can be described with user/device profiles and be stored at content server, the client only keeps a profile reference for accessing its profile.

Currently, there are many efforts devoted to set international standards for describing the objects and access channels, for example, standards for describing device capability and users profile such as Composite Capabilities / Preferences Profile (CC/PP) created by the W3C, and User Agent Profile (UAProf) created by the WAP Forum. [9]

To enable content adaptation, we use CC/PP describe and resolve user/device profiles, and implement the mechanism with open source software tools such as Deli as the CC/PP parser to resolve user/device profiles, and use Cocoon as XSLT engine to provide adapted content based on the resolved user/device profiles. [10][11]**[12]**

In Figure 1, before the delivery of resource, severs will select a suitable style-sheet based on resolved device information. Then the resource will work with the selected style-sheet to deliver a preferable visualized content to client.

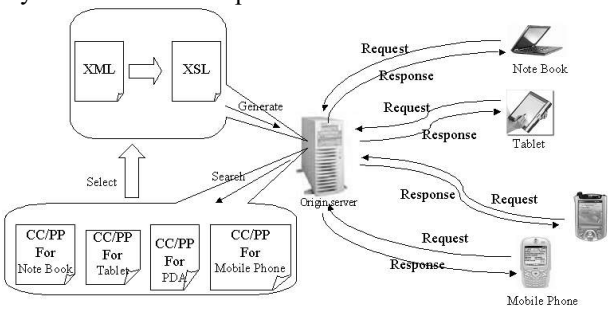


Figure 1. Content adaptation process.

## 3. Personalized metadata annotation

Based on previously study, there are several topics need to study, likes basic information, preference, learning management, and portfolio. In this paper, we will focus on the personalized metadata applied to learning management. The original idea is that personal opinion will be annotated or described by means of assigned or selected a corresponding property values. Student can use this information to remind the whole learning process, and then know where needs study after finish the class. Teacher also can use his metadata information to recall the whole teaching process and annotate the response or feedback from student which will be very helpful in next same course or share with other teacher. Through sharing this experienced information, the knowledge will be fast established, aggregated and constructed in short time.

In this paper, three kinds of metadata have been defined, such as basic metadata, student's personalized metadata, and teacher's personalized metadata. The basic

metadata mainly are used to represent the resource. So any important features about the resource will be described in metadata schema. We will use geography course to illustrate the proposed metadata mechanism.

In past time, map is the most important tools which used to record and deliver geography information. Since 1970, with the evolution of information technology, charting techniques has been gradually computerized. Due the computing speed, capacity of storage, and mobile capability of computer, the whole geography has been integrated with information technology. A system, called Geography Information System (GIS), which integrate natural resource, environment protection and geography information, help people make a decision based on nature geography and human geography. A basic introduction of GIS is scheduled on second grade of high school. Teacher will prepare topics of course content based on Figure 2. For example, it is clearly that there are two topic "vector" and "raster" should addressed in "spatial information" of section 1 "information storage".

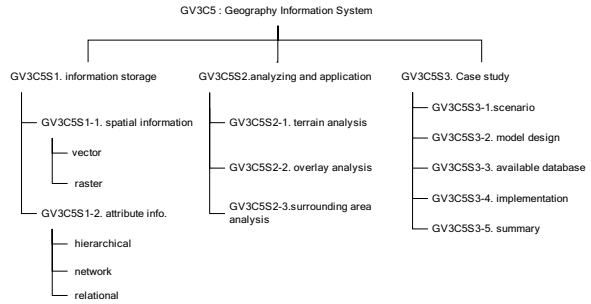


Figure 2. An example of organization about GIS (course organization).

Table 1. Basic metadata (simplified)

| | GV3C5S1 | GV3C5S1-1 | … | GV3C5S2 |
|---|---|---|---|---|
| Title | information storage | spatial information | … | analyzing & application on GIS |
| Creator | LungTerm Inc. | LungTerm Inc. | … | LungTerm Inc. |
| Subject | **Spatial, attribute** | **vector raster** | … | **terrain overlay …** |
| Description | Geography info. is composed ... | Two mode are used in spatial information … | … | Using GIS information to… |
| Publisher | LungTerm .. | LungTerm Inc. | … | LungTerm ... |
| Date | 2003-June | 2003-June | … | 2003-June |
| Type | Digital content | Digital content | … | Digital content |
| Format | ppt | ppt | … | ppt |
| Identifier | GV3C5S1 | GV3C5S1-1 | … | GV3C5S2 |
| Source | 163.18.53.205/f4001 | 163.18.53.205/f4001 | … | 163.18.53.205/f4001 |
| Language | ZH-TW | ZH-TW | … | ZH-TW |
| Relation | Is part of GV3C5 Has part: GV3C5S1-1 GV3C5S1-2 | Is part of :GV3C5S1 Successor: GV3C5S1-2 | … | Is part of GV3C5 |

Teacher and student can easily find out the desired course content than traditional way by basic metadata. During the preparation, class, or review, teacher and student can annotate their own opinion by personalized metadata mechanism.

During learning process, teacher concerns whether knowledge of content has been clearly delivered to student. If not, teacher needs to provide further explanation with figures, tables, or examples (basic, detail, or advance). Teacher also needs to control teaching schedule, so he needs to make a decision based on priority, sequence (predecessor and successor) and others. He also can take a note during the class to record the response from students. These responses can be used to improve the design of course content to increase the learning effect in future class or share with other teachers. Due to above situation can not be described or expressed by Dublin Core; we need to develop a new annotating schema which will be used in the learning environment.

The teacher personalized metadata schema has been tabulated shown in Table 2. The row of Table 2 indicates the property which described or represent resourced, i.e. teacher's point. The value of column indicates the value of corresponding property. In Table 2, resource has different properties compared with "basic metadata" shown in Table 1. For example, property "schedule" is used to arrange teaching schedule, "priority" indicates importance of resource, and "experience" indicates depth of content. It is obviously, the value of "topic" has strongly relationship with "subject" on basic metadata shown in Table 1. Topic is the concept about the course content in which teacher annotate relating points to remind him.

Table 2. Teacher's personalized metadata

| | GV3C5S1 | GV3C5S1-1 | GV3C5S1-2 |
|---|---|---|---|
| Identifier | GV3C5S1 | GV3C5S1-1 | GV3C5S1-2 |
| Schedule | Week 3 | Week 3 | Week 3 |
| Priority | important | Important | Common |
| Action | Explain | Explain | Explain |
| Experience | Basic / Simple | Basic / detailed | Basic |
| Predecessor | GV3C2, GV3C4 | GV3C5S1 | GV3C5S1-1 |
| Successor | GV3C5S1 | GV3C5S1-2 | GV3C5S2 |
| Topic (extended from basic) | **Spatial, attribute** | **Vector (w/e) Raster (w/e)** | **Hierarchical Network (w/e) Relational** |
| Student response | n/a | n/a | n/a |
| Remark | | | |

In the point of student, the personalized metadata will emphasis on learning status about content or concepts. The student's personalized metadata schema has been tabulated shown in Table 3. The definition of row and column in Table 3 is same with Table 2. It can be found that "topic" is the key of learning status, and it is also extended from the property "subject" on basic metadata. Student can annotate these

concepts with "known", "hard to understand", or "question". These values will remind student which one needs teacher's further explanation and discussion. The property "note" recorded what student has learn, likes reflection, opinion, or memo.

Table 3. Student personalized metadata

| | GV3C5S1 | GV3C5S1-1 | GV3C5S1-2 |
|---|---|---|---|
| Identifier | GV3C5S1 | GV3C5S1-1 | GV3C5S1-2 |
| Priority | important | Important | Common |
| Topic (extended from basic) | **Spatial** (Known) **Attribute** (Known) | **Vector** (Known) **Raster**(Need detailed … | **Hierarchical** (Known) **Network** (Known)… |
| Note | Basic concept | Definition Review before test | Structure of database (review if available) |
| Predecessor | GV3C2, VG3C4 | GV3C5S1 | GV3C5S1-1 |
| Successor | GV3C5S1 | GV3C5S1-2 | GV3C5S2 |
| Supplement resource | | | |
| Remark | | | |

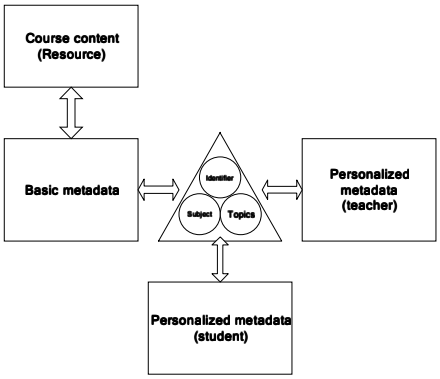


Figure 3. The relationship among resource, basic metadata, and personalized metadata

It is obviously, it exist some important relationship among Table 1, 2, and 3. The property "topic" in student's and teacher's personalized metadata is derived from property "subject" on basic metadata (shown in Table 1). All the users' opinions can be traced around these properties. The property "identifier" is used to identify the resource. Using "identifier", "subject", or "topics", the desired resource and personalized metadata can be easily managed and traced shown in Figure 3. Using these metadata the personalized information can be created and maintained without any ambiguous matter.

## 4. Implementation

The proposed personalized metadata mechanism is build over Apache web server, PHP interface and MySql database. In our experiment, we use Deli which supports CC/PP to detect the device's capability and personal preference on the client and also use Cocoon which support XSLT to adapt content based on CC/PP information.

To explain the proposed implementation, we will use a scenario of geography class in high school. Kevin is a high school student. On Monday morning, Kevin goes to library of school and uses his mobile device to login school's LCMS. After verified his identification, system will retrieve Kevin's personalized portfolio and standby. Kevin uses either the basic metadata query interface or index of GIS course content (extracted from basic metadata) to download the GIS course content. After download process, Kevin can study Chapter 5 content before class. The course content of section 1 "information storage" is shown in Figure 5 and an adaptive content for PDA is shown in Figure 6. He finds there are two subjects "spatial" and "attribute" in the section 1. Kevin has a little confused with the definition about "raster", so he uses personalized metadata interface to annotate the value of topic "rater" with "Need detailed explain". During the class, when teacher talked about the "information storage", Kevin can use his personalized metadata to remind himself to concentrate on topic "raster". After detailed explanation, he understand the definition and related application. So he add his personal opinion on this topic with "review before test" to the property "note".

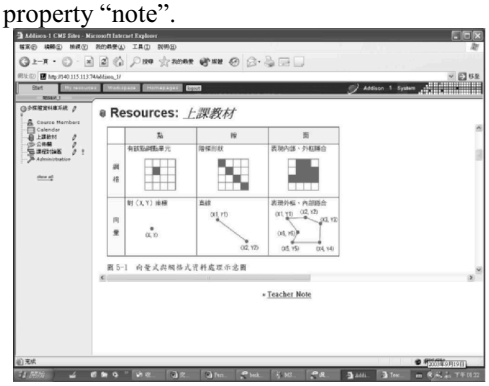


Figure 4. Example: Course content shown in Notebook.

Figure 5. Example: Adaptive course content shown in PDA.

For geography teacher Sophia, when she prepares the course content about "information storage", she check her personalized metadata about this content. She finds "raster" is easily to be confused based on her previously experience.

So she needs using more examples to explain the "raster" and annotate "with example" of property "topic". During the class, the response from student also can be collected and add on property "student response". In the end of semester, Sophia can use her personalized metadata to review the teaching process and find out where need to be improved or provide more examples, or learning projects.

All the annotated metadata are stored into the personal portfolio on server side. There are many reasons to do this way, likes, synchronization of learning status between mobile devices and sever, trace and management of metadata. All the metadata likes basic metadata, teacher's metadata, and student's metadata are designed in RDF format. So we use a well defined relational database to store this RDF information. All the syntax of query should be first found from the basic metadata repository in sever side. Using the built-in link function in database management system, all the metadata and resource can be connected and worked perfectly.

There are many different device has been developed every years. Each device has their specific feature to facility usage. This diversity will affect the presenting effect. The proposed system has successfully support universal access service. That is responsible for delivering a suitable presentation format to any device likes, PDA, tablet PC, NB, or PC. From Figure 4 and 5, it is found the content shown in Figure 5 has been adapted in a preferable visualized presentation for PDA. Well designed course content deserved to be shown in a good visualized format for mobile device. In this way, teacher can focus on course content designed, and let the system do the style-sheet adjustment.

## 5. Conclusion

In this paper, we use a mobile learning scenario to demonstrate our personalized metadata mechanism. We use the basic metadata interface to help user find out desired resource before actually download the whole information. Using the proposed personalized metadata interface, the valuable personal opinions about content can be fully and efficiently managed, likes student's reflection and note and teacher's teaching experience. We also demonstrated adaptive mechanism which transforms content presentation successfully to mobile device PDA, notebook, and tablet PC. This can help teacher focus on course content designed not the presentation designed.

In preliminary study, the proposed personalized metadata mechanism has been successful demonstrated applied to mobile learning environment. There are still some topics need to be studied and extended, likes the synchronization of metadata between system and users and metadata exchange mechanism to enhance teaching experience accumulation.


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