Applying Adaptive Course Caching and Presentation Strategies in M-learning Environment

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Abstract - **The use of portable device like pocket PCs and smart phone to support teaching and learning is not a new concept. Although the variety of mobile platforms provide more flexible and extendable learning experience, the various hardware restrictions consequently become the unavoidable challenges and barriers we need to overcome. In this paper we focus on: (1) improving the learning performance by prefetching the upcoming learning content; (2) improving the reading experience on small screen by adaptive content presentation; (3) distributing the well presentation learning content corresponding to user's specific mobile platforms by multi-presentation course package. There are four Web Service based modules proposed to carry out the above ideas.**

Keywords: **Adaptive, m-learning, Caching, Web Service**

I. INTRODUCTION

There are four main modules proposed to promote the immediacy, accessibility and interactivity for SCORM-compliant m-learning environment. Firstly, Course Segmentation Module: The module can separate a course into several smaller unites namely course clusters. The produced smaller clusters are considered as basic operation units that are manipulated by other modules to carry out their specific functions under restricted memory capacity conditions. Secondly, Course Presentation Adaptation Module: The module is providing different adaptation templates to help the author automatically and efficiently reproduce high-quality learning content presentation which is appropriate to read on specific mobile learning platforms. Thirdly, Course Caching Module: The module can precisely predict the access of courses and to download them before learning begins; the learning process can not only reduce the waiting time significantly but also offer the downloaded content for offline learning. Finally, Course multi-presentation Packaging/Delivering Module: The user may use the Course Adaptation Module to create plural course versions for different presentations on specific mobile learning platforms such as pocket PCs and smartphones. The module can integrate all produced course versions and package as a standard Common Cartridge Course Package. Furthermore, correctly delivering the corresponding course version to the learner's mobile learning platform is another purpose of this module.

II. RELATED WORKS

A. *ADLSCORMS S&N and IMS CC*

The SCORM S&N model 0 serves as a coordinator between individual learner and the back-end learning management system. The main purposes of SN model are to define and to standardize the sequencing rules while delivering SCORM compatible learning contents from server side to learners. The trigger of S&N model depends on specific learner-initiated or system-initiated navigation events, and results in different learning activities to be delivered to learners.

Common Cartridge [2] is a specification being developed by the IMS. The idea of the Common Cartridge is to create a package of learning material that will play on any of a number of learning management systems. The specification is officially a combination of previous IMS specifications.

The Common Cartridge format includes the following specifications:

- Content Packaging v1.2
- Question & Test Interoperability v1.2
- IMS Tools Interoperability Guidelines v1.0
- IEEE Learning Object Metadata v1.0
- SCORM v1.2 & 2004

B. *Related Research Literatures*

The need to adapt content for use on handhelds has been long recognized in [3][4][5], and both manual and automatic approaches to implement the content adaptation have been proposed. This research [6][7][8] mostly focused on adapting normal Web Pages such as commercial web sites or portal sites. Usage-AwaRe Interactive Content Adaptation (UARICA) and Feedback-driven Context Selection (FCS) [9] made adaptation prediction for a user based on the history of the community of users and reflect both the user's context and content's usage semantics. The TF/IDF weight [10] (term frequency–inverse document frequency) is a weight often used in information retrieval and text mining. This weight is a statistical measure used to evaluate how important a word is to a document in a collection or corpus. The importance increases proportionally to the number of times a word appears in the document but is offset by the frequency of the word in the corpus.

III. PROPOSED M-LEARNING MODULES

There are four main modules proposed to carry out the course caching strategy and presentation adaptation methods that aim at promoting the immediacy, accessibility, and interactivity for SCORM-compliance

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mobile learning environment. The Fig.1 depicts the entire framework which based on Web Service and Context-Aware technologies to develop the four modules.

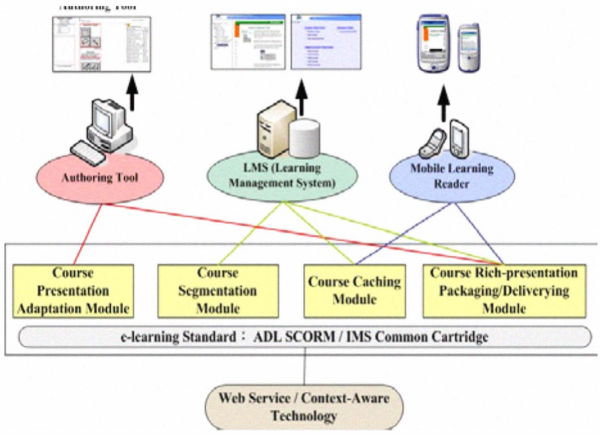

Fig. 1. Proposed Web Service based modules for m-learning systems

A. Course Segmentation Module

As shown in Fig. 2, a course activity tree can be separated into several smaller cluster units which considered as a basic building block of learning activity. SCORM sequencing is especially applied to clusters. The cluster includes a parent learning activity and its immediate children. The parent activity of the cluster will contain the learning sequencing information. The children can be a set of leaf learning activities which are the physical learning resources for delivering to learners.

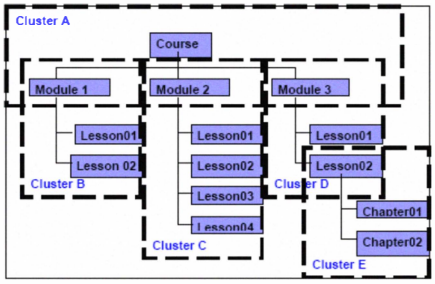

Fig. 2. An illustration of Clusters within a Course

In our proposed strategies, a cluster can be considered as the basic unit to be manipulated. According to the definition of a cluster, the module segments the course structure that includes a parent learning activity and its immediate children. Thus, there are five clusters can be separated from the navigation tree and the parent activity of the cluster will contain the learning sequencing information.

B. Course Presentation Adaptation Module

The module is composed of three main adaptation models. First, the textual adaptation model is responsible for handling the complicated textual body that may make users feel confused or lost while reading on a restricted small screen. We referenced progressive disclosure [11] for text, it combined with keywords and a summary help present the original content incrementally, has the best improvement of average I/O expenditure and completion time across all tasks.

1) Semantic Unit (SU) and Presentation Unit (PU)

The adaptation process begins by partitioning the content into presentation unites (PUs). A content page will be separated into several PUs, which instead of presenting in the actual HTML, each PU is a rectangle around a section which typically presents a paragraph, list, table, image, etc. Accordingly, each PU is considered as a basic unit of the adaptation process. Because each PU contains various contents, the question is which SU should execute the adaptation process. We will define the other unit, namely screen unit (SU) that helps us to evaluate and decide which PU is required to be adapted.

The display area size of a PU is varies because it may contain a paragraph or an image; a SU is a virtual rectangle presentation block where the boundary is fixed according to different handhelds displaying ability. Precisely speaking, the size of a SU is matched to correspond to the screen sizes of handhelds For example, pocket PC's and smartphone's in which the typical resolution are 240*320 and 176*220 respectively. The content of each PU will be retrieved then filled into each SU. The main concept is that it does not need to adapt a text or image within a PU if it can be entirely displayed within a single SU without additional scrolling. Mathematically, we evaluated whether a PU is required to be adapted with a simple formula that calculates a threshold value. We defined a value, textual information density (TID) as follows:

TID = number of words in a PU / area of a SU (1)

The area of a SU is constant according to which adapted target platform is required by a user. The default value of TID is allowing a PU to present the maximum number of words without additional scrolling. Users are also allowed to adjust the TID, which will affect which PU is required to be adapted. For example, a larger TID allows a good deal of textual information located in a PU without any summarization so that the user may need more necessary scrolling actions for reading.

2) Keyword and Summary Sentence Extraction

Keyword extraction from a text body relies on an evaluation of each word's importance. According to the idea captured in the TF/IDF measure. The importance of a word W is dependent on how often it occurs within the body of text, and how often the word occurs within a larger collection that the text is part of. Intuitively, a word in given text will be considered as the most important one if it occurs frequently within text, but infrequently in the larger collection.

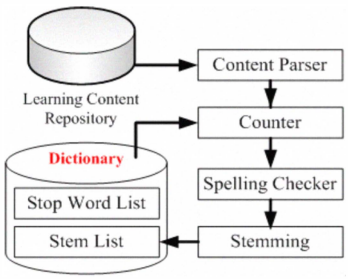

Fig. 3. Construct a dictionary of weighted words

Fig. 3 shows each step of constructing the dictionary of weight words from our learning content repository. It begins from the content parser which fetches learning courses from the repository and extracts all the words from each course, unless the frequent stopped words such as "is", "are", "and", etc. Then, each uniquely extracted word will be tagged by a counter module with a number and keeps track of the number of courses where the word occurred. Once the counting is complete, the words that occurs less than a chosen threshold value across all the courses are eliminated. The value is required to be tuned because it depends on the size of the repository. It would conserve too many insignificant words if the value is too large. On the contrary, it is probable to remove rare words that may quite important and have the potential to become keywords. The remaining words are passed through a spell checker and finally, words that have the same grammatical stem are combined into single dictionary entries.

When the significant keywords must be extracted from a PU, all the words in the PU are stemmed. For each word, the module will search the dictionary to discover the frequency with which the word occurs in the course. The word's frequency within the course package that contains the PU is found by scanning the course package in real time. Finally, these values are computed for the word's TF/IDF weight. Words with a weight beyond the chosen threshold are selected as significant.

Rather than summarizing the input text automatically, we can only pick up a few significant sentences to represent the text summary. Because of the previously revealed keywords in a PU a user intends to explore the portion of the content's summary due to his/her interesting. A sentence will be intuitively considered significant if it contains one or more keywords. Therefore, the method of extracting summary sentences is based on keyword extraction result.

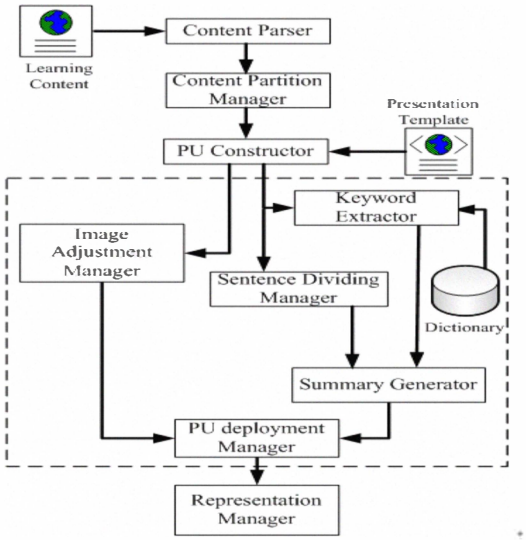

Fig. 4. Processing of the learning content adaptation

The procedure of summary sentence extraction is as shown in Fig. 4. Each sentence in a PU will be extracted by a sentence dividing manager, and then passed to the summary generator. Meanwhile, the previous extracted keywords are also passed through the summary generator in which each sentence will be extracted and listed in order if it contains the matched keywords.

3) Image adaptation Model

Similarly, image adaptation replies on comparing its size to a SU's. An image may not be able to adapt its size to perfectly match the proportion of a SU and reside in it. Hence, a large image might be shrunk proportionately until its width is fit to display in a PU without additional horizontal scrolling action. The entire adapted content will have the default displaying in a single column where vertical scrolling for browsing is necessary, so the height of a image beyond a SU's is acceptable.

4) Layout Adaptation Model

The presentation adaptation mode provides two main functions for user to reedit the content's layout. One is allowing users to pick up PUs to delete, the other is let users rearrange PUs' position manually. After the previous automatic adaptation, each PU should contain appropriate displaying content-content that has either been adapted or not. A few PUs might be required to be eliminated, because they may present relatively insignificant objects such as pictures decorated only for aesthetic purposes in its original content.

C. Course Caching Module

The course caching module is mainly applied to mobile learning applications with very limited bandwidth or impermanent network environments. The system can be automatically executed as a daemon program without human control. It is similar to virtual memory management in conventional operating systems that can provide a virtual network environment so that the cached

clusters are sufficient for learner's requirements even stays at offline status. It mainly addresses the suspension due to the intermittent network connection. In contrast, the other purpose is similar to caching of disk. This mode can prepare the possible incoming learning resources in advance to avoid the time-consuming process of downloading the required contents.

1) Course Download/Replacement Management

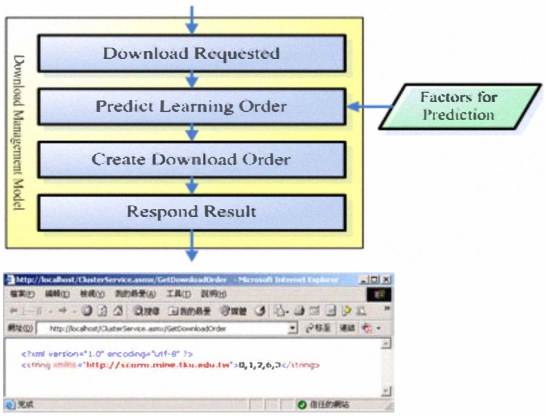

Fig. 5. Flow Chart of Download Management Model

The primary task of the download management model is to create the downloading order of clusters. This is the main function that affects the efficiency of the course caching system. When an appropriate order is created by the download management model, the client can avoid unnecessary downloading and replacement of the learning contents. The download management flow chart is illustrated in

Fig. 5.

The replacement management model is a function on the client side. It will drop some clusters automatically when the assigned storage capacity of the learning device reaches its limit and new clusters are requested.

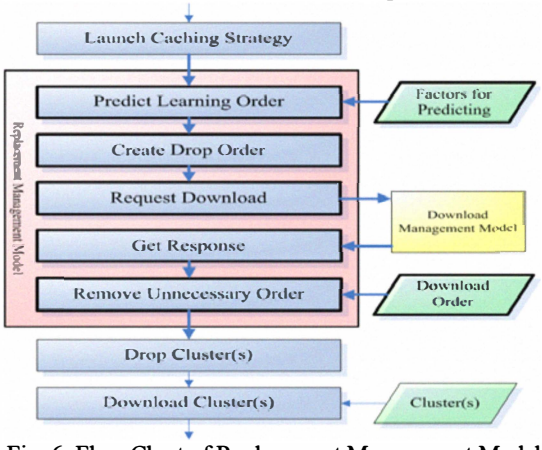

Fig. 6. Flow Chart of Replacement Management Model

The flow chart of the replacement model is illustrated in Fig 6. In order to prevent the omission of some clusters that might be necessary for the incoming learning activities, it is important for this model to make a good decision. Furthermore, a good course caching system should not spend a considerable amount of time on swap in and swap out operations. Accordingly, the replacement management model can be considered as the kernel of the caching system so that the Internet can be accessed more efficiently.

D. Multi-presentation Course Packaging/Delivering Module

The multi-presentation Course packaging utilizes the significant characteristic of Common Cartridge to compose a multi-version course package. The Fig. 7 shows the Common Cartridge file structure having a learning application object folder that includes three different SCORM course versions corresponding learning platforms: pocket PC, smarthpone and regular PC.

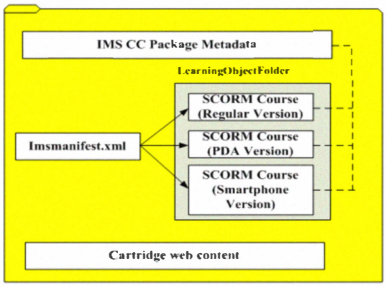

Fig. 7. An example of multi-presentation course package

The primary work of this module is combining an adaptive content delivering system that has the perception of learners' platforms. Utilizing the device-aware technology, the server can correctly delivering the required and corresponding course package to learners.

IV. CONCLUSION AND FUTURE WORK

In this paper, four modules are proposed to carry out the adaptive course caching and adaptive course presentation strategies that facilitate m-learning systems conformed to SCORM or Common Cartridge. These Web Serviced based modules can be adopted to improve learning environment in which the learning process may be degraded or interrupted due to difficult network situations. In addition, the course's layout template reduces the cost and ensures the transformed presentation quality corresponding to learners' mobile platforms. The future work will focus on considering and referencing more context information in learning environment.

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