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Distributed Database for Reusable Learning Object-Based System

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Abstract: In this study, discusses enhancing the e-learning system by employing a distributed database that apply reusable learning object as one of the technologies that is applied to e-learning development. An e-learning system named e-notes is able to assist students and facilitators to interact with each other. Learning objects are used to conceptualize the learning process and offer accessibility, interoperability, adaptability, durability, reusability and granularity for the e-learning environment. This study also shows the test result of a comparison for learning objects' performance applied to a centralized database and a distributed database and the performance in reusability of learning objects. The e-notes architecture, based on a client-side application, is designed with the intention to help the student in a computer tutorial system which offers reusability attributes.

Key words: E-learning, client-side application, reusability, online teaching, performance, centralized database

INTRODUCTION

Essentially, e-learning involves the use of computers or electronic devices to transfer skills and knowledge. Learning materials are transferred via the Internet, intranet, video tape or CD-ROM. Roca and Gagné (2008) discussed that perceived usefulness and perceived playfulness are motivational factors that are proposed as antecedent variables that are likely to have an influence on the type of motivation that e-learning users are likely to adopt and how these different types of motivation will influence intentions to continue using e-learning. Hence, the study conducted by Rohleder *et al.* (2007) showed a positive aspect of e-learning, which allows students at the South African University two-way communication with the facilitator for an unlimited amount of time, thus giving an exposure them the potential to study anywhere and anytime. Furthermore, the study made by Hijon-Neira *et al.* (2008) demonstrated that e-learning is useful for student interaction in the course taught. What challenges educators the most is often not the lack of teaching materials, but the constraints imposed upon a course (Ryoo *et al.*, 2008).

In this study, learning objects are chosen as a component in order to develop an e-learning system. As mentioned by Fuentes *et al.* (2008), learning objects play a role as digital representation where it able to capitalize knowledge on the better practices occurred in the teaching-learning process. Therefore, to keep up with the fast development, continuous research is required on controlling several aspects of the learning objects, such as the content design, back-end delivery and front-end presentation, in order to improve the quality of content delivery. On the other hand, according to Michael Brennan's definition, a learning object consists of four major characteristics that are the basis for system implementation which are learning content, learning objective, assessment and metadata which is mentioned by Liu *et al.* (2005).

As mentioned by Ajami (2004), learning objects consist of many characteristics. The most common are accessibility, interoperability, adaptability, durability, reusability and granularity. However, the reusability characteristic is the most important aspect of learning objects' development, evaluation and/or usage. Liu *et al.* (2005) stated that this is because reusable learning objects can be applied alone or in combination to meet individual needs in the learning process and it can be reused repeatedly in different learning contexts and for various purposes. As the Web evolved, web-based distance e-learning systems emerged, where the course materials are managed virtually through the Internet. In learning content management systems, learning objects are stored in a central database, which is called a learning object repository that will be discussed further on the next part.

Hence, the objective of this study is to develop a distributed database for a reusable learning object-based

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application that enables end-users to search, retrieve, assemble and reuse the learning objects. Since this project is only concentrates on the reusability characteristic, the result of reusability testing will be discussed in the next part of this study. This study also the output of the performance result comparing a describes distributed database and a centralized database.

ANALYSIS

Learning objects are chunks of data that are authored, stored, indexed, assembled, delivered and evaluated by an e-learning system. In other words, the learning content can be broken down into small sizes and reused several times in different learning contexts as mentioned by Ihsan *et al.* (2006). Learning content could be of the interactive or passive type and in any format or media types including HTML, JavaScript, PDF, audio, video, PowerPoint presentations, online textbooks and so forth (Daniel and Mohan, 2004). Each of the units will be allocated to their own database that is stored in a different location on the computer network.

As mentioned earlier, learning objects consist of many characteristics that help the e-learning system to perform successfully. Examples of learning objects include multimedia content, instructional content, executable program and others as mentioned by Kerer *et al.* (2005). In general, learning objects could be classified into two categories: structural classification and functional classification. Structural classification reflects the way that academic programs are structured. For example, a curriculum consists of courses, a course contains lessons, a lesson includes of sections and so forth (Pukkhem and Vatanawood, 2005). Instructional design and technology have a close relationship with the functional classification. In this classification, learning objects are defined in the context of units of study. Each unit of study plays its individual role of a framework and encapsulates a wide variety of types of learning objects, such as learning objective, prerequisite, role, activity and environment.

In fact, there are some reasons encouraging the adoption of learning objects in education and reusability is the most well-known reason. When the knowledge content is packaged as a learning object, it can easily be incorporated into different applications and used without spending additional effort to recreate and redesign the knowledge content. It also ensures high quality education contents because the learning objects are reusable and can keep on being enhanced and improved upon in order to produce better quality content packages (Kerer *et al.*, 2005). The reusability characteristic enables the small units of learning objects to be reused many times and in different learning contexts. It also allows the learning objects to be applied alone or in combination to meet individual needs in the learning process. The advantage of the reusable learning objects is that they enable the user to construct, modify and distribute contents among multiple contexts.

As an example for reusable learning object is, in a situation where the user has searched for an HTML page via the information search agent in the system. Then, the user can decide either to save the whole HTML page as his or her personal learning content page, or save the learning objects that exist in the HTML page selectively. If the user decides to save the learning objects one by one, then the system provides a section which enables the user to select the learning objects that he or she intends to download and save. All the saved learning objects can be modified and reused in many chapters repeatedly.

Learning object repositories: Most of the current research work on the reusability of learning content emphasizes the notion of the learning objects. Learning objects are small content components stored in the learning object repositories and are reusable and sharable in different contexts and for different end users. As mentioned by Olivier *et al.* (2008), learning object repositories store both learning objects and their metadata either together or separately in order to facilitate their distribution and reuse.

Client-server-based learning object systems can be categorized into two types, which are centralized learning object repositories which consist of a single server to hold the learning objects and their metadata and distributed learning object repositories which consist of more than one server to hold the learning objects and their metadata separately as mentioned by Neven and Duval (2002). Generally, learning object repositories can be classified into two major models of database. The most common model is a centralized model where the learning objects are stored in a central database which resides on a single server for end-users to retrieve and assemble larger learning modules depending on individual learning needs. Another model is a distributed model where the learning objects are stored on a number of connected database servers.

Centralized database learning object systems: Most learning object repositories use stand-alone architecture and act as portals which contain a web-based user interface and search mechanism to retrieve the learning objects that have been requested. Essentially, there are

two major repository models and the most common suggests a centralized model in which the learning objects and the metadata are stored on a single server or website.

In a centralized model as discussed by Musa (2004), learning objects are managed by a central database which resides on a single server. Communication between end-users and the central database is carried out through a web service. This enables multiple users to retrieve and assemble learning objects easily, even if they are at different geographical locations. However, there are some drawbacks to applying the centralized database system. If the central database crashes, then it causes the entire learning content management system to collapse. This breakdown is called a single-point failure, as there are no alternative databases to take over its role and the entire database operations have to be suspended. Another drawback is bottleneck performance, because it needs to maintain a huge database and respond to thousands of queries every second and query flooding dumps a significant amount of traffic onto the Internet. As pointed out by Kriegel *et al.* (2005), the centralized database model causes high response times and it may be restricted by the network and security constraints. In addition, it may be inappropriate to send the entire data over a public network to a global server in terms of privacy issues. Basically, the centralized database model is not suitable for most distributed environments. Most of the learning object-based systems apply a centralized database model in which a central database is stored on a single server. However, a centralized model has its limitations, such as the data searching and retrieval time being delayed when the data volume is increasing continuously and the problem becoming worse if the database is not well designed. This influences the data processing performance, as the system may not run efficiently when it has an extremely large amount of data. In addition, the centralization of data increases the failure impact of the system. Since all users rely on the availability of the database, any failure of the system can therefore bring operations to a halt or result in data loss.

In general, performance problems could arise in a centralized database learning-object system with a single centralized repository when the number of learning objects increases as mentioned by Neven and Duval (2002). It may be able to handle the data searching and retrieval process efficiently in the early stage of the system, but as time passes and the data volume is increasing continuously, it is not an easy job for the system to perform the data searching and retrieval task, especially when a particular file type of data is required to be searched for and retrieved within a short time period. Besides, the reusability of learning objects s greatly limited by the current available system for locating learning objects. In that case, learning objects are located in a particular location or a particular format and are proposed for one kind of use only. The vision of learning objects should encompass the reusable characteristic that enables users dynamically to construct, modify and distribute contents among multiple contexts.

Distributed database learning object systems: Another alternative repository model is a distributed model in which the learning objects' metadata is contained in a number of connected servers or websites. Thus, the distributed model becomes an alternative to solve the centralized model problems. In distributed database systems, the content will be retrieved from multiple collections with standard query submissions to multiple search engines simultaneously and dynamically exchanging the content. From Kriegel *et al.* (2005) view, a distributed database model can be applied to many applications for which the data sources are distributed at different locations and each location generates its own data and manages its own database. Examples of distributed learning object repositories are POOL and SMETE.SMETE, in which each library uses different document formats, different systems of classification and different database and repository management schemes.

Typically, it employs peer-to-peer architecture in which a variety of repositories may be searched from a single portal. Distributed systems retrieve content across multiple collections with sets of standard query submissions to multiple search engines simultaneously and dynamically exchanging content. One of the techniques implemented consists of indexes. The index technique is applied in the database structure design and can retrieve data more efficiently and speed up the response to user queries. In this technique, an index is a table that contains a key value for each record in the data table and the index also contains pointers that tell the database engine where the actual record is located. Its concept is similar to an index in a book by Loren (1999). In order to improve the limitations of a centralized database learning object-based application, a reusable distributed object database approach will be an alternative to dedicate to the improvement of knowledge delivery and sharing in the academic domain. Nowadays, Daniel and Mohan (2004) have introduced a new approach for developing reusable learning content, known as learning objects, is increasingly applied in the education and

training context. Liu *et al.* (2005) pointed out that learning objects is derived from the concept of object-oriented programming that emphasizes on the reusability and sharability of objects.

MATERIALS AND METHODS

In order to develop the e-notes, there are two stages to apply. Firstly, data gathering has been carried out from different resources, such as electronic journals, articles, electronic books, reference books, reports from the Internet and libraries. Most of the useful information was obtained from the ISI Web of Knowledge, Scopus, IEEE, the ACM and SpringerLink digital library. Besides, the Main Library of the University of Malaya also provides a lot of valuable information to accomplish research works. The gathered information is useful for scope planning and definition. In this project, the testing will be performed to determine whether the system can serve different purposes. This testing was conducted in December 2007 at the University of Malaya. In this study, the performance criterion is defined as the average response time for a transaction within a processing load. In the e-notes system, two characteristics were emphasized during performance testing, which consisted of testing on a distributed database and testing on reusable learning objects. In order to execute the performance testing on a distributed database, the system was tested with a centralized database approach and a distributed database approach. The expected results of this testing are that the quality of the system performance has been improved. In this case, the performance criterion can be the average response time for a transaction within a processing load. In order to test the accomplishment of reusable learning objects in this system, two different sets of personal learning contents were created.

RESULTS AND DISCUSSION

Two sets of test results have been generated, which are the test results based on the centralized database and the test results of the distributed database. In this testing, the test data are the learning objects in increments of 10 until 100 learning objects are reached within a processing load. The response time's measurement unit is seconds. Table 1 shows the test results of the centralized database, which were generated by the centralized database system with a set of test data. Table 2 shows the test results of the distributed database, which were generated by the distributed database system with a set of test data.

Table 1: Test results of centralized database

No. of learning objects	Response times (sec)
10	5
20	8
30	11
40	16
50	19
60	23
70	28
80	32
90	35
100	39

Table 2: Test results of distributed database

No. of learning objects	Response times (sec)
10	1
20	1
30	1
40	2
50	2
60	2
70	3
80	3
90	4
100	4

Based on the information gathered during the system runs, it has been determined that the distributed database system performance is better than the centralized database system, although the data retrieval response times within a processing load are increased when the number of learning objects has been increased progressively for both systems.

However, Table 2 clearly shows that each processing load is less than 5 sec even when the number of learning objects has been increased up to 100 units and this is due to the index technique being applied in the database structure design, as it can retrieve data more efficiently and speed up responses to user queries. In the implementation of the index technique, a structure is associated with the file that contains records consisting of the key value and address of the data file and this is similar to an index in a book.

Figure 1 and 2 shows the test results of the reusable learning objects of this system. To execute the testing, learning content has been created from the sharable learning contents section. In this case, the Overview of a C Program content is selected and this is under the Learning C Programming topic with the chapter title Introduction. Additional learning content has been added to the Overview of a C Program content. In Fig. 1, a Hello Program is added and the dissection of the program is explained in the board file section. However, in Fig. 2a Depth Program is added and the dissection of the program is explained in the board file section. In the board file section, each learning object or segment of the code is stored in an image file type. Each learning object has detailed explanations attached. Some of the learning

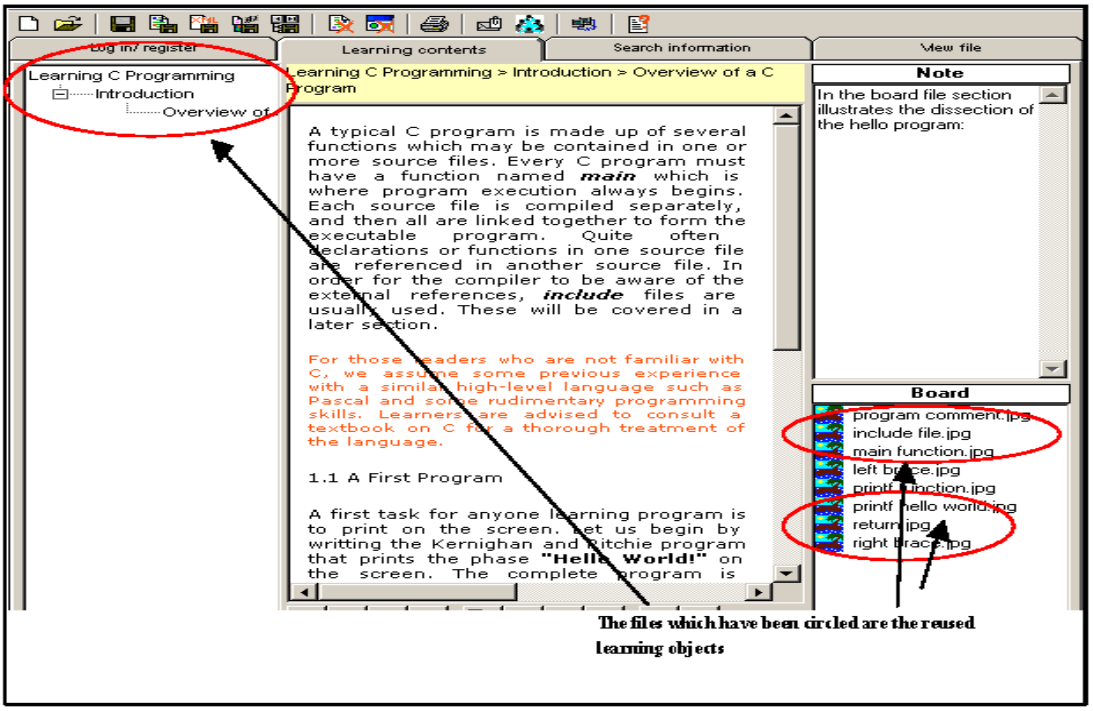

Fig. 1: Test results of reusable learning objects-1

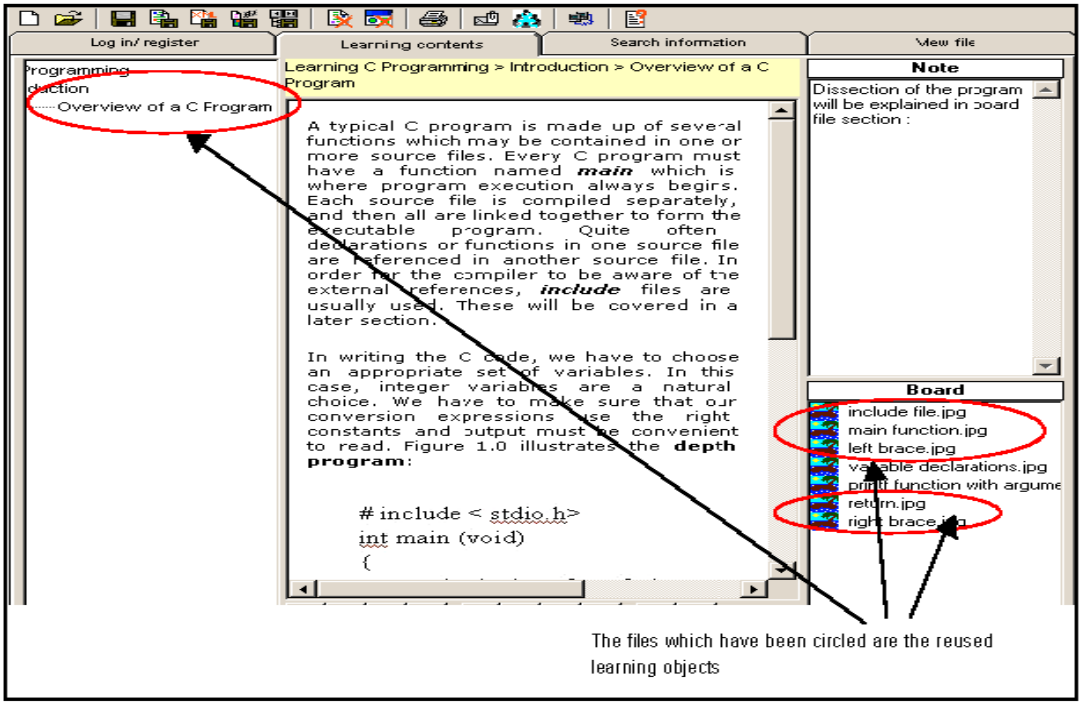

Fig. 2: Test results of reusable learning objects-2

objects which have been used in Fig. 1 are also used in Fig. 2. The files in Fig. 1 and 2, which have been circled are the reusable learning objects and those learning objects can be reused repeatedly in other learning contents in the system.

Basically, the new learning object system is divided into two parts, which are client-side and server-side. The client-side application is the main operation system for the new learning object system. The server-side application is a socket that is used to receive the required information passing from the client-side application and send the required results back to the client-side application. The server-side application is used when the registered users choose to save their learning contents online. However, the distributed database concept will be implemented in the client-side application only.

Even though the server-side application will not be included in the system, a brief description of L3OP language will be given. The L3OP language was adapted to the system and used when the data communicates between the server-side application and the client-side application. When the client-side application communicates with the online database in the server-side application, all the requested data and results will be in L3OP language. L3OP language is a language that is designed based on the SCORM concept that is used in L3OP data passing. It is similar to Extensible Markup Language (XML) but the two languages differ in their tags. For instance, XML language uses <CHAPTER> and L3OP language uses {|CHAPTER|}.

In this system, the client-side application plays the main and most important role. It plays a role as a client-server application and as a client-side application as well. The client-side application is a stand-alone application and it is used when the registered users choose to save their learning contents offline and not in the online database. Basically, the offline database and online database have the same data structure and the only difference between them is that they are stored in a different side.

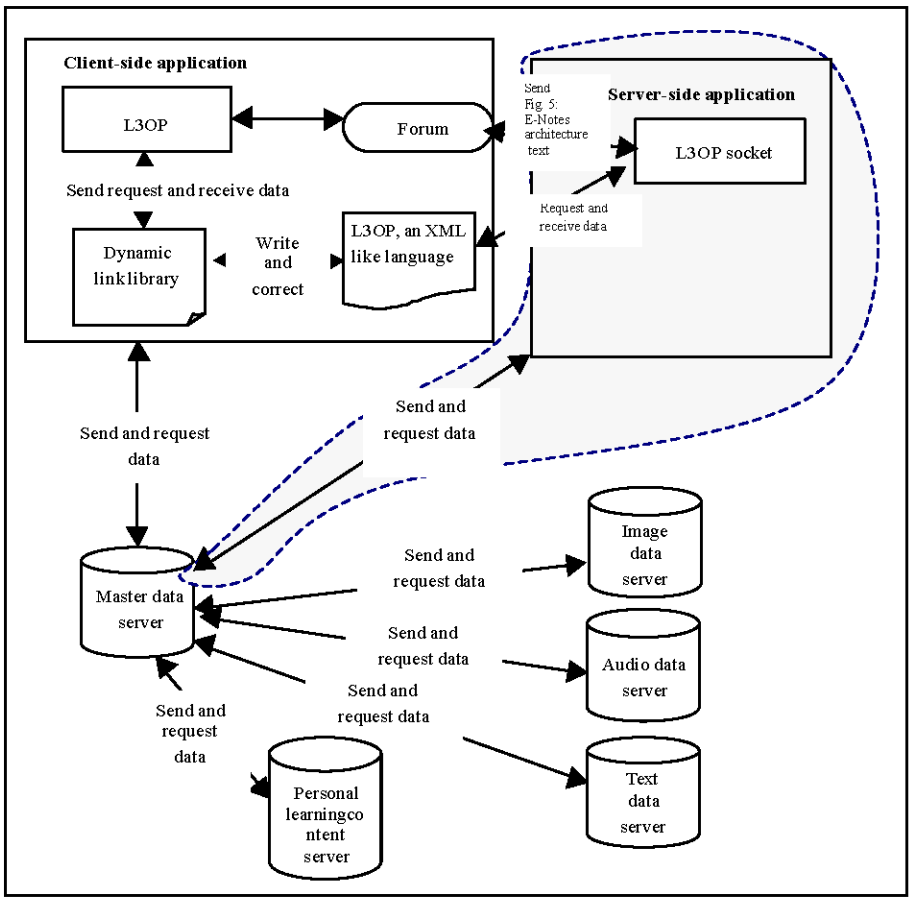

Fig. 3: E-Notes architecture

The client-side application communicates with the offline database through a self-created DLL file. The client-side application has five main features, which are learning contents editor, information searching agent, file viewing tool, reader agent and communication tool. The communication tool is a forum that is similar to a chatting application and is developed by using Microsoft Winsock control. In the client-side application, the offline database is divided into a master database and several file type databases, which are the image database which stores image files with formats of. gif,. jpeg and. bmp. The audio database stores multimedia files with formats of wav, avi and swf and the text database stores text files with formats of txt. The personal learning content server stores all the registered user's personal learning content files and it will be identified by the registered user name. The master database stores the base files that are needed to operate the system. Figure 3 shows the system architecture for the new reusable learning object system. The dotted area that shows in Fig. 3 is the server-side application, which will be excluded from the distributed database implementation.

CONCLUSION

A distributed database for e-notes modules which make use of reusable learning objects has been developed, in which users are able to search, save, edit and reuse the learning objects in graphic, text, audio and video representations across the computer network. The developed system allows users to use the existing learning contents but new learning contents can be added to the database as sharable learning content for future studies as well. Sharable learning contents are the existing learning contents that have been created and are to be shared among users. However, the sources of the sharable learning contents can also be obtained from the Internet or other registered users who would like to share their personal learning contents with other users.

The system user can search for and retrieve the learning objects from heterogeneous distributed offline databases. Since the developed system applies a client-server based and distributed approach, it can cater for a growing number of users. In order to provide more choices in the reusable learning object environment, learning objects are distributed to the other databases according to the learning object categories respectively on the network. Even though the project has been successfully completed, it does have some limitations which require project enhancement in the future. The limitations of this project are:

- The distributed database approach has been implemented on the client-side application only. Therefore, the distribution and retrieval of learning objects will be restricted on the offline databases
- The reader agent component of this project requires a Microsoft Windows 2000 or above operating system in order to support the component installation and execution
- The learning contents and learning objects that are stored in the online database and the offline database are not the same. Even though both databases have the same data structure, each of the databases has a separate and independent learning contents set. For instance, when the user selects the offline mode before logging on to the system, then they are limited to manipulating and retrieving the learning contents from the offline database only

Several project enhancements are suggested in order to improve the project limitations. These suggested enhancements are:

- The distributed database approach should be implemented in the server-side application as well, so that the benefits of the distributed database for reusable learning objects could be utilized in the client-side application and the server-side application as well
- Learning contents should be transferable within the online database and offline database. If the transferable concept is applied to this project, then redundant jobs are eliminated, since the learning contents which are stored in the online and offline databases are synchronized. In such a case, the user does not need to update the same learning contents again when he or she switches to a different system runtime mode
- It is suggested that an additional page which displays the search results of board files should be created. Readable and useful search results information that is generated during the searching task executed on a collection of distributed databases should be provided, so that the user can select a suitable board file and use it in his or her personal learning contents
- Full use of XML technology will decrease tremendously the executing response time.

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