Web-based Collaboration System to Improve the Interactivity for Mobile Education through Smart Devices

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***Abstract*—Mobile education is a term that describes a relatively new way of education. Generally speaking, mobile education is aimed to facilitate teachers, students, and parents to interact with each other through mobile devices. This term gains much popularity especially in recent years with the smart devices coming into vogue. With the development of broadband networks as well as the evolution of smart devices, more and more people have come to realize that smart devices can become an effective medium for mobile education. This paper proposes an innovative approach to implement a mobile education system through web technology, which is regarded as an effective mean of overcoming cross-platform obstacles caused by the diversity of smart devices. Considering the constraints of web technology, research and development are undertaken to enhance the stability of the connection as well as the instantaneity of communication. Also, an awareness component is designed for detecting the user's environment such as location, network condition, and hardware specification in order to provide appropriate services. Our research and development lead to significant improvement in the interactivity and the usability of a web-based system.**

Keywords—interaction; smart device; mobile education; mobile learning; remote education; web-based system

I. INTRODUCTION

A. Concept and Background of Mobile Education

Mobile education is a term that describes a relatively new way of education. One definition of mobile education that is commonly accepted by the public is that educational activities can happen anywhere, at any time, by taking advantage of mobile technologies. The concept has gained much popularity in China in recent years.

When this technology was just beginning to develop, a number of apparatuses were exclusively designed for mobile education, one such example being a series of digital learning devices produced by the Noah Corporation, which undertook a case study on the implementation of mobile learning in basic education [1]. However, this type of apparatuses faced several challenges such as the low performance on its hardware, difficulty to upgrade software, and the high cost for maintenance. Later, people began to try implementing mobile education through mobile phones [2]. Nevertheless, these types of systems were only able to provide teachers and students with limited functions owing to limitations of network bandwidth and hardware performance at that time. With the development of broadband networks as well as the evolution of smart devices, more and more people have come to realize that smart devices could become an effective medium for mobile education and some researches have already been undertaken in recent years [3] [4].

B. Necessity of Mobile Education

It is anticipated that mobile education makes flexible and ubiquitous leaning possible. Meanwhile, another "side-effect" of mobile education is that it can greatly enhance the interactivity between students and teachers by using the smart devices. It is widely acknowledged that students' learning efficiency can be greatly improved through interactive pedagogical activities. Based on this point, many educators are seeking new approaches for education with the principle of enhancing interactivity. In this paper, an innovative mobile education system for classroom scenario by taking advantage of smart devices is introduced, which also takes the special need of China market into consideration.

C. Prerequisite for Mobile Education

In order to fulfill the functionalities of mobile education, which is to make flexible and ubiquitous learning possible, several prerequisites should be considered.

- Network condition: In this paper, a survey on the 3G network services provided by several major providers in China in terms of the accessibility and expense is conducted. A report from China Telecom, which is one of the major telecommunication carriers in China, indicates that on average 97% of the urban area and 92% of the rural area have been covered with 3G networks by the end of 2012. In addition, the proportion of the users who have subscribed the telecommunication plan with the bandwidth of no less than 4 Mbps to all has reached to 70% by 2012. Besides, the expense varies from 80 RMB per month to 300 RMB per month based on the available utility time and data volume, which is affordable for the majority

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of the families in China. Therefore, the network infrastructure in China has provided a ready-to-use environment for mobile education.

- Mobile devices: With the advent of smart devices, it is widely accepted that these inventions can become a useful tool for mobile education. An earlier study [5] shows that students are more willing to use mobile devices for learning because such devices can provide them a flexible way of assimilating knowledge. In the meantime, the physical design of the most recent smart devices such as accessibility of wireless network, large screen size, and user-friendly interfaces makes them easier to be utilized for mobile education.

Therefore, the development of wireless and mobile technologies makes it feasible to implement the mobile education in China right now.

D. The Obstacle for the Implementation of Mobile Education from the Perspective of Technology

An earlier study [6] points out that one of the core issues for mobile education is how to facilitate users to utilize different devices to participate in educational activities. Currently, the most commonly used operating system for smart devices are iOS, Android, BlackBerry, and Symbian. As a result of that, the biggest headache for the developers of mobile education is to implement the interconnection among all kinds of smart devices. Thus, this paper also presents an effective way for solving this problem by taking advantage of web technologies.

E. The Outline of the Paper

This paper consists of four parts, among which the first one introduces the concept of the mobile education. It also gives analysis of the necessity, the prerequisite, and the difficulty of mobile education. The second part illustrates a mobile education system from the perspectives of functionalities, architecture design and workflow, followed by the third part, which evaluates the characteristics of the proposed mobile education system. Finally, the market promotion information related to this system is presented and certain future works are proposed in the fourth part.

II. SYSTEM DESIGN

A. Functionalities

After analyzing the most frequently used teaching methods, it is found that in the majority of situations, the teacher employs pedagogical techniques, while the students passively follow the teacher's instructions and explanations. Therefore, the following functions are designed for teachers and students based on the principle derived from the above phenomena.

1) Teacher:

a) Lesson preparation: The proposed system provides teachers an interface to prepare a lesson easily. A survey conducted by Hitachi researchers shows that most of the Chinese teachers prefer making courseware such as PPT, PDF, and short videos in advance. Consequently, the designers for the mobile education system consider the habits of the teachers and provide them a flexible approach to utilize their existing courseware. The proposed system allows the teacher to upload the prepared courseware beforehand.

b) Courseware distribution: As stated earlier in this paper, teachers get used to taking advantage of the courseware which is prepared in advance for efficient teaching. The proposed system provides them a convenient way to distribute their courseware which is uploaded during the "lesson preparation" phase. The courseware can be mainly classified into two categories, one of which is the document such as Word, PDF, and PPT, the other is the multimedia such as short videos and audios. After a teacher starts a lesson, the server of the proposed system will send related courseware to the teacher's and the student's clients according to their operations.

c) Teaching and demonstration: The proposed system provides teachers the functionality to demonstrate the courseware. These functions can be classified as two categories, one of which is for demonstrating documents such as Word, PDF, and PPT, the other is for demonstrating multimedia such as videos and audios. For instance, if the teacher chooses to show a PPT, he or she can directly flip to the slide which is required to demonstrate to the students. Besides, the client of the teacher provides basic tools for the teacher to make annotations directly on the document which can be kept even after the end of the lesson for the students to review later. These tools, such as straight-line pen, rectangle pen, and ellipse pen, can greatly facilitate teacher's teaching process. In addition, the system provides the teacher unlimited white boards for drawing and writing. In this way, all these valuable and useful notes can be conserved completely, which solves the problem caused by limited space of one white board in the traditional classrooms. For another instance, if the teacher chooses to play a video, he or she can click down and drag the playback progress bar to adjust the playback progress.

d) Camera and microphone control, question collection: The proposed system allows the teacher to open the student's local camera to transmit video image back to the teacher. Besides, the teacher can also open his or her local camera for the students to look at the teacher. This function is necessary and essential especially when there is a strong demand for demonstrating the experiment process during the class such as chemistry, physics, and biology. Besides, the teacher's client will automatically display the questions which are collected from the students' clients. This can greatly help the teacher to understand the difficulties that the students encounter during the course of learning, and then adjust the teaching process appropriately and timely.

e) Controlling transfer: During the teaching process, the teacher may often need to appoint one student to temporally act as the teacher to give a presentation. In this case, the proposed system allows the teacher to transfer the controlling right to a specific student, which enables the student to carry out all the operations just like the teacher.

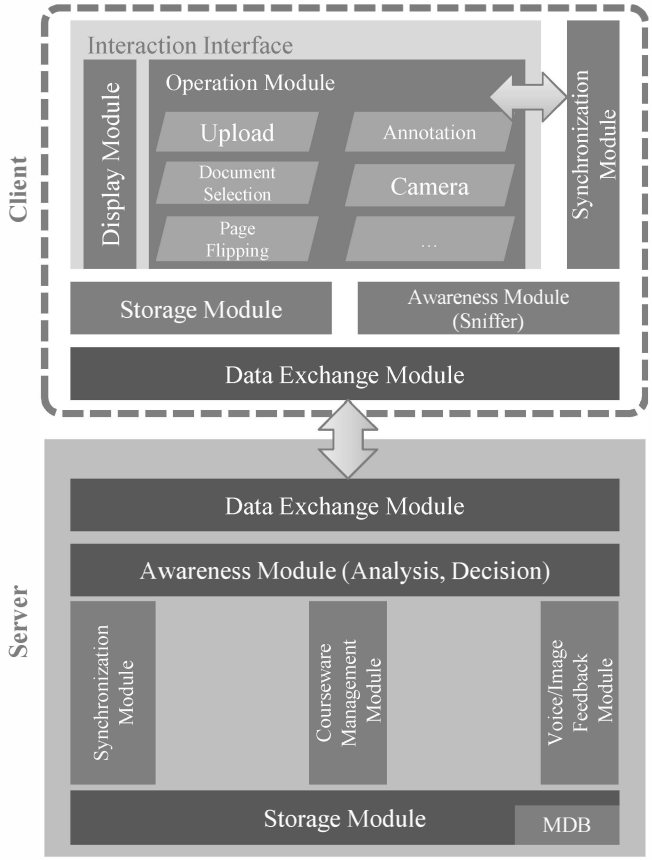

Fig. 1 Architecture of the mobile education system

However, the teacher can retrieve the controlling right at any time.

2) *Student:* The system provides students two modes to use, which are the passive mode and the active (self-study) mode. The student can decide to switch over between the two modes according to his or her own choice. If a student chooses the passive mode, the student no longer need to do any operations and his or her client will duplicate the main client's operations (main client is the teacher's client, otherwise it is the student's client to which the teacher transfers the controlling right) without the student's triggering. For example, once the teacher flips a document, the documents on the student's client will be flipped automatically. Once the teacher broadcasts a video, the video will be played on the student's clients simultaneously. Besides, all of the annotations made by the teacher will be synchronized to the student's client in real time. However, students can type their questions into a text area and then send to the teacher anytime during the class. In contrast, if a student chooses the active mode, then the student can operate to view all the courseware separately.

B. Architecture

The design of the architecture for the proposed system is aimed to eliminate the technical obstacles raised in the first part, which are the instability and the delay over ordinary network environment between various smart devices as well as the cross platform issue.

Browser-Server structure (BS) is chosen as a basic framework to implement the system. Since the HTML5 progresses greatly in the recent years, it has greatly increased the capability of web browser by supporting the latest multimedia. Besides, some of its new features make it possible to complete complex and smooth interactive operations through a web browser. Furthermore, almost all kinds of the operating systems for smart devices integrate the web browsers, so BS structure can help eliminate the cross platform issue easily.

Fig. 1 shows the architecture of the proposed system. In order to explicitly illuminate the architecture, this section explains the client and the server separately.

1) The architecture of the client consists of the following parts:

a) Interaction Interface: Interaction interface contains two modules, which aim at bridging the system and the users. In other words, it provides the functions directly related to users. One of the modules in it is the display module that renders certain contents on the client's screen. The other one is the operation module that processes the commands received from the user or the synchronization module.

b) Synchronization Module: This module helps implement the function related to synchronization by managing a status record of its own client. The format of the status record is shown in TABLE 1. Each courseware, such as the document or the multimedia (video and audio), is assigned a unique ID after the teacher uploads it to the server. And each client keeps the record of the "Document ID" and the "Video/Audio (V/A) ID" of which are being demonstrated. Meanwhile, the "Page Number" of the demonstrated document and the "Playback Time" of the demonstrated video or audio are kept. Besides, the status of the local camera and the microphone is also kept in the record.

If a client is a main client, for example, the teacher's client, it will send the status of its own to the server automatically for other's synchronization. If a client is a subordinate client, it will retrieve the status of the main client and compares it with its own. After that, certain functions of the operation module in the interaction interface will be invoked automatically for synchronization if it finds differences.

c) *Storage Module:* It mainly stores two kinds of content, one of which is the courseware downloaded from the server, and the other one is the client's status information which is used by the synchronization module.

d) Awareness Module (Sniffer): This awareness module

TABLE 1. STATUS RECORD

Courseware				Camera and Microphone
Document		Video and Audio		
Document ID=0	*Page Number=0*	*V/A ID*	*Playback Time*	*no/off*

collaborates with its counterpart on the server side to acquire appropriate services for the client according to its environment. The client's awareness module collects the environment parameters such as the network bandwidth, the available memory, the screen size and resolution, then sends them to the server.

e) Data Exchange Module: It is designed for establishing and maintaining the connection between itself and the server.

2) Corresponding to the client architecture, the architecture of the server consists of the following parts:

a) Data Exchange Module: It collaborates with the client's data exchange module to implement the communication between the server and the client.

b) Awareness Module (Analysis, Decision): It receives and saves the information which is collected by the client's awareness module (sniffer). Then, this information is analyzed by the server for better understanding each client's environment. Finally, the decision is made on what kind of services should be provided to each client.

c) Synchronization Module: This module maintains a copy of the status record for the main client. It modifies the record as long as the record of the main client changes in order to keep them unified. Subordinate clients then keep synchronization with the main client by comparing the record of their own with the record of the server.

d) Courseware Management Module: This module manages the courseware, including compressing, storing, and acquiring documents and multimedia uploaded by the teacher.

e) Voice/Image Feedback Module: This module controls each client's camera and microphone for retrieving image and voice.

f) Storage Module: This module abstracts database accessing from the upper level. The upper level modules send the requests with the unified format to this module for the requirement of storing and acquiring information. In order to provide rapid synchronization among all devices, frequently used data and public information such as the main client's status record is kept in the memory database (MDB).

C. Workflow

This section explains how each module cooperates with each other to complete the interaction between the teacher and the students. It is supposed that all the courseware has been uploaded to the server through the teacher's client before the class. When the class begins, all clients, including the teacher's and the students', connect with the server and each of their display modules shows a courseware list.

The Fig. 2 illustrates the workflow of the function that a teacher selects a document and then a student synchronizes with the teacher's operation. The part rounded by the dashed line is the main procedure that implements the synchronization, which is introduced below in detail.

First, the teacher selects a document through the operation module. Then the synchronization module modifies the status

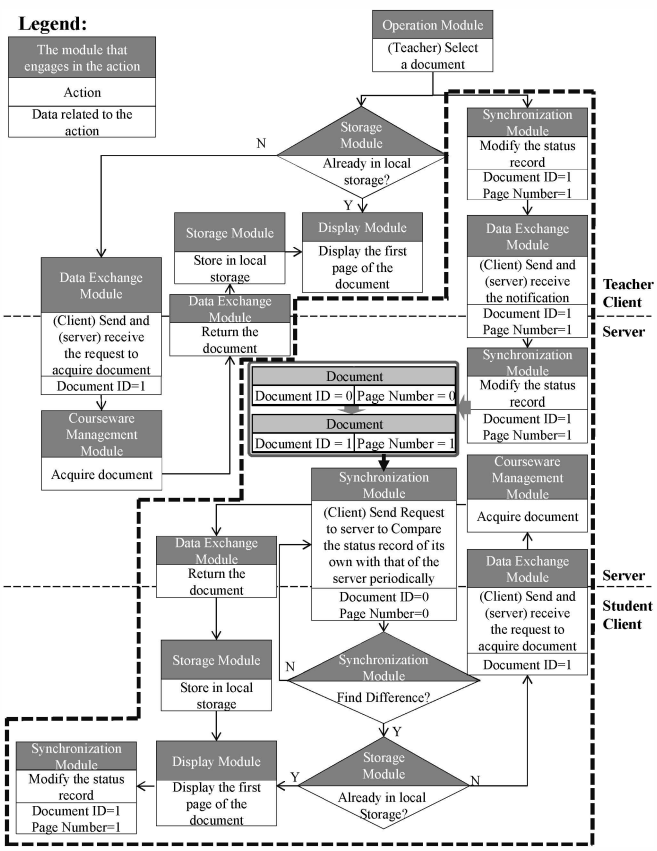

Fig. 2 Workflow

record from the initial state (Document ID = 0, Page Number = 0) to a new state (Document ID = 1, Page Number = 1), and the data exchange module sends a notification to notify the server in the next step. After receiving the notification, the synchronization module of the server also modifies the status record from the initial state (Document ID = 0, Page Number = 0) to the new state with "Document ID = 1" and "Page Number = 1" in order to keep the same with the teacher's client.

The synchronization module of the student's client sends requests to the server to compare the status record of its own with that of the server periodically. As soon as a difference is found, it will invoke certain process to synchronize with the server.

After the server modifies the status record, the student's synchronization module finds that its own status record (Document ID = 0, Page Number = 0) differs from the server's. Then the storage module checks whether the document with the "Document ID = 1" has already been stored in its local storage. If so, the display module will display the first page of the document and the synchronization module will modify its own records with the "Document ID = 1" and "Page Number = 1" to keep the same with the server's. If not, the student's client will send the request to the server for acquiring the document with "Document ID = 1" then store it in its local storage for displaying. After that, it will modify the status record to be identical with the server's.

TABLE 2. WIRELESS ROUTER SPECIFICATION

Cisco CVR100W	
Wireless transmission rate	300Mbps
Transmission standard	IEEE 802.11b/g/n

TABLE 3. SERVER AND CLIENT SPECIFICATION

		Server	Client (iPad)	Client (Sumsung P5110)
Hardware	CPU	Intel G645	A6X	NVIDIA Tegra 3
	Memory	4GB DDR3	1GB	1GB
	Storage	250GB	32GB	16GB
Software	OS	Windows 7 ulimate	iOS 6	Android 4.1
	Browser	Chrome v21.0.1180	Safari	Chrome Android

D. *Awareness*

The proposed system also contains an awareness function, which can take the environmental information into consideration for providing teachers and students with appropriate services. There is an awareness module in both the client and the server but they are different in functionality. The awareness module on the client side is responsible for collecting client's environmental information such as the network condition, the available memory, the screen size and resolution, which will be sent to the server periodically. The awareness module on the server side is responsible for saving the environmental information for each client. Furthermore, it analyzes the information in order to better understand the users' circumstances so that it can adjust the services provided to the teacher and students accordingly. For instance, a student's client reports its network bandwidth every five minutes to the server through its awareness module. The server notices that this client's bandwidth is decreasing for certain reasons. As a result of that, the server makes the decision that documents with the lower resolution should be provided to the client for avoiding the transmission delay. After that, the server sends the client the documents with a lower resolution each time the client sends a document acquisition request.

The awareness module on the server side can work independently. It keeps records of the decisions made for each client. As long as there is a request to provide certain service to a client, the server can refer to these decisions and take action reasonably.

III. EVALUATION

A. *Evaluation Purpose and Approach*

The purpose of this section is to verify the stability and the instantaneity of the system. The system is built in a real classroom environment, and the monitoring software WireShark 1.6.3 records the data transmission time and the data size.

First, a wireless local area network is established through the router "Cisco CVR100W". Then one server and ten clients, including five iPad and five Samsung P5110, are connected to the network so that they are interconnected with each other. The technical specification for the router, the server, and the clients are listed in the TABLE 2 and the TABLE 3.

B. *Test Results*

The main functions that have been tested are document selection, page flipping, and annotation creation. The synchronization time for each operation begins at the moment that the main client makes an operation and ends at the moment that the last subordinate client completes the same operation. The transmission data size for each operation is the total size of the data that is required to be transmitted between the server and a client for synchronization. Each operation listed in the Fig. 3 and the Fig. 4 is repeated for one hundred times. The synchronization time and the transmission data size for each operation are recorded and the average values are calculated accordingly. The Fig. 3 shows the result that in the various operations, the average synchronization time of the system is 886 milliseconds, which is less than 1000

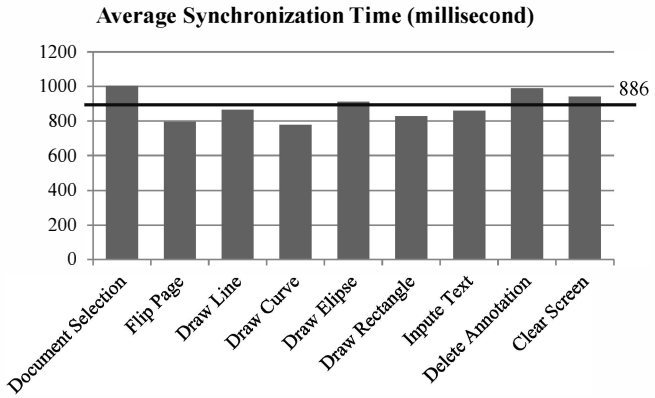

Fig. 3 Average Synchronization Time

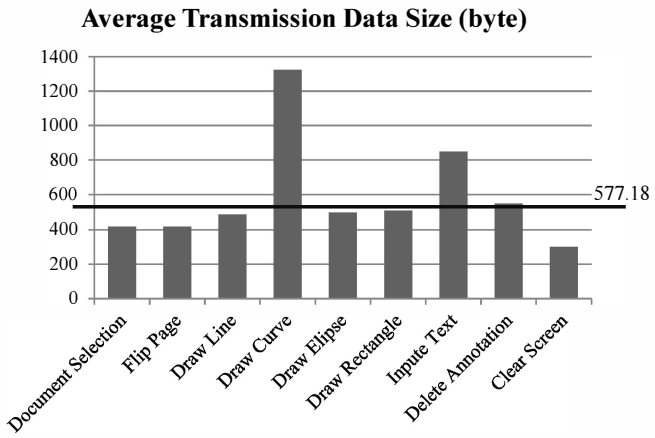

Fig. 4 Average transmission data size

milliseconds. The data proves that it can support smooth education process with tolerable delay in the real classroom environment. The Fig. 4 shows the result that in the various operations, the maximum transmission data size is 1300 byte, and the average data size is 577.18 byte. The regular 3G networks should be able to carry this kind of data amount with full capability to achieve the stable and real-time data communication for educational purpose.

IV. CONCLUSION

This paper proposes a relatively new way to implement a mobile education system. Through introducing the latest web technology, the system has many advantages such as zero cost deployment, cross-platform, and high interactivity. These features are always the key factors that determine whether a mobile education system can be successful.

So far, this system has been proposed to many Chinese local education bureaus and showcased at a number of exhibitions. The fact that numerous feedbacks have been received indicates that it has huge potential to become a dominant product in education industry in China. Many teachers comment that this system truly incorporates their teaching demands and habits, which makes it easier for them to accept and use. On the other hand, this system takes good advantage of children's interests in smart devices, a fact that can potentially trigger their desire for learning.

There is still a long way to go to improve the mobile education system. As mentioned at the beginning of this paper, the system considers only the teaching phase currently as the first attempt. It also has the potential to be adopted as a tool for remote education. In order to build a complete education system that covers the whole education process, further investigation and research must be carried out.

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