MOBILE EXAM SYSTEM – MES

Architecture for Database Management System

Joan Lu[1], Aswin Sundaram[1], Zhaozong Meng[1], Vidyapriyadarshini Arumugam[1], Gehao Lu[1],

John B Stav[2]

[1]*Informatics, University of Huddersfield, UK*

[2]*Faculty of Technology Sør-Trøndelag University College, NiST, Norway*

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Abstract

As the mobile applications are constantly facing a rapid development in the recent years especially in the academic environment such as student response system (Lópeza, Royoa, Labordab & Calvoa, 2009; Ngai & Gunasekaran, 2007; Mary & Biju, 2008; Nayak & Erinjeri, 2008; Roth, Ivanchenko & Record, 2008; Lu, Stav & Pain, 2009; Lu, 2009; Turning technologies, 2010) used in universities and other educational institutions; there has not been reported an effective and scalable Database Management System to support fast and reliable data storage and retrieval. This paper presents Database Management Architecture for an Innovative Evaluation System based on Mobile Learning Applications. The need for a relatively stable, independent and extensible data model for faster data storage and retrieval is analyzed and investigated. It concludes by emphasizing further investigation for high throughput so as to support multimedia data such as video clips, images and documents.

Keywords: Mobile Computing, Mobile Exam System, Database Management System, and XML Schema

Mobile Exam System - MES

Ever since Mobile Technologies emerged in 1980s, enormous amount of development has been made and improvements are constantly evolving everyday that almost any given Internet application can now be utilized to its maximum usability on a handheld device such as PDA, iPhone, iPod, Android etc, (Mantyjarvia & Seppanenb, 2003). Further developments are being made to enhance higher data rate, effective use of smaller screen size and the ability to handle multimedia data formats such as images, documents and video clips as if they are used on a personal computer or a work station (Jonsson, Nass & Min Lee, 2004). Currently the academic bodies are making good use of mobile applications for e.g. student response system (Lópeza, Royoa, Labordab & Calvoa, 2009; Ngai & Gunasekaran, 2007; Mary & Biju, 2008; Nayak & Erinjeri, 2008; Roth, Ivanchenko & Record, 2008; Lu, Stav & Pain, 2009; Lu, 2009; Turning technologies, 2010) particularly mobile based response system which can be evolved to support a large number of concurrent users to access resources (Amailef & Lu, 2008).

Mobile technology is dramatically shaping the nature of teaching, learning and social interaction. Students and teachers may integrate technology and learning both in and out of the classroom, due to portability of mobile devices and their ability to connect to Internet almost anywhere. Is it possible to improve students' learning by organizing the teaching process in different methods that are more time effective and efficient, for instance, by using modern hand held mobile computing solutions in learning processes? *Student Response Systems (SRS)* seems to be a promising technology in the recent days. Successful initiatives have recently been reported from UK. Mazur (Mazur, 1997) outlined effective use of SRS in peer instruction in 1997. Main research findings in the area of clicker based response technology, point out to us that attributes like i) feed-back on learning (Rice, 2006), ii) increased involvement (Rice, 2006), and iii) more discussions and peer-learning (Masikunas et al & Bates et al, 2006) are commonly appreciated by the students.

Students may indeed soon answer tests by using a mobile device like their own Smartphone. Could such tests be designed to enhance learning by utilizing interactive learning methods? The European Commission has recently funded a KA3-ICT project that is going to use Smart phones to turn results of tests into a creative learning process. The project are going to develop a new evaluation model where test results for a class are turned into an active, creative and collaborative learning process by the use of immediate feedback:

- Verification feedback led by a teacher: why is this particular answer correct and why are the others incorrect.
- An elaborate feedback discussion run by students: the answers are displayed but they don't know which the (in) correct ones are.
- An elaborative feedback discussion led by one student: the deviation from the correct answer without addressing why this is correct and the other ones are incorrect.

This objective of this investigation is to propose a suitable architecture for database management to support 'Innovative Evaluation System in mobile learning.

Background

A student evaluation system that utilize Smart phones must give the teacher a new tool, allowing him/her to either give verification or elaborative feedback to individual students or groups of students immediately after a test. This is a key factor helping students to improve their skills by the use of active collaborative supported learning. Students will, when they still remember the questions in the test, learn why the correct answer is correct and why the other ones are incorrect. Thus, mobile technology provides new evaluation and testing criteria for education and training.

According to contemporary models of learning, individuals understand and remember new material best, when they elaborate on that material in some manner (Pressley et al., 1992) for inclusion of elaborative interrogation, and (Wittrock, 1990) for new models of Informative Technology [IT] generative learning. Elaboration can take the form of adding details to the information, clarifying an idea, explaining the relationship between two or more of the new concepts, making inferences, visualizing an image of some aspect of the material, applying an analogy relating the new ideas to familiar things, or in some other way associating the new material with tests. A guided questioning strategy may facilitate learning, by prompting students to solve specific thought-provoking questions pertaining to the material to be learned, and those questions in turn, elicit relevant explanations. The characteristic of the questioning strategy that accounts for these effects is the critical-thinking nature of the question prompts and the high degree of learner autonomy and independent learning within the structure of such a strategy. However, students cannot today immediately verify their learning by using open online student response system technologies during tests/exams, as feedback is published after days/weeks by use of traditional written solutions. The EduMecca project, 2009-10 provided an open, easy to use web-based (a HTML page) student response services for iPod/iPhone (EduMecca & Stav et al, 2010), where the instructor may post one question to a class, and the students may respond by polling anonymously at a predefined number of alternatives provided by the teacher. The ongoing Done-IT project (Done-IT 2011), which is part of the KA3-ICT within the Lifelong Learning Programme, is going to go beyond the EduMecca project, and develop a prototype for carrying out tests and examinations on mobile devices, thus extending use of SRS into examination processes.

The new student evaluation system may serve as a gateway to active learning for students that may be used for in-class laboratory experiments, but also for distance training purposes. Each student may use their Smartphone to answer and mark multiple-choice tests with a number of questions. An embedded automatic marking system is included. The training method includes using cases and/or experiments demonstrating what to do, how it works, and what the deviation will look like. The new open mobile technology based evaluation services may help improving certification processes.

Mobile Exam System

Mobile exam system refers to the exam process that involves using mobile devices. The process is integrated with the mobile technologies, e.g. Smart phones, mobile computing and signal communications (Joan Lu, 2011). The system links to data management services and mobile application interfaces acting as multiple clients in the wireless communication system. The system is portable, dynamic and flexible in comparison with online desktop exam systems (Šárka Hošková-Mayerová and Pavlína Racková, 2010). XDIR research group proposed a new prototype to improve operational efficiency of Mobile Exam System based on pure mobile devices (J. Lu, Meng, G. Lu, 2011). Objective of this research was to identify a simple and relatively faster solution for using the mobile based exam system simultaneously for e.g. in a classroom.

It has been found in this system:

1. Mobile based application could be simpler and faster
2. Users do not have to always rely on Internet browsers, therefore cost effective by using alternate methods such as Wi-Fi connection.

Importantly mobile devices can potentially reduce a large amount of hardware, memory and storage in comparison with workstation.

Database Management System for Mobile Applications

Because of the fact the data collected by the response system (J. Lu, Meng, G. Lu, 2011) are short codes of limited character sets; the need for a data model seems inevitable and hence structured data for storage in data management systems such as relational databases in considered as the starting stage of the database architecture and hence the idea of using RDBMS arises (Scalability performance of MySQL, 2011).

RDBMS in Mobile Applications

Ideally the data model has to evolve in such a way that whenever the application interfaces are changed, the database mechanism acts in a relatively stable manner. This will strongly pave way to scale the data model to accommodate multiple application support.

Many successful and effective RDBMS are available in the market such as MS SQL Server, Oracle, MySQL, MS Access, SyBase etc. For the initial investigation, the database architecture will implement MySQL and analyze the results.

There has been constant increase in the number of companies using MySQL for instance Youtube video, Adobe, Virgin Media, McGraw-Hill Education, iStockphoto, social networks such as Wikipedia have currently benefited and effectively using MySQL (MySQL customers, 2011).

Relational database servers generally provide:

1. Data Management
2. Data backup and recovery
3. Data Integrity
4. Data Security
5. Transaction processing

ORDBMS

Object-Relational Database Management System is very similar to relational database management but with object-oriented database model like classes, objects, inheritance, polymorphism and other object-oriented concepts that are directly supported in database schemas and query language. When an application uses this type of database, it will generally consider the data that is stored as objects. Similarly, for data retrieval, it must be reconstructed from simple data to complex objects.

The aim of ORDBMS is bridge the gap between conceptual data modeling methods like ER diagrams with Object-Relational Mapping [ORM].

ODBMS

Object-Oriented databases are also referred to as *Object Database Management System [ODBMS]*. These types of databases store objects instead of data such as numbers, strings and other integers.

XDBMS

An XML Database Management System is also called as XDBMS, innovative database technology software that allows the data to be stored in an XML format. The data thus stored can be queried, exported and serialized into any desired format.

There are two types of XML database that exist. They are:

1. XML – Enabled
2. Native XML (NXD)

Advantages of XML Databases

1. *Efficient* – Eliminates redundancy; generates consistent and cost-effective workflow.
2. *Sturdy* – Fast, stable, traceable and comes with a sophisticated authorization system.
3. *Simple* – Automatically takes care of complex tasks and relatively simple.
4. *Connected* – Effortlessly assimilates existing data collections.
5. Object-oriented and relational.
6. Embedded security and high-speed access to even the complex data models.
7. Reduced maintenance and flexible interfaces.
8. No more redundancy.

Problem Identified

However, the system has also identified that there are a few major limitations as follows:

1. Traditional data management system could pose bottleneck because the response system is based on 'many to many' relationship at any given time and will scale to a large number of simultaneous responses.
2. The system has to serve a large number of concurrent users accessing or responding to the system and hence the need for a suitable database management system arises.

The response collected was in an unorganized format and concern for storing this data and retrieve readily is inevitable.

Aims and Objectives

The system solution should be so fast to use that the teacher when going through the tests at each single question may decide on the fly if he/she will use a traditional verification feedback, or one out of the 2 alternative elaborative feedback solutions described above. The later alternatives also include peer instruction learning processes, where students may get a possibility to consider changing their mind. This system solution is going to give the teacher a new tool where he/she may give either verification or elaborative-based feedback to single students or groups of students immediately after a test. This is a key factor helping students to improve their skills by use of active collaborative supported learning.

Questions could be stored in a database. Each student may get (some) separate tasks on a test. The teacher prints the test on paper, and distributes them to the students. Students use secure identification and answer their test by using a mobile device. They may start wherever they want, and easily jump forth and back between tasks as in an ordinary test. Immediately after they have submitted the final answer, they get feedback with the score, and the teacher gets automatically the result for the class. Each and every student is been identified using the latest XML security techniques and thus securing confidentiality. Student login information (student ID) is managed in database systems, which will be linked to exam session, answered question number, current test and history tests as well. Results will be managed by local database system and further transferred to data repository.

Based on previous investigation, the student response system can be scaled to an 'Innovative Evaluation System' and the paper proposes:

1. To design a suitable architecture for database management system to support 'Innovative Evaluation System'.
2. The architecture to support an independent data model that is relatively stable and scalable.

Effectively convert raw data or responses that are in the form of tables into well-defined XML schema so that it can be stored as data objects into database and to be able to retrieve readily when required.

Proposed Database Architecture

The data or response collected in raw format such as tables, texts are parsed and converted into an XML schema. This well documented XML schema is then set as data feed through an API access over a server scripting language like PHP run on an apache server as shown in figure 1.

XML schema is then converted into data objects by the use of Object Relational Mapping [ORM] open source tools such as Doctrine (http://www.doctrine-project.org/) or Propel (http://www.propelorm.org/) based on Objected Oriented Programming concepts and data model. This mechanism makes it possible to address the access and manipulate objects without having to consider how those objects relate to their data sources. Thereby lets the system maintain a consistent view of objects over time, even as the sources that deliver them, the sinks that receive them and the applications that access them change. The API then adds system parameters, deploys indexing techniques and automatically generates the code to create, insert, read, update, and delete (CIRUD) records from the database systems.

For the initial system architecture, RDBMS is used as the initial attempt but not limited to it. Keeping in mind they are powerful because they require few assumptions about how data is related or how it will be extracted from the database. As a result, the same database can be viewed in many different ways. Due to the fact that RDBMS is used, the data models describe structured data for storage at this stage. The API layer is designed to perform all the data storage and retrieval mechanisms associated with the system.

Database Indexing Algorithms and Techniques

Basically, database indexing is a data structure that improves the performance of the system by faster retrieval of records from the database table and thereby decreasing the time consumed and increasing the data storage. Database indexing is a very important task in the huge database storage systems. The Index table occupies very less storage when compared to other tables in database system.

Index architecture can be classified into two major types:

1. Clustered
2. Non-Clustered

In *Non-Clustered* index, the data is spread in a random order that is data rows are randomly spread out in the database tables. On the other hand, in *Clustered* index the data rows are sorted in order. As a result, only one clustered index can be created on a given database table. These types of indices greatly increase the overall speed of the retrieval but when a range of items is selected or when the data is accessed sequentially.

Even though there exist many ways of improving the performance of the database system; the most effective and efficient method should effectively implement the data indexing mechanism. The most used indexing mechanism in nowadays Database Request Module System [DBRMS] is *B-Tree, Bitmap, R-Tree and Tree.*

Bitmap Index

Bitmap index is a unique structure of database indexing technique that uses bitmaps. This type of indexing has a significant advantage of space and performance over other data structures. Bitmap indexing generally uses bit arrays and functions by performing bitwise logical operations on these bitmaps.

History of Bitmaps

The original concept of bitmap index was first introduced by Professor Spiegler and Maayan (1985) in their research "Storage and Retrieval Considerations of Binary Data Bases".

B Tree Index

B Tree is also called as a *Balanced Tree.* This tree represents sorted data that allows basic operations like insertion and deletion of records, each of those identified by their unique *key*. It is dynamic and multi-level index that has the block or node with maximum and minimum bounds on the number of keys in each segment. Its main objective is to store data for efficient retrieval of records in block-oriented storage structure, mainly file systems.

History of B Tree

The B tree was first described in the paper *Organization and Maintenance of Large Ordered Indices Acta Informatica* 1: 173–189 by *Bayer* and *McCreight* (1972). Then, the theory was further developed as B+ tree, B+_ tree (Allaoua Maamir, William I. Grosky, 1997). Gradually it becomes a popular technology in search mechanisms in database operations (Driscoll, et al, 1987, Cheng et al, 1996, Ohn, Cho, 2007).

R Tree Index

The hierarchical structure of an R-Tree, also called as *height-balanced tree* is quite similar to B-Tree with index records at it leaf nodes containing pointers to data objects and its data indexing slightly different from B-Tree. R-Tree data access methodology organizes data in a tree-shaped structure called R-Tree index. R-Tree indexing is one among different spatial indexing types used in spatial databases for multimedia retrieval.

Antonin Guttman (1984) was the first person to introduce the concept of R-Tree that will handle spatial data effectively and help to retrieve data items quickly according to spatial locations.

Tree Index

The Tree structure is the most widely used data structure in indexing consisting of a hierarchical tree structure with a set of linked nodes.

TPR*-Tree Index

TPR*-Tree is an optimized spatio-temporal access method for predictive queries (Tao, Papadias & Sun, 2003). TPR-Tree uses insertion and deletion algorithms of R*-Tree, designed for only static data. In contrast, TPR*-Tree uses some unique features of dynamic objects with the help of some enhanced set of construction algorithms. Due to numerous emerging applications like traffic control, meteorology monitoring, mobile computing, etc., the spatio-temporal databases that are mainly used for large databases are becoming increasingly important in the recent days. These systems are generally used to deal with past information based retrieval or future prediction based on present scenario; for example, "find all flights that fly over London in the next 15 minutes".

Case Study

With the guidance theory of simplicity and efficiency, prototype starts from a system with adobe flex supported interface for teacher control (figure 7). On the other hand, the student's two different types of the devices, i.e. Android phone and iPhone/iPod touch, are tested in house. Mobile Exam System (MES) is been implemented with very simple and easy clicks from both sides of the users i.e., teachers and students.

Figure 7 shows teacher's login page with login credentials prompt been displayed, i.e. username and password. Once the login credentials is been verified by the system, the user, in this case the teacher, is allowed to gain access to the dashboard.

Figure 8 shows a side menu been displayed in the following sections: "Current test" means for the test which is running or in-use; "Pre-test" means the teacher is going to do the preparation for the test; "Post test" means that teacher can find their previous records from the system after the test; "SRS" means that once teacher clicks the SRS button after the test, students can be linked to the SRS system automatically without any further delay and the students can evaluate their understanding by attending the test.

Figure 9 shows the step 3 for the preparation of test(s). Once the login is successful, teacher starts to prepare exam in the following four steps:

1. Get session code;
2. Set the time required for the exam;
3. Set the number of questions.
4. Submit the preparation.

The steps 1, 2 and 4 can be done as easy as a simple single click but contradictory to other steps, step 3 requires some extra tasks to be performed by the teacher (see figures 7, 8, 9).

In step 3, teacher can set the types of question formats, e.g. in the case of text format, yes, no or do not know; or in the case of alphabetic format, a, b, c, and d are alternatives for answering the questions. The teacher can also set the weightage of each and every question. For example, in figure 9, question 1 is weighted as 20% for the test. So, if the same weightage is been applied for 5 questions, it will amount to 100%. This means the final mark will be calculated with the weightage of each question that is been attempted by the student in the test. Once the preparation is complete, the system prompts the teacher to have a final check before submission or to make changes for the preparation. Once the submission is accepted, the voting page is initialized automatically. Then the teacher can start the session by clicking the start button.

Figure 10 shows that the test is ready to start by just after the submission of prepared questions by the teacher. This page just fits the theory of simplicity. Figure 11 explicitly displays that once the start button is clicked, the end user initialized the test. In this page, teacher can view what types of questions have been designed for the students to answer and the weightage given to each question in the test, e.g. question one will be weighted as 20% for the whole test mark. Meanwhile, the system can also be paused temporarily and then continue the test later if necessary. For example, in the case of emergency situations like fire alarm, the test can be paused for a while and continued later by clicking the restart button and without losing designed test time.

Figure 12 clearly shows that results are been displayed instantly after the test is been completed. They can be viewed graphically, such as in the form of pie charts, vertical and horizontal bars or form format to see the data with student IDs, questions, response answers and final marks. Also, data can be saved in text, PDF and excel file formats.

The system can collect data, retrieve the data and present the data automatically (see figures 12, 13). That means any current data that can be stored into the database systems also can be stored into individual teacher's personal storages, such as a file folder in the hard disk. Meanwhile, historical data also can be treated as the way for the current data, but additional function can be used is to query them through a date function, i.e. dd/mm/yyyy, (see figure 13).

On the other hand, students using two types of smart phones, Android (figure 14a) and iPhone/iPod touch (figure 14b) have been tested. Students should login with a session code, which is initiated by the teacher, and his/her student ID (see figures 14a-b). Once the system verifies the login credentials, next page is been loaded automatically (see figure 15a-b).

Once teacher initiates the session, the question alternatives will be loaded up on the mobile screen for the students, and the students then submit their answers by pressing respective option buttons (figure 16a-b). During voting process, students can go back to previous vote to undo previous vote if they have changed their mind before the session is closed. The whole system has been tested in house exhaustively (see table I).

System Requirements:

1. For Teacher's Interface:
Software Used: Adobe Flex
Hardware Used: iMac
Operating System Used: Mac OS 10.5.8

2. For Student's Interface:
Hardware Used: HTC Android Phone & Apple iPod
Software Version Used: Version 2.1 (HTC Android Phone) & iOS Version 3.1.3

It is found that the system finds no error for the above-mentioned functions but further improvements are been carried out.

Conclusion and Future Work

Achievements

1. A scalable, stable and rationale database management system is required to build an 'Innovative Evaluation System' for mobile-based application.
2. Data model to effectively handle and manipulate objects or instances of data.
3. Simple to use and fast data storage and retrieval for a mobile-based application requiring a large number of concurrent users.

Future Work

1. Further development in teacher interfaces for multiple session tests with multiple panels at the same screen;
2. Further development to co-ordinate any changes from teacher controls;
3. Testing in both in-house and real world
4. Further development for complex mechanism in efficiency and simplicity.

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Table: 1 RDBMS Advantages and Disadvantages

RDBMS	**Advantages**	**Disadvantages**
1	Relational theory	Increase resources – increase performance linearly
2	Transactions: atomicity, consistency, isolation levels	Throughput
3	Multiple indexes, auto increments/sequences and triggers	Vertical scalability (scaling up)
4		Horizontal scalability (scaling out)
5		Performance (sub-queries/correlation, joins, aggregates)

Table: 2 ORDBMS Benefits and Performance Constraints

ORDBMS	**Benefits**	**Performance Constraints**
1	The main benefit of this type of database is that the software to convert the object data between RDBMS format and object database format is already provided and therefore not necessary to write a code for conversion between two formats	ORDBMS converts the data between object oriented format and RDBMS format and hence the speed and performance of the database is degraded substantially
2	Database access is easy and simpler when accessing from an object oriented computer language	Additional conversion work for the database

Table: 3 ODBMS Advantages and Disadvantages over RDMBS

ODBMS	**Advantages over RDBMS**	**Disadvantages over RDBMS**
1	Easier Navigation	Lower efficiency when the data and its relationships are simple
2	Better concurrency control	Relational tables are simpler
3	Less code required when applications are object-oriented	More user tools exist for RDBMS

4	Data model is based on the real world	Standards for RDBMS are more stable
5	Works well for distributed architectures	Late binding may slow access speed
6	Reduced paging	Support for RDBMS is more certain and changes are less likely to be required

Table: 4 XDBMS Vs. RDBMS

Number	**XDBMS**	**RDBMS**
1	An XML based database management system does not worry about relations between data. It just stores the data in the database.	A relational database management system stores the data in such a way that it explicitly shows the relation between the data.

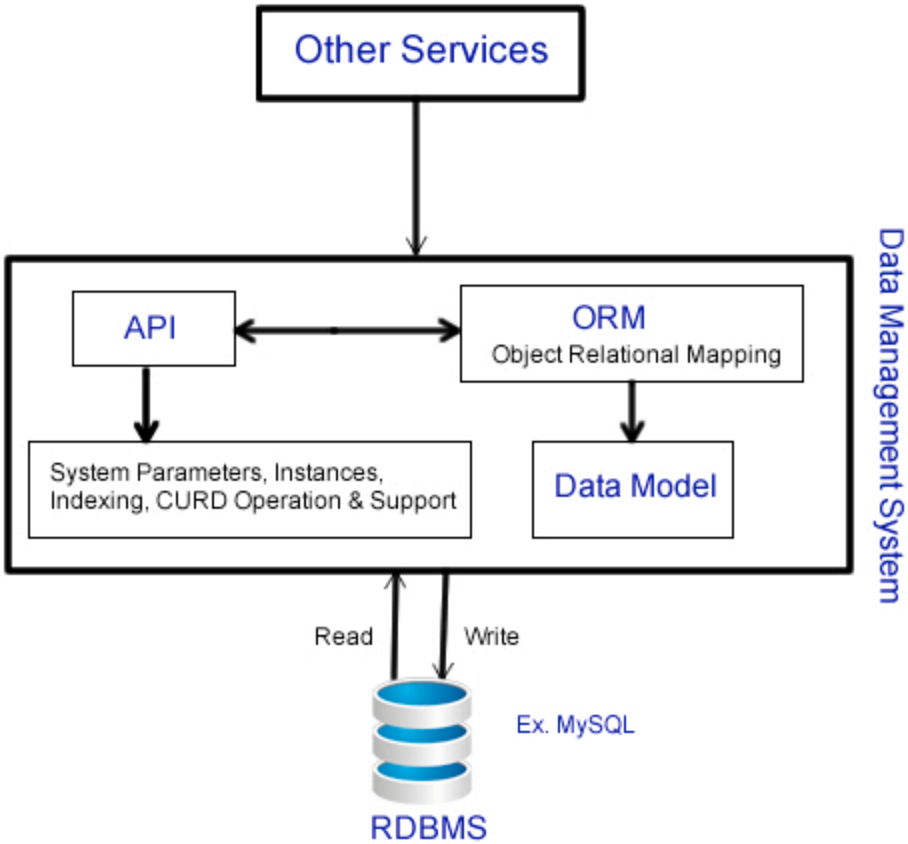

Figure 1. System architecture for MES data management.

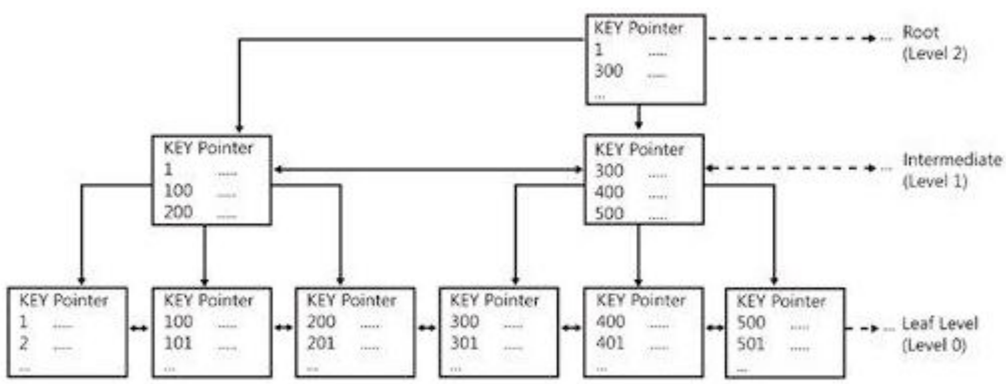

Figure 2. Al-Farooque Shubho (2009) MES data sorting.

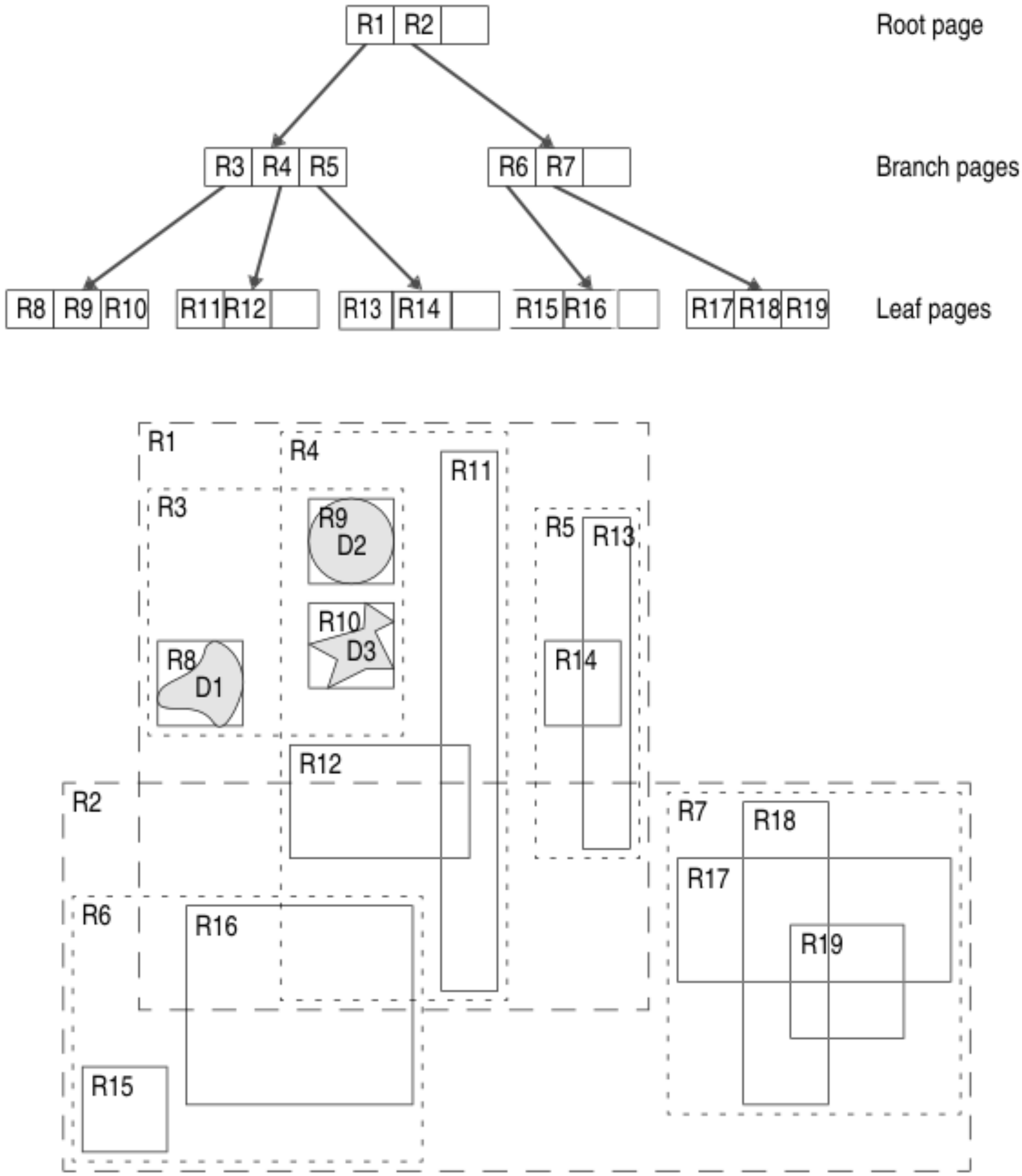

Figure 3. IBM (2011) R-Tree Index Architecture.

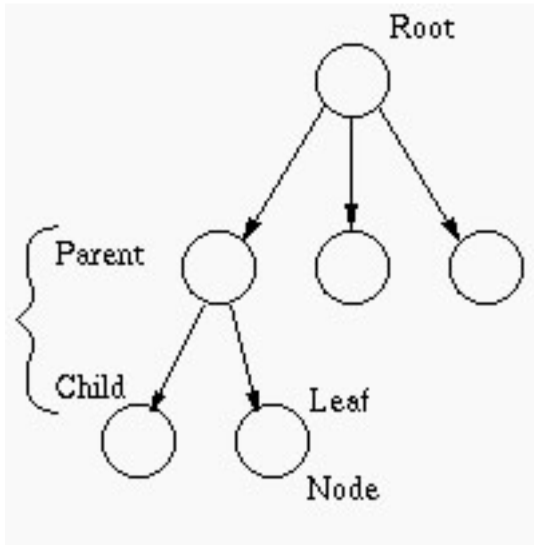

Figure 4. Timothy J.Finney (2006) Tree Data Structure.

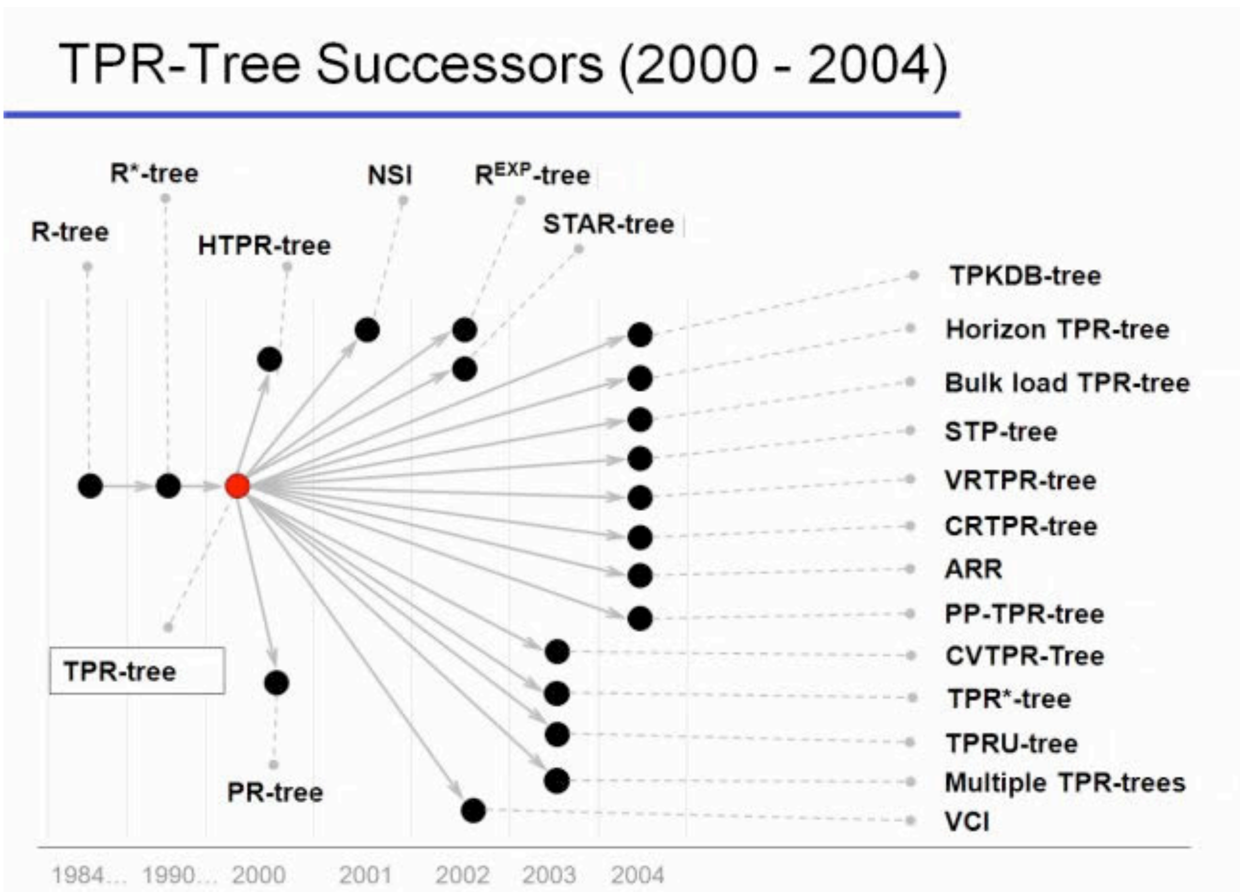

Figure 5. Prof. Christian S. Jensen (2008) TPR -Tree Successors (2000-2004).

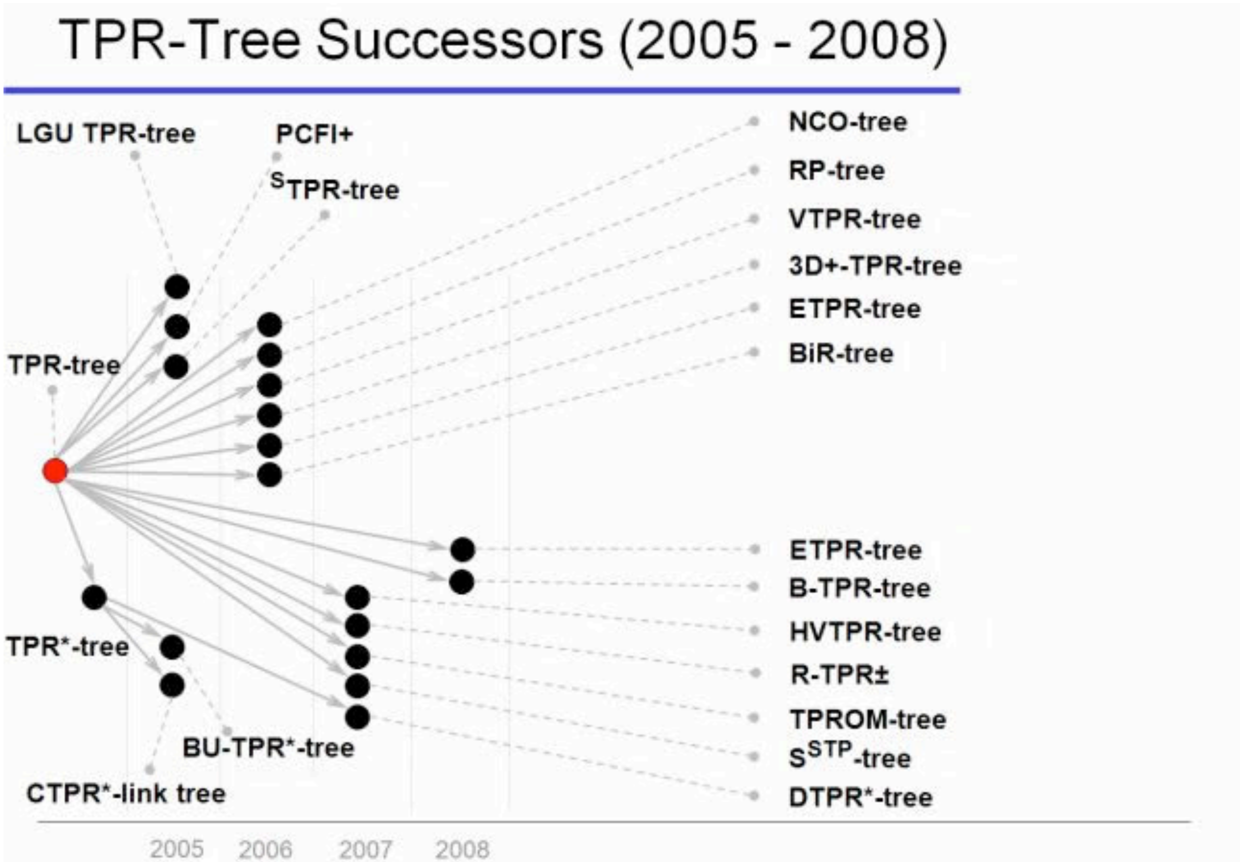

Figure 6. Prof. Christian S. Jensen (2008) TPR -Tree Successors (2004-2008).

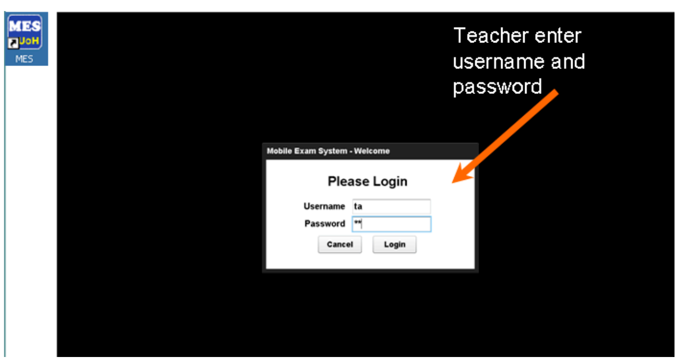

Figure 7. MES login for teachers.

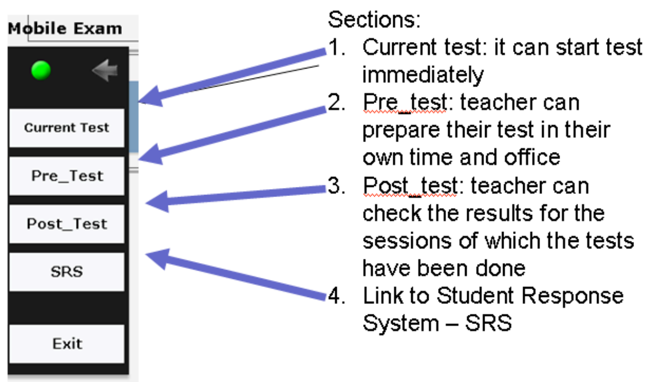

Figure 8. MES side menu.

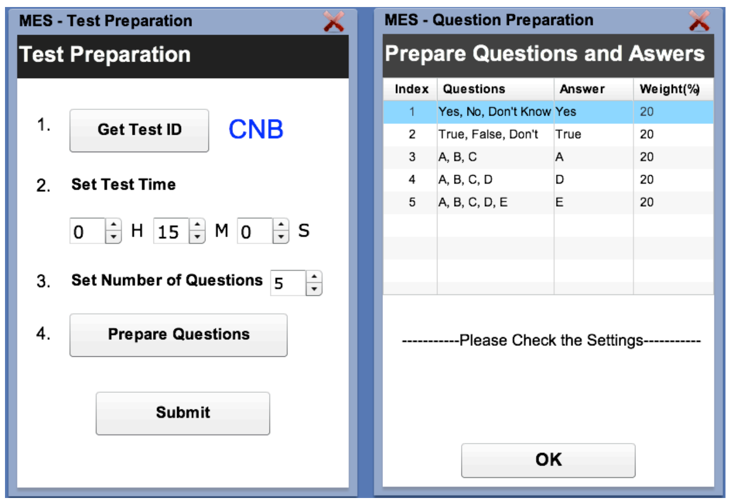

Figure 9. MES preparation page.

Figure 10. Start the exam session.

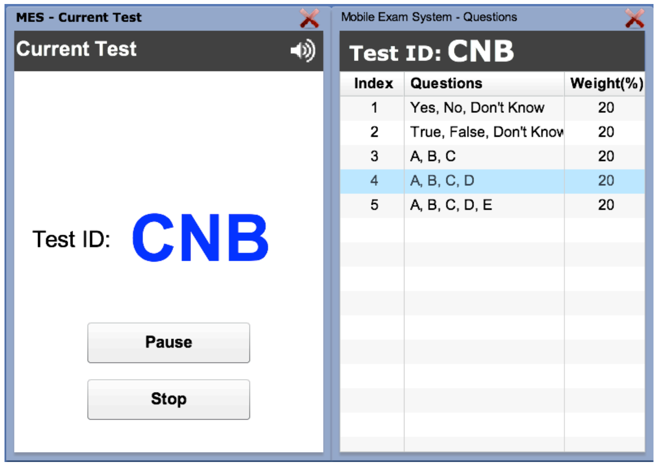

Figure 11. Running the exam session.

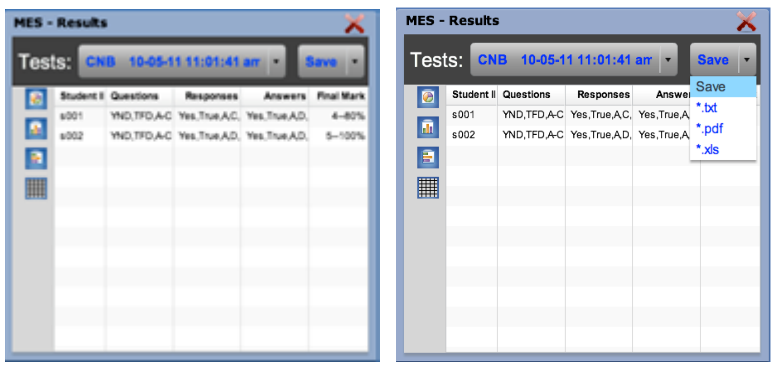

Figure 12. MES - viewing and saving the results

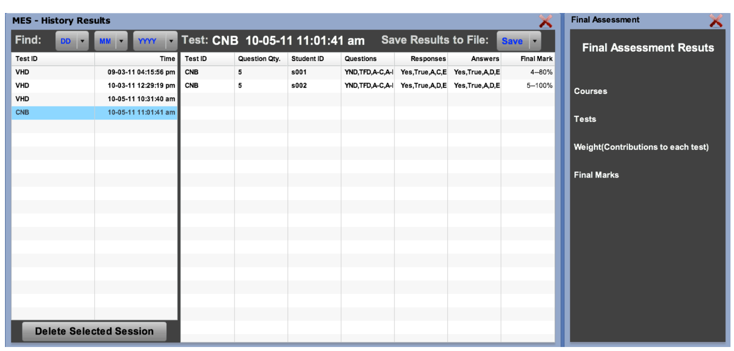

Figure 13. MES – showing previous results.

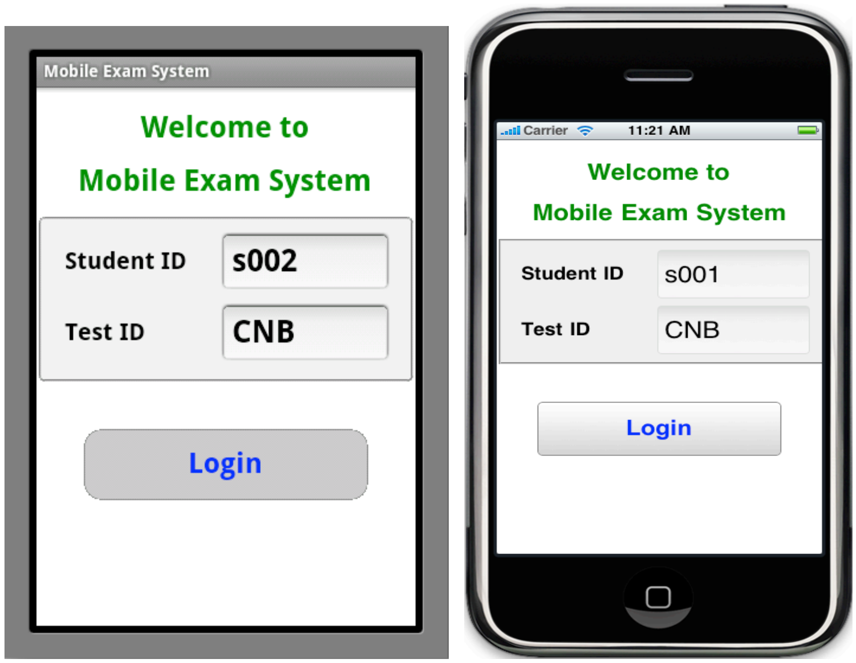

Figure 14. Student login using Smartphone.

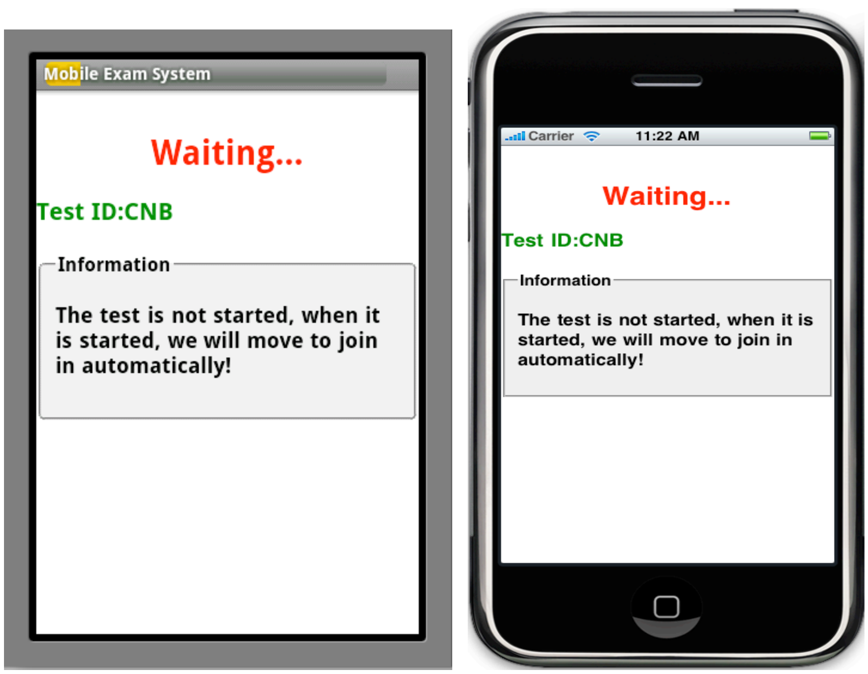

Figure 15. Student is waiting for teacher to start the session.

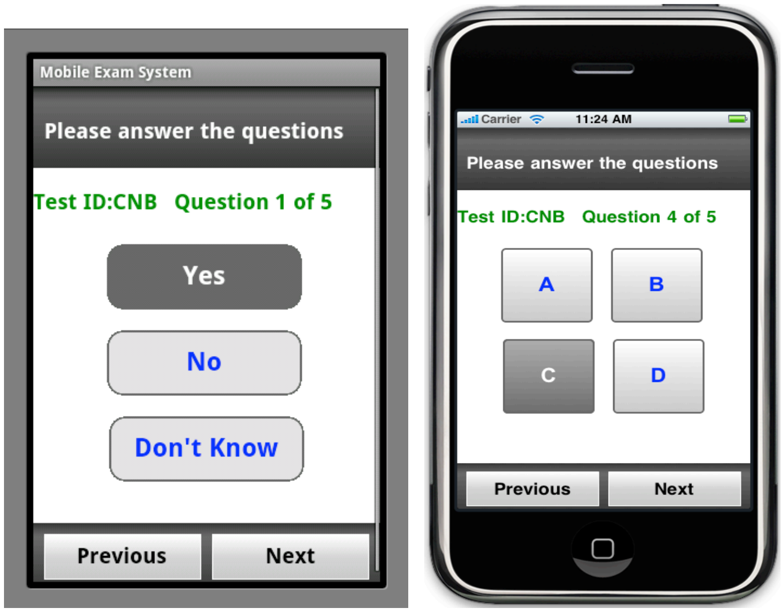

Figure 16. Students Voting.

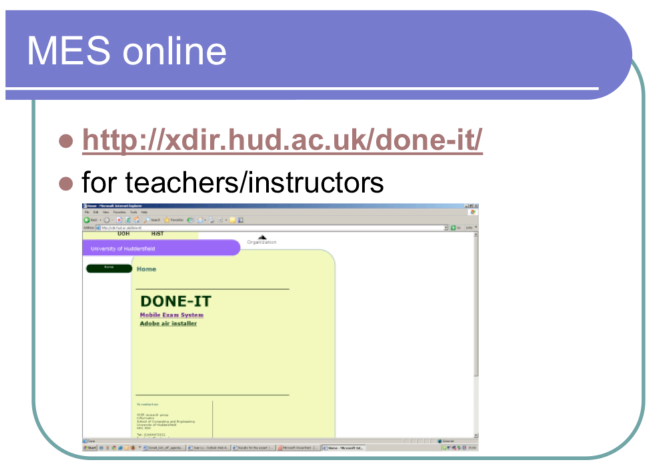

Figure 17. System can be downloaded online for teachers.

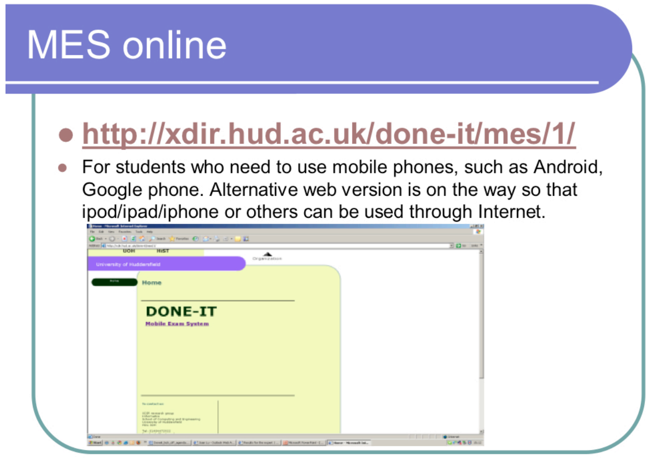

Figure 18. System can be downloaded online for students.