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# A SERVICE ORIENTED ARCHITECTURE TO INTEGRATE MOBILE ASSESSMENT IN LEARNING MANAGEMENT SYSTEMS

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## ABSTRACT

**Mobile Learning (M-Learning) is an approach to E-Learning that utilizes mobile devices. Learning Management System (LMS) should enable M-Learning. Unfortunately, M-Learning is not the same at each educational institution. Assessment is one of the learning activities that can be achieved electronically and via mobile device. Mobile assessment relies on services that are not part of the LMS. Integrating different external systems and services to be virtually part of LMS is one of integration challenges. This paper presents a Service Oriented Architecture (SOA) to integrate mobile assessment in LMS. Proposed Architecture consists of two layers: Interface layer, and Service layer. Interface layer interacts with instructors and learners via portals, and with external organization services via Web services. Service layer contains core system services and has three sub layers:**

- **Orchestration,**
- **Application Services, and**
- **Agents layer.**

**Orchestration layer is the layer that holds business logic required by system processes. Application Services layer contains set of stateless services that are capable of performing certain tasks. Agents' layer presents the suggested required software agents to serve the overall system. Suggested agents are Analyzer and Tracker. Analyzer is required to analyze students assessments to detect learning deficiencies. Tracker agent tracks students to remind with missing assessments. SOA facilitated integration of software agents within LMS, and implementation of new processes to support learning.**

**Keywords:** **Learning management system, service oriented architecture, software agent, mobile learning, and mobile assessment.**

## INTRODUCTION

**Several key organizations have been working on definitions of e-learning. E-Learning can be defined as the learning process created by interaction with digitally delivered content services and support (Chairman 2007). E-Learning involves intensive usage of ICT (Information and Communication Technology) to serve, facilitate, and revolutionize learning process (Duffy and Kirkley 2004, Horton and Horton 2003, Ma 2006, Moore and Anderson 2003, Tino 2007).**

**Learning Management System (LMS) is a comprehensive integrated software package of variety of tools for the delivery and management of courses (Billings 2003). LMS will automate the handling of Course catalog, Course delivery, Students enrollment and tracking, Assessments and quizzes (Henderson 2003). Formal and informal assessment of learning has existed for centuries (Earl 2003). Assessment lies at the very heart of learning. Teaching, learning, and assessment are indivisible (Ellis 2001). Assessment is the systematic process of collecting and interpreting information to make an informed decision. Educational assessment can be defined as the formal attempt to determine student's status with respect to educational variable of interest (McDonald 2002).**

## 1.1 Assessment Approaches

**Assessment is an integral part of learning, guiding the process and stimulating further learning. Assessments approaches are (Earl 2003):**

- **Assessment *of* Learning: it is the predominant kind of assessment. Its purpose is summative, intended to certify learning and report about students' progress. It is typically done at the end of a unit, a course, or a grade. It takes the form of tests or exams that include questions drawn from the material studied during that time. Results are expressed symbolically, generally as marks or letter grades.**
- **Assessment *for* Learning: it focuses on the gap between current learner orientation of the learning process and the desired goal of learning. Assessment for learning can be defined as activities undertaken by teachers and/or their students, which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged (Black and William 1998). Learners learn best when they understand what they are trying to learn, what is expected of them, given feedback about the quality of their work and what they can do to make it better, given advice about how to go about making improvements, fully involved in deciding what needs to be done next, and who can give them help if they need it (Ellis 2001).**
- **Assessment *as* Learning: This is part of the cycle of assessment where learners and instructors set learning goals, share learning intentions and success criteria, and evaluate their learning through dialogue and self and peer assessment (Henderson 2003).**

**A balanced assessment system takes advantage of assessment of learning and assessment for learning; each can make essential contributions. When both are presented in the system, assessment becomes more than just an index of learning institution success. It also serves as the cause of that success (Chappuis 2004).**

## Assessment Importance

**Assessment is a formal process that involves a deliberate effort to gain information about a student's status in relation to educational variables such as knowledge, attitude, and skills. It is one of the interactive educational components that should direct and even modify the teaching approach (McDonald 2002). Assessment that is explicitly designed to promote learning is the single most powerful tool for raising standards and empowering life long learning (Gardner 2006). The main goal of assessment is to obtain valid, reliable, and useful information about learner achievement, and effectiveness of the instruction. Some reasons for assessing teaching and learning are (Ellis 2001, McDonald 2002):**

- **Classify learners: One job of learning institutions is to determine who has learned sufficiently. Learners should be sorted on the basis of their achievements.**
- **Diagnose the learners: Diagnostic tests, expert opinion, and other means of diagnosis are often used to place learners in situation where their academic needs are best met. Assessment should consider both students' strength and weakness.**
- **Encourage and support learner learning: learners need to know their progress of learning. A good progress influences learners need and ability to learn.**
- **Increase learners confidence: learners feel that no matter what they do, they will not be able to pass exams. Repeated continuous learners assessment increases learners' self-confidence by highlighting learners' weaknesses and strengths.**

## Assessment Format

**Multiple-choice and essay questions are two different formats for assessments. One format is not inherently superior to another (McDonald 2002). While multiple-choice items do have limitations, they also have several advantages.**

**Multiple-choice format can be used to assess a wide range of learning outcomes across all cognitive levels. Multiple-choice items are adaptable to all types of subject matter. Their scoring is accurate and efficient. Multiple-choice items require much less time for recording answers when compared to essay questions. The difficulty level of multiple-choice items is easier to control than with essay questions. Multiple-choice items are compatible with efficient and accurate computerized scoring. Computer software can store multiple-choice items in an item bank for future use. Multiple-choice items can be saved and improved based on item analysis for use on future tests.**

**Limitations of multiple-choice questions include enormous time consumption of development particularly to prepare the incorrect options. Learners might only need to recognize the correct answer; they do not need to organize and construct their own response. The format is susceptible to guessing. But well developed multiple-choice items can get rid of all limitations. Effective multiple-choice items do not enable learners to choose the correct answer by guessing or simple memorizing.**
**The debate over the qualities of different item formats should not be the main focus of assessment builders. The multiple-choice format is the most versatile type of assessment item format (McDonald 2002).**

## Mobile Learning

**Mobile Learning (M-Learning) is an approach to electronic learning (E-learning) that simply utilizes mobile devices, yet it can also be viewed as a quiet different learning experience (Hulme and John 2005). It is possible to force series of interactive SMS exchanges between learner and LMS to achieve completion of a task or goal. Learner will take part, and complete the task (Stone et al 2002). M-learning has been used as a pre and/or post activity to other types of learning (Rogers 2004). M-learning has been widely considered and implemented.**

**Three wireless and mobile based application systems that can serve in M-learning are presented in (Fischer and Konomi 2005). Assessment for learning can be thought as one of the post learning activity that can be achieved via mobile phones. Mobile Assessment is about assessing learning via mobile phones.**

**The organization of this paper is as follows: In section 2, problem definition is presented. Section 3 introduces mobile services architecture.**

**Proposed LMS architecture is presented in section 4. Section 5 focuses on LMS analysis highlighting the take mobile assessment process. Section 6 illustrates LMS design and implementation, which includes designing Web services and software agents. Conclusion and future work are presented in section 7.**

## PROBLEM DEFINITION

**M-Learning can only be delivered with an awareness of the special limitations and benefits of mobile devices, so known design requirements of E-learning cannot simply be applied into the mobile learning context. Awareness of the constraints of the user interface is vital. Mobile devices suffer from small screens, poor input methods and limited battery life. Therefore, the interface design for M-Learning services must meet users' needs without overloading them with unnecessary complexity or operating too slowly (Parsons et al. 2006). Additionally, nowadays commercial LMSs do not support Mobile assessment. Mobile assessment requires integration of external services; services that are responsible for exchanging SMSs between LMS and learners. Besides, mobile assessment should be integrated with other LMS components, like Course Management System (CMS), and Exam Management System. SOA is a design pattern that helped enterprises overcome integration obstacles, and gain agile and interoperable features among their architectures (Barry 2003, Erl 2005, Riad and El-Ghareeb 2007b).**

**Educational institutions can make use of SOA in integrating mobile assessment activities in LMS. Integrating mobile assessment is not about exchanging SMSs between LMS and learners, but it is concerned with automation of the whole process, governing and orchestrating LMS to achieve accepted level of performance. A SOA based LMS is presented in order to unleash SOA advantages for educational institutions.**

## MOBILE SERVICES ARCHITECTURE

**Mobile assessment utilizes new mobile services architecture to deliver interactive messaging automatically to send assessment questions and receive multiple responses Short Messaging Services (SMS).**

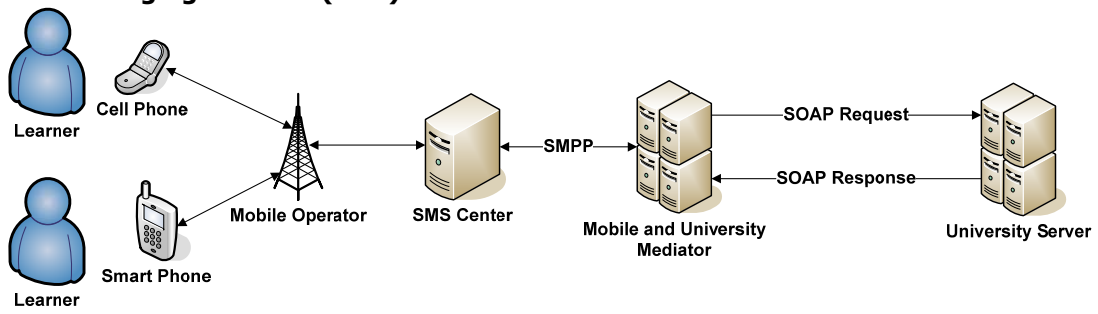



**Figure: 1**
**Mobile Services Architecture**

**SMS responses should be integrated within LMSs to enable M-learning. Figure: 1 presents Mobile Services Architecture required to enable learners to interact via mobile SMS with university server that holds LMS. Learner is connected to her/his mobile service provider via cell/smart phones. Mobile operators implement one or more SMS centers. Those are centers that manage sending and receiving of SMSs.**

**University needs a mediator in the way to SMS center. Mediator connects directly to different SMS centers using Short-Message Peer-to-Peer (SMPP) protocol. SMPP is a telecommunication industry protocol for exchanging SMS messages between SMS peer entities such as SMS center. It is often used to allow third parties to submit messages in bulk. SMPP has been designed to offer services for various cellular networks such as GSM, CDMA, and TDMA (Henry-Labordere and Vincent 2004). Mediator is connected directly the University server over the internet, via standard Web services. Via SOAP request, university can receive SMSs aimed to it, and via SOAP response, university can send new SMSs. University LMS should manage sessions with different users, utilizes data within SMSs in managing learners profiles.**

## PROPOSED LMS ARCHITECTURE

**Figure: 2 depict proposed LMS architecture. LMS consists of two main layers: Interface layer, and Service layer.**

### Interface layer

**It is the main gate of the system with users and other services providers/consumers. LMS has two main types of users: Instructors, and Learners. Each user type has a stand alone portal that provides different functionalities for each user. Display service is responsible for preparing dynamic output prepared to users, and calling the suitable web page to display data. Display service passes suitable set of data to appropriate pages, and acquires input from users when needed. There is no business logic embedded within this layer. Separation of interface design and implementation from business logic has proven many advantages (Erl 2005). Other services providers/consumers like Mediator have Web services as the interface of machines that represent service providers/consumers. LMS and Mediator expose set of Web services required to satisfy system supported processes under SOA design pattern.**

### Service Layer

**Service layer is the layer that holds services composing core of the LMS. Service layer has three sub layers: Orchestration layer, Application Services layer, and Agents layer.**

### Orchestration Layer

**Orchestration layer manages interaction details required to ensure that service operations are executed in a specific sequence (Erl 2005). Sequences are determined based on processes supported by system. Orchestras within this layer are: Mail Manager, Recommendations Manager, Course Manager, Session Manager, Assessment Manager, Finance Manager, Exception Manager, Learners Manager, Instructor's Manager, and SMS Manager.**

### Application Services Layer

**Application Services are set of stateless services perform certain. Process is the summation of tasks performed by one or more application services layer in the sequence that is maintained at orchestration layer services.**

**Application Services Layer include: Send Mail, Manage Recommendations, Manage Courses, Manage Session, Manage Assessment, Pay, Insert Exception, Manage Learners, Manage Instructors, Manage SMS, Send SMS, and Retrieve SMS.**

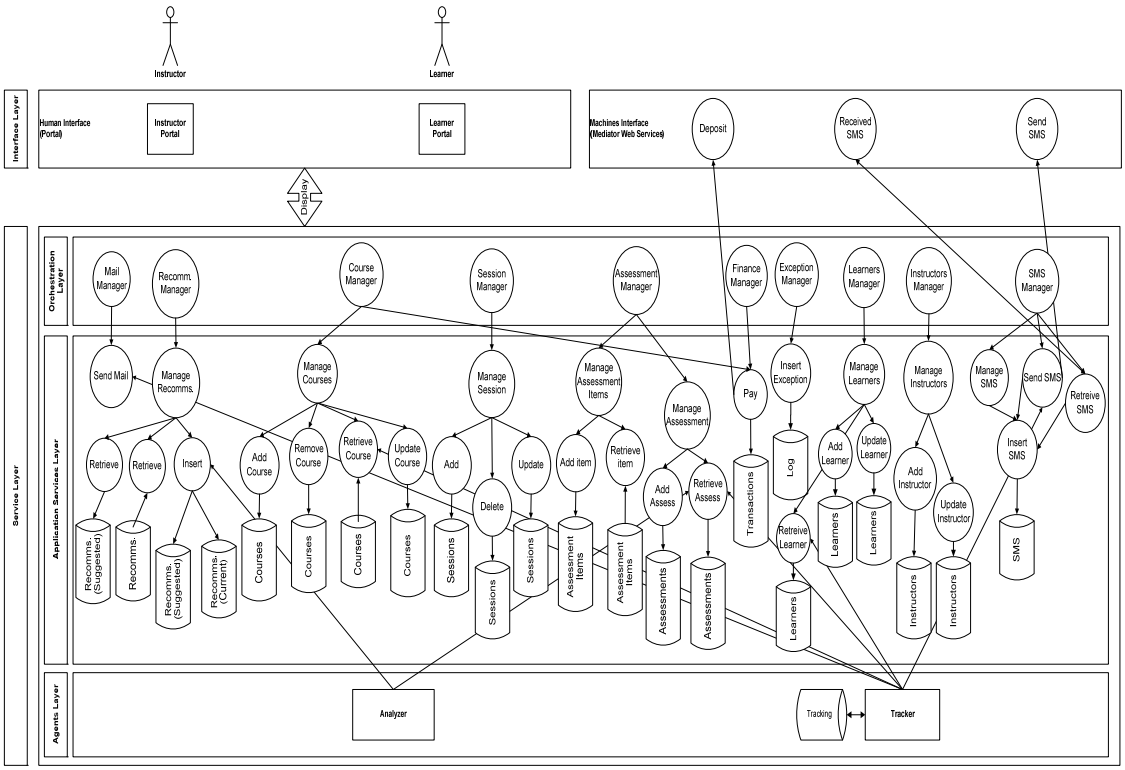



**Figure: 2**
**Proposed LMS Architecture**

## Agents Layer

**Specific task agents are required to serve system. Software agents are always the optimum solution for track and analysis tasks. Software agents are: Analyzer, and Tracker Agents. Analyzer agent is the software agent that analyzes system's log to detect most happen reasons causing failed imports, thus provide a feed-forward dynamic CMS. Tracker agent is the software agent that is responsible for ensuring that instructors provided feedback for courses they have imported.**

## LMS ANALYSIS

**Proposed LMS addresses one process namely Take Mobile Assessment process as depicted in the use case diagram at Figure: 3. Figure: 4 presents detailed analysis of the process.**

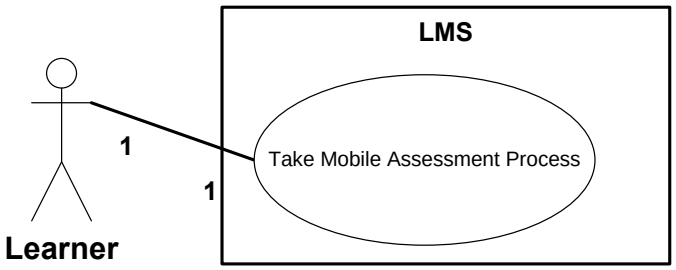



**Figure: 3**
**LMS Processes Use-Case Diagram**

**Take Mobile Assessment process is initiated by learner, managed and maintained by Assessment Manager, and Session Manager. Figure: 4 is divided into two main areas: outside LMS scope, and LMS scope. Activities within outside LMS scope area can not be handled, maintained, neither controlled by LMS.**

**Those are mainly activities related to mobile operators and mediators. LMS scope presents activities handled, maintained, and controlled by LMS. Take Mobile Assessment process begins for LMS once system retrieves SMS that is aimed for assessment. Take Mobile Assessment process is an example for processes that contains activities outside organizational boundaries.**

## LMS DESIGN AND IMPLEMENTATION

**LMS design includes designing automation of the mentioned process, besides designing software agents required to support system. Designing process includes designing composing services, activities performed by each service, and database required to support this service. Database design methodology is required for efficient database design (Conolly and Begg 2004). Proposed LMS is a collection of stateless Web services in order to obtain advantages of integrating different external services.**

### Development Framework

**.Net framework is an emerging Microsoft technology that was presented in year 2000 to enable execution of any .net compiled code on any machine that has .net framework installed. Machines are: PDA; personal digital assistants, Tablet PCs, Smart Phones, and Computers. .Net framework is not a software developing tool, neither a programming language. .Net framework supports more than 30 programming languages, including Delphi, Visual Java, and Visual C++ (Liberty 2005). Choosing .net framework as the development environment was affected by two other factors: efficiency of Microsoft SQL Server 2005, and seamlessly efficiency of integration between it and .net framework. Microsoft SQL Server 2005 presents new vision for database management systems that worth respect. Additionally, .net framework deals with standards efficiently.**

### Web services as SOA enabler

**Web services technology is currently the major implementation of SOA (Bai et al. 2006). Web services are applications that use standard transports, encodings, and protocols to exchange information (Shodjai 2006).**

**A Web service is a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically WSDL).**

**Other systems interact with the Web service in a manner prescribed by its description using SOAP messages, typically conveyed using HTTP with an eXtensible Markup Language (XML) serialization in conjunction with other Web-related standards (Booth et al. 2004).**

**Web Services Description Language Version (WSDL) provides a model and an XML format for describing Web services. WSDL describes a**

**Web service in two fundamental stages: one abstract and one concrete (Chinnici et al 2007). At an abstract level, WSDL describes a Web service in terms of the messages it sends and receives; messages are described independent of a specific wire format using a type system, typically XML Schema.**

**At a concrete level, a binding specifies transport and wire format details for one or more interfaces. SOAP is a lightweight protocol intended for exchanging structured information in a decentralized, distributed environment (Gudgin et al 2003).**

**XML solves a key technology requirement that appears in many places. By offering a standard, flexible and inherently extensible data format, XML significantly reduces the burden of deploying the many technologies needed to ensure the success of Web services (Booth et al 2004).**

**W3C defined XML Information Set required to enable information interchange between Web services (Cowan and Tobin 2004). Web services are stateless services that can not maintain business logic, operation flow, or user state; so, the need of an orchestration layer is addressed.**

**Orchestration layer services include business logic required to take decisions based on previous state on which next Web service to invoke, and what action should take place next (Erl 2005).**

**SOA provides a fine granularity and modularity that solves many integration problems, but adds complexity to systems design.**

**SOA utilization provides process level integration based on services, not just data or application integration. Figure: 5 presents Take Mobile Assessment Process design.**

**Take Mobile Assessment Process is maintained by assessment manager, and utilizes other Web services namely: Manage SMS, Manage Learner, Session Manager, Manage Assessment Items, Manage Session, and Insert Exception.**

**Some of the core Web services to the mobile assessment systems are:**

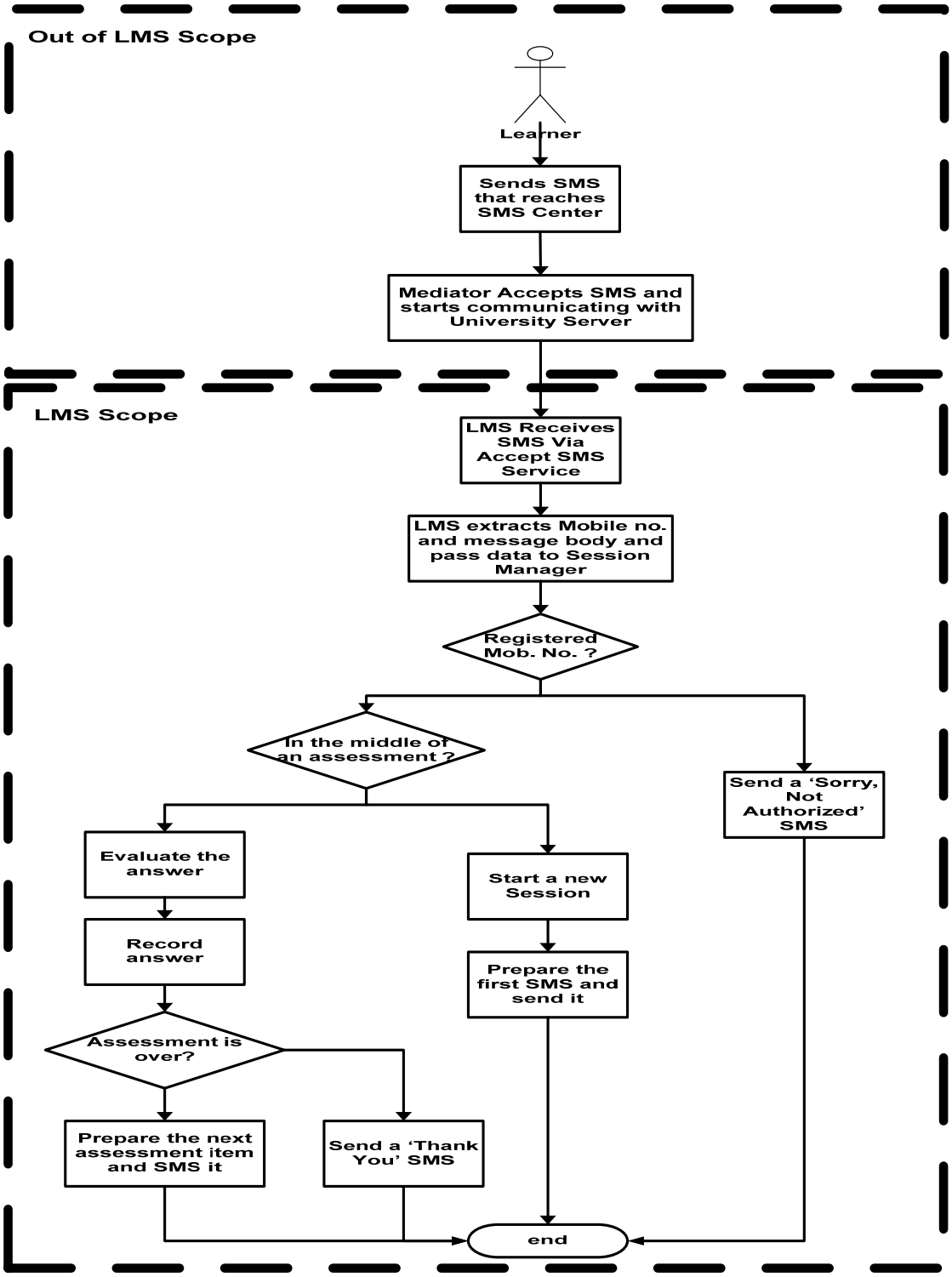



**Figure: 4**
**Take Mobile Assessment Process Analysis**

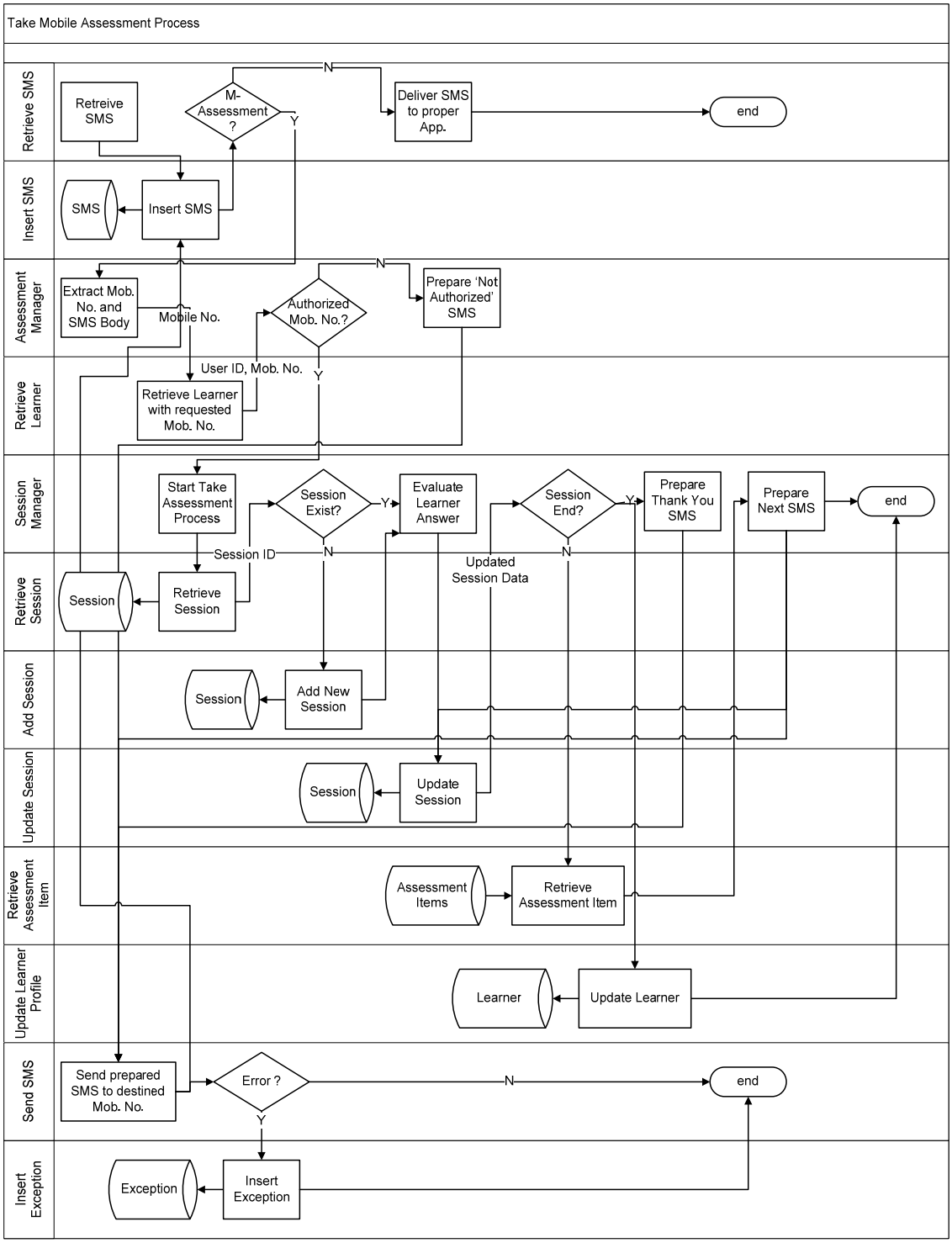



**Figure: 5**
**Take Mobile Assessment Process Design**

### Manage SMS service design

**Manage SMS is a collection of services that include: Retrieve SMS, Send SMS, and Insert SMS. Retrieve and Send SMS are two services that map mediator exposed Web services. Mediator receives and sends actual SMSs. LMS maps exposed mediator's Send and Receive SMSs into internal Retrieve and Send SMS. So, when LMS consumes both services, it is actually consuming Mediator's Send and Receive SMS services.**

**Insert SMS keeps a log of all received and sent SMSs. This log is important in calculating fees to be paid for mediator, and for other record management issues. Figure: 6 shows required database table for Insert SMS service.**

### Manage learner service design

**Manage Learner focuses on three main database operations: insert, update, and delete (Conolly Begg 2004). Learners data and profiles must be maintained in order to keep track of the system and update learners profiles based on their assessment. Figure: 7 presents required database tables for learners data and profile.**

### Manage assessments service design

**Assessments are collections of questions, or what will be called assessment items. Figure: 8 shows required database tables to store and manage assessments. Manage assessments service is concerned with the three main database operations: insert, update, and delete.**

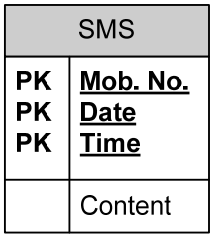



**Figure: 6**
**Table of Insert SMS Service**

### Manage assessment items service design

**Assessment items are the main focus of the system. Assessment items needs to be well prepared for all subjects in order for the assessment to be efficient. Assessment items can be categorized according to courses. Assessment items can be classified into three main classes: easy; 1, medium; 2, and hard; 3.**

**Classes are used to determine difficulty of each assessment item. As depicted in Figure: 9, each assessment has entries for number of each assessment item class should exist in the assessment. Example of an assessment of learning item is:**

**Which of the following connects existing networks to form an internet?**

- **Bridge**
- **Router**
- **Switch**
- **Repeater**
-

**And correct choice is (b); the difficulty of this question is '1'; easy.**

## Session manager service design

**Sessions are the main enabler of take mobile assessment process. Session refers to the period of time the learner is identified by the system as in the middle of a process, types and effects of activities learner performs on the system.**

**Session manager is a main manager of mobile assessment because it is responsible for recognizing either the learner is in the middle of an assessment, or attempting to a new mobile assessment. Incase learner is in a middle of an assessment; session manager retrieves the next assessment item to be sent to the learner, and passes it to the Send SMS service.**

## Manage session services design

**Manage session service is responsible for performing three main database operations on sessions. Three main operations are: insert, update, and delete.**

**Insert session is invoked when the learner initiates a new session.**

**Update session is invoked for existing sessions where learner sends an assessment item answer. Based on the learner's answer, score of the learner is updated, and number of assessment items sent to learner is updated. Delete session is initiated when learner completes the assessment.**

**Figure: 10 shows the required tables for manage session services.**

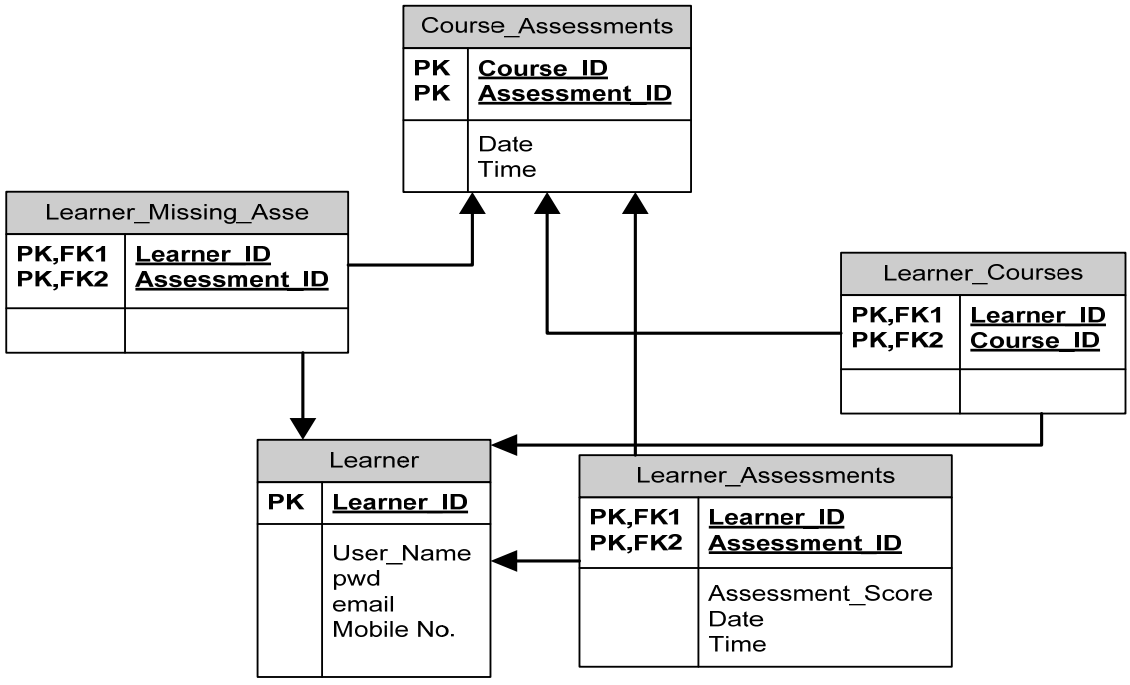



**Figure: 7**
**Tables of Manage Learner Services**

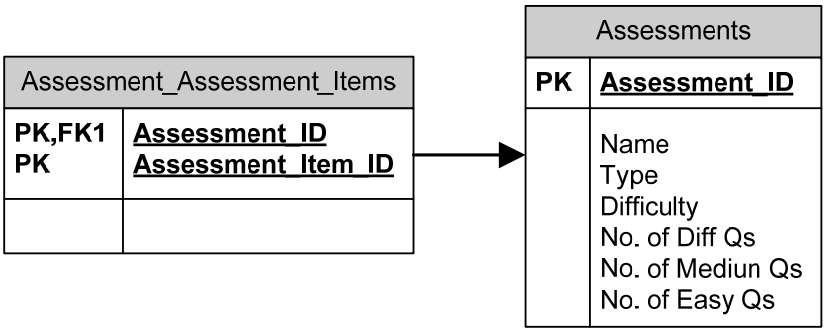



**Figure: 8**
**Tables of Manage Assessments Services**

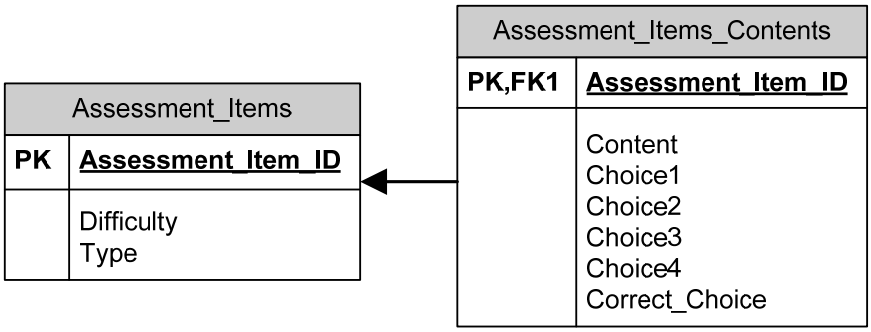



**Figure: 9**
**Tables of Manage Assessment Items Services**

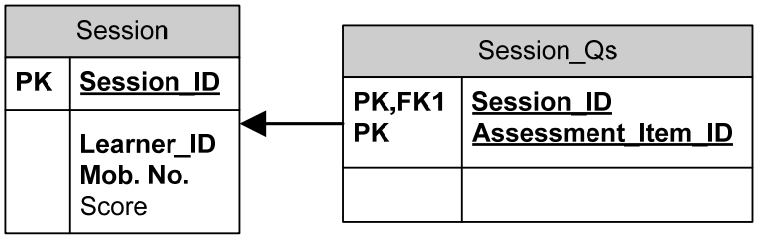



**Figure: 10**
**Tables of Manage Session Services**

## Software Agents

**Software Agent is a computer system that is situated in some environment and is capable of autonomous actions in this environment in order to meet its design objectives (Riad and El-Ghareeb 2007b, Wooldridge 2002).**

**Software Agents have characteristics that make them suitable to perform complex functionalities. Characteristics include: Autonomy, Interactivity, Reactivity, Proactivity, Intelligence, and Mobility (Turban et al 2004). Proposed architecture utilizes two task-specific software agents: Analyzer, and Tracker.**

## Tracker agent

**Tracking systems has been widely known and accepted. Figure: 11 presents required table to support tracking activity. Figure: 12 depicts Tracking process design. Tracking process is initiated and maintained by Tracker agent. Tracking process consumes five Web services: Read Learner Data, Read Course Data, Read Assessment Data, Send Mail, and Send SMS.**

| Tracking | |
|---|---|
| PK<br>PK | Learner_ID<br>Assessment ID |
| | Warning Limit<br>Current Limit |

**Figure: 11**
**Table of Tracker Agent**

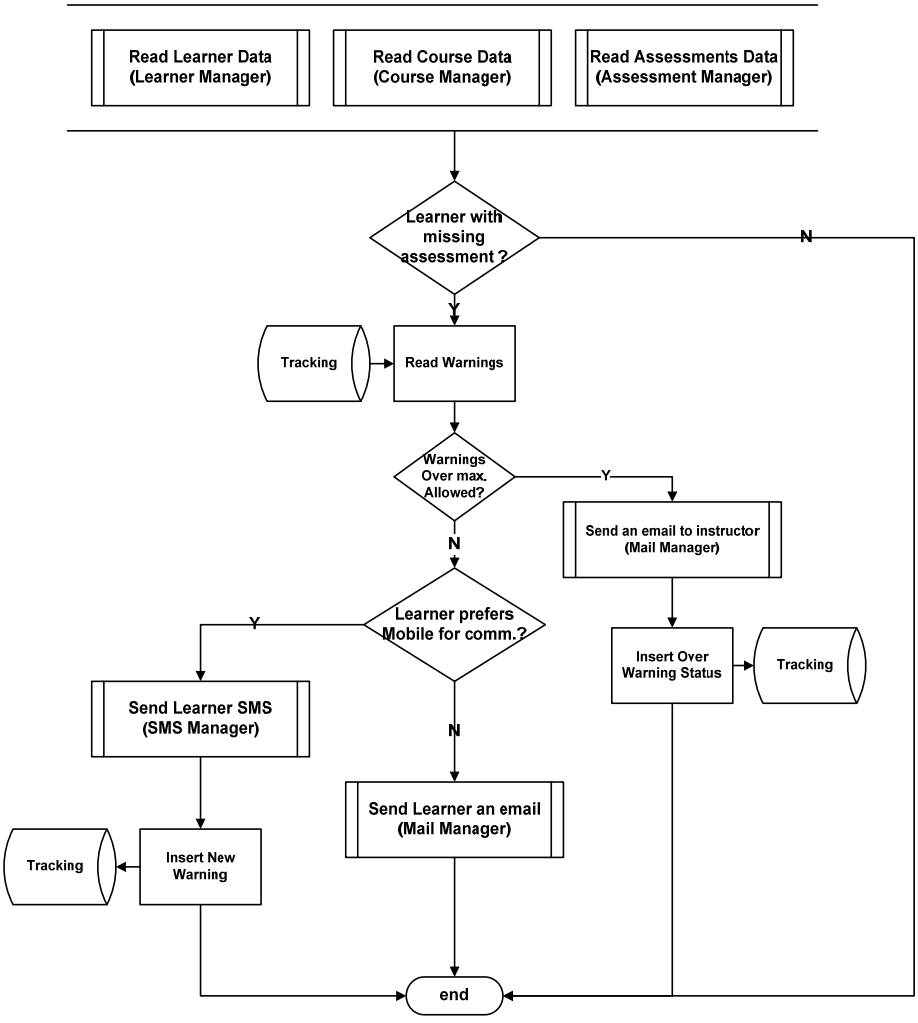



**Figure: 12**
**Tracking Process Design**

## Analyzer agent

**Analyzer agent is the software agent responsible for analyzing previously stored assessment results by detecting the most cause of negative feedback and suggesting new recommendations to enhance educational activities. Recommendations are inserted temporarily in the recommendations database, waiting for the approval of instructors. Analysis of assessment data tend mainly to increase system overall performance by adapting system to meet/exceed learners expectations.**

**Figure: 13 shows Analyzer process design. Analyzer agent consumes two Web services: Read Assessments data, and Insert Suggested Recommendations. Instructors; via instructor portal, can approve/deny recommendations made by analyzer. Analyzer can keep statistics on how many recommendations were approved/denied by instructors in order to ensure efficiency of analysis rules. Analyzer can keep track of approved recommendations, and new assessments results to ensure that new recommendations have met negative feedbacks from learners.**

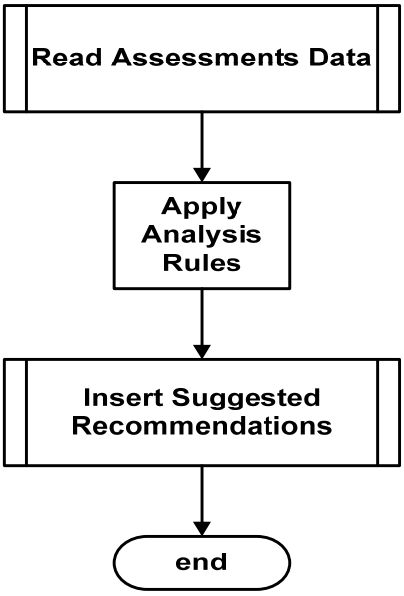



**Figure: 13**
**Analyzer Process Design**

## Interface Design

**Mobile assessment is one of the activities that can be managed by instructors. Current University LMS enables instructors to manage different aspects of the learning activity. Faculty in-house implemented LMS is SOA based that integrates new processes and presents new functionalities as required. Riad and El-Ghareeb presented a SOA based LMS of the faculty (Riad and El-Ghareeb 2007a.). Mobile assessment is the new added activity that was added easily and efficiently due to utilization of SOA.**

**Figure: 14 show instructor portal and some of the activities that can be managed. Figure: 15 depict screenshots of the students' interactivity via mobile assessment.**

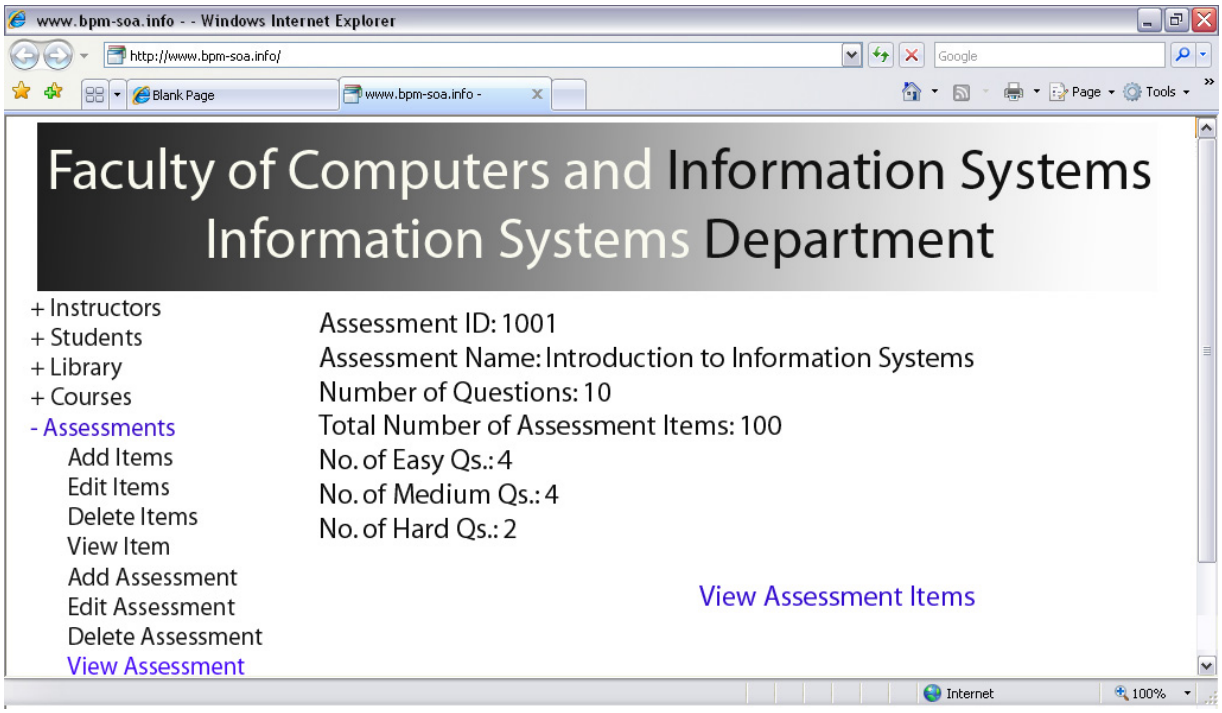
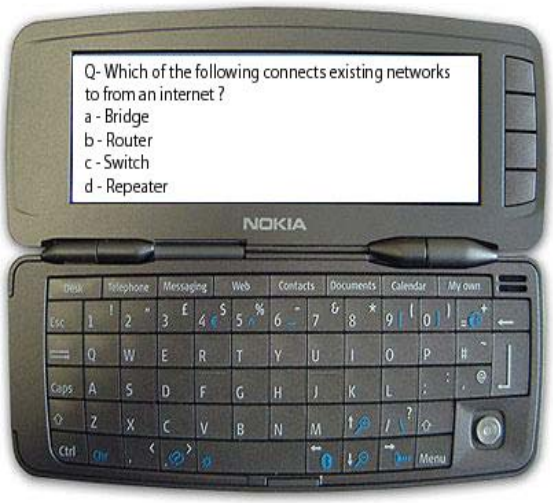



**Figure: 14**
**Instructor Portal**



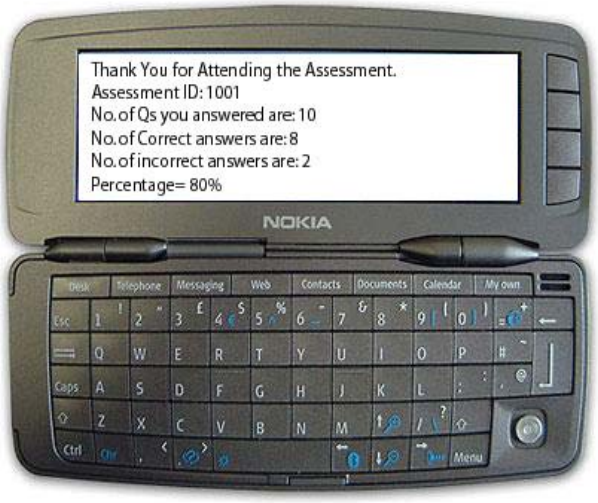



**Figure: 15**
**Mobile Assessment Screenshots**

## CONCLUSION

**This paper presented a proposed LMS that integrates mobile assessment within LMS. An automated mobile assessment is presented. Utilizing SOA to integrate Web services and software agents in LMSs highlighted the unlimited advantages of Web services and its capabilities to facilitate software agents integration within systems. LMS should be thought of as a collection of stateless Web services. SOA provides a fine granularity and modularity that solves many integration problems, but adds complexity to systems design. SOA is a design pattern that helped enterprises overcome integration obstacles, and gain agile and interoperable advantages within architectures. Pedagogical advantage of added process is mainly facilitation of assessment process by presenting mobile assessment, thus encourage learners to assess learning.**

**Future work includes automating more learning activities that can be achieved via mobile devices and integrating them into current LMS.**

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