

Interactive Prototypes for Mobile Collaborative Learning (MCL) to Substantiate Pedagogical Activities

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Abstract—Deployment of new emerging technologies have attracted and motivated a great deal of attention from researchers and scientist in various disciplines to develop and design the learning management systems, virtual learning environments and conference systems with support of MCL for education and other organizations. This technological revolution of connecting large numbers of potential learners through mobile telephony creates new challenges for developing the new architectures for education and business. Some of the MCL paradigms are proposed and implemented in various fields such as university, corporate, health and military but they lack completeness. This paper introduces new server and client side interactive prototypes with support of various working components, which help the users in obtaining the contents from server to meet the pedagogical requirements. This paper also proposes and integrates the features of content-server with cache-server to provide the faster delivery of contents for MCL. Furthermore, the paper proposes and implements some features of a novel "group application" to support asynchronous and synchronous and multimodal features to facilitate the students for MCL. Finally, the paper validates the features of interactive architecture and applications. This contribution will encourage and motivate the students to pursue their education again because the students will be able to get the course contents at anytime and anywhere.

Index Terms—Design; Development; Theory, Mobile collaborative learning (MCL); mobile devices; Server side architecture; client side protocol; group application; cache server.

I. INTRODUCTION

Latest studies show that MCL is highly focusing paradigm for research particularly in distance and online education. The idea of mobile-based learning is different from traditional classroom-based learning. The mobile-based learning pedagogical method provides many possibilities. It helps the people to bring together working in same or different organizations for achievement of any specific goal. MCL exhibits intellectual synergy of various combined minds coming together to handle the problem and stimulate the social activity of mutual understanding. According to survey, MCL provides some limited features and functionalities to support the knowledge-sharing [1]. Deployment of new emerging technologies and its fast growing trend encourages the people to develop supporting MCL environment for real learning management systems, virtual learning environments and conference sys-

tems. These environments lack the most promising supportive architectures and softwares. From other side, The embedded emerging technologies onto mobile devices; such as blue tooth, motion sensors, blackberry, Infra-Red, cameras, Global positioning System (GPS) , GSM and faster broadband connections will make the dream into reality. Mobile devices are also more suitable to incorporate the existing services by employing web-based interface. The developed applications for mobile devices provide motion recognition, geo-location, academic profile of user and history of activities [6] & [15]. All of these rich features can provide a promising platform to foster healthy MCL environment.

We believe that MCL contributes a larger pedagogical agenda. This paradigm is being highly acknowledged and implemented in schools, colleges, universities and different organizations across the world. From other side; MCL lacks the Interactive architecture and intellectual applications to substantiate the pedagogical requirements. Many MCL theories handles some pedagogical issues explained in [16]. However, all of these MCL theories face some major challenging issues in open, large scale, dynamic and heterogeneous environments. The most performance affecting issues are knowledge sharing, faster delivery of contents, request for modified contents, delivery of large rich multimedia contents (video-on-demand), asynchronous and Synchronous Collaboration, support for multimodal, provision for archive updating, user friendly interface, middleware support, and virtual support.

To handle these issues, The contribution proposes and implements innovative client and server based architectural prototypes to improve pedagogical activities. These prototypes will handle almost all of the major challenging issues and provide an access to all users in obtaining the contents on mobile devices at anytime and anywhere.

II. RELATED WORK

In this section, we discuss the salient features of related published work. Kwang lee & Abdul Razaque [1] have introduced the idea of server based architectural prototype at the abstract level to support MCL in education. On the basis of usability testing and ranking discovered the features necessary for MCL. Xiaoyong Su, et al.[14] proposed the four layer framework and prototype for multimedia mobile collaborative system. The proposed framework supports user, device and session management. The authors claim that mobile collaborative environment could possible be made by upgrading the devices and network technologies. The contribution is interesting and providing

the abstract level of concept for introducing the framework for MCL. Vladimir Zanev and Rodney Clark [2] have discussed the concept of prototype for wireless course management system. They handle login and authentication, wireless calendar, wireless syllabus, and wireless testing. The paper also presents contents of course and guides the teacher to interact with students by using HTML based interface. Lahner F. and Nosekabel H. [3] have implemented a program to display e-learning contents on mobile devices in the University of Regensburg, Germany. Mildard Marcelo et al. [4] have designed C-note to provide an opportunity for collaboration in the university of Vaxjo, Sweden. They store the notes and information in database. They use a specialized C-Pen to scan the material of research project with support of C-note application. In addition scanned information is restored in database and the teacher can check the activities of each member of group during collaboration.

Jorge Bardosa et al.[7] have proposed prototype for mobile and ubiquitous devices in undergraduate course of reference (nicknamed GRefe). The prototype consists of user profile that stores the information regarding learning process. Allision Druin et al.[5] have discussed the prototype for their ongoing participatory design project with intergenerational design group to create mobile application and integrated onto iPhon and iPod touch platforms. They claimed that designed application could provide the opportunities to bring the children and grand parents together by reading and editing the books. Ch. Bouras et al. [12] have introduced INVITE architecture and discussed the user's requirements to meet the demand of e-learning in collaborative virtual environment. They have also discussed the technology and standards required for designing the INVITE. Mobile Learning community (MLC) in Department of Computer Science, University of Illinois [13] has launched the project "exploring social trust in mobile educational environments" funded by NSF, Google Inc and Vodafone Inc. The project has developed four applications Recorder, Announcement, Quiz and Message. The main purpose of the project is to introduce the mobile learning material for course "cs241" for undergraduate students. All of these studies in MCL environment show that neither any contribution particularly worked on architecture based design nor on supporting systems and specific applications running on mobile. They mostly develop the courses and few contributions touch the technology but not implemented. This paper introduces rich MCL client-server based architecture that supports to management systems, virtual learning environments and conference systems within educational institutions and several organizations. The paper also develops an interactive application for MCL running on this architecture. It meets the basic requirements such as exchange for the delivery of communication contents for group discussion, short message service (SMS), Emails, audio, video and offer on-line information to collaborative group. The challenging issues motivating this contribution are: does this contribution provide innovative and interactive opportunities for synchronous and asynchronous online communications? to what degree architecture is more effective and result oriented? does architecture develop multicultural standards for MCL? Does paper handle all the important features necessary for effective MCL? Are group application and other light weight software threats sufficient to meet pedagogical needs and other collaborative requirements? How the

findings are used to engineer the requirements of Students, teachers and other administrative staff of University of Bridgeport (UB) and other institutions? What are the socio-economic impacts of the research on USA and beyond the world? The goal of this paper is to obtain the learning materials to meet pedagogical needs and other collaborative requirements for educational and other organizations through mobile devices at any time and everywhere.

III. PROTOTYPE DESIGN OF MCL AT SERVER SIDE

The server side protocol for MCL is envisioned as promising platform that substantiates latest technologies and mobile applications to meet pedagogical requirements and other collaborative activities within educational institutions and beyond. This integrates various functional components to cover all necessary features for MCL from sending SMS to large size of videos. It supports to content generation, content fragmentation, content buffering, content modification, content integrating, content diagnosing, content retrieving , content refinement, content visualization and ultimately to dissemination of results. Content server is a central processing unit at server side protocol shown in figure 1 with architectural design, which is based on content server engine (CSE). Content server continuously senses the traffic to receive the request from client side. If new request is arrived then it is dealt with requirement of user. CSE identifies the mobile users on basis of mobile information device profile (MIDF), status

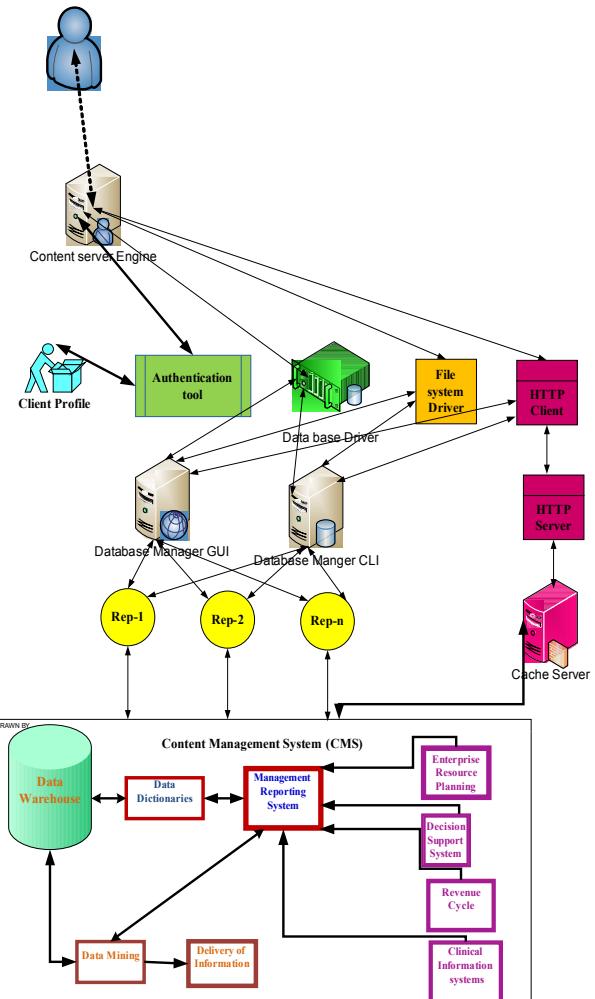


Figure 1. Architectural Prototype for MCL at server side

of previous network condition and requested URL. Another promising feature of server side protocol is to satisfy the authorization and authentication process in order to provide the access to legitimate users only. This job is done with help of CSE to verify the status of the users. If illegitimate user sends the request for getting the contents for collaborative learning that request is declined. CSE is implemented on internet information server (Web server) that also provides the access to legitimate users. CSE deals with three types of services normal, low priority and high priority. If request is about normal service that is handled with file system manager. It supports to text, graphs and small size of videos. Requests about large size of videos is dealt with database manager that is considered as low priority service provider. High priority covers all type of data services including text, graph, images and voice. This task is performed with integration of cache server, which sets its own hyper text transfer protocol (HTTP) connection. Integration of cache server process provides the faster delivery of learning material. With introduction of cache server, time can be saved of backups and log monitoring because the substantial time is spent on these activities every day. It improves the performance of health, military and law enforcement departments because they need high priority services to achieve their targets at anytime and anywhere.

CSE can save and get data from either database driver or file system driver. Both database and file system drivers forward the request to the database manager GUI and database manager CLI. Single CSE can support to many storage mediums. To obtain the contents faster, we propose HTTP client and integrate with CSE. At the server side, we also introduce the cache server, which has feature of setting up its own hypertext transfer protocol (HTTP) connection. The cache server gets the request from HTTP client and delivers the requested contents immediately; if they are already cached on server, otherwise forwards the client's incoming request to content management system because cache server has direct access for getting the requested contents. There is another advantage of the cache server because it does not need backups and log monitoring. Database manager CLI is functional component at server side. It creates programming interface, documentation and module. The beauty of database manager CLI is to provide the faster delivery of contents. From other side, it monitors, generates, restores and manages backups. CLI provides the limited services but supports for priority services. It fosters interactive and background operations. We access the database manager CLI tool by using C++, Java, XML and other high level programming languages. To overcome the limitation of CLI, The server side also introduces database manger GUI tool that works like database manager CLI with same but more extra features. GUI involves more extra features, which are diagnosing the contents, displaying information, several interactive options and updating database software. The database manager GUI also supports several featured mobile devices. The most promising feature of GUI is provision of friendly user-based interface to access the remote mobile devices to start successful MCL process.

GUI and CLI collectively provide the access to connect with different repositories for storing and extracting the contents for mobile devices. Both GUI and CLI make decision to which repository should be selected for obtaining the requested contents. The repository plays a role as

bridge connecting GUI and CLI with EDW for obtaining the requested contents. The rapid increase in consumption of different medias cause of mixing all the contents and resulting loss of data occurs. To control this issue; various repositories are introduced at MSCS for each media that handle the scalability issues and loss of data. Each repository serves as table to obtain and store different kind of contents. The multiple use of repositories capture and preserve communication process and serve as tangible indicators for improving the quality of mobile learning [11]. The repositories are supported with content management system (CMS). The CMS provides logical storage for different devices. Hence we can switch from Rep1 to Repn in single table for finding the requested contents easily for collaboration.

IV. CLIENT SIDE PROTOTYPE FOR MCL

The Feed Demon and iOS version of net news wire support iPhone and iPod Touch. They help mobile devices to get the contents from sever. The latest version of net news wire lite 4.0 was introduced to substantiate the apple macintosh store (AMS) with limited features. The AMS provides the digital distribution platform for Macintosh OS [17] and [18]. Despite of some missing features, net news wire 4.0 helps the users to obtain and share the contents with other mobile users. To collaborate with other users, the supporting software Really Simple Syndication (RSS) 2.0 is used. The RSS creates RSS feed (online resources) for members of group. The RSS feed is storage area used for asynchronous collaboration. The handheld devices store the contents obtained from server side onto their respective RSS feed. The RSS aggregator is another enhancement with integration of video aggregator. It is highly influential feature to support several on-line sources (RSS feed) and helping to store the contents. The video aggregator collects and sorts out on-line video for RSS feed. To make successful MCL, Apple iPhone can be used with Lite feed RSS reader. Lite feed involves several utilities such as compressing files, cache and fast access to obtain the feeds. Lite feed also helps the handheld devices to view the whole article and share an information among other users. The passage of article is shown in figure 2.

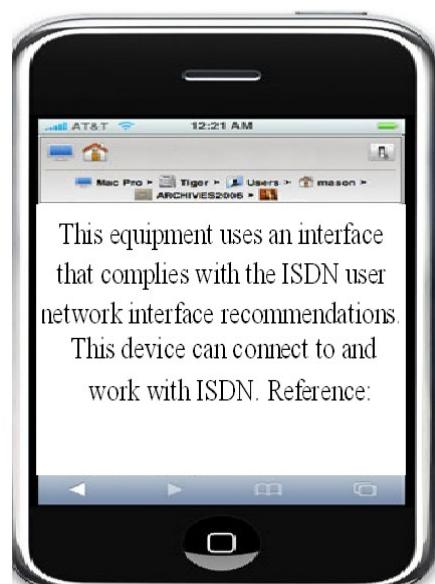


Figure 2. Received contents from server side

Another application is also bit-Torrent based on peer-to-peer that supports mobile RSS 2.0. The application allows a client to download the files automatically. The RSS 2.0 is the main source of sharing and downloading the information for MCL. The specific RSS aggregators can resolve the pedagogical issue because they are very helpful in building the blog [8]. Mobile RSS provides audio and video updating [1]. RSS reader is another supporting software that can check the subscribed feeds of the clients. It also builds user friendly interface. Each participant is assigned separate feed to store and read the information. When any mobile device wants to collaborate with rest of group. It obtains the contents from server and stores on its RSS feed. It provides an opportunity to other users to use an information for MCL. The interested user in collaboration takes one more responsibility to send multicasting message to invite the group-members to start MCL. The multicasting message is broadcasted but based on the size

of group. The users can join and leave the group and recognized with class ID. The track group membership and route datagram are required to send multicast messages to the members of group. The group membership management is used to control the local delivery at at local level. Global is used to handle the remote multicasting [9]. Internet Group management protocol is used to track the location of clients. When participants send the response with reports they are recognized as members, taking part during MCL. Similarly, the global is inter-domain multicast protocol that is used for multicasting the message. The beauty of the protocol is to control the scalability and network convergence issues. It also helps the users to download the contents by using RSS 2.0 software from feed of interested participant who wants collaboration. All of the users get the contents from RSS fed then start the collaboration. The process of multicasting and storing the contents is shown in figure 3.

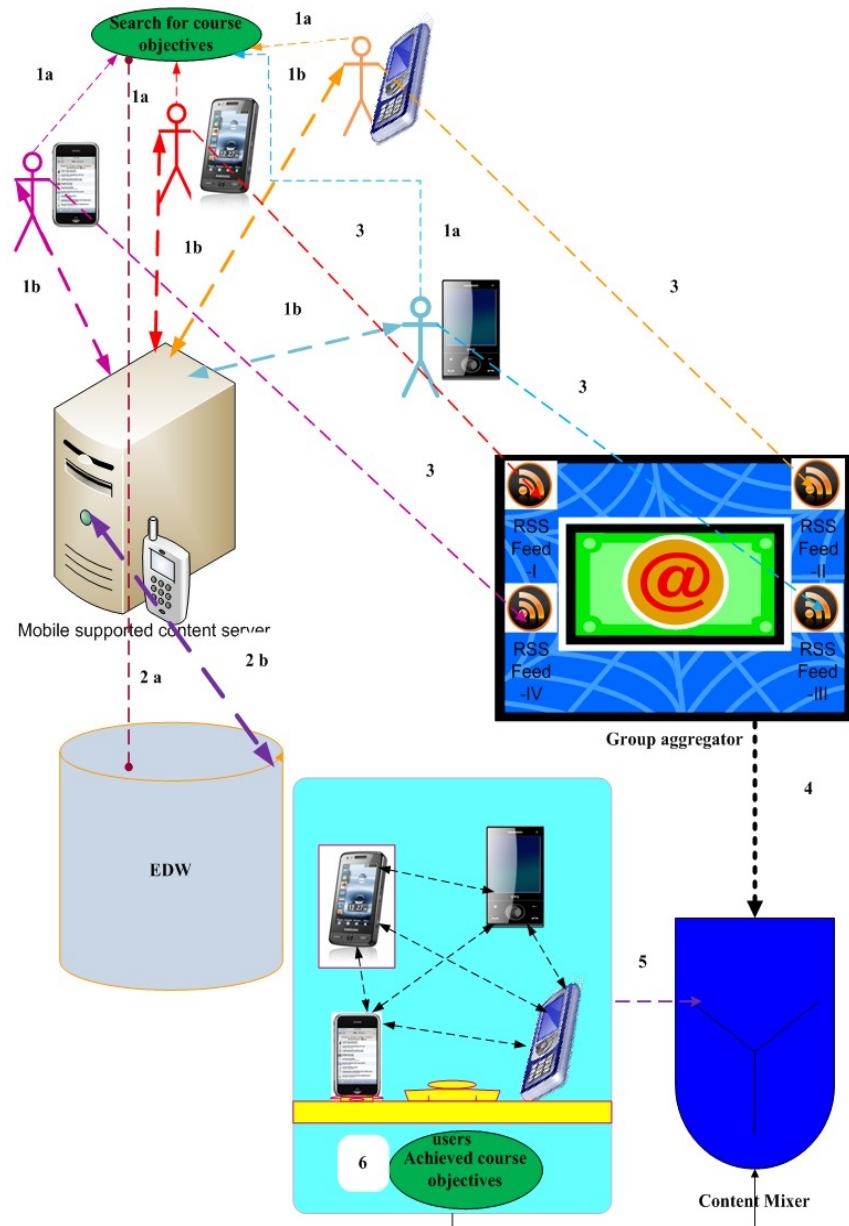


Figure 3. Content storing and extracting process from client side

V. GROUP APPLICATION AND CASE STUDY PROTOTYPE FOR MCL

MCL is a emerging concept in education since last several years. It allows the users to gain computer-based information through mobile devices. MCL provides various advantages such as portability, context awareness, connectivity and social interaction [6]. Mobile devices can be more successful tool for collaboration, allowing the students to obtain and share the information to meet the pedagogical objectives. From one side, mobile creates bridge of several opportunities, and from other side, limitations affect the deployment in MCL environment. The highly performance affecting factors are small size of screen, mobility, navigation issue, bandwidth, low resolution, and limited memory [1] and [6]. With deployment of emerging technologies and its best use make the task easy and accessible to all. The paper proposes and implements user side group application with some features at an initial state. The prototype of application is used as case study that resolves the barriers being faced mobile users to obtain the contents at anytime and anywhere. The prototype of group application helps the students to obtain the required contents to meet the course requirements. Assume the students want to obtain the contents of course "mobile and wireless communication". As these devices get the course contents from the server of UB to make MCL. The sufficient information is stored in EDW to meet the standard of course explained in [2]. Information of courses cover textbook information, course ID, course name and course description. The main focus of case study is around the course description that comprises of course contents.

The objective is completion of course contents during the semester to fulfill course requirements. The Course objectives are met with support of quizzes, class tests assignments, discussion, research projects, labs etc. These all of the requirements are obtained through MCL. Figure 4 supports the process of case study prototype for MCL.

Suppose Integrated Services Digital Network (ISDN) and its components are the contents of the first chapter of mobile and wireless communication course. To meet the course requirements, we want to create MCL environment but due to limited capability of mobile devices and installed software threads cannot provide easy access to achieve the objectives. To meet the requirements, we recommend to use feed demon or net news wire software with support of (RSS) 2.0 software. Furthermore, we suggest to incorporate android mobile operating system, which consists of software stack for mobile devices. The following recommendations will be implemented to add new application.

1. add new application with name "group" in application section by using Java programming and eclipse.
2. extend resource manager and activity manager and provide extra responsibilities to control different features of "group" application.
3. modify and extend libraries section to facilitate structured data storage.
4. enhance display Driver of Linux Kernel to support MCL activities.

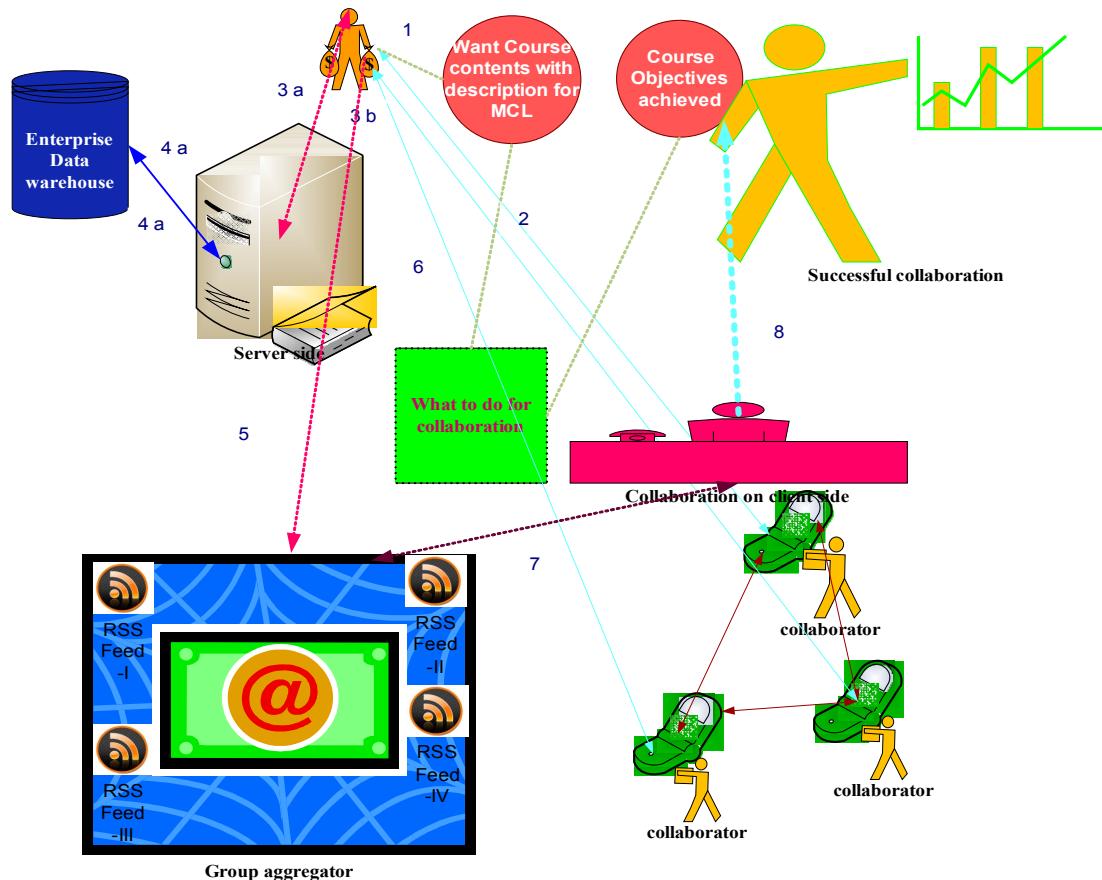


Figure 4. Process for obtaining the course contents through MCL

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If these recommendations are implemented in android, new application "group" with new features will support for obtaining the contents from server side. group application is shown on android with other applications in figure 5.

The "group" application consists of two basic options Control and Delivery. The control option performs several functions including add new contact, edit contact, delete contact, existing collaborative group (C-G) and make new C-G. Delivery Option consists of two sub basic functions "Receive" and "send". When user wants to obtain the contents from server side, delivery option is used and contents are saved by using the store option. The store option controls and handles all type of data. Store involves file, audio and video. The store has download option. The participating users use this option to download the data and stored onto RSS 2.O for collaboration. Each section of store option manages the several files, audio and video. When contents are obtained from server that are saved onto store. The uploaded option of application is used to upload the contents to RSS Feed. The upload option helps the users to put any type of contents in RSS feed. The contents to be stored are used by member of the group for MCL. The requested user makes group call after storing the contents in RSS feed. The user also informs the collaborative group to join for MCL by making group call as shown in figure 6.

When participants of group receive an invitation message for collaboration, they start to download the contents from RSS feed of requested user. When group finish the process of downloading the required contents from RSS feed of inviting user. Finally they start to follow the process for MCL given in figure 7.

If members need file for MCL, they open to read an information of the contents. If an information is not sufficient for clarification of the topic, they can play the video of related information obtained in figure 8.



Figure 5. Group application with other applications

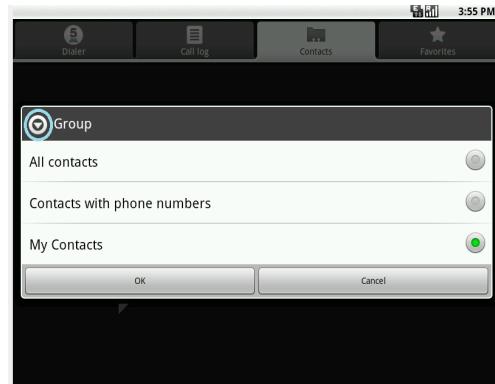


Figure 6. Making group call to all participants



Figure 7. Sharing of contents for Mobile Collaborative Learning (MCL)

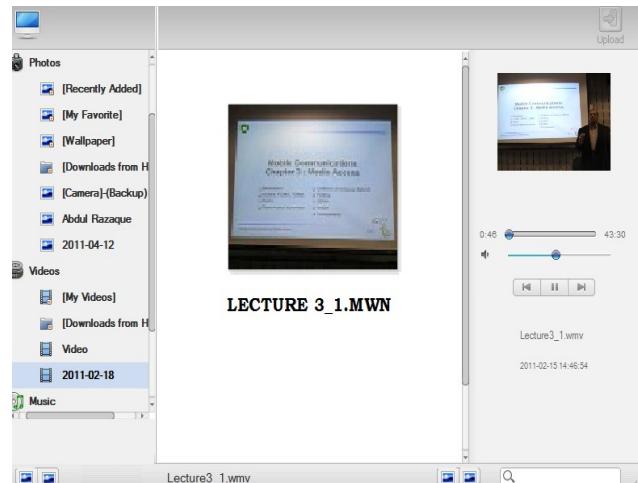


Figure 8. Sharing of Video for Mobile Collaborative Learning (MCL)

The “group” application provides utility to manage the contents by using separate options for each media . The file option is used to get text-based contents otherwise audio and video options are used. When all of the members get sound knowledge of the topic, subsequently initiate the process of collaboration by using existing collaborative group (Existing CG) option. The process is supported with TCAP, ISUP, Q.931, H.323 and other underlying protocols. These protocols collectively support real-time audio and video communication [1] & [10].

VI. ANALYSIS & VALIDATION OF ARCHITECTURE AND APPLICATIONS

The most important and critical task is validation of application and architecture. The paper uses two methodologies applied in validity testing supported with five likert formula. The methodology involves laboratory and field testing. The laboratory testing is conducted for architecture and application including light weight software threads. The field testing covers application and few light weight software threads. The benefits of laboratory testing involve human interaction and heuristic evaluation to accomplish the task. The paper does not depend on single testing procedure in laboratory. It comprises of four testing phases including unit testing, integration testing, performance analysis requirement or beta testing and user acceptance testing. The unit testing is initiated after finishing each task to check the functional performance of each component or feature. If any bug is detected that is removed at the initial stage. The unit testing is more helpful for introducing cost-effective and high-quality product explained in [19] & [21]. Integration testing (IT) makes the task easier because it combines all integrated aggregate into one unit to identify the problems to be occurred. IT reduces number of possible errors to make successful analysis [20]. Requirements analysis is applied when establishing the goals for conducting the validation. It combines the features of usability attributes and applies nine generic usability attributes explained in [22] & [23]. IT helps to find out the reflection and attitude of users when using mobile application for accomplishment of task. The users try to understand the presented contents for improving their performance. The quality of menus, navigation design of application, accuracy and completeness is identified to achieve certain goals. User acceptance testing (UAT) is recognition of party's work done by other party. It is final testing process to screen out any issues if users identify. The laboratory testing method is handy to focus on comparing multiple interface designs and mechanisms for input data of mobile devices. UAT makes easier to deploy video device to capture the emotions and reactions of participants when using mobile application. The dynamic mobile features are hard to simulate in laboratory and they need real environment to identify the valid findings about the performance of features explained in the studies [24] & [25]. This statement motivates to measure the performance of group application and including few light software threads outside the laboratory. The field testing faces three basic problems reported in (Palen & Salzman, 2002). To control these issues, we introduce the scope of mobile fea-

tures prior to conducting field testing. The scope highlights movement and position of testers and environment scenario. It is more convenient to deploy effective methods for collection of data in field. We use real mobile devices in both testing methodologies, which help the testers to collect realistic facts and figure in static, dynamic and heterogeneous environments. The basic data collection methods w involve the questionnaire, interview, verbal protocol and regular meetings to get feedback from participants and testers to improve the quality of Interactive architecture and applications. In this section, we discuss the procedure of testing for group application based on heuristics and questionnaires. We apply both testing methodologies with 08 participants to be conducted at the University of Bridgeport. The participants analyze and evaluate the some basic features of server side Interactive protocol and group application. With this testing procedure, the users transfer files between laptops and the mobiles. The testing procedure invites the participants belonging to different background. Some are familiar and belonging to mobile and wireless communication field and fewer possess less expertise in this field but know how to use mobile devices to make MCL. The group leader who is much familiar with this field records the performance for the features of Interactive architecture and applications on the basis of activities performed during the testing. The performance analysis requirement or beta testing method also involves three steps. First, we introduce the testing procedure from design phase to conducting the test. Second, make all the related operations of architecture and applications and finally, we give the questionnaire to all the participants based on 5-level Likert method, so that testers give the feedback and answers after completing the appropriate tasks shown in figure 9.

When questionnaire procedure is finished, we arrange the meeting in which all the participants come and share their experiences and give their impression regarding the test. We also get suggestions regarding the redesign and modification of architecture and application. When participants leave the room, we compile the results and arrange in form of table for better understanding shown in table I.



Figure 9. Testing procedure for some features of group application

TABLE I.
SHOWING THE COMMENTS OF PARTICIPANTS AFTER ANALYSIS AND VALIDATION

Post Usability Testing of fields	Comments of participants
Should be easy to use	Strong Positive=08; Positive=00;Neutral=00; Negative=00;Strong Negative=00
Should be User friendly interface	Strong Positive=08;Positive=00;Neutral=00;Negative=00;Strong Negative=00
To be flexible to collect and extract the data.	Strong Positive=06;Positive=01;Neutral=01;Negative=00;Strong Negative=00
To provide text, graphs, images, audio and video services to meet the requirements of related course of study	Strong Positive=06;Positive=01;Neutral=01;Negative=00;Strong Negative=00
To support multimodal MCL	Strong Positive=05;Positive=01;Neutral=02;Negative=00;Strong Negative=00
The Students should have alternative choices for selecting any topic to discuss.	Strong Positive=03;Positive=02;Neutral=02;Negative=01;Strong Negative=00
To provide the facility to contact and invite the members for collaboration	Strong Positive=02;Positive=03;Neutral=03;Negative=00;Strong Negative=00

VII. CONCLUSION AND FUTURE WORK

The main objectives of introducing the architecture-based prototypes are to obtain the learning materials on handheld devices particularly on mobile devices. The deployment of these prototypes in educational institutions will foster the pedagogical activities. The students can get course-contents at anytime and anywhere. The paper introduces the novel architecture for server to support MCL in education. The design and development process of server-based architecture provides faster delivery of contents to users. The content server is also optimized by integrating it with cache server at server side. This integration saves time of users to collaborate quickly. The client-based architectural prototype gives complete directions to researchers and market oriented persons how to make the mobile device efficient to obtain the contents from server and store onto RSS 2.0 for MCL. The paper also targets to implement some basic features of the new group application and recommends some valuable suggestions in android operating system of mobile devices. Furthermore, the paper discusses the development process of group application including the prototype based case study for the University of Bridgeport to meet the course requirements. Finally, the paper validates the features of interactive architecture and applications to prove the claim. In future, we will use marking and ranking method to find out the basic user requirements. In light of basic user requirements, group application will be extended and also validated by using usability testing method and heuristic evaluation.

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