

# Performance of Mobile Learning System Based on Triple Play

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**Abstract**— The development in the mobile computing lead to development of small and portable mobile devices can be used in our daily life. Also the increment in wireless networks technology make these devices more appropriated to use in different fields such socialization, banking, controlling , education, etc. In this paper we proposed mobile learning system aims to enhance learning aspects by using triple play services as a mean to delivering multimedia learning content including audio, video and data to the end users (students) by using wireless channels. The system is implemented by using open source framework combined of PHP, MySQL, WebRTC and ImageMagick that give the system flexibility and compatibility in the design adaption where the system is designed in modular architecture which allow changes in individual modules or subsystem without direct effect on other modules and subsystems. The system was tested and the performance is evaluated results over wireless channels.

**Index Terms**— 3G mobile learning, M-learning system, Mobile learning, Triple Play, Triplr Play services simulation.

## 1 INTRODUCTION

The main purpose of mobile phones when it invented is to provide mobile communication by using voice calls with SMS. Later, the mobile devices and networks support another type of communication which is multimedia services that help to make mobile learning more efficient by sharing images and videos that offer more interaction with learners that contributed in the growth of this type of learning and make mobile devices more than a mean of communication and increasingly became multi tasks tools.

Also, the extremely use of new technology tools and devices by people increasingly produce new generations of learners have a gap between them attitudes and aptitudes and the found learning environment cause difficulties in teaching them with traditional legacy methods[1]. In the same time, Internet technology appearance has improved the communication activities providing a different level of interaction among geographically separated parties where it can be employed in the creation of learning environments that appropriate the needs of learners activities such as collaborations, conversations and problem solving[2].

The emergent of E-learning solves some of the issues that faced learners and education systems in the last years. E-learning rely on the desktops or laptops computers that distributed in houses or offices and campus of universities. Usually these computers are insufficient because it shared among family or students members. Also most of the learner spend most of their daytime out of home that make the E-learning less efficient way of learning[3].

Due to the fact that mobile devices are easily accessible by learner and support for standard Internet technologies. It may become the optimal tool for learning purpose. Where it provides anywhere at any time access to varied types of data resources, such as websites, audio and videos, images and e-books which stored locally in the device or accessed through Internet using wireless connection[4]. M-learning is used to describe the learning environment that takes place anytime and anywhere using mobile device that meet learners demand for flexible and alternative methods of delivering course materials[1]. By using the modern methods and techniques inte-

grated in M-learning, help in making the learning of students more interesting, more interactive, widely available and flexible as cost-efficient that helps students to learn more without traditional restrictions.

## 2 SYSTEM WORKFLOW

M-learning system mainly have two ends. First end represent data servers as information resources ,while the second end is represented by:

- mobile nodes (students) consumer of information resources.
- almost fixed nodes (lecturer) represent the producer of information resources.

All interactions and operations take place between these two ends. To get better understanding of the system work the Fig. 1 shows layers of the system workflow. Layer one is presentation layer that located in the clients end that provides interface for all interaction between two ends of system.

Layer two is the network layer that route all traffic between ends and divided into two sub layers. Mobile network sub layer represented by the mobile operator that provide wireless connection between mobile terminal and local mobile wireless network resources that has gateway to internet used to pass traffic to other networks.

Internet sub layer which is represented by high speed global network, provides bridging between mobile wireless network and data servers that connected to wide world network. Application layer is logical layer that directly connected to data layer and the end users. Applications run over system servers represented by system modules that provide specific type of services related to education activities.

Data layer represents the core network, contains the system servers that store all information about users and courses and other system data. This layer is based for all above layers that handle all requests and processing operations, but in the same time data layer is completely transparent to the end users and they have to interact only with application layer that contain modules for data transmission between these two layers.

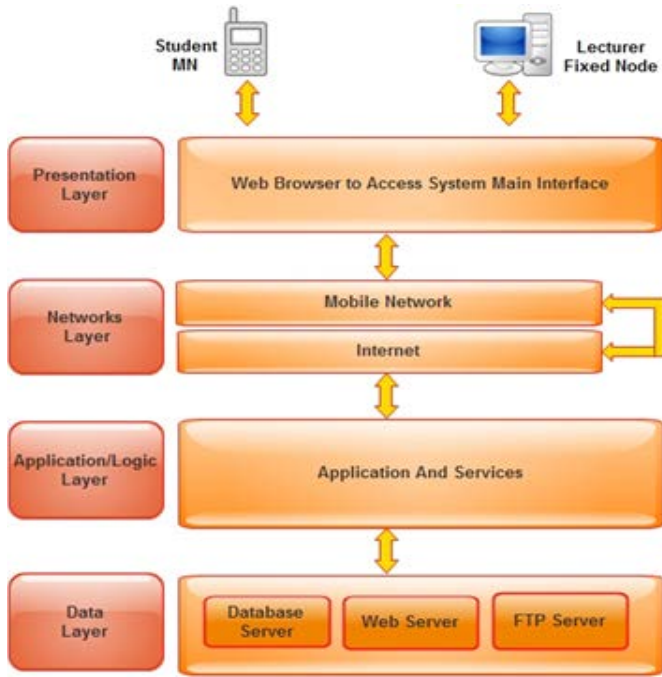


Figure 1: system work flow

### 3 SYSTEM ARCHITECTURE

M-learning system was organized into subsystems. Each subsystem deal with specific related functions to simplify development and reduce the work in implementation. Also provide simplicity in error allocation and correction of modules and subsystem during testing or system refinement and maintenance. Subsystems are integrated to represent M-learning system structure that is specified in the design stages. All subsystems interact with each other directly or indirectly by data and control messages.

### 4 SYSTEM IMPLEMENTATION

Due the system present variance functions depend on the type of service provided by the specific modules, the system is implemented by using different techniques fit system functionality with users requirement. The main subsystems of the M-learning system are courses management subsystem, tests management subsystem, virtual library subsystem, online lectures broadcasting subsystem, offline lectures subsystem and administration subsystem that described in the next subsections.

#### 4.1 Courses Management Subsystem

This subsystem used to providing services for both students and lecturers. The lecturers have ability to create new courses by several easy steps consist of course details insertion and course material selection. The course creation module store course information in the database server after checking courses tables for a similar course hold same name . This process followed by creation of a new folder in file server which contains course material. Another module take care of converting PDF file of course material into serial of images have

certain format and resolution stored in the folder located at file server to be fetched later during online lectures broadcasting. The flowchart in Fig. 2 shows all these operations of course creation activity. Another service provided to lecturer is courses management, where the lecturer can manage his courses details using edit and remove options. Also lecturer can keep tracking of students whose join courses with options of students removal and blocking, where subsystem modules fetches all courses related to specific lecturer based on his email address. Any changes created by lecturer update the tables in the database server and file server by using AJAX technology that provide transparency in interactions between system modules and system servers. Students also can manage their joined courses by exploring joined courses to download course material, join lectures or to leave the course by using the same techniques provided in other modules. If you are using Word, use either the Microsoft Equation Edi

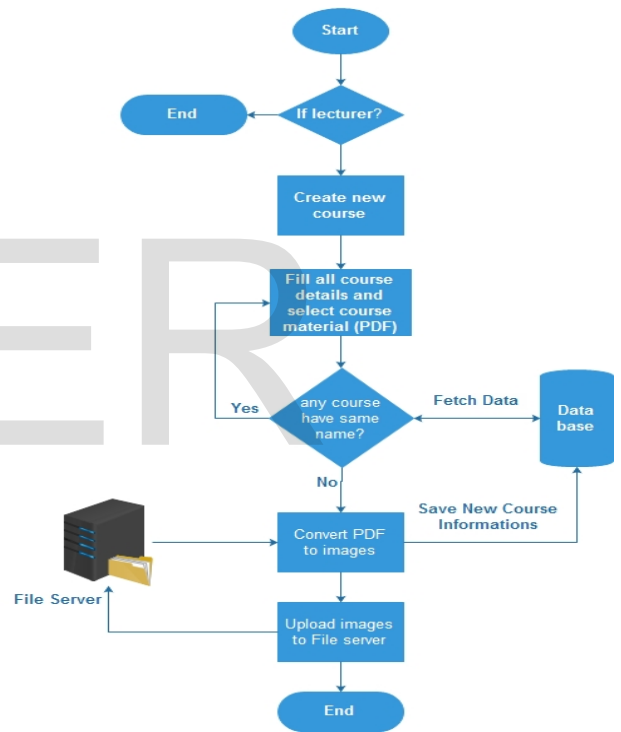


Figure 2: course creation flowchart

#### 4.2 Tests Management Subsystem

This subsystem provides services for both lecturers and students. Lecturers need to measure the level of students understanding and improve the learning activities. To perform such process tests are created by the lecturers by filling test form which contain the test details. Test creation module take all details filled by lecturer to store it in tests table located in the database server with test creator to specify the test owner and bound the new test with course created by the same lecturer. Then, lecturer start process of writing different types of questions which supported by the system. Three types of questions are supported MCQ, True & False and Description questions. Description questions give the lecturers more flexibility in question writing over the traditional system which limit the

lecturer with specific type of questions. Where the lecturer can write any question with option of attach a figure with it. But, this type of questions don't come without tradeoff where the lecturer has to correct this questions by himself unlike the other two types which corrected automatically by the system. Questions tracking module store all question with their details such as test name, question choices, right answer, question mark and question type in the questions bank that located at the database server. Test name play import role to distinct questions related to specific test from other questions in the questions bank. The students use this subsystem to navigate and perform the tests in the deadline date that specified by the test creator and every student have a chance to perform the same test for one time only. AJAX technology is used in all this subsystem modules to provide transparent data transmission between modules and server and to prevent modules from reloading during test creation or performing, where it provide ability to update just a part of entire module transparently which have another advantage in reduce the overall data transmission between the two ends users and servers. Figure 3 shows the flowchart of test creation operations that explained in this subsection.

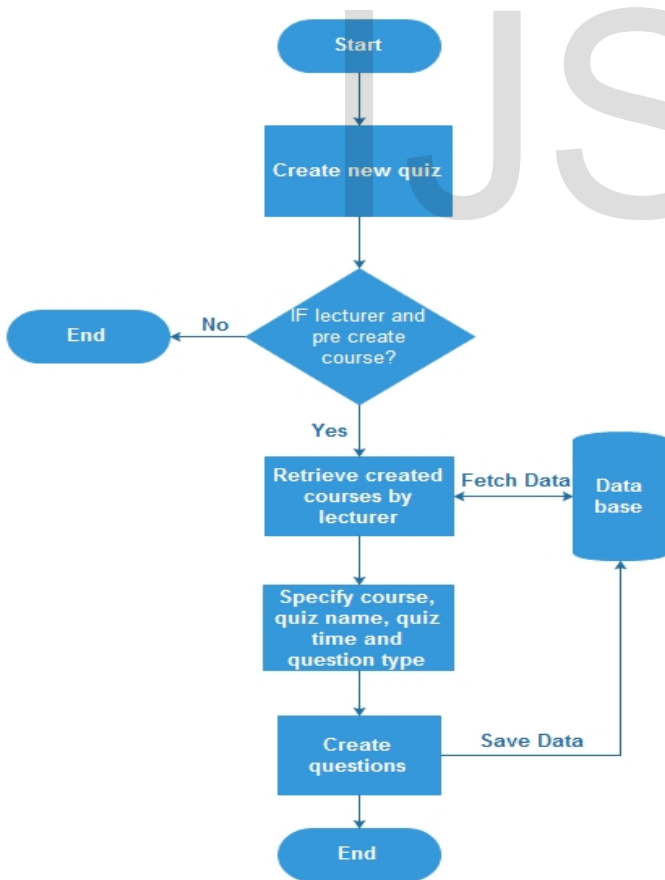


Figure 3: test creation flowchart

### 4.3 Virtual Library Subsystem

Libraries is an important part of the educational systems, since it provide extra references and information resources for students who looking for more knowledge about specific subject. The virtual library in our M-learning system provide these facilities. Where the lecturer can upload an additional books or articles that may related to specific course and mention the students to get it from the library if it seems the course material not enough for them. To upload new document, lecturer select the PDF file from his device and fill the form which contains information about the new document. The uploading module is connected to database and file servers to store the PDF file in the library shelves located in the file server and store all the required information in the database server which is easy the search operations to find this document. In other side, students can search and explore the library content in two main sections books and articles. The section of the document specified by the document uploader (lecturer) during insertion of file details in uploading processes. The student have to choose to download the document and read it offline in any time or to read it online using PDF reader that imbedded in the system which useful for students who want to take a look for the book or article before downloading. Where the online reader load only the page that user engaged with reading it without downloading entire file which contribute in minimizing data transmission between client and server.

### 4.4 Online Lecture Broadcasting Subsystem

Lecturer can broadcast their online lectures by using this subsystem. This subsystem provides variety of tools used by the lecturers to mimic the education activities of real classrooms and mix them with advantages of mobile learning. The first part of this subsystem is the video broadcaster which depend on Web Real-Time Communications (WebRTC) technology that used to provide mobile real time application without external plug-in supported by the most platforms. This application is used to broadcast live video streaming with resolution (352 \* 240) and minimum bandwidth allocation 256 kbps for video and 50 kbps as minimum bandwidth for voice. The video frame rate will be between (3-15 fps) depending on web camera capacities. The video session starts by opening new channel between the lecturer and signaling server to select session parameters like used codec, video resolution, frame rate and unique session id followed by live video streaming. Students join the lecture by make negotiation with signaling server to join video session with certain id and retrieve session parameters to receive the online video broadcasting. VP8 encoder is used as online lecture video encoder and will explained in the next sections. The results in Fig. 4 shows the bitrate of the video when this coder is used. the average bit rate is 250 Kbps with frame rate was set to 10 fps. This result shows that this subsystem can run over 3G mobile wireless networks which are currently available and being used in Iraq.

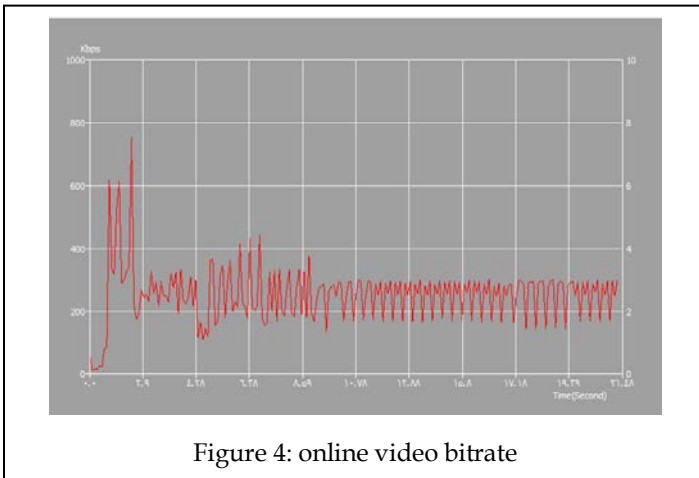


Figure 4: online video bitrate

The other part of this subsystem is data broadcasting which broadcast the lecture material slides that previously processed and stored in the file server during course creation. Lecturer control the operations of start/stop broadcasting session and the way in which the slides will be previewed. Since only lecturer have ability to audio/video broadcasting to communicate with students, the students need low cost communication method to communicate with lecturer and each other in the same time. Instant text message by using AJAX and jQuery techniques represent light and effective method to meet this demand without installation of extra chat server to synchronize the messages between all parties, where chat box appropriated to each virtual classroom for communication or announcements purposes. Figure 5 shows the main components of this subsystem.

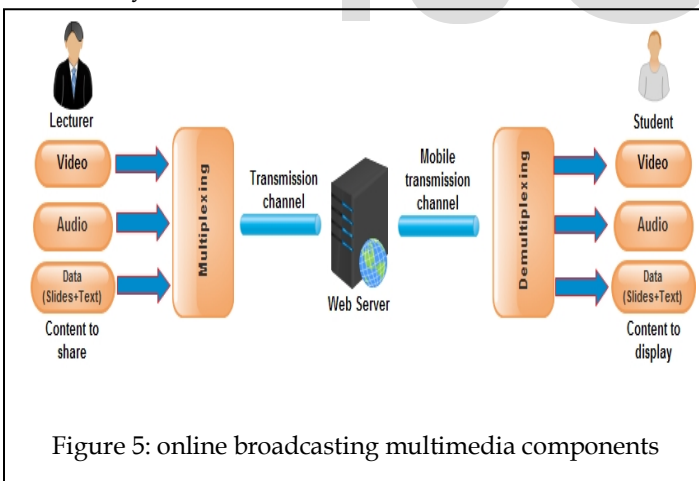


Figure 5: online broadcasting multimedia components

Tutorial module is one of the subsystem modules that provide collaborative whiteboard used in tutorial lectures. The principle of work for this module is similar to that found in online lectures broadcasting module. Session started when lecturer or student is connected to signaling server to open new channel which is used for synchronization among all connected parties. All session members can write on the whiteboard and the writing shared with all members by sharing the coordinates of user writing on HTML5 canvas element with other users. Figure 6 shows the interactions and messages between system

users and system servers to start and join online session for lecture broadcasting.

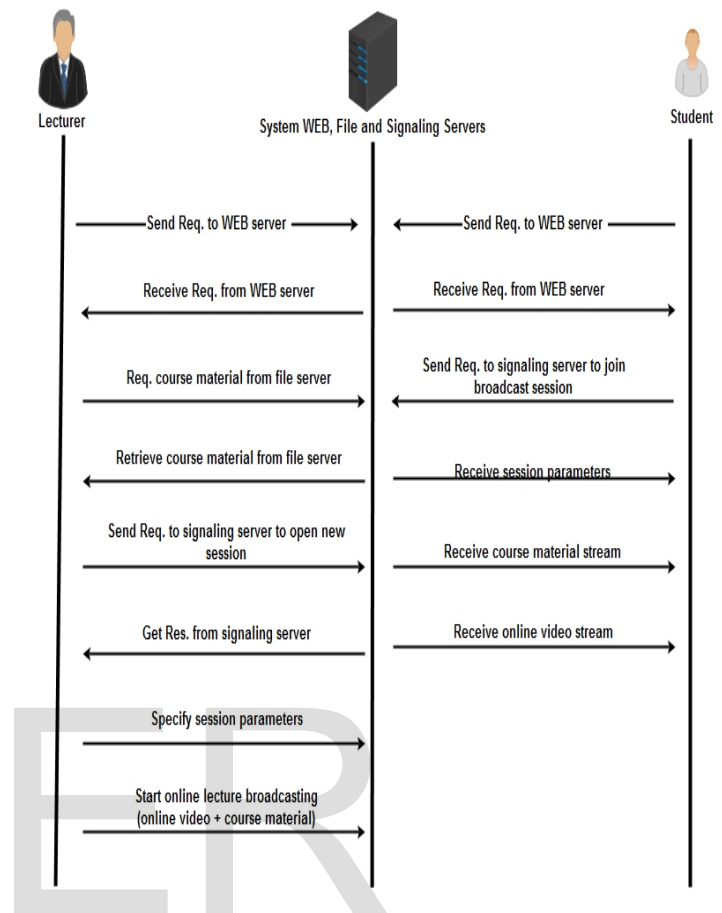


Figure 6: online lecture broadcasting interactions

#### 4.5 Offline Lectures Subsystem

This subsystem allows the lecturer to upload prerecorded lecture to the M-learning system. Students can access these lectures as on demand videos (VoD) at anytime and anywhere by setup point to point connection between client and server. HTML5 video element is used instead of adobe flash plugin for transmission of video content over HTTP which solves compatibility issues that occurred with devices not support for flash players. MPEG-4 is used as a format for uploaded videos where this format provide high compression ratio, good video quality and supported by the most browsers installed on the mobile devices. This subsystem gives the student more flexibility in time of the learning process, but as a tradeoff with online interaction with the lecturer and other students.

#### 4.6 Administration Subsystem

This subsystem exclusively used by system administrator, where it contains set of modules provide services to ease management tasks of the system resources. These tasks include database server management, file server management, streaming management and lecturers approving.

## 5 VP8

VP8 is an open source video compression format which is dedicated to developing a high-quality, open media format for the web that is freely available to everyone. VP8 has many distinctive technical features that help it to achieve high compression efficiency and low computational complexity for decoding at the same time. Generally, VP8 has low bandwidth requirements that make it suitable to use for mobile web based video applications which relatively, run over limited bandwidth capacity. Also, it solves some of the compatibility issues, where it supported by variant range of devices from mobile and embedded devices to the most advanced desktop computers and have other technical characteristics in the video coding and comparison makes it a competitor to other encoders like H.264 video encoder[6].

### 5.1 VP8 Reference Frames Types

VP8 support three types of references frames that used in inter frames prediction. Last frame(previous frame), golden frame and an alternate reference frame. The last reference frame is a frame or number of frames used in prediction and construction of the current frame. the laboratory experiments showed that it is very rare for more than three previous reference frames to provide significant quality without increase the memory to increase the number of reference frames. By depending on the decompressed content, a frame from the distant past can be very beneficial in terms of inter prediction when objects re-appear after disappearing for a number of frames. So, VP8 use a buffer to store one high-quality reference image frame from an arbitrary point in the past updated periodically or on demand, this frame known as golden reference frame or key frame. The alternate reference frame is different from other two types of references frames. While the other two types are always displayed to the user by the decoder, this type of frame may or may not be shown in the decoder because it has an option of not being displayed. The encoder can use this frame to transmit an extra helpful data in compression and decompression methods and not for display. For example the encoder can construct one alternate reference frame from multiple source frames, or it can create an alternate reference frame using different macroblocks from many different video frames. This allows many types of usage of the alternate reference frame for improving coding efficiency[6].

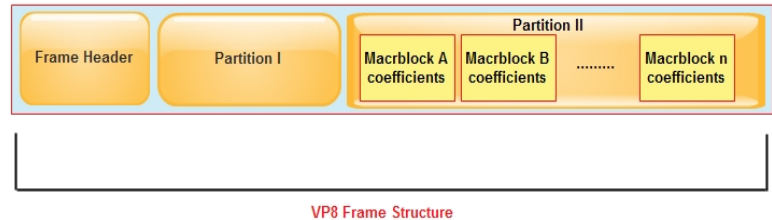
### 5.2 VP8 Frame Structure

The frame structure of VP8 encoder as shown in Fig. 7 includes three sections frame header, partition I and partition II. Frame header composed of number of bits contains uncompressed information that include:

- 1-bit for frame type: is a flag assigned by encoder 0 refers to key frame and 1 refers to inter frame.
- 3-bits for version number: is a value from 0 to 3 for specify the profile type and complexity of the decoder. The other values are reserved for future work.
- 1-bit for show frame: is a flag set to 0 for hidden frames and to 1 for display frames.
- 19-bits field contain the size of the first partition in bytes.

Partition I contains information for the entire frame such as

per-macroblock information to specify how each macro block is predicted. Where it contains the prediction mode parameters and motion vectors for all macroblocks. The partition II contains texture information represented by the quantized DCT or WHT coefficients. There can be one, two, four or eight DCT/WHT partitions per frame depending on encoder settings.



VP8 Frame Structure

Figure 7: VP8 frame structure

## 6 SYSTEM PERFORMANCE MEASUREMENT

System performance is evaluated by building network architecture of wireless network using OPNET modular. The tests focused on the access wireless network that connect the mobile node which use the M-learning application to the core network that contain the system servers. The system evaluated by using two different wireless channels, WiMAX and UMTS wireless access technologies that supported by OPET simulator and provide channel bandwidth suitable for our system demands. Figure 8 shows the architecture of the network used in system performance evaluation which composed from three parts remote servers network, Core Service Network (CSN) and access network. The remote servers network consist of remote gateway router that connects the servers to the global network of internet and the system servers web server, file server, database server and video server that connected directly to local switch that connected to the gateway router. The second part is the CSN which consists of core gateway router used to connect the core network to the remote servers network through global network and Access Service Network (ASN). ASN represent an entry point of mobile user to the wireless network that contain a number of base stations (Bs's) connected to ASN router. Finally the third part is an access network which represented by the mobile nodes that is connected to the BS through radio frequency (RF).

## 7 SIMULATION PARAMETERS

Each node in the network has a set of parameters that specify the behavior of this node during the run of simulation. Some of these parameters are set to its default values while others changed to simulate the real implemented M-learning system and provide best results analysis. Table 1 shows the characteristics of each scenario.

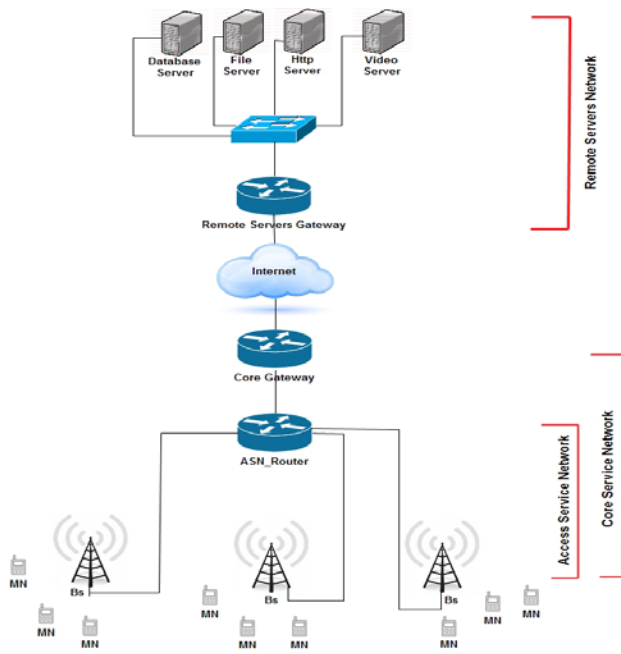


Figure 8: Wireless network architecture

Table 1: Simulation parameters

Parameter	WiMAX	UMTS
No. of BS's	5	5
No. of MN's per BS	9	9
Carrier Freq. Band	3.5 GHz	1.8 GHz
Channel Bandwidth	20 MHz, 10 MHz, 5 MHz	5 MHz
Subcarriers	2048, 1024, 512	512
Modulation Schemes	QAM 3/4, QAM 1/2, QPSK 1/2	QAM 1/2, QPSK 1/2
Duplexing Schemes	TDD	FDD
Frame Duration	5 ms	10 ms
BS Transmission Power (W)	7	7
Pathloss Parameters	Free Space	Free Space
Multi Path Channel Model	ITU Pedestrian A	ITU Pedestrian A

## 8 SIMULATION RESULTS

Figures below show the simulation results based on popular network performance metric response time, delay, jitter and throughput. Figure 9 shows the response time for the FTP servers where Y axis represent the time required to grant the file to the client over different wireless channels where the

response time increased when channel bandwidth is decremented. Figure 10 shows the HTTP response time over wireless channels. We can notice that response time for HTTP service are convergent somewhat due to use of best effort tag for HTTP traffic over all channels. Figures 11 and 12 shows the channel performance for video applications where the MN's use online lectures video broadcasting service and video on demand service (offline video). The results show success in using DSCP technology to grant specific QoS that make the channels suitable to carry delay sensitive traffic like online video traffic with time delay less than acceptable. Also the channel shows stability in term of jitter during data transmission where it reach to 3 mille second as maximum value in all scenarios. Figure 13 shows the wireless channels throughput where the network utilization increased when the wireless channel capacity is increased.

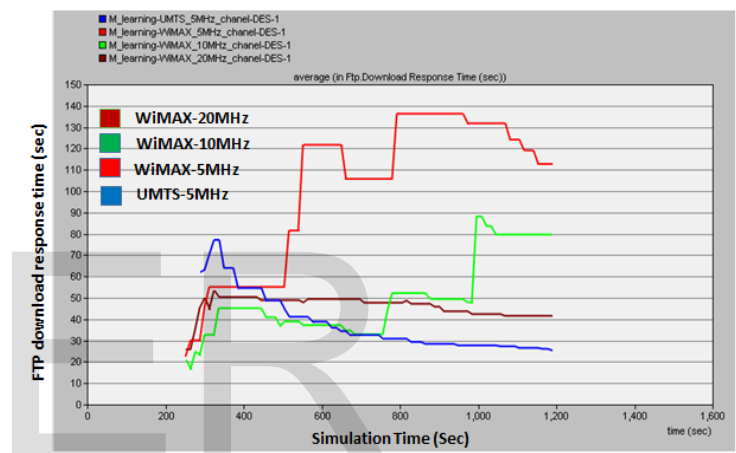


Fig 9: FTP resp

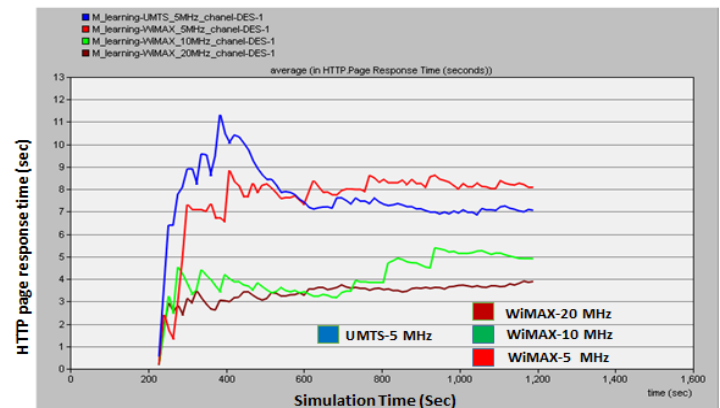


Fig 10: HTTP response time

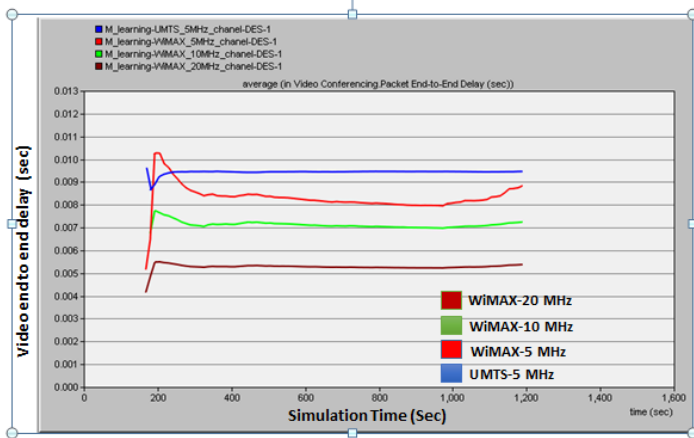


Figure 11: Video end-to-end delay

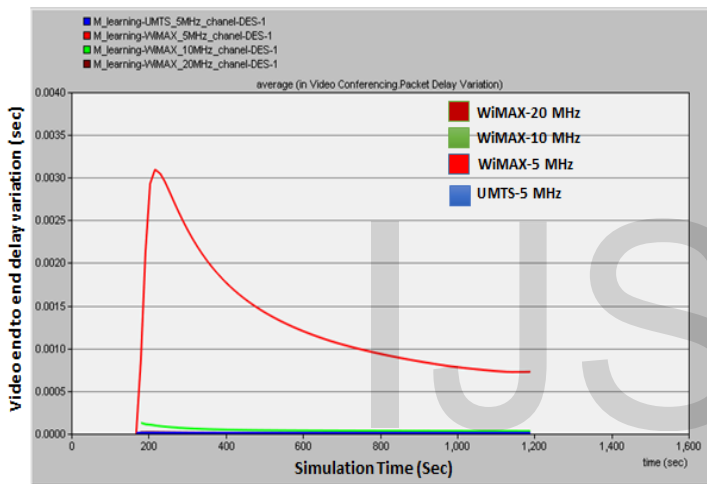


Figure 12: Video delay variation (Jitter)

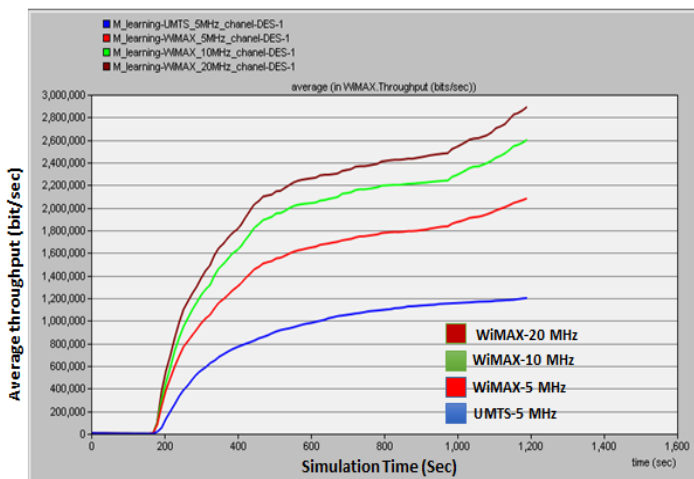


Figure 13: Average throughput

## 9 CONCLUSION

This paper shows the design, implement and evaluate M-learning system based on Triple Play services. The proposed M-learning system solve some of the technical issues that faced learners in the previous generations of educational systems by employing the advancements occurred in mobile computing and web based applications technologies. Where the system provides self-learning facilities in anytime and anywhere. The results shows that Triple Play services could effectively be used to enhance the M-learning system activities by providing extra interaction methods which can easily accessed by mobile terminals that are connected to modern wireless network.

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