Design and Development of Multimedia Network System for eLearning in Nigerian Universities

*Akintola K.G., ** Akinyokun O.C.

*Computer Science Department, University of Houston-Victoria,Texas 77901
United States of America
Akintola2087@yahoo.com

**Computer Science Department, Federal University of Technology Akure
Ondo State, Nigeria.

Abstract

Various technologies have been explored for distance learning in recent times. Such include correspondence, instructional television, instruction radio, and recently web-based systems. These methods of instructional delivery in distance learning were found to be non-effective. Also contributing to these problems is lack of enough experts in various fields of specialization in Nigeria.

In this research paper, A framework of multimedia computer network system for teaching and learning to aid expert instructors in their bid to reach wide audience is proposed. This involves the cable and wireless network design, the communication protocols and the transmission media. The implementation of the framework is done using streaming technology of RealNetworks systems. A website is designed using hypertext markup language (HTML) for easy access to the online lectures at the remote sites. A prototype is developed in FUTA community with a view to determining the effectiveness of the system.

Keywords: *eLearning, virtual classroom, multimedia*

1. Introduction

Distance Education such as correspondence courses, continuous education, satellite campuses, mega universities, open universities etc. have been considered as the panacea to the problems confronting education at tertiary Institutions in Nigeria. However the methods and media of instructional delivery in distance learning such as print, instructional radio, instructional television and so on, were found to be non-effective.

Learners value timely feedback regarding assignments, examinations and projects [Egan etal 1991]. The existing methods of instructional delivery lack timely feedback. In recent years, educators have witnessed the rapid development of computer networks, dramatic improvements in the processing power of personal computers, and striking advances in magnetic storage technology. These developments have made the computer a dynamic force in distance education, providing a new and interactive means of overcoming time and distance to reach learners. Computer networks were found to give timely feedback and can maximize learner control.

Most of the existing methods are single media, that is, it is either text, or voice. HyperCard, hypermedia, and a still-developing generation of powerful, sophisticated, and flexible computing tools have gained the attention of distance educators in recent years. The

goal of computer-based multimedia system is to integrate various voice, video, print, and computer technologies into a single, easily accessible delivery system, which of course will be more effective than the existing systems.

Motivation is a factor that determines success in any form of education [Ehrman 1990]. Learners are more motivated if they are in frequent contact with the instructor [Codeway etal 1980]. Computers facilitate self-paced learning, interaction and gives immediate reinforcement and feedback hence increases motivation more than the existing methods.

Computer networks increase access; local, regional, and national networks link resources and individuals, wherever they might be. In fact, many institutions like University of Leicester in Britain now offer complete undergraduate and graduate programs relying almost exclusively on computer-based resources.

In [Akinyokun 2003], it is recognized that the field of education provides the most fascinating application of computing system, which has consequently attracted considerable attention from educationists and policy makers since the late 1960s when computers were introduced into classrooms. Various information technologies have been applied in learning and teaching, such as Computer Aided Instruction, [CAI], Computer Aided Learning [CAL], Computer Managed Instruction [CMI], Research Packages, Project Monitoring, Computerized Libraries and so on. As a result of technological advancement in microelectronics, computing networks, multimedia technology, computers are now being applied in on-line teaching and learning in higher institutions.

The scarcity of experts in several fields of specialization in higher institutions necessitated the Authors in designing of a computer network where an expert in a field can capture widely dispersed classes. The Authors have carried out a pilot study of multimedia computer network system for education in Federal University of Technology Akure (FUTA) community. The objectives of the study are to:

a. Design a Computer Network for teaching and learning in the Federal University of technology, Akure [FUTA]. .

b. Provide a platform for sharing the knowledge of lecturers in choice subjects across Universities in Nigeria.

2. Architecture of Multimedia System for Teaching and Learning

This section presents the architecture of the multimedia system for Teaching and Learning (T&L) with emphasis on the following:

a. Block structure.

b. Design considerations.

c. Detail structure.

2.1 Block Structure

The multimedia system has three levels or stations of activities, namely: lecture capture station,

The multimedia system has three levels or stations of activities, namely: lecture capture station, lecture file server station and lecture view station. The block structure of the stations is conceptualized in figure 2.1.

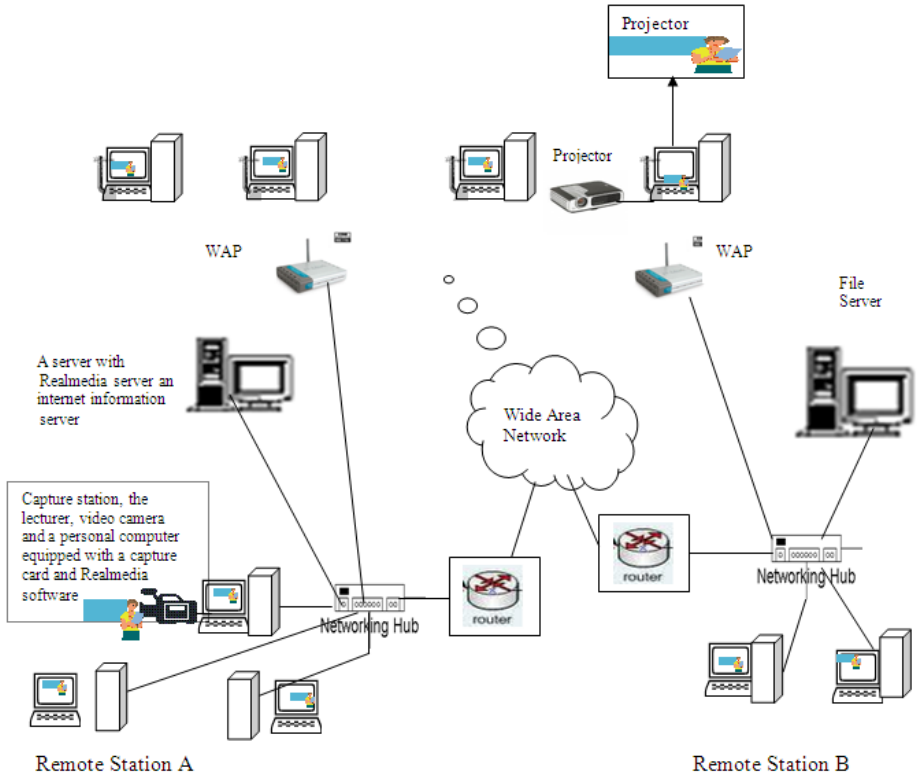

Figure 2.1 – Conceptual Diagram of the Levels of System

2.1.1 Lecture Capture Station

The capture station has hardware and software that are to be used for digitizing and compressing video signals. It comprises of workstations equipped with video cameras and microphones and video capturing software.

2.1.2 Lecture File Server Station.

A server is a computer hardware and software which makes available services for other computers on request. Server hardware are designed to handle requests and handle them effectively and efficiently. As a result whenever there is need to deploy a server, consideration is always given to what the server is meant to be used for. Servers need high capacity storage and high I/O capability. The Server make services available to the client and capture stations on the network. The server receives request from clients (the users) to send or receive their data. The client sends a request to the server indicating:-

a. Address of the server

b. The request (what information to ask)

c. The return address (where to send the information)

The captured lecture programmes from the capture station are stored on the server machine. The server is the distribution agent using multimedia server software to stream the media files. This streaming technology support both live video as well as video on demand.

In case of video on demand the whole lecture is stored on the server before playback begins. While in case of real time playback, the video is streamed into the workstations for immediate playback.

The The Features of the lecture file server station are as follows:

a. Server Hardware: Designated to handle the request from both the lecture capture station and the client station. A server hardware is a full multimedia full duplex micro-computer with very high processor speed, large RAM size and large Hard disk capacity for storage of text, audio and video and lecture materials.

b. Operating System: This is the program or the interface between the actual hardware and the application programs. Because the operating system is a key component of the server solution, selecting one wisely is important. The operating system contains all the tools that allow the server to be configured, maintained and backed up. For this project Windows NT is used.

c. Media Server (Software): A multimedia server answer requests from the clients for media files. It provides the mechanisms for access control in multimedia environment. Typical configuration are: RealSystem Server Intranet 8, and 400 client connections.

d. Web Servers : This serves as a means of retrieving the pages that contains the web page from the media server . Microsoft internet information server for windows NT is used.

e. Mail Servers: Used for distribution of mails : Microsoft Exchange Server is selected.

2.1.3 Lecture View Station.

The lecture view stations where the proceedings of course lectures are being viewed either live or on demand after they have been stored on the server. They decompress video streams and display the video on the video display unit. The audio aspect is played back through a pair of speakers or headphones.

The lecture view station is as follows:

a. The lecture view station will be composed of multimedia workstation equipped with video card, speakers, video player software, and a projector for playing back the audio-video lectures.

b. Two pairs of multimedia speaker: This is used for the audio reception of the lecture.

2.2 Design Considerations of the Multimedia System

The practical issues of the multimedia system are:

a. Computer network topology

b. Messages transmission media

c. Protocol for the transmission of messages

c. Website design for online access to lectures by students.

2.2.1 Computer Network Topology

A star-ring topology is proposed for the computer network. Teaching and learning are viewed as a process which involves the broadcast of signals from a source to a number of targets. The targets are to roam and pick those signals that are relevant to them. The major features of the star-ring topology are the following:

a. The workstations at the lecture capture station or client station can communicate with one and another via the server machine. When the flow of messages via the server machine is congested, there is an options for the workstations to communicate with one and another independent of the server machine. Thus, reliability and flexibility is guaranteed in the system.

b. Cabled network and wireless network are allowed to coexist and cooperate in the system.

2.2.2 Messages Transmission Media

The purpose of a communication system is to convey information from one point to another. In its basic form, communications system consists of a transmitter, receiver and a channel of some type for connecting the transmitter with the receiver.

In this project, Unshielded Twisted Pair (UTP) cables are used to connect computers at the capture station to the server. This is because of the close range of the server to the workstations. Twisted pair wire is relatively low in cost, It is the most cost-effective choice for single building connection at low traffic requirements.

Fibre optics is proposed for other subnets to the server stations because of its advantages of low losses, very wide bandwidth, extremely high isolation between parallel fibre, immunity to inductive noise, and interference is extremely small. It is however very costly and tapping into it is very difficult.

For the wireless access we proposed a Radio spread spectrum technology; a wideband radio frequency designed to tradeoff bandwidth efficiency for reliability, integrity and security. More bandwidth is consumed but the signals are louder, easier to detect and secured.

2.2.3 Protocol for the Transmission of Messages

A protocol may be conceived as a set of rules between two communicating entities, to facilitate the orderly exchange of information, and to efficiently manage network resources. The communicating entities may be user application programs , file transfer packages , electronic mail facilities. There are a number of network protocol stacks to choose from when designing a distance education system.

The MPEG-1 and MPEG-2 standards define syntax for digital bitstreams containing audio and video. MPEG-1 supports compression of VHS quality video and CD quality audio into a 1.5 Mbps bitstream or higher quality at proportionally higher bitrates. MPEG-2 supports compression of wide ranging quality video and audio beyond that of MPEG-1 and approaching that of HDTV.

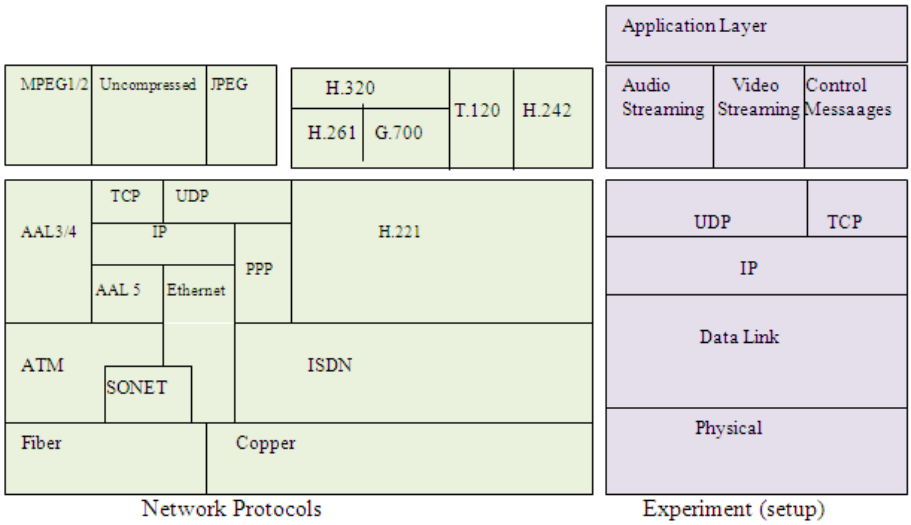

Figure 2.2 Multimedia Network Protocols

The H.320 family of international teleconferencing standards provides for simultaneous audio (G.700), video (H.261) and data transfer (T.120) using communication bitrates from 56 kbps to 1.92 Mbps. H.320 is designed to work with the range of bitrates available using ISDN. Automatic negotiation between connected sites through H.221 and H.242 allows dynamic assignment of bits to individual audio and video channels based on the multimedia capabilities at each site and the available bandwidth. Additional connections can be established as more bits are required and both audio and video compression rates can be adjusted up and down to match limited bitrates. Compatibility with H.320 ensures interoperability with the widest range of third-party teleconferencing systems.

The ATM Forum has established a family of ATM Adaptation Layers (AALs) for the various types of data that will be carried over ATM networks. AAL1 and AAL2 include end-to-end timing information with AAL1 supporting constant bitrate (CBR) traffic and AAL2 supporting variable bitrate (VBR) traffic. Because end-to-end timing adds additional overhead and is not clearly required by distance education applications, we have only considered the remaining adaptation layers which do not include timing information. AAL3/4 supports variable bitrate and is optimized for compressed, continuous data streams such as video or audio. AAL5 is a simplified adaptation layer designed for maximum efficiency and compatibility with other LAN protocols such as TCP/IP.

The Internet Protocol (IP) family of protocols forms the common language for the global packet-switched network known as the Internet. IP is inherently connectionless-based. Transport Control Protocol (TCP) supports error correction, packet ordering and acknowledgments. User Datagram Protocol (UDP) provides minimal overhead but without any of the benefits of TCP listed above, but with a resulting increase in efficiency. Point-to-Point Protocol (PPP) supports the layering of IP and other packet-switched protocols on connection-oriented bitstreams including typical DS-0 serial lines and ISDN.

For our experiment, MPEG-1 was used for video compression in order to maximize video quality for distance teaching within the available processing and bandwidth limitations. Audio was sampled using 16 bits/sample to provide CD-quality two-way audio for teleconferencing. Data, including lecture notes , and system layer messaging were transferred uncompressed. Each of these data streams (video, audio, data, control) was assigned to an IP socket and transferred using TCP/IP layered over Ethernet. A different logical channel is created for

each type of data, including video, audio, images, and system messages. Data transfers are coordinated through the system message channel. Whenever one workstation needs to start sending video, audio, or image data, a system message is sent. Information is also sent on the system channel that ensures the two workstations are synchronized.

The transport protocol TCP and the network protocol such as IP and the same applications protocol are used both in the cabled and in the wireless networks. The IEEE802 standard defines a vendor-independent Ethernet-like hardware technology for 2.4GHz license-free frequency band. It provides a scalable radio access capacity varying from 1 to 11Mbits/sec within a few tens of kilometers.

2.3 Detail Structure

The structural design of the proposed multimedia system has the following three components:

a. Backend machine platform

b. Cabled network platform

c. Wireless network platform

2.3.1 Backend Machine Platform

The backend platform which is presented in Figure 2.3 supports data transmission and reception in a telecommunication network.

It consists of the wireless network platform, short range mobile and fixed communication platform, cabled network platform and long range mobile communications platform.

- The wireless communication layer Consists of Mobile Nodes, such as personal computers and Notebooks which are connected using wireless media.
- The short range mobile and fixed communications platform consists of the following:
    i. Wireless Access Points (WAP) which is an access point is a radio equipment that has roaming capability. It allows a group of workers in a network to stay tied into the LAN for file and print services and still move seamlessly from one access point to another without the concerned of losing their connection to the network. They use a combination of advertising to the client station and coordination amongst themselves during transmission. The advertising is in the form of message frame called Beacons, which the access point broadcast. Beacons contains the domain identification number [ID], the Beacon key, and access point ID. The last two are encrypted together. Clients decides in which access point to attach to, based on the signal strength. When a client registers with a new access point, its 'sign on' request messages include the network address of its old access point. The new access points can then notify the old of the change so that packets addressed to the client will arrive at the right destination. Access points are usually mounted on walls or ceiling.

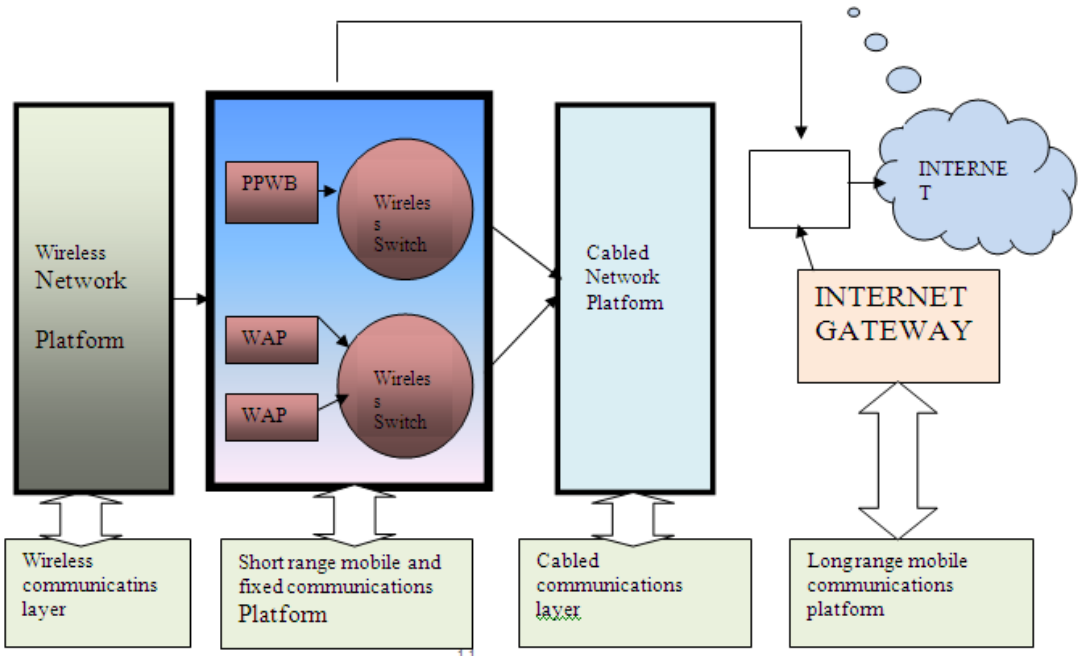

Figure 2.3 – Conceptual Diagram of Backend Machine Platform

ii. Wireless Bridge which is a device that collects the data packets it receives from one network and retransmits them as soon as possible to intended recipient on another network through wireless medium. This implies therefore, that a bridge connects two networks. The purpose of the bridge is to allow the network administrator to manage the traffic that travels to various segments of the network. The bridge system functions like a single large network. Its connection allows multiple networks to appear as one. A bridge can filter the data moving into its domain in a variety of ways, and block extraneous information or unwanted access within the network segment it is linking.

iii Wireless Switch which takes two or more input signals from the access points and routes it through a single channel to the cabled network. It acts as a concentrator or multiplexer. It allows the efficient use of the channel.

- The fixed Network which is the central component of the cabled network system. It has the lecture capture station, and the server station. It houses the database, media server, web server ,and Gateway.
- The long range mobile communication platform which consists of Internet link to the fixed network through radio or Very Small Aperture Terminal (VSAT) using mobile internet protocol (MOBILE IP).

2.3.2 Cabled Network Platform

The multimedia environment will run a Local Area Network (LAN) with a lecture file server machine and two categories of clustered workstations machine using Fibre Optics cable and Unshielded Twisted Pair wire (UTP).

The conceptual diagram of the cabled network platform is given in Figure 4.4. The first category of clustered workstations serves as a platform for capturing lectures and are located

in a Multimedia Center analogous to the conventional Audio Visual Centre which houses the lecture file server machine. Each of this category of workstations is connected to the lecture file server machine using UTP cable. The second category of clustered workstations serves as a platform for students to view lecture online or off line. Each of this category of clustered workstations is located in designated modes such as lecture theaters, lecture rooms or student play room and is connected to the lecture file server machine using fibre optics cable.

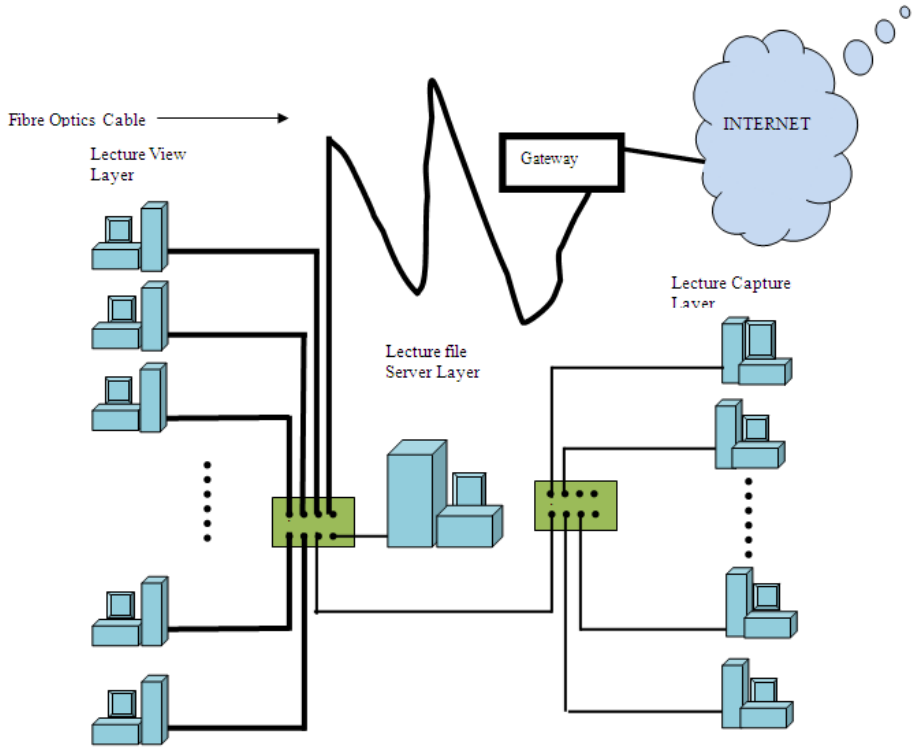

Figure 2.4 – Conceptual Diagram of Cabled Network Platform.

2.3.3 Wireless Network Platform

Wireless access to the computer network is achieved using Wireless Access Points (WAP) which are fixed at strategic locations in the multimedia environment. The Transmission Control Protocol (TCP) coupled with Internet Protocol (IP) is used for the transmission of messages and data in the network environment while mobile protocol is used for the wireless access. [Wilder 93].

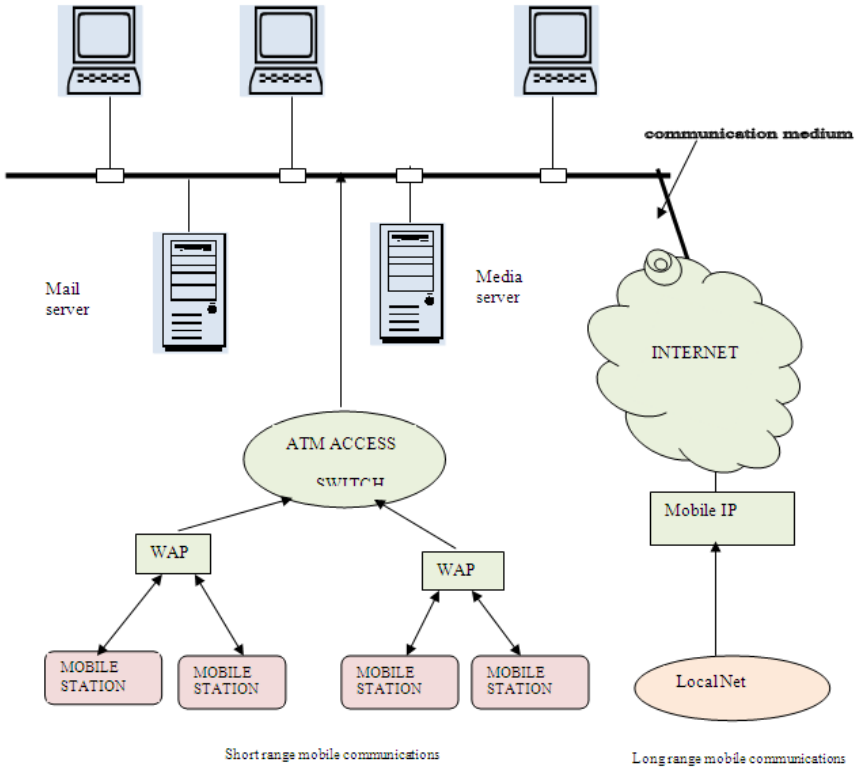

Figure 2.5 – Conceptual Diagram of Wireless Network Platform

The wireless mobile protocol such as mobile adhoc protocol (MANET) or the infrastructure protocol allows the mobile nodes to roam about without loosing their connection with the network.

The environment, therefore, supports the coexistence and cooperation of both fixed communications and mobile communications of messages. The structural design also provides a mechanism for connecting into the internet. The conceptual diagram of the wireless network platform is given in Figure 2.5

3. The Web-Based User Interface

A web-based user interface is designed to handle interactions with the system by the users and also to support heterogeneous network environment where different computers are involved. Hypertext markup language (HTML) and PHP MYSQL used for the Website design are cross-platform applications that can work on any browser such as Netscape navigator or Internet explorer or any browser running on Microsoft operating system or Unix operating system.

The multimedia system provides a user-friendly interface. The user friendliness of the interface is desirable because many students who constitute the major users of the multimedia system may not necessarily be IT literate. The operation of the system is keyboard and mouse driven. The students are made to concern themselves with the use of the keyboard and mouse in the selection of built in commands. Indeed, the students are meant to know what they want from the system and not how to get what they want.

The action of a student through the keyboard or mouse informs the (HTML) to retrieve the lecture from the server machine. The web server retrieves the media from the media server and playout agent in the playback station is activated which, in turns, plays the video. The conceptual diagram of the logic of student access in the environment is presented in Figure 3.

Figure 3 Futa Edunet HomePage

4. Conclusion

In this research, a multimedia system, which is capable of performing the following is developed and tested in the Computing Laboratory of the Department of Computer Science of the Federal University of Technology (FUTA) Akure.

a. On-line and on-demand lecture programme that supports the viewing of lecture that are going on in real time mode (live) as well as lectures that have been stored on the hard disk for later playback.

b. Fixed communications on the platform of cabled computer network and mobile communications on the platform of wireless computer network. This is capable of supporting access to Internet services.

c. Capable of operating and functioning in an heterogeneous environment characterized by different hardware and system software such as operating system.

d. Provides bi-directional communications, which facilitates on-line dialogue between lecturers and students as often found in a real life class setting.

The multimedia system proposed in this project may serve as a tool for re-engineering teaching and learning in Nigeria universities for the purpose of restoring the efficient performance of the major actors in the system. The application of the proposed multimedia system may serve as a platform for the uniform distribution of expert knowledge among collaborative Nigerian universities. The platform may also serve as a window to the terrain of the standardization of measurement and evaluation of students' academic performance in Nigerian universities.

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