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RESEARCH ARTICLE

INTERNET ACCESS TO RURAL AREAS USING WiMAX

***Chinmay Karanjkar, Vedant Salvi, Manjusha Mishra and Lipika Mahajan**

K.J.Somaiya College of Engineering, Vidyanagar, Vidyavihar (E), Mumbai – 400 077

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ABSTRACT

Internet access has been gaining popularity over the years for various purposes but there are some rural areas which are still not verse with Internet Technology. This paper emphasizes on introducing WiMAX technology as a heterogeneous network along with the in place technology for internet access such as WiFi and infrastructure based networks. Detailed implementation of WiMAX technology over the current existing network has been depicted. This paper also proposes an e-education program for digital empowerment of the citizenresiding in rural areas through WiMAX technology.

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INTRODUCTION

Even though there exist many programs for educating the masses, they are not aware of it due to no access. WiMAX can be used for providing better access, primarily free access in a faster and cheaper manner. Private corporations are providing free but limited access which shall primarily involve merchandising of their own products.WiMAX (IEEE 802.16) is a wireless communications standard that is proposed for wireless Metropolitan Area Networks (MAN). Though WiMAX is intended for metropolitan area networks, the ability of a single tower to cover up to 8,000 square km, is what allows WiMAX to provide coverage to remote rural areas. WiMAX can provide broadband wireless access (BWA) up to 50 km for fixed stations and 5 - 15 km for mobile stations (MojtabaSeyedzadegan and Mohamed Othman, 2008). Contrary to this, the WiFi (802.11) wireless local area network standard provides coverage to only 100 - 300 feet (30 - 100m). The respective description and data rates of various versions is: (Simba *et al*., 2011)

WiMAXSystem

A WiMAX system primarily consists of two parts:

1) A WiMAX tower – It is similar to a cell-phone tower- A single WiMAX tower can provide network coverage to a very large area of 3,000 square miles i.e.approximately 8,000 square km) (MojtabaSeyedzadegan and Mohamed Othman, 2008).
2) WiMAX subscriber station (subscriber station) – Subscriber station are devices that provide connectivity to a WiMAX network (Mojtaba Seyedzadegan and Mohamed Othman, 2008).

There will be 2 subscriber stations installed per village. More can be installed if the installed stations are unable to handle the load. The subscriber stations will be separated with respect to their functions –

Standard	Description	Data Rate
802.16d	The standard only supports fixed operation.	70 Mbps
802.16e	The standard supports mobile usage.	15 Mbps
802.16m	Can support both fixed and Mobile Users	100 Mbps for Mobile 1Gbps for Fixed

E-education

a. This subscriber station shall be given more priority by the Weighted Round Robin scheduling algorithm.
b. It shall primarily be used for distribution of data packets from the main base station for conducting e-education sessions.

General purpose

a. This subscriber station shall be used for general purpose access by the regular user.

****Corresponding author: Chinmay Karanjkar,***
K.J.Somaiya College of Engineering, Vidyanagar, Vidyavihar (E), Mumbai – 400 077.

b. It can be used by the general public for information access such as government policies, updates, and current economic situations.

Current devices have been modeled according to IEEE 802.11 standards due to which they are incompatible with WiMAX. The solution to this problem:

1) Make the end devices compatible to WiMAX, which is an expensive option.
2) Backhaul inter-WiFi mesh network –The ad-hoc Mesh in the village is connected to the Subscriber terminals.This ad-hoc mesh is formed by WiMAX mesh routers across the village (TychoBom). WiFi routers connected to the WiMAXMeshrouters will provide access points to the devices like smart phones, laptops and tablets.

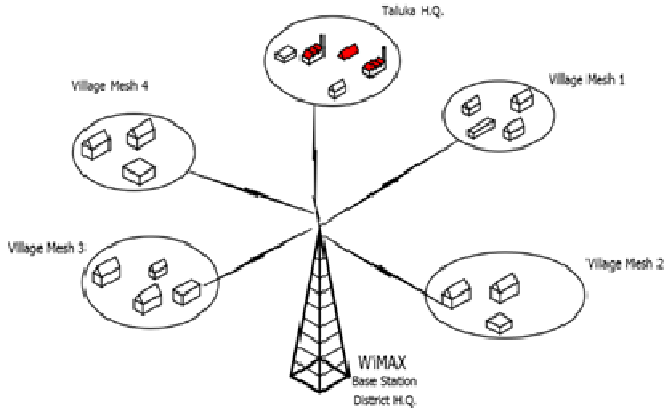

Figure - 1 Overall Connectivity to multiple villages via Single Base Station

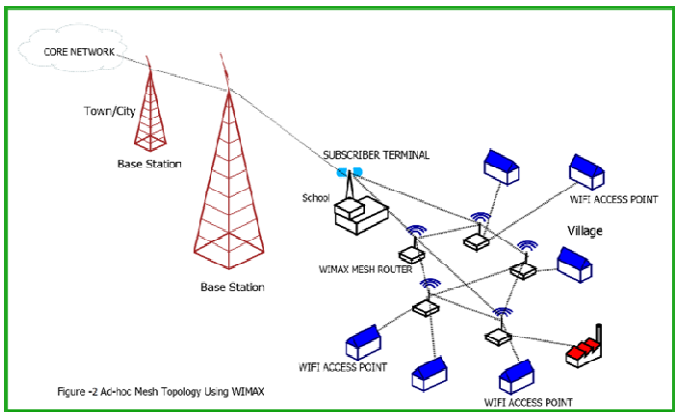

Figure -2 Ad-hoc Mesh Topology Using WIMAX

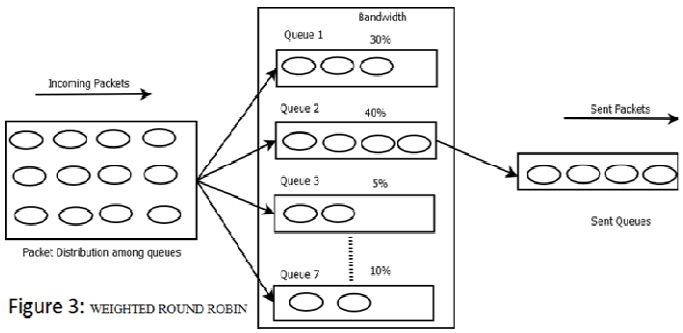

Figure 3: WEIGHTED ROUND ROBIN

Layers in WiMAX

A.Physical layer

The WiMAX physical layer is based on OFDM i.e. orthogonal frequency division multiplexing. OFDM is transmission scheme used for high-speed data rate and multimedia (GyanPrakash and Sadhana Pal). It is based on the traditional frequency division multiplexing (FDM). OFDM enables simultaneous transmission of multiple signals separated into different frequency bands (subcarriers) and sending them parallel. OFDM removes guard band but keeps the signals orthogonal to mitigate the signal interference.

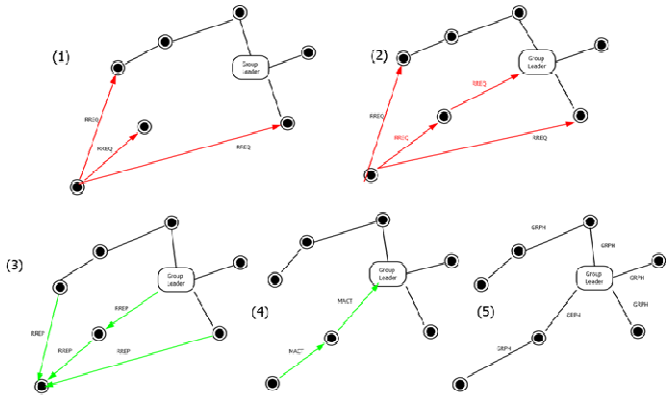

Figure 4 -MAODV Packets

B.MAC layer

WiMAX MAC layer supports high bandwidth and hundreds of users per channel. It utilizes spectrum efficiently by supporting bursty traffic. The convergence sub layer of MAC layer offers supports ATM, Ethernet, 802.1Q, IPv4, IPv6 (GyanPrakash and Sadhana Pal). The core sub layer MAC layer provides packet fragmentation, ARQ and Quality of Service (QOS). The MAC Privacy Sub layer integrates security features in WiMAX such as Authentication, encryption and Key exchange.

Topology (Myung J. Lee and Jianliang Zheng, 2006)

Using WiMAX technology there will be a single base station in the targeted area. The subscriber station will be connected to a base station. The base station and the subscriber stations will be connected in a graph topology. Each subscriber station will be located at a school in that particular area. It will be further connected to the end users via relay nodes through an ad-hoch mesh (GyanPrakash and Sadhana Pal). In order to reduce load and segregate the e-education program, the other subscriber station is meant to provide the internet services to rest of the users in the area. The interconnection of these networks will follow mesh topology.

Scheduling algorithm

Weighted Round Robin (WRR) scheduling algorithm is an extension of the Round Robin (RR) algorithm. (Poulomi Das *et al*., 2013) Round Robin scheduling algorithm is implemented for resource sharing in a network. It takes into account the queue status where each queue is assigned a weight. Higher weight establishes the connection first. So the SSs are assigned bandwidth according to their weights (Vijay Gabale *et al*., 2013). The weight of each queue is determined by average size of packets in each queue. It is easy to implement and provides fairness among all the queues. It works best for heterogeneous networks by providing maximum throughput, end to end delay and minimum jitter. (Wail Mardini, 2011) The only disadvantage of this algorithm is that it doesn't provide good performance for variable sized packets.

Routing protocol

MAODV

The Multicast Ad hoc On-Demand Distance Vector (MAODV) protocol enables dynamic, self-starting, multihop routing between participating mobile nodes wishing to join or participate in a multicast group within an ad hoc network. MAODV enables mobile nodes to establish a tree connecting multicast group members. MAODV assigns unique sequence numbers for multicast groups. Each multicast group has its own sequence number, which is initialized by the multicast group leader and incremented periodically. These sequence numbers ensure that routes found to multicast groups are always the most current ones available.Route Requests (RREQs), Route Replies (RREPs), Multicast Activations (MACTs), and Group Hellos (GRPHs) are the message types utilized by the M AODV. The aforementioned messages are handled by UDP, and normal IP header processing applies. MAODV does not perform any function, as long as the multicast group members remain within a multicast tree. When a node wishes to join a multicast group, the node broadcasts a RREQ to find a route to the multicast tree associated with that group. When a join is requested, a route is determined when the RREQ reaches a node an existing member of the multicast tree, and the node's multicast group sequence number is at least as great as the RREQ's defined group sequence number. In case of non-join requests, any node with a current route to the multicast tree may respond to the RREQ (9). A present route is defined as a live multicast route table entry whose associated group sequence number is at least as great as the RREQ's defined group sequence number.The route to the multicast tree is made available by unicasting a RREP back to the source of the RREQ. The RREP can be unicast back to the source from any node able to satisfy the request. Once the source node has waited the discovery period to receive RREPs, it selects the best route to the multicast tree and unicasts the next hop along that route a MACT message which activates the route. Nodes monitor the link status of next hops on the multicast tree. When a link break on the multicast tree is detected, RREQ/RREP/MACT messages are used to immediately repair the link.(Elizabeth M. Royer and Charles E. Perkins, 2000)

Example – When a student wishes to join the multicast group, he shall send a RREQ through the device to the multicast group leader (teacher). The group leader replies with a unicast RREP through the device to the requesting node. Thus the student is able to join the e-classroom.

Each multicast group has a group leader. The primary responsibility of this node is the initialization and maintenance of the group sequence number. The leader constantly broadcasts a Group Hello message over regular intervals. It contains a multicast group and group sequence number and corresponding group leader IP address.

Rural e-education using WiMAX technology

One of the classic examples is the Indian rural education programs-BetiBachao, BetiPadhao schemes. This program is initiated to ameliorate the conditions of the girls residing in the rural areas. The major obstacle faced by girls is the unwillingness of their parents to let them go to schools.

1. The implementation of this program is achieved in a systematic way.
2. Girls in their homes are connected to the BS through the SS via their end terminal device. As we have mentioned there is a single SS dedicated to the e-education program.
3. This dedicated connection segregates it from the other internet access by the rest of the users thereby reducing interference. The girls can avail this e-education facility from their homes which is the main aim of BBBP program.
4. Each device is connected to the SS through the ad-hoc mesh network. Each student joins a particular group according to the lessons they want to study and the same is broadcasted by the SS. Each student is assigned equal weights for transmitting and receiving data packets. So each student will be services with same priority.
5. The MAODV routing protocol allows us to create multicast groups, each identified by a unique sequence number and group leader. In this scenario, the
6. Teacher shall be the group leader and in charge of the multicast group.
7. The ability to create segregated multicast groups allows us to conduct multiple e-classrooms concurrently. They can be setup based on different subjects, lessons for students of different ages.
8. It allows us to avoid interference and incorrect packet delivery across e-classrooms. Thus an e-classroom for 5th standard students studying Mathematics and an e-classroom for 2nd standard students studying Marathi will be kept separated.
9. The added advantage is direct and speedy packet delivery to the appropriate end terminal (the student) from the appropriate host (the teacher) along with efficient bandwidth utilization. As there is no role of the other user's services apart from the e-education, less interference with faster network access speed is provided.

Conclusion

WiMAX is a better and more efficient solution to currently existing Internet access technologies such as WiFi and infrastructure-based networks. It is cheaper to install, has higher coverage area and has a faster data rate. The topology proposed above is a cost-effective measure which supports equalized distribution of resources by using the Weighted Round Robin scheduling algorithm. The MAODV protocol feature of creating multicast groups highly supports simultaneous conduction of e-classroom sessions.

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