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Energy Efficient Scheduling For Wimax Network

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ABSTRACT

For conserving the power of mobile terminals and to support battery powered mobile broadband wireless access devices efficiently IEEE 802.16e defines a sleep mode operation. By regulating the sleep parameters of the IEEE 802.16e such as starting sleep time, initial sleep window size, minimum sleep interval, maximum sleep interval and listen window size the energy can be efficiently utilized. This project proposes a scheduling scheme that supports the efficient energy usage by regulating the sleep parameters for both the uplink traffic. The base station calculates the sleep parameters for the real time and the non real time traffic by considering the available resources and the traffic rate. By this project both the power saving class I and II sleep efficiency can be regulated by changing the sleep parameters according to the delay constraints and required minimum reserved traffic rate.

Keywords: Wimax, Sleep period, Uplink, Traffic flow, Base station, Mobile station.

1. INTRODUCTION

The broadband wireless access networks such as Wireless Interoperability for Microwave Access (WiMAX) is one of the hottest technologies recently and has a rapid progress. To extend the lifetime of battery-powered Mobile Stations (MS) by reducing the power consumption the IEEE 802.16e has introduced the sleep mode and the idle mode to decrease the usage of air interface resources of serving Base Stations (BS). An MS enters into a sleep cycle after negotiating with serving BS and stops its traffic service temporarily in the sleep mode. Even more power saving is allowed the idle mode. Once enters into the idle mode a subscriber mobile station periodically receives downlink broadcast messages in discrete interval. No handoff or re-registration is needed while a mobile station travels across multiple base stations and hence the idle mode is simpler than the sleep mode.

The mobile WiMAX working group has listed these two modes as power saving mechanism that must be implemented by electronic terminals. Sleep mode is a state in which an MS conducts pre-negotiated periods of absence from the serving BS air interface. To Downlink (DL) or Uplink (UL) traffic these periods are characterized by the unavailability of the MS as observed from the Serving BS. Sleep mode is intended to minimize MS power usage and decrease usage of Serving BS air interface resources. Sleep mode implementation is optional for the MS and mandatory for the BS. A key feature of IEEE 802.16 is that it is connection-oriented at the MAC layer. Connections established between an MS and a BS can have different Quality of Service (QoS) parameters in terms of service categories.

For normal operation, sleep state management for all MSs registered to it is performed by a BS. It buffers all data destined to the registered MSs during the sleep interval, and notifies MSs by sending indication message to switch to wakeup mode. A mobile station continues to retain the management connection and perform periodic ranging at the sleep mode. The BS keeps one or several contexts, for each involved MS, each one related to certain Power Saving Class.

A group of connections that have common demand properties can be defined as a Power Saving Class. According to there their activation/deactivation procedures, parameter sets and policies of MS availability for data transmission there are three types of power saving classes named Power Saving Class (PSC) of Type I, II and III. These three PSCs entail different power saving strategies to suit for different businesses. The PSC of type I is recommended for connections of Best-Effort Service (BE) and Non-Real-Time Polling Service (nrtPS). The PSC of type II is used for connections of the Unsolicited Grant Service (UGS), real-time Polling Service (rtPS) and extended real-time Polling Service (ertPS). And the PSC of type III is designed for multicast connections as well as for management operations.

Before entering into sleep mode an MS sends request to its BS requesting to enter into sleep mode. The MS enters into sleep mode once the message to grant the request has been received. A sleep mode is comprised of one or more sleep cycles and each sleep cycle consists of a sleep interval (T) and a listening interval (L). During the listening interval an MS checks whether there is packet transmission to determine whether to keep sleep or to wake up, while in a sleep interval, an MS closes communication in order to reduce power consumption. After the first sleep interval, the mobile station enters into listening interval monitoring broadcast messages from the base station to determine whether there have been messages destined to the mobile station in the last sleep interval. The mobile station returns to wake mode after this listening interval,if there have been messages. Otherwise, it enters into the next sleep cycle until the MS receives the indication messages at listening interval (Ln) that show there have been packet transmissions from the BS at the Nth sleep cycle. During the whole sleep process, the MS alternates periodically between sleep mode and wake mode.

2. RELATED WORKS

Several recent studies have investigated the issue of energy consumption with various sleep mode operations and various power saving classes. A Power saving schedule for one mobile station with multi UGS connections is proposes by Wen-Chuan Huang [1] uses a bucket checker algorithm. Wen-Chuan Huang *et al*. [2] proposed an adaptive sleep mode management system that adjusts an MS's sleep cycle and listening window in an adaptive manner based on online monitoring and estimation of the traffic condition. It minimizes power consumption by the MS and limits the average packet delay. Minimum fair allocation of the channel bandwidth for each packet flow is done by R.Murali Prasad *et al*. [3] to minimize power consumption of mss with multiple real-time connections. Here only the real-time connection is considered. JianbinXue *et al*. [4] proposed a system Based on time scheme to trigger transition from awake mode to sleep mode and a sleep window to next sleep window. This enhances the power consumption and bounds the delay in the required range. Wen-Hwa Liao *et al*. [5] proposed a Scheduling Algorithm for Multiple MSSs in IEEE 802.16e Networkto avoid the potential interference between the MSSs. Arun M Bhaskaran [6] proposed a system that adjusts the sleep interval according to the packet arrival rate of the serving base stationin order to minimize power consumption and decrease the use of serving BS resources. The authors present a Framework for multicasting scalable video streams over mobile WiMAX networks to Maximize video quality while minimizing the energy consumption of mobile receivers in [7]. The Joint operation of sleep mode and idle mode is done for evaluating the joint performance in WiMAX network [8]. The Sunggeun Jin et al. [10] numerically analyze the performance of sleep mode IEEE 802.16m operation serving both real time and none real time traffic simultaneously. In [11] a system that dynamically changes the sleep interval T based on traffic rate of serving service is proposed to minimize overheads transmitted between MS and BS. HaraldBurchardt *et al*. [12] effectively control the uplink interference by reducing transmit power of the interfering MS to Diminish the tradeoff between system capacity and energy efficiency. GeorgiosPaschos [13] Capture the behavior of single sleep mode algorithm and provide accurate approximation for the hybrid case using a Hybrid combination of sleep mode algorithms.

3. PROPOSED SYSTEM

From the study made on the existing systems, it is clear that there are many systems for sleep management. But the best system is to schedule the uplink traffic by the base station for efficient sleep management. This paper focuses on the sleep management by an energy saving centric uplink scheduling. This system provide user satisfaction and better energy saving. To achieve better radio resource usage in a heuristic manner, the energy saving centric uplink scheduling applies the SBTconcept using hybrid sleep arrangement policies for connections with different services [14]. Figure 1 shows the proposed system flowchart. In the uplink scheduling scheme, the BS waits for the request from the MS to allocate bandwidth as per the requirement and the previously allocated bandwidth.

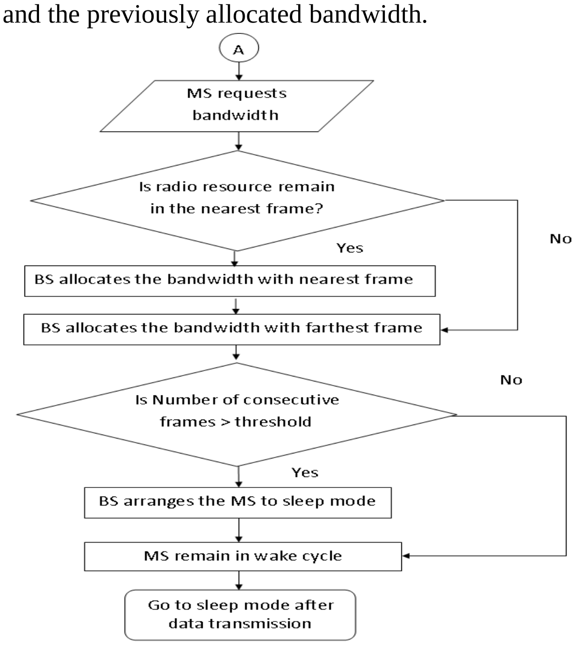

Fig 1: Proposed system Flowchart

Energy Saving Centric Scheduling (ESCS) method is used which properly manages sleep periods to conserve the energy of MSs under the QoS constraint for uplink scheduling. In this approach, the BS schedules the traffic for a better sleeping arrangement when receiving the BR from the MS to achieve better sleep efficiency and reduce switching between the sleep and awake modes. To ensure the desired QoS of each user, both real-time and non-real-time connections were considered in the scheduling schemes. Using hybrid sleep arrangement policies for connections with different services, the ESCS scheme applies the 'Sleep before Transmission' (SbT) concept to achieve better radio resource usage in a heuristic manner.

To achieve broadband wireless access, WiMAX adopts Orthogonal Frequency Division Multiple Access (OFDMA) technique WiMAX BS manages and arranges the radio resource for the uplink traffic of each MS, in addition to allocating the radio resource for downlink traffic. In order to obtain the required bandwidth of uplink each MS needs to issue a BR to ask BS for the radio resource for uplink transmission. Traditionally, on receiving the bandwidth request from the MS, the BS allocates the radio resource to the MS as soon as possible by considering the QoS requirements such as the delay tolerance or Minimum Reserved Traffic Rate (MRTR).

A better method for efficient energy savings is to allow the MS to accumulate its uplink traffic for a period without activating its transmitter and receiver (i.e., in sleep mode) and immediately provide enough radio resource for the accumulated traffic when the MS is initiating transmission. Two major algorithms focused by the system model to address the scheduling are the bandwidth allocation algorithm and the sleep cycle decision algorithm. At the MS, the uplink traffic is generated and queued and waits for scheduling. MS issues a BR message to the BS to request radio resources on the reception of a polling message from the BS when the MS has traffic waiting for transmission. Based on the allocation condition,the bandwidth allocation algorithm properly allocates the radio resources to the MS and decides the sleep period. The MS does not awake during the sleep period assigned by the BS despite arriving traffic during this period.

The BS begins allocating the bandwidth of the farthest frame backward to the nearest frame until the required bandwidth is satisfied,based on the reservation concept, Moreover, the bandwidth of the farthest frame does not violate the QoS constraint of the MS. Then the BS will inform the MS to sleep until the frame with the reserved bandwidth arrives,if the BS can allocate the bandwidth for the MS in the farther frames.

Compared to the traditional scheme, the reservation-based approach allows the MS more sleeping timeand can still maintain the QoS requirement. If BS does not receive a bandwidth request from the MS, the BS notifies the MS to enter a sleep period When the MS awakens from a sleep period; it must issue a BR and wait for the UL_MAP for the resource allocation information if it has uplink traffic waiting for transmission. The BR issued by the MS can be categorized into the incremental based and aggregated based in the specification.

In the incremental- based BR approach the BS remembers the unallocated bandwidth of the previously issued BR and the current BR is the required bandwidth of the newly generated traffic. The BS adds the quantity of requested bandwidth to its current perception regarding the bandwidth needs of the connection for the incremental-based approach. The BS replaces its perception of the bandwidth needs of the connection with the full quantity of requested bandwidth when the BS receives an aggregated bandwidth request. The incremental-based approach assumes that the MS issues a BR at each frame whenever it has traffic to be sent. The MS issues a BR to the BS if any uplink traffic is queued for transmission; otherwise, it begins a new sleep period, When the MS wakes from the sleep period.

The traffic may be generated during the sleep period and hence an MS may request more bandwidth than specified in the previous BR. The bandwidth requested by the MS may include the bandwidth specified in the previous BR. The MS originally transmits the scheduled traffic when it awakes and the bandwidth requested in the previous BR message should be prescheduled by the BS at that moment. Since the MS remains awake to transmit data in the prescheduled (reserved) frames. If those frames have available bandwidth, the allocation of the latest generated traffic by the BS in those prescheduled frames is better from an energy-savings and resource-usage viewpoint. Therefore, the available bandwidth of the reserved frames initially allocated by the BS is extended to the required bandwidth of the MS on receiving the BR. For a longer sleep period for the MS the BS seeks to schedule the unallocated bandwidth as far as possible, if the residual bandwidth of the reserved frames cannot satisfy the required bandwidth.

The BS initially allocates the residual bandwidth of the three prescheduled frames when the BS receives the BR at the current frame and allocates the bandwidth of the farthest three frames for the MS. After that the BS will provide the resource allocation information at the next frame of the current frame and informs the MS to enter sleep mode at the last prescheduled frame. The resource allocation bases the provisioning of the 'just enough' QoS and length of the sleep period on effective resource allocation. If the sleep period is shorter than a specific threshold the BS may not allow the MS to sleep, because the frequent state change may result in a higher consumption of energy. The MS will not issue a BR when polled by the BS if the MS transmits its data completely and has no queued data to send. In this scenario the BS will request MS to enter sleep mode for the period of the tolerable delay. The scheme decides the farthest frame that can be allocated for the issued BR without violating the desired QoS. The real-time polling service and non-real-time polling service have different QoS requirements. The MRTR is a major parameter for nrtPS connections and the delay tolerance is critical for rtPS connections when fair resource usage is concerned and hence the acceptable farthest frames of the rtPS connection and nrtPS connection are decided in a different manner.

The ESCS scheme adopts the reservation based approach to allocate the radio resources for the MS to maximize the sleep period or minimize the idle period. To conserve more energy, the resource allocation scheme tends to support the just enough QoS requirement and the SbT concept manages the sleep operation more efficiently. For the rtPS connection, the scheme uses the delay tolerance as the performance index for traffic scheduling. If the MS has not been allocated with radio resources for the required bandwidth or the residual bandwidth of the pre-scheduled frames for the MS on receiving the BR from MS, they will be insufficient for the required bandwidth. In such a situation the BS will decide the farthest frame which satisfies the maximum delay tolerance to backwardly allocate the radio resource.

4. RESULTS AND DISCUSSIONS

The system focuses on the energy saving centric scheduling, which includes uplink traffic. This system is a network of WiMAX nodes which deals with both rtPS and nrtPS data is simulated using MATLAB. The deployment of the nodes in a network and the bandwidth allocation is shown in the figure 2. There is a base station along with 200 nodes which are grouped

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into five clusters. Each cluster has a cluster head which will communicate with the BS and allocate bandwidth to the communicating nodes. The QoS parameters for the system model are given in table 1.

Table 1: QoS parameters

Parameter	Value
Number of connections	40
Number of MS	5
Total amount of bandwidth	20Mbps
Frame duration	5 ms
Simulation time	20 sec

One of the cluster head handles the rtPS connection and the other nrtPS connection. The bandwidth is allocated after checking the required bandwidth and the bandwidth already reserved. The simulation result can be studied from the graphs showing average BER, average delay and the throughput.

For uplink scheduling, ESCS method is used which properly manages sleep periods to conserve the energy of MSs under the QoS constraint. In this approach to achieve better sleep efficiency and reduce switching between the sleep and awake modes. the BS schedules the traffic for a better sleeping arrangement when receiving the BR from the MS To ensure the desired QoS of each user, both real-time and non-real-time connections were considered in the scheduling schemes. Using hybrid sleep arrangement policies for connections with different services, the ESCS scheme applies the 'Sleep before Transmission' (SbT) concept to achieve better radio resource usage in a heuristic manner.

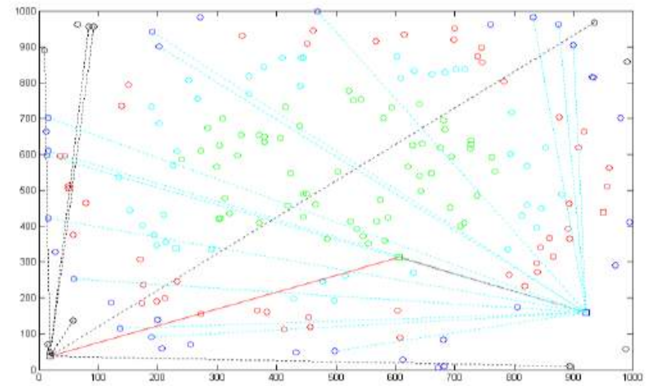

Fig 2: Node distribution and bandwidth allocation

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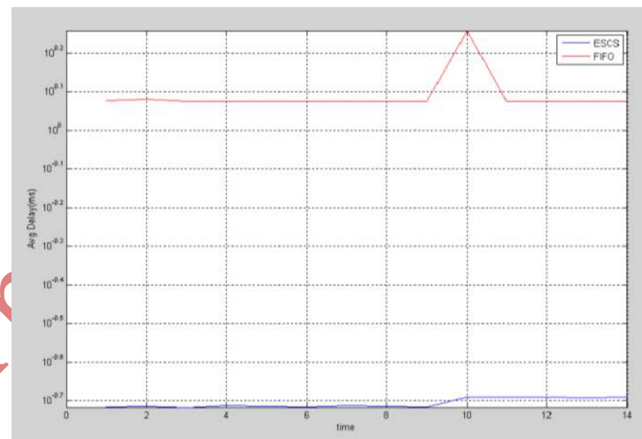

Fig 3: Avg. delay Vs Time

The system considers the average delay as a main factor in its scheduling algorithm and utilizes an emergent queue to increase the emergent packet transfer probability. The performance of the average delay is shown in figure 3. It shows that the average delay increases as the threshold value increases and the delay maintains a constant value throughout the transmission.

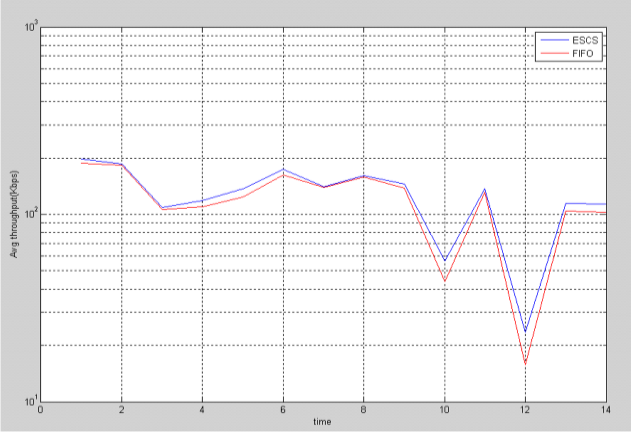

Fig 4: Avg. throughput Vs Time

. The average throughput is defined as the ratio of the actual bandwidth allocated for the MS to its required bandwidth. The average throughput for the proposed system over the traditional system is shown in figure 4. From the figure it is clear that the throughput is almost same for the proposed system and the traditional system except some points

5. CONCLUSION

The scheduling scheme is proposed from an energy-saving viewpoint. Contrary to the traditional concept the novel SbT concept is introduced in the proposed scheme. The proposed scheme analyzes the sleep efficiency with the QoS constraints to determine whether the MS is suitable to enter sleep mode and calculates the proper sleep period in a systematic manner if the MS can enter sleep mode. In the proposed scheme both rtPS and nrtPS connections are considered. This scheme improves the energy-saving efficiency under the desired QoS constraint. The ESCS scheme arranges the radio resources to satisfy its QoS in a just enough manner to maximize the sleep efficiency. As the future work this approach can be adopted for LTE network by extending the proposed concept to be applied for the relative energy saving parameters.

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