Design and Evaluation of Scheduling Architecture for IEEE 802.16 in Mobile Ad-Hoc Network

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ABSTRACT

A worldwide demand for high speed broadband wireless systems across commercial and residential regions is emerging rapidly due to the increasing reliance on web for information, business, entertainment and new upcoming high bandwidth intensive or real-time applications. The IEEE 802.16 standard which has emerged as Broadband Wireless Access (BWA) solution is promising to meet all such requirements and becoming the most popular way for wireless communication. The IEEE 802.16 advantages includes variable and high data rate, last mile wireless access, point to multipoint communication, large frequency range and QoS for various types of applications. We propose Weighted Fair Queue (WFQ) based MAC scheduling architecture for IEEE 802.16 in both uplink and downlink direction. Our scheduling architecture accommodates parameters like traffic priority, minimum reserved bandwidth and queue information for various applications. Comparing with the traditional fixed bandwidth allocation schemes, the proposed architecture incorporates the traffic scheduling mechanism based on weights of flows and provides more fairness to the system.

Keywords: Broadband Wireless Access, IEEE 802.16, AD-HOC, MAC

INTRODUCTION

deployment, high speed data rate, large spanning area, and large frequency spectrum. The IEEE 802.16 standard provides Quality of service to all different kinds of application including real time traffic in the form of flow type associated with each application. The IEEE 802.16 MAC layer is divided in three parts–Privacy Sublayer (lower), MAC Common Part Sublayer (middle) and Convergence Sublayer (upper). The core MAC layer is Common Part Sublayer (CPS). The MAC CPS is designed to support PMP and mesh network architecture. The IEEE 802.16 MAC is connection oriented. Upon entering the network, each SS creates one or more connections over which their data packets are transmitted to and from the BS. Each packet has to be associated with a connection at MAC level. This provides a way for bandwidth request, association of QoS and other traffic parameters and data transfer related actions. Each connection has a unique 16-bit connection identifier (CID) in downlink as well as in uplink direction. The MAC PDU is data unit used to transfer data between MAC layers of BS and SS.

Comparison of Our work with Previous Work

In this section, we will compare our work with available literature for IEEE 802.16. We have given the brief description of literature in previous section. Now we will compare our work in Table 1.1 to make a clear distinction of our work with others.

| Study | Uplink | Downlink | Simulation | Analytical model |
|-------|--------|----------|------------|-----------------|
| Our architecture | WFQ | WFQ | NS-2 | - |
| Parekh | max-min fairness | WFQ | QuadNet | - |
| Cha | WRR | - | - | - |
| Hawa | WFQ-FIFO | - | - | - |
| Chen | DFQ+EFQ+WFQ+RR | - | Yes | - |
| Oh | - | - | OPNET | Yes |
| Moraes | Priority Scheduling | - | - | Yes |
| Lee | - | - | - | Yes |
| Ganzi | SP+EFQ+WFQ | - | - | - |

Table 2.1: Comparison of our architecture with prior work

OUR SCHEDULING ARCHITECTURE

Design Goals:

We have designed our scheduling algorithm with the following goals:
We want to provide delay bound scheduling for real-time traffic (UGS and rtPS flows) and maximum throughput for data traffic (nrtPS and BE flows).

We believe that the scheduling algorithm should provide best QoS for all types of applications. This means the number and types of flow matters to us rather than number of SSs. So we have designed our scheduling algorithm for the GPC grant mode and not for the GPSS grant mode.

Proposed Architecture:
The IEEE 802.16 standard divides the uplink sub-frame into three periods namely ranging period, bandwidth contention period and data uplink period. We call this the Band Width Contention (BWC) mode. We also consider a case where we completely remove the bandwidth contention period in our architecture and call this the No Band Width Contention (NBWC) mode. In NBWC mode, the uplink sub-frame is divided between two parts only - ranging period and data uplink period. Consequently the total number of data uplink slots is more in NBWC mode.

We chose WFQ as the scheduling mechanism for uplink and downlink direction because of mainly two reasons - WFQ provides bit wise bit fairness (according to the assigned weights) to all active flows, secondly WFQ also provides flow isolation. As mentioned in Miguel paper that flow isolation is also necessary at the router (BS is an router also) in the case of unresponsive flows. Our proposed scheduling architecture broadly contains five parts - WFQ module, BS allocation module, SS uplink module, BS downlink module, and Classifier module. WFQ module has been used twice in our architecture. One copy of WFQ module is inside the BS allocation module (for uplink slot allocation) and the other standalone copy is used for downlink scheduling. The Figure 1.2 shows our IEEE 802.16 scheduling architecture. We will discuss each of these modules in detail below:

We have used Network Simulator (ns version 2.29) as our simulation platform. We have performed extensive simulations in both uplink and downlink directions to show the effectiveness of WFQ scheduling algorithm. More specifically we want to evaluate the following in our architecture:

- Effect of one type of flow on other type of flow. That is keeping a constant number of one type of flow, evaluate the average performance degradation (delay for UGS and rtPS flows and throughput for nrtPS and BE flows)
of this type of flow with the increment in the number of other type of flow.

- Choice of appropriate bandwidth contention period in BWC mode with a constant number of flows of same flow classes.
- Performance comparison of BWC and NBWC mode with above choice as bandwidth contention duration in BWC mode.

In our simulations, we have used the following weights: The UGS and rtPS flows have 22.4 Kbps and 64.0 Kbps as average bandwidth respectively.

| Flow type | Weight |
|-----------|--------|
| UGS       | 22.4   |
| rtPS      | 64.0   |
| nrtPS     | 100.0  |
| BE        | 10.0   |

Table 1.2: Weights for different flow type

The weights for nrtPS and BE traffic are taken in such way that, with a given number of nrtPS and BE flows, the maximum available part of whole bandwidth should not acquired by these flows only. In this manner, we are giving preference to UGS and rtPS flows with the proper choices of weights and number of flows. The length of polling time is 2 frame length (=20 msec). Running time for our all the simulations is 20 sec. For all our simulations, the calculated delay are application level (or agent level in ns2 terms) one way delay and then averaged over the number of flows.

**Delay Analysis for Uplink Flows:**

The default used data rate is 11Mbps. It is same as the maximum data rate in IEEE 802.11b standard. The higher data rate may affect our simulations in the context of 802.11 PHY implementation of ns-2. It might be possible BS and SS not able to communicate at higher data rate. On the other hand, we will send data packets in fewer number of slots on higher data rates. We chose 11Mbps because we are using of IEEE 802.11 PHY channel for data communication.

| Parameters         | Value          |
|--------------------|----------------|
| Data Rate          | 11 Mbps        |
| Basic Rate         | 1 Mbps         |
| Slot Time          | 8 micro sec    |
| Frame Length       | 10 msec        |
| Downlink Frame     | 2 msec         |
| Uplink Frame       | 8 msec         |
| Ranging period     | 100 slots (=0.8 msec) |
| Bandwidth Contention | 100 slots (=0.8 msec) |
| Data Uplink Slots (BWC) | 800 slots (=6.4 msec) |
| Data Uplink Slots (NBWC) | 900 slots (=7.2 msec) |

Table 1.3: Simulation parameters for uplink flow analysis

**Effect of BE increment on 30 UGS flows:**

**Effect of rtPS increment on 30 UGS flows:**

**Effect of BE increment on 20 rtPS flows**

**Effect of nrtPS increment on 20 rtPS flows:**
Effect of UGS increment on 20 rtPS flows:

![Figure 1.10: Average rtPS delay with UGS flows](image)

Throughput Analysis for Uplink Flows:

![Figure 1.11: Throughput of nrtPS flows](image)

Total Throughput in BWC and NBWC:

![Figure 1.12: Total throughput with 30 UGS flows](image)

Total Throughput with 20 rtPS flows:

![Figure 1.13: Total throughput with 20 rtPS flows](image)

Total Throughput with 10 nrtPS flows

![Figure 1.14: Total throughput with 20 rtPS flow](image)

Conclusion:

In this thesis we presented a scheduling architecture for IEEE 802.16 standard. Our scheduling architecture use a WFQ as the downlink as well as the uplink scheduling algorithm. Downlink scheduling is easy because only involve entity is BS and it has all the required information for the same. For uplink scheduling, each SS has to send its queue information to BS. As defined in the standard, SSs can send their bandwidth request to BS either in bandwidth contention period or in unicast slots which is allocated to SSs in each frame or through piggyback the connections demands with data packets. In the NBWC mode of operation, we completely remove bandwidth contention period and send bandwidth request piggybacked with data packets thus we are removing any possibility of collisions at BS. We propose polling time concept to remove this drawback.

Our simulation results show that NBWC mode performs better in terms of delay for real time traffic and in terms of throughput for high data rate traffic in both uplink and downlink direction. We chose a very simple approach to design our architecture and showed that this architecture indeed satisfy the QoS requirements of different application flows. The simplicity lies in our scheduling algorithm (WFQ) also which is known from last 2 decades and is able to perform satisfactory for newly designed IEEE 802.16 architecture. Besides this, the developers do not need to bother about the two different scheduling algorithm for uplink and downlink direction. In the performance analysis to NBWC mode, we have shown that it is possible to omit the bandwidth contention period from IEEE 802.16 standards.

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REFERENCES
[1] http://www.cse.iitk.ac.in/users/braman/students/2006/abhim/index.html

[2] IEEE 802.16, IEEE Standard for Local and Metropolitan Area Networks-Part 16: Air Interface for Fixed Broadband Wireless Access Systems, IEEE Std. 802.16, Oct. 2004.

[3] IEEE 802.16 Working Group on Broadband Wireless Access. http://wirelessman.org

[4] Supriya Maheshwari, “An Efficient QoS Scheduling Architecture for IEEE 802.16 Wireless MANs,” Masters Thesis, IIT Bombay, 2005.

[5] Guosong Chu, Deng Wang, and Shunliang Mei. “A QoS architecture for the MAC Protocol of IEEE 802.16 BWA System.” IEEE International Conference on Communications Circuits and System and West Sino Expositions, vol.1, pp.435–439, China, 2002.

[6] Parekh, A. K. and Gallager, “A generalized processor sharing approach to flow control in integrated services networks: the single node case.” IEEE/ACM Trans. Netw. 1, 3 (Jun. 1993), 344-357. DOI= http://dx.doi.org/10.1109/90.234856

[7] M. Hawa and D. W. Petr, “Quality of service scheduling in cable and broadband wireless access systems,” 10th IEEE International Workshop on Quality of Service, May 2002, pp. 247–255.