Performance Evaluation of Weighted Round Robin based Scheduler over Wimax

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Abstract—Wimax is a wireless network that was designed to serve all kind of traffic. Therefore, Wimax is required to fulfill QoS requirements of any applications and information passing over the network. Appropriate scheduler implementation for packets carried on Wimax network can increase QoS achievement possibility.

Wimax module used in our simulation was developed by Networks & Distributed Systems Laboratory (NDSL), Taiwan, as an extension to NS-2 simulator. This module uses the Weighted Round Robin (WRR) based scheduler to deal with packets transmission. This paper is aimed at evaluating WRR based scheduler in relation to Wimax network performance. Performance metrics reported in this work are packet loss, throughput, and average delay.

Keywords—Wimax, ns-2, Weighted Round Robin

I. INTRODUCTION

IEEE 802.16 standard defines specification of MAC layer and PHY layer in Wimax wireless network technology. MAC management message, i.e. request-response ranging (RNG-REQ/RNG-RSP), the downlink/uplink channel descriptor (DCD/UCD), downlink/uplink map (DL-MAP/UL-MAP), and other control messages are implemented to operate on Wimax network.

Network Simulator 2 (NS-2) has been the de-facto standard for simulating packet switched network. There are a lot of network research published works that use NS-2 to evaluate and verify the research. Although a few researchers have developed IEEE 802.16 simulator over NS-2, the tools are not for public usage.

NS-2 can quickly combine various models from traffic, network layer protocol, and MAC layer protocol. These components enable NS to simulate different types of network along with its topologies.

In our work, we install a Wimax module on NS-2.29 simulator. The Wimax module is developed by Networks & Distributed Systems Laboratory (NDSL), Taiwan. This module is focused to improve MAC protocol which inherits from original MAC protocol in NS-2. The MAC protocol implements scheduler based on WRR to manage packets transmission.

Traffic over Wimax network are classified into five classes of service, which are Unsolicited Grant Service (UGS) for traffic with constant bit rate (for example Voice Over IP without silence suppression), enhanced real time polling service (ertPS) for traffic with variable bit rate but guaranteed delay and data rate, real time polling service (rtPS) for application that generate data at variable rate periodically, non real time polling service (nrtPS) traffic with flexible delay and guaranteed minimum data rate, and Best Effort (BE) which does not have any QoS requirement.

In this page, we review the basic theory which underlies this work and present the result analysis of the simulation on WRR scheduler over Wimax.

II. BASIC THEORY

II.1. Wimax Architecture

MAC layer in IEEE 802.16 can be divided into three sublayers, which are:

- **convergence sublayer.** This sublayer maps specific traffic in transport layer with MAC common part sublayer. The main function of this sublayer is to change IP address from upper layer to several Service Flow Identifier (SFID) or reverse process (from SFID to IP address) and record the mappings between SFID and Transport Connection Identifier (TCID). This function enables MAC layer to record important information on QoS parameters and their destination address.
common part sublayer. This sublayer independent of transport layer mechanism. This sublayer responsible for fragmentation and segmentation packets received from MAC upper layer, Service Data Unit (SDU), controlling QoS, scheduling, and MAC PDU retransmission.

Security sublayer, handles the security of the network, which are authentication, secure key exchange, and encryption.

Convergence sublayer classifies incoming SDU based on traffic type (voice traffic and web browser) and allocate SDU into service flow using SFID 32 bit.

When service flow is admitted or activated, the service flow is mapped into a MAP connection which will handle QoS requirement using 16 bit CID. A service flow contains a collection of several QoS parameters. Using adaptive burst profile, each service allocated to a certain physical layer configuration (for instance, modulation scheme, FEC, and more) to run the service.

After service flow is given a CID, service flow will be forwarded to the correct queue. Uplink packet handling is managed by Base Station (BS) through signaling process to Subscriber Station (SS). In SS, packet scheduler will pick the packet from the queue and transmit it to the network with suitable time slot as defined in Uplink Map Message (UL-MAP) sent by BS.

Packet header suppression is used to avoid redundant information transmission through the air. It helps decreasing the packet delay, which is required by applications such as VoIP. After service flow has been classified and has been given CID, unchanged information header (such as ATM cell header or IP header) will be suppressed.

1. CS sublayer
2. CPC MAC sublayer

II.3. Weighted Round Robin

WRR is a scheduling algorithm that can be implemented in many fields, for instance resource sharing in a computer or network. In network, WRR serves a number of packets from non-empty connection queue. Number of packet can be computed by normalizing weight divided by the average of packet size. The following pseudo-code presents the general WRR mechanism [2]:

```plaintext
//calculate the number of packets to be served in each round by the connections
for each connection c
    c.normalized_weight = c.weight / c.mean_packet_size
min = findSmallestNormalizedWeight
for each connection c
    c.packets_to_be_served = c.normalized_weight / min
// main loop
loop
    for each non-empty connection c
        min(c.packets_to_be_served, c.packets_waiting).times do
            servePacket c.getPacket
```

Scheduler is responsible in managing general uplink bandwidth such as in distributing resources in keeping the quality. Scheduler standard is not defined in IEEE 802.16 standard. Thus, it is an open area for academia or industry to implement scheduler which is suitable for their own purposes.

III. EXPERIMENTAL RESULTS

Based on the referenced Wimax module, our simulation uses the topology shown in Figure 2.

![Figure 1. Traffic mapping to the correct QoS queue [3]](image)

Protocol Data Unit (PDU) from the upper layer is inserted into different level of queue after SFID-CID mapping. Data packet in this queue is treated as MSDU and fragmented or packed into various size, depend on the scheduling operation occurs in MAC layer. Those packets are then processed using selective block Automatic Repeat Request (ARQ) if the ARQ capability is enabled.

II.2. Wimax Module

Some Wimax module components have been used in this simulation:

![Figure 2. Simulation Topology](image)
The complete simulation scenario is provided in Table 1.

<table>
<thead>
<tr>
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<th>UGS</th>
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<th>nrtPS</th>
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</table>

Table 1. Variation of SS for a certain QoS class

For SS with Unsolicited Grant Service (UGS), enhanced real time Polling Service (ertPS) and real time Polling Service (rtPS) class, Constant Bit Rate (CBR) data is generated from UDP agent. Meanwhile, for the non real time Polling Service (nrtPS) class and Best Effort (BE), we use FTP agent. This condition is created since CBR traffic requires minimum throughput guarantee, and FTP traffic generates variable flow size. In addition, FTP is more tolerant to delay.

Subsequently to compute the Wimax network performance, we computed the packet loss, throughput, and average delay calculation. Analysis is made per scenario and per class, in a certain node. In this simulation, node 0 (BS) is the node being analyzed, because all traffic from all SS are sent to BS, and BS also sent traffics to SS.

Throughput is computed base on the Equation 1:

$$\text{Throughput} = \sum_{i=n}^{t+1} \frac{\text{packetSize} \cdot \text{sendPacket}}{\text{receivePacket} \cdot \text{receiveTime}}$$

Packet loss is also computed using Equation 2:

$$\text{Loss} = \left( \frac{\sum_{i=n}^{t+1} \text{dropPacket}}{\sum_{i=n}^{t+1} \text{sendPacket}} \right) \cdot 100 ; \quad 0 \leq n \leq t$$

The computed delay is the average delay, not delay per packet, because this module produces trace file which is in “receive” records, packet sequence numbers are reset to 0. Formula for calculating average delay per second is:

$$\text{Delay} = \left( \frac{\sum_{i=n}^{t+1} \text{receivedPacket} \cdot \text{receiveTime} - \sum_{i=n}^{t+1} \text{sendPacket} \cdot \text{sendTime}}{\sum_{i=n}^{t+1} \text{receivedPacket}} \right)$$

From the throughput graphs above, it can be seen that the number of SS using a certain QoS class, affects the throughput from the QoS class. The more SS using that class, the higher the class’s throughput. From the graphs, it also can be observed that WRR based scheduler performance have the same outcome for all classes. Therefore, throughput from all QoS classes are relatively stable, and each class obtains throughput value as it should be.

Throughput for rtPS class it relatively higher than from other classes. This is because of variable packet size generated by traffic generator while rtPS also has a medium priority (3) among other classes.
III.2. Average delay

From delay graphs above, it can be observed that the number of SS using a certain QoS class, does not significantly affecting the average delay. The graphs also show that WRR based scheduler cannot suppressed delay of ertPS class. Delay of ertPS class increases along with the increase in time. Generally, WRR does not support average delay which is suitable for multimedia application QoS requirement. It is shown by the average delay of all QoS classes which values exceed delay limitation for multimedia application.

From the graphs in Figure 9 to 18, it can be seen that there are increasing packet loss in the beginning of simulation. It is because in the beginning of simulation, all SS and BS are busy doing the process of ranging to enter the network.
After a period, the packet loss is almost zero. It is shown that WRR based scheduler have positive effect to suppress packet loss.

III.3. Packet loss

IV. CONCLUSIONS

It can be concluded that WRR based scheduler implementation in Wimax has supported Wimax QoS by suppressing packet loss and providing each QoS classes throughput value as they should be. However, WRR has not been able to reduce average delay from each QoS classes. Therefore QoS classes cannot obtain delay value as they should. Implemented WRR scheduler is not suitable for ertPS, especially to lessen the delay of ertPS traffic.

Implementation of improved WRR algorithm or other algorithm for Wimax scheduler should be done for future improvement, so that Wimax can fully support the advanced requirement of multimedia application.

REFERENCES