The Impact of Channel Bandwidth with Network Asymmetry in WiMAX Network Using TCP New Reno

Kailash Chandra Bandhu, Rajeev G. Vishwakarma

Abstract— The World Wide interoperability for microwave access (WiMAX) technology support to the flexible channel sizes and different countries use different channel it depends on the rule and regulation of countries and their environment. The WiMAX network asymmetry is largely depends on DL:UL ratio. This paper investigates the effect of channel bandwidth in WiMAX network with network asymmetry using TCP New Reno. The performance of WiMAX network is evaluating by varying MAC layer parameter such as channel size, DL:UL ratio and other operating parameter such as downloading traffic (number of downloading wireless nodes). The performance of WiMAX network is measured in terms of throughput, goodput and number of packets drop.

Index Terms— Downlink (DL), Goodput , IEEE 802.16, Medium access control (MAC), OFDM, Packet drop , Subscriber Stations (SSs), Transmission Control Protocol (TCP), Throughput, Uplink (UL) and World Wide interoperability for microwave access (WiMAX).

1 INTRODUCTION

WiMAX is abbreviation `Worldwide Interoperability for Micro-wave Access', is a new wireless OFDM based technology that provides high throughput broadband connection over long distances based on IEEE 802.16 [5][6].
WiMAX network increasingly more intelligent and agile communication systems, capable of providing spectrally efficient and flexible data rate access [6].
Network asymmetry means that network characteristics in one direction do not match with the other direction [10].
Network asymmetry can affect TCP performance, since TCP relies on the timely arrival of acknowledgments (ACKs) to increase its congestion window and data sending rate. Under normal network conditions, an ACK is duly received for packets sent, and this helps the sender to increase the data sending rate. In the case of congestion, typically indicated by packet loss, TCP abruptly decreases its congestion window, and retransmits the lost packets. The retransmission may aggravate the congestion. Normally, there are two ways to indicate the packet loss or congestion:
(1) Expiry of retransmission timer (for severe congestion), or
(2) receipt of 3 or more duplicate ACKs (for milder congestion).
In the presence of an imperfect ACK channel, the ACK clocking is disrupted, i.e., packets sent are not duly acknowledged. Consequently, at the sender, the timer expires which TCP interprets as congestion, the congestion window plummets and the packets are retransmitted, even though these packets may have correctly reached to the receiver. This implies that the TCP throughput and goodput not only depends on the characteristics of the data sending channel, but also on the reverse channel used by ACKs [10][4][1].
WiMAX support to the flexible channel sizes. In order to adapt to different regulations in different countries, and to allocate bandwidth as needed in IEEE 802.16-2004, many different channel sizes have been defined. Channel sizes defined in the standard are 1.25 MHz to 28 MHz Equipments is currently available for general implement of 3.5, 5.0, 7.0 and 10.0 MHz channel sizes. This gives maximum over the air rates of 17.5 Mb/s to 50 Mb/s [6].
The rest of the paper is structured as follows. The system model for the investigation is introduced in Section 2. In Section 3, simulation scenarios are presented and the results are discussed. Finally, the conclusion is present in Section 4.

2 SYSTEM MODEL

This section present the system model used in investigation. The network setup is shown in Fig. 1. All subscriber stations are downloading stations (SSs).

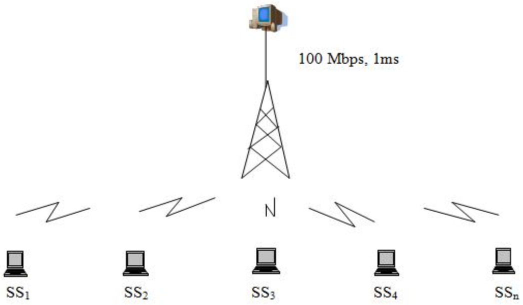

Fig.1. Topology

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2.1 Simulation Environment

The investigation was through simulation. The simulation platform is ns-2 (ns2.31) and the WiMAX module is from the National Institute of Standards and Technology (NIST) [2]. The simulation parameters are summarized in Table 1.

TABLE 1
SIMULATION PARAMETERS

WiMAX and OFDM Parameters	
Channel bandwidth	3,5,7,10,20,28 MHz
Frame duration	5 ms
Modulation & Coding	64QAM 3/4
Cyclic prefix	1/16
Contention size	5
Traffic Source and Other Parameters	
TCP version	New Reno
TCP segment size	960 Bytes
No. of DL WL Nodes	5,10,15,20,25
Delayed ACK factor	2 s
TCP start time	30 s
Simulation duration	1000 s

2.2 Performance Metrics

The performance studied by means of three metrics:

1. Throughput that measures the amount of raw bytes sent by a source.
2. Goodput that measures bytes that are sent and successfully acknowledged.
3. Number of Packets drop.

3 SIMULATION RESULTS

This section, present the simulation scenarios and discuss the results obtained. Several scenarios are considered to highlight the effects of number of downloading wireless nodes (SSs) for different channel bandwidth considering different DL:UL ratio using TCP New Reno.

3.1 Scenario 1: Effect of number of downloading wireless nodes (SSs)

In the scenario 1, the DL:UL ratio kept constant and number of downloading wireless node is varying for different channel bandwidth.

In figure 2, it is observed that the throughput increases when the downloading wireless nodes (SSs) are increases and obtaining the maximum throughput 14 Mbps (approximately) for channel bandwidth 20 and 28 MHz for 20 downloading wireless nodes (SSs) because the larger channel bandwidth handle large amount of traffic when the asymmetry does not exist (DL:UL=0.50).

The DL:UL =0.50 means the equal portion of channel is allotted to DL and UL.

Similarly the goodput is also increases as throughput when the number of downloading wireless nodes increases and asymmetry does not exist. But the value of goodput is less than the throughput because of dropped packet.

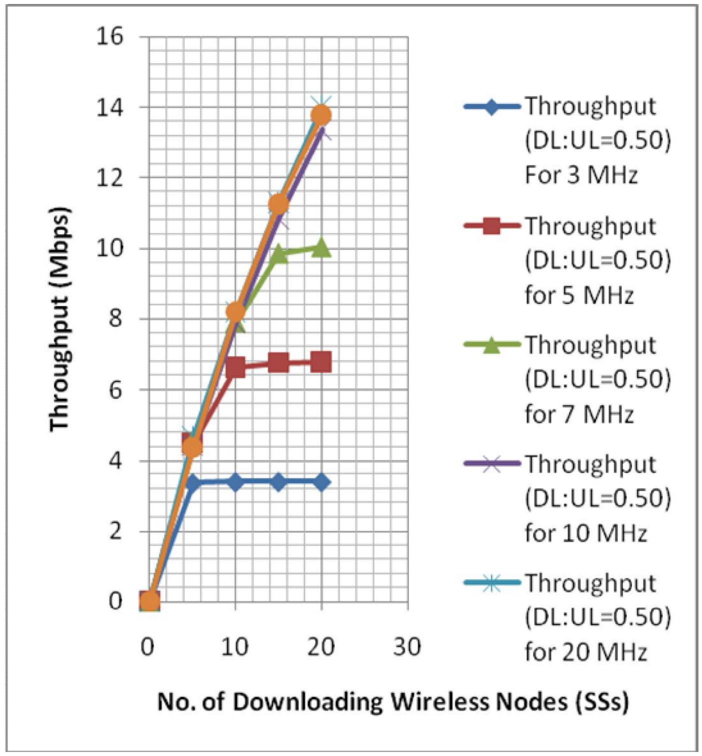

Fig.2. Throughput for SSs with different channel sizes considering DL:UL=0.50

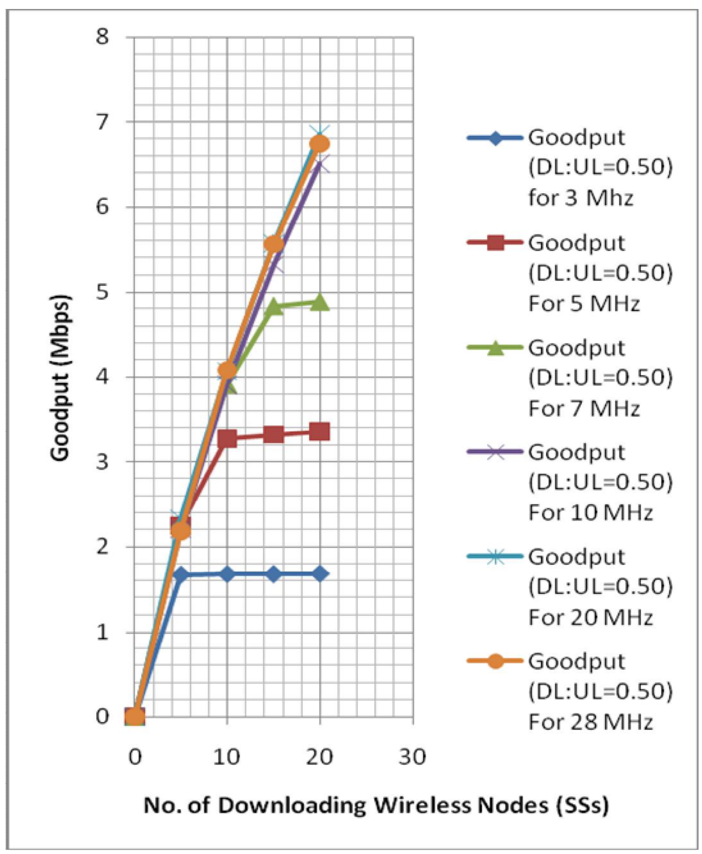

Fig.3. Goodput for SSs with different channels sizes considering DL:UL=0.50

The maximum obtained value of goodput is approximately 7 Mbps for channel bandwidth 20 & 28 MHz with 20 downloading nodes (SSs) shown in figure 3.

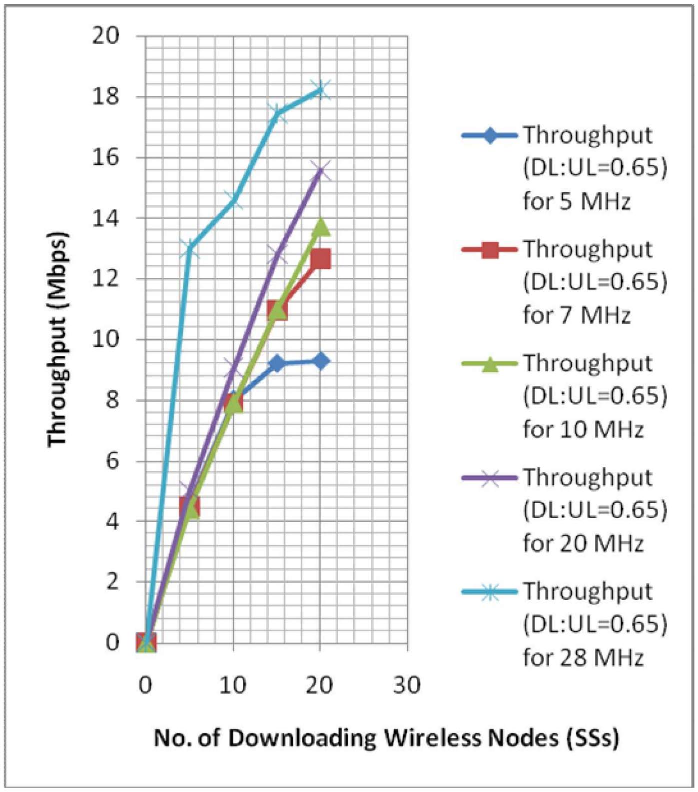

Fig.4. Throughput for SSs with different channels sizes considering DL:UL=0.65

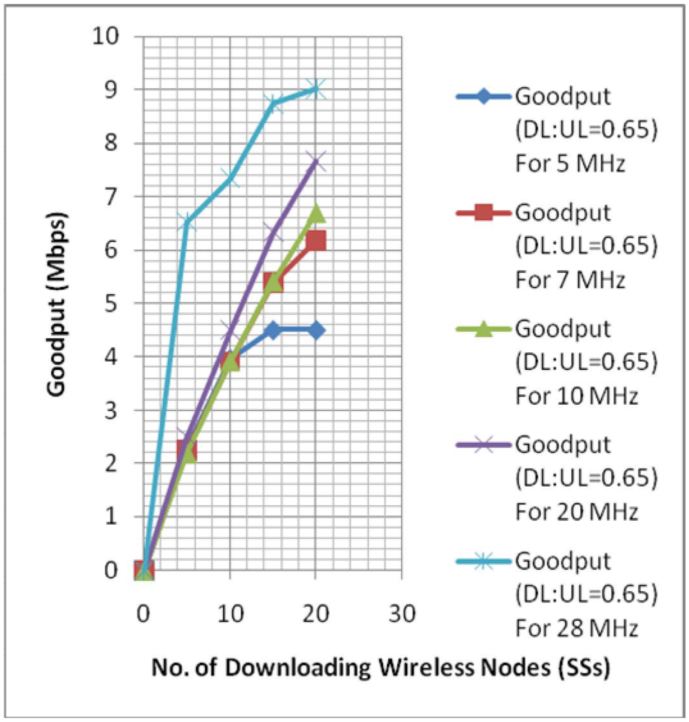

Fig.5. Goodput for SSs with different channels sizes considering DL:UL=0.65

It is observed in figure 4 & 5 the throughput and goodput is increases when the downloading nodes increases (SSs) for different channel bandwidth when less asymmetry exist (DL:UL=0.65).

The obtained maximum throughput and goodput are 18 Mbps and 9 Mbps (approximately) respectively for 28 MHz channel bandwidth with 20 downloading nodes (SSs).

The throughput and goodput for DL:UL ratio 0.65 is higher as compare to DL:UL ratio 0.50 and the reason behind that higher DL:UL ratio support to higher downloading traffic.

The 3 MHz channel bandwidth doesn't support to DL:UL=0.54 and higher only support up to 0.53.

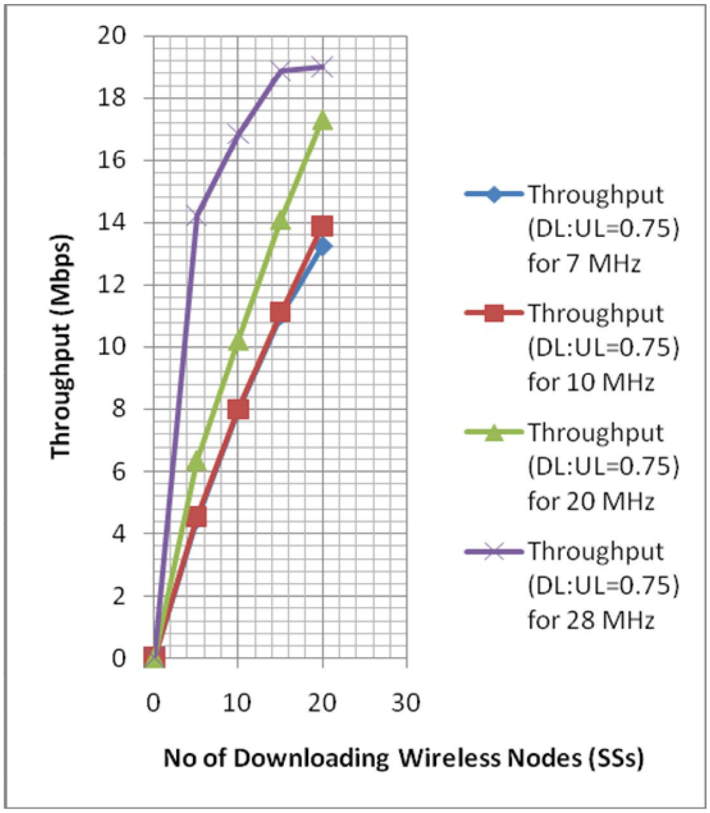

Fig.6. Throughput for SSs with different channels sizes considering DL:UL=0.75

The throughput and goodput increases in when the downloading nodes increases for different channel bandwidth with DL:UL =0.75. The maximum throughput and goodput are 19 Mbps and 9.5 Mbps (approximately) respectively for 28 MHz channel bandwidth with 20 downloading nodes, which is shown in figure 6 and 7 respectively.

The throughput and goodput for DL:UL ratio 0.75 is higher as compare to DL:UL ratio 0.50 and 0.65 because higher DL:UL ratio and higher bandwidth support to large downloading traffic.

The 5 MHz channel bandwidth doesn't support to DL:UL ratio 0.73 and higher.

The 7 MHz, 10 MHz and 20 MHz channel bandwidth doesn't support to the DL:UL = 0.81 & higher, 0.87 & higher, 0.94 & higher respectively.

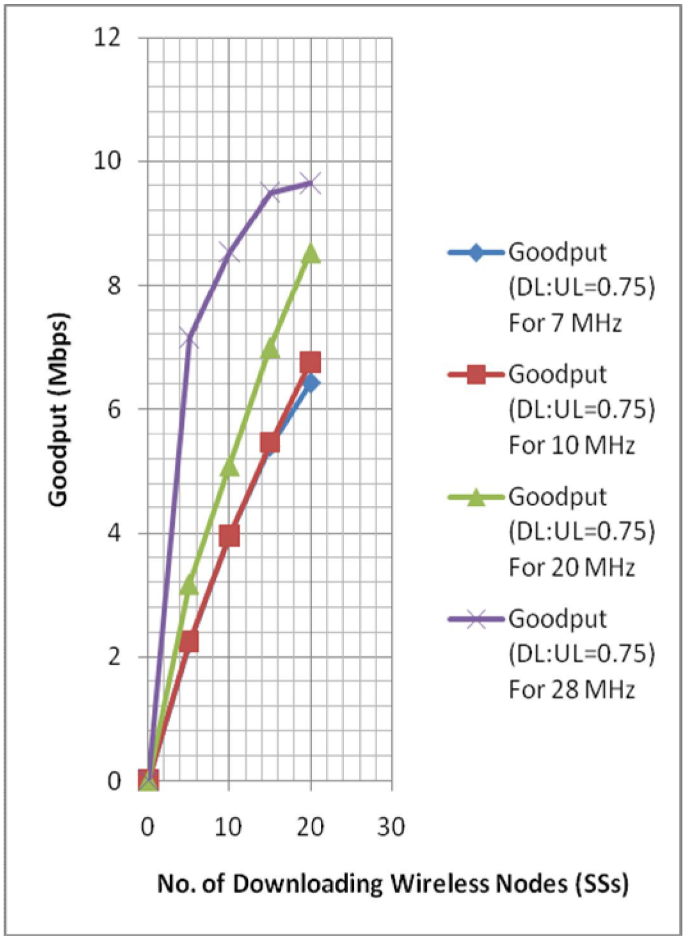

Fig.7. Goodput for SSs with different channels sizes considering DL:UL=0.75

3.2 Scenario 2: Effect of Channel Bandwidth

The figure 8 shows the throughput and goodput for different channel bandwidth with different DL:UL ratios.

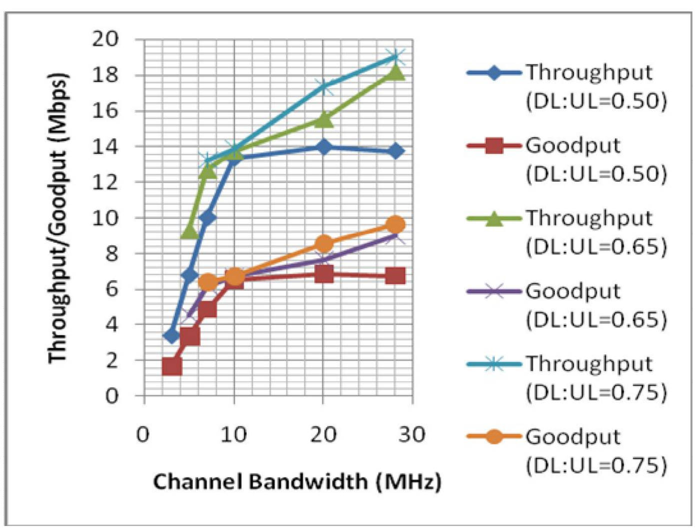

Fig.8. Throughput/Goodput for channel sizes with different Channel Bandwidth

In figure 8, it is observed that the throughput and goodput increases when the channel bandwidth is increases with different DL:UL ratio.

The maximum obtained, throughput and goodput is 20 Mbps and 10 Mbps (approximately) respectively in case of 28 MHz channel bandwidth for DL:UL ratio 0.75 (asymmetry exists).

The minimum obtained, throughput and goodput is 4 Mbps and 2 Mbps (approximately) respectively in case of 3 MHz channel bandwidth for DL:UL ratio 0.50 (asymmetry doesn't exist).

The figure 8 proved that higher channel bandwidth and higher DL:UL ratio provides higher throughput and goodput and lower channel bandwidth and lower DL:UL ratio provides lower throughput and goodput in WiMAX network.

3.3 Scenario 3: No. of Packets Dropped

The figure 9 shows the number of packets dropped with channel bandwidth. When the channel bandwidth increased the number of packets dropped also increases for different DL:UL ratios.

The large number of packets dropped for higher channel bandwidth and higher DL:UL ratio and less number of packets dropped for lower channel bandwidth and lower DL:UL ratio.

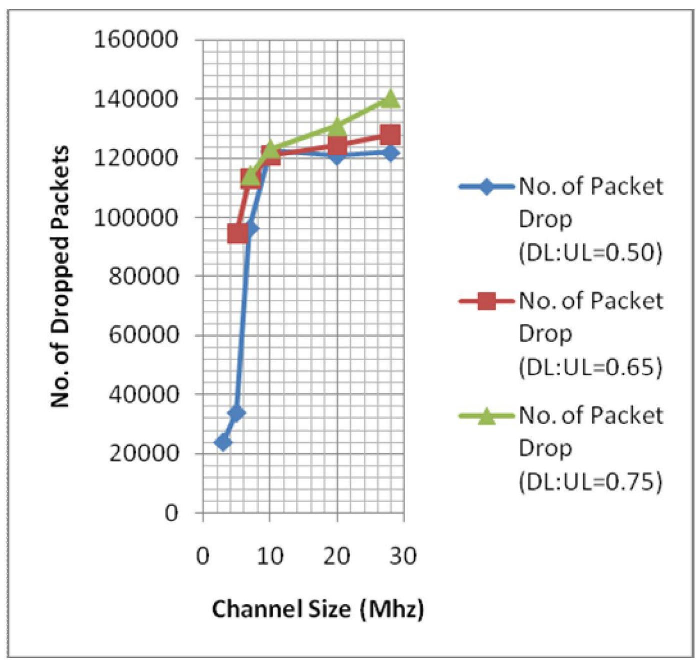

Fig.9. Dropped packets for channel sizes with different DL:UL ratio

The approximately 140000 packets dropped for 28 MHz channel bandwidth with DL:UL ratio 0.75 because wireless channel is unreliable channel and higher channel bandwidth and higher DL:UL ratio carry the large traffic in downloading then the large number packets will be dropped.

The approximately 20000 packets dropped for 3 MHz channel bandwidth with DL:UL ratio 0.50 because lower channel bandwidth and lower DL:UL ratio carry the low downloading traffic then the less number of packets will be dropped.

4 Conclusion

This paper investigates the impact of channel bandwidth in WiMAX network with network asymmetry using TCP New Reno.
The investigation is done by considering channel bandwidth, number of downloading wireless nodes (SSs) and DL:UL ratio.
In this investigation it is observed that whenever the downloading nodes increased the throughput and goodput also increased for different channel bandwidth and different DL:UL ratio.
It is also observed that the large number of downloading nodes and large DL:UL ratio for different channel bandwidth provides higher throughput and goodput.
Whenever channel bandwidth increases the throughput and goodput also increased for different DL:UL ratio.
The higher channel bandwidth and higher DL:UL ratio provides higher throughput and goodput.
Whenever channel bandwidth increases the number of packet dropped also increased for large DL:UL ratio.

Acknowledgment

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