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WiMAX Network Optimization Using Frame Period with Channel Allocation Techniques

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Abstract:
Internet connectivity in WiMAX networks, along with various applications, is increasing rapidly, so the connectivity of internet and data transfer speed are always challenges for effective data transmission in wireless networks. Several factors affect the performance of networks. One important factor is to choose a suitable frame period for effective data transmissions. The performance of different frame periods with Round Robin and Strict Priority is evaluated in this work. A frame period in Round Robin performs better than a Strict Priority in terms of throughput, but a Strict Priority performs better in terms of drop rates. This paper also demonstrates that an effective frame period, when combined with a proper bandwidth allocation algorithm, yields better results. This work gives the analysis that Round Robin performs 83.8847% better while Strict Priority performs 86.0020% better than the earliest deadline first algorithms for 10 subscriber stations in terms of throughput. This work is helpful to researchers and industrialists for actual implementations in WiMAX networks.

Keywords: *IEEE802.16, WiMAX, Bandwidth allocation algorithm, Frame period, Round robin algorithm, Strict priority algorithm*

1. Introduction

The WiMAX is a kind of Broadband Wireless Access (BWA) network for high-speed data transfer that can be used where the lying of cables is not feasible [1]. Various technologies have been designed based on IEEE standards. It includes IEEE802.11 for Wi-Fi, IEEE802.16-2004 for fixed WiMAX, and IEEE802.16e for mobile WiMAX. It is a BWA system that follows the IEEE802.16-2004 and IEEE802.16e standards [2]. Wireless services are challenging in rural, dense areas, and sometimes, in uneven geographical areas, there are high data rates in WiMAX networks with large coverage areas and a large frequency spectrum for integrated video, audio voice, and data services required in those areas. Network enhancement and performance improvement are still a challenge in mobile WiMAX networks. In real-life scenarios, packets are dropped while using the quality of services (QoS) such as audio, video, or voice. The dropping of packets using the existing technique affects system performance due to various factors, such as infrastructure, environments, and applied algorithms.

This work is based on the applied algorithm in which the performance of the system is affected. The performance of the proposed system is increased by optimizing the frame periods. The frame duration, along with the channel bandwidth algorithm, is an important area to enhance the performance of WiMAX networks in rural, dense, and uneven geographical areas for different data services. The current implementations are done using a base station and subscriber stations for audio, video, and data services in fourth-generation techniques. The connectivity between the SSs and BS for data transfer is done using individual Transmission Control Protocol (TCP) connections and synchronization, which is a must for transmission of data [3]. All SSs receive data from the base station at the start of every frame using an Uplink Map (UL MAP) message [4]. The Light WiMAX uses the principle of orthogonal frequency division multiplexing and provides various qualities of service and multihopping techniques [5].

This work also found that the existing frame period is not at peak efficiency and demonstrates better results. When varying the frame periods in the existing algorithm, optimized new frame period in the existing algorithm gives better results.

The next sections of this paper include the literature survey with network structure, followed by bandwidth allocation algorithms, then results and discussions, and finally the conclusion and future work.

2. Related Work

Huge work has been done in wireless communication systems in scheduling, but there are still various needs to be done for effective performance in WiMAX networks. Previous work has been done on various algorithms like Round Robin [6], Weighted Round Robin [7,8], and Weighted Fair Queuing [9], which are generally proposed for WiMAX networks. These algorithms are general algorithms and do not take care of specific applications of WiMAX networks. These algorithms are not effective for high-speed data networks but are still used in many applications of WiMAX networks. Some wireless applications are channel aware applications, while some algorithms are non-aware of channel bandwidth. Some of the predefined algorithms are still not suitable for high-speed internet services, while some algorithms are not suitable for mobility applications. When channel aware schemes are discussed, it is required to understand channel state information.

Priority is given to those subscriber stations whose channel conditions are good. Also, if channel conditions are good and proper allocation techniques like radio resources and utilization are available, it becomes easy to enhance the performance of networks. The issue with these schemes is in the allocation techniques, in which subscriber stations starve for substantial intervals if channel conditions are poor, while overprovisions are made for SSs with good channel conditions. MAC layer schemes are designed with ideal channel conditions in mind. The purpose of MAC layer schemes is to assure maximum throughput, minimum traffic rate, and fairness. Since various QoS classes are defined in WiMAX networks with different requirements, an important scheduling decision must impose some sort of priority. Multiantenna mode and available bandwidth are responsible for high-speed data transfer rates over the air of about 1Gbps speed. This type of work is suitable for good quality and higher capacity services and internet protocols suitable for a vast range and quality-based internet services. These services are not only sufficient to maintain full backward compatibility but also support those services that may be useful for next-generation internet services. This work mentioned all the technical aspects of IEEE 802.16m in which next-generation internet services are proposed in the future [10].

For full utilization of frames, mobile WiMAX allows packet fragmentation, which enhances network capacity. Variations in channel conditions cause variations in time and location. Deficit round robin with fragmentation and the earliest deadline first algorithms are some algorithms that were previously proposed. Resources are allocated as per the variation in link capacity in mobile WiMAX in an effective manner to transmit fragmented packets in the network [11]. Deficit round robin with fragmentation gives better performance in terms of throughput than DRR, which is about 80% higher, giving minimum overheads than global positioning systems. Some work has also been done on frame durations to improve the performance enhancements of WiMAX networks. This paper considers data rate in terms of spectral efficiencies, cell coverage, latencies, spectrum efficiency, and quality of service, including complexities. This paper explores the improved WiMAX technology focusing on the physical layer, MAC layer, and those services essential to improve quality of services for network betterments [12]. This work focuses on detailed scheduling and collaboration with service providers. Channel awareness cross-layer scheduling is proposed, which describes the reduction of packet loss and delay and gives better throughput [13]. This paper details the transmission control protocol and user datagram protocol performance in IEEE 802.16 [14]. In this work, the author discusses and analyses issues like coverage holes and capacity optimizations. This work also suggests the relay station as an effective solution for multi-hop relays that guarantee performance. This paper also gives better results when optimal relays are used in the networks [15].

End to end delay in packet transmission and receiving in the networks is proposed by weighted Round Robin scheduling in WiMAX networks to analyze the performance [16].

Designing a network structure with constraints in mobile multi-hop relay-based networks is a challenge in IEEE 802.16 with a suitable frame structure. The frame structure design using different parameters in terms of dimensions, design constraints, and challenges is still a problem. The flexible frame structure design is proposed, which is used to perform various multi-hop operations while maintaining backward compatibility with legacy systems on mobile stations. Using such a system increases the capacity improvement in mobile multi-hop relays and also establishes a better understanding in terms of range extensions in relay networks [17].

This work proposes the scheduling architecture for uplink and downlink connection of IEEE 802.16. This architecture includes various quality of service parameters, which include latency, sustained rate, jitter toleration, minimum reserved bandwidth, request transmission policies, traffic priority, burst size, SDU size, and queuing for different service flows. In this paper, two important algorithms, named first in, first out, and earliest deadline first and self-clock fair queuing algorithm for efficient bandwidth, are used along with the quality of services [18].

This research evaluates the choice for effective frame structure in non-transparent relay stations in WiMAX networks. Single frame structure and multiple frame structure are two types of standards proposed by IEEE 802.16j -2009. No comparisons are made among these frame structures. Light WiMAX is used to evaluate two frame structures using ntRS of QoS. This work is mainly focused on achieving higher throughput using the multi-frame structure for voice capacities in terms of delays [19].

This work proposed for IEEE 802.16j quality of service scheduling scalable architecture which guarantees quality of service for various mobile applications. This paper focuses on finding an appropriate quality of service improvements. The SQSA supports QoS architectures SQSA modules and support its functions for mobile applications [20].

This work is done to increase the data-sending rate and extend the network coverage area using relay stations with IEEE 802.16. The performance is increased by allocating an appropriate resource to individual relay stations as per the needs of the networks. This work also finds that if resource allocation is not properly done, then relay stations will experience congestion, which results in performance degradation in terms of throughput and delay. Base stations dynamically schedule the data transmissions to relays by centrally managed relay stations. IEEE 802.16 standards define decentralized radio resources by means of existing scheduling. Conventional service decreases the system performance; hence those services are used that increase the system performance.

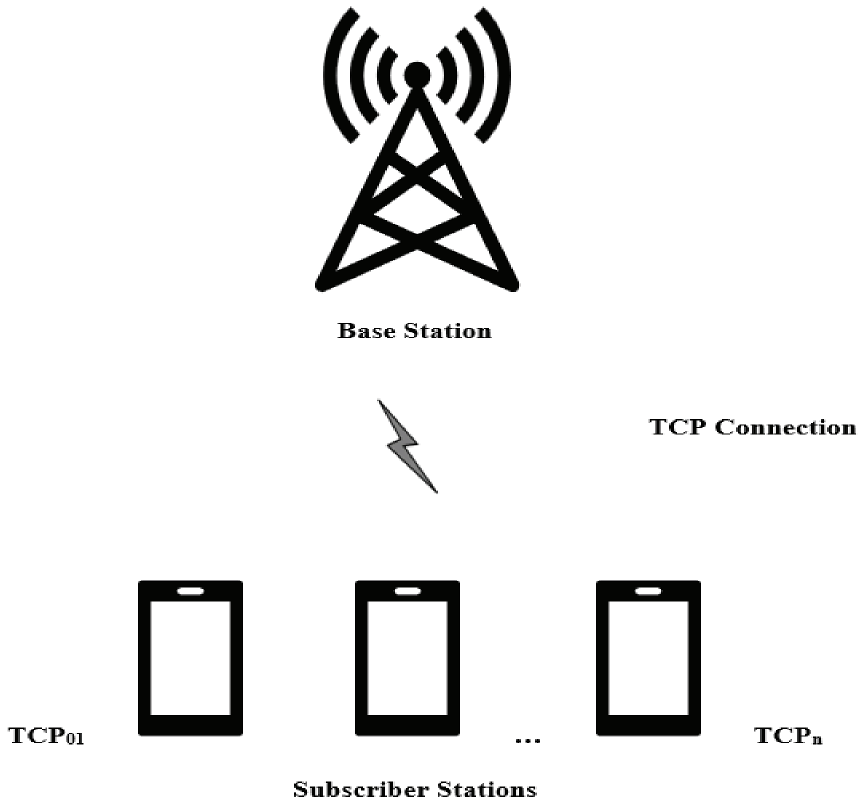

Figure 1. Network structure

These services are used not only to maximize the throughput but also to minimize packet delays and reduce signaling overheads by pre-allocating and decentralizing controlled relay stations. This paper also mentioned default radio resources, which show that relay stations independently assign resources without asking the base station so that traffic, overhead, and packet delays can be reduced [21].

This work investigates the improved throughput and minimum delays for end users with various applications like voice, video, and audio services by reducing the cost using the available spectral resources by using relay stations. The proposed work gives a cost-effective solution by installing the three-relay station with adaptive modulation and coding schemes, cell sectoring, and directional antennas in IEEE 802.16. This work increased the throughput with a lesser number of relay stations within the same base station range without compromising the quality of service [22].

This work proposes relay stations in WiMAX networks with different bandwidth allocation algorithms to enhance the signal power over long distances with relay stations. This paper shows that the relay station extends the coverage with high throughput and high bandwidth of channels. This paper focuses on performance analysis of bandwidth allocation algorithms with and without relay stations. This work compares the channel bandwidth allocation algorithm with and without relay station, and performance enhancement is proposed and evaluated [5].

3. Network Structure

The network structure shown in Figure 1 consists of one base station and many subscriber stations. The base station (BS) is connected to subscriber stations (SS) through individual wireless TCP connections. The data is transmitted from the base station to the subscriber stations through a wireless medium. A downloading link is established from the base station to the subscriber station, and the channel is allocated to subscriber stations using Round Robin and Strict Priority channel allocation techniques; the base station transmits data to subscriber stations using individual TCP connections with allocated channel bandwidth, which is shown in Figure 1 for performance evaluation.

Various network tools are also available to perform the study of WiMAX networks, like MATLAB, Netsim, Opnet, OMnet++, and many more. One such simulation tool is Light WiMAX [5]. To evaluate the performance of WiMAX networks the Network Simulator (NS-2) is used. The Frame_LWXtimer() function is used to add the Medium Access Control (MAC) Layer. Once the packets start transmitting, the MAC source address and MAC destination address are defined. Port numbers at the source and destination are also defined for data transmissions in the code. If no node matching the destination address is found, the packet is dropped. Data is only transmitted from BS to SS, and bandwidth allocation is done using a variable defined in the code.

In the simulation, two variables are used: "1" for the round robin algorithm and "2" for the Strict Priority algorithm. The collection of downlink flow into a corresponding flow queue is stored in the link program.

4. Bandwidth Allocation Algorithms

The bandwidth allocation algorithm ensures proper bandwidth management for the smooth transmission of networks to subscriber stations. The Strict Priority scheduling based on either preemptive or non-preemptive bandwidth allocation algorithm for wireless network. Priority scheduling generally suffers from the problem of starvation; high priority task applications will be in ready or waiting condition if, on the base station, the process loses control in waiting conditions [23]. In the scheduling techniques, the higher priority processes are processed, whereas lower priority processes are neglected. In non-priority preemptive scheduling, it takes a longer time as compared to higher priority processes on the base station, which can lead to a starvation condition [24].

Another algorithm is the Round Robin algorithm, which is the preemptive scheduling algorithm. Each process is given a set amount of time to complete; this is referred to as a quantum. Preemption is needed for the execution of one process within a given time interval [25]. Context switching is used to save states of preempted processes [8].

Every bandwidth allocation algorithm has its own channel allocation workings [26]. This work used the frame duration with Round Robin and Strict Priority algorithms. There are two paths that could be chosen: one that goes directly to the base station and one that goes through relay stations. In this paper, two hop relays that transmit data from SS to BS only are used. Various steps are involved when using the AODV routing protocol, which includes the discovery of paths, setup of path selection, forward path selection, routing table management with path maintenance, and local connectivity management. The main advantage of using the AODV protocol is that it is scalable and can be used for a large number of nodes. Broadcast minimization is another advantage of using this algorithm. Another advantage of using this routing algorithm is that it reduces memory requirements and can be used in networks for loop-free routing maintenance.

For performing the real-world implementation of the scenarios, Network Simulator 2 is a simulation tool used to perform various simulations. To execute the code, this tool used the C++ language in conjunction with Tool Command Language [27]. The simulation environments are used to carry out the entire deployment. This tool is an event-driven tool that provides a dynamic environment for creating scenarios that are identical to the real parameters required for network creation. Simple commands are used to implement the tool for defining network configurations.

4.1. Algorithm 1: Round Robin – Downlink Bandwidth Allocation

1) Start
2) Create pointer to each flow type's queue to allocation
3) Get symbol number of DL and UL
4) Create algorithm calculation variable
5) Reset all relative variables' value in flow's attribute
6) Set Path selection
   a) Find the path (directly to BS or passing though Relay Station RS)
   b) Set BWA_Flow _Type and BWA_Next _Hop
7) Select path
   a) If (this flow has relay link, use the first relay link and its next hop)
   b) Else use access link
8) Bandwidth allocation
   a) Access zone:RR +min QoS Gurantee
   b) Relay zone: only RR
      i. Collect flow into corresponding flow queue
      ii. Bs->SS and BS->RS should also be scheduling together, because they use the same bandwidth
9) Downlink access bandwidth allocation
   a) Satisfy each dl flow's Rmin
   b) Satisfy each dl flow by Round Robin
   c) Final dl BWA setting
   d) Log each phase's bandwidth allocation of each downlink flow
10) Downlink relay bandwidth allocation (RS->SS)
   a) Satisfy each dl relay flow by RR
   b) Final dl BWA setting
   c) Log each phase's bandwidth allocation to each downlink relay flow
11) Uplink access bandwidth allocation
   a) Satisfy each ul flow Rmin
   b) Satisfy each ul flow by RR
   c) Log each phase's bandwidth allocation of each downlink flow
12) Uplink relay bandwidth allocation (RS->SS)
   a) Satisfy each ul relay flow by RR
   b) Final UL BWA setting
   c) Log each phase's bandwidth allocation of each downlink relay flow
   d) Lwx_tests_msg("RR's UL Relay BWA")
   e) Osttringstream log_send_plt
   f) Log_send_pkt
   g) Get packet
   h) Get log
   i) Lwx_test_msg("dl". Log_bwa.str());

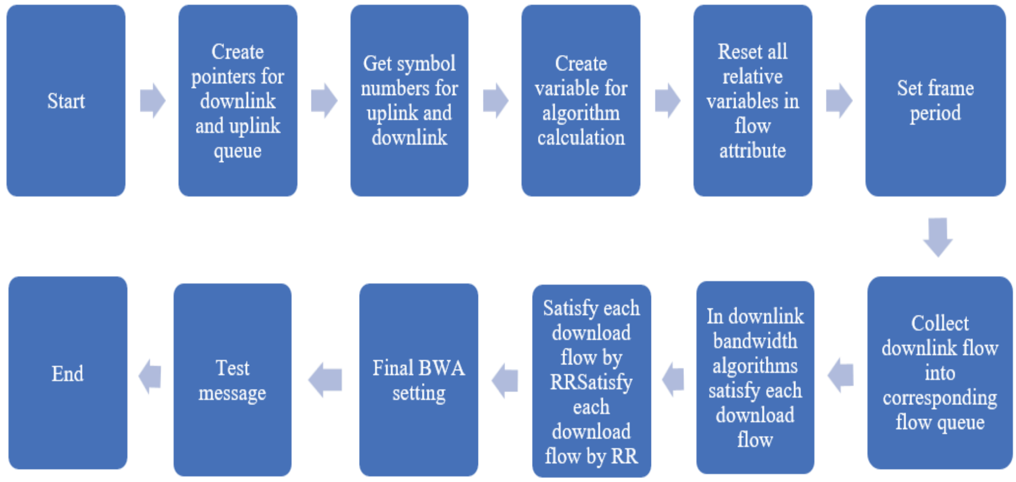

Figure 2. Workflow diagram: round robin – downlink bandwidth allocation

   j) Decrease BWA_Total
   k) Pin this packet
   l) Send down packet
13) Timer flow chart:
   a) Create pointer to downlink and uplink queue to allocation bandwidth efficiently
   b) Classify flows of the node and call the corresponding transmission functions whose node ID is source into corresponding flow queue
14) End Timer
15) End

4.2. Algorithm 2: Strict Priority – Downlink Bandwidth Allocation

1) Start
2) Create pointer to each flow type's queue to allocation
3) Get symbol number of DL and UL
4) Create Strict Priority algorithm calculation variable
5) Reset all relative variables value in flow's attribute
6) Set Path selection
   a) Find the path (directly to BS or passing though Relay Station RS)
   b) Set BWA_Flow _Type and BWA_Next _Hop
7) Select path
   a) If (this flow has relay link, use the first relay link and its next hop)
   b) Else use access link
8) Bandwidth allocation (Strict Priority)
   a) Access zone:RR +min QoS Gurantee
   b) Relay zone: only RR
      i. Collect flow into corresponding flow queue
      ii. Bs->SS and BS->RS should be also scheduling together, because they use same bandwidth
9) Downlink access bandwidth allocation
   a) Satisfy each dl flow's R-min
   b) Satisfy each dl flow by Round Robin
   c) Final dl BWA setting
   d) Log each phase's bandwidth allocation of each downlink flow
10) Downlink relay bandwidth allocation (RS->SS)
   a) Satisfy each dl relay flow by RR
   b) Final dl BWA setting
   c) Log each pahse's bandwidth allocation to each downlink relay flow
11) Uplink access bandwidth allocation
   a) Satisfy each each ul-flow R-min
   b) Satisfy each ul-flow by RR
   c) Log each pahse's bandwidth allocation of each downlink flow
12) Uplink relay bandwidth allocation (RS->SS)
   a) Satisfy each ul relay flow by RR
   b) Final UL BWA setting
   c) Log each phase's bandwidth allocation of each downlink relay flow
   d) Lwx_tests_msg("RR's UL Relay BWA")
   e) Osttringstream log_send_plt
   f) Log_send_pkt
   g) Get packet
   h) Get log
   i) Lwx_test_msg("dl". Log_bwa.str());
   j) Decrease BWA_Total
   k) Pin this packet
   l) Send down packet
13) Timer flow chart:
   a) Create pointer to downlink and uplink Strict Priority queue for allocation of bandwidth

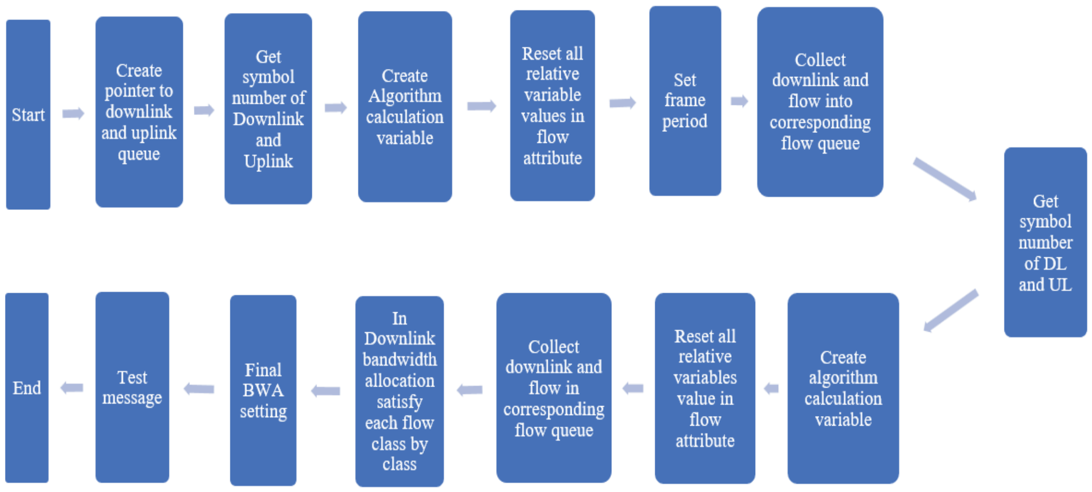

Figure 3. Workflow diagram: strict priority – downlink bandwidth allocation

b) Classify flows of the node and call the corresponding transmission functions whose node id is source into corresponding flow queue

14) End Timer

15) End

5. Results and Discussions

5.1. Simulation Parameters

Table 1 shows the various simulation parameters used in this work. One of the parameters used in this work is a routing table based on ad-hoc techniques. On-demand routing protocols used in wireless networks are loop-free protocols. This protocol is a self-starting protocol used in the subscriber station environment. This is also used to implement various other parameters like mobility of nodes, failure link management protocols, and loss of packet identification. Hence, to identify all these works in wireless works, the AODV protocol plays an important role.

Ad-hoc on-demand routing protocol is maintained by a routing table, which keeps the details about the nearby routers [28]. The routing table maintained by AODV consists of three types of information, including the next hop count, sequence numbers, and the total hop count, which is needed to transfer the data among the nodes. Next, hop count is used to identify the distance of current nodes to the intended nodes.

The second parameter used is transmission protocol, which may be either connection-oriented or connection-less. In this work, a transmission control protocol is used [29]. Two algorithms, Round Robin algorithm and Strict Priority, are used in this work. Also, a sustainable time of 300 seconds is used for simulations to have accurate results. Subscriber stations, referred to as nodes in this paper, are assigned initially with ten numbers and increase up to 100 nodes with a difference of 10 nodes each time. In this work, the frame period is 5 ms, 2.5 ms, 1.25, and 0.625 milliseconds are taken, and the rest of the parameters are varied to analyze the performance of WiMAX networks.

Table 1. Parameters for simulation

Parameters	Values
Routing Protocols	Ad Hoc On Demand Routing Protocol
Transport Protocol	Transmission Control Protocol (TCP)
Bandwidth Allocation Algorithm	Round Robin (RR) and Strict Priority (SP)
Simulation Duration	300 Seconds
Number of Wireless Nodes	10, 20, 30……up to 100
Frame Duration	0.005, 0.0025, 0.00125, 0.000625 Millisecond
Frame Symbol	48

The following parameters are considered for analyzing light WiMAX networks, which are shown in Table 1.

5.2. Performance Evaluation

The performance evaluation is done on the basis of the following matrices:

1) Throughput: The raw data sent by the sender machine during a specified duration.

$$Throughput = \frac{Number\ of\ Packets\ Sent * 8}{Simulation\ Duration} * 10^{-6}\ Mbps \quad (1)$$

Where the,

Number of packets sent: Total packets sent by sender machine of size 1024 Byte each.

Simulation Duration: The duration of data transfer in seconds.

2) Goodput: The packets successfully received and acknowledged by receiver machine.

$$Goodput = \frac{Number\ of\ Packets\ Received * 8}{Simulation\ Duration} * 10^{-6}\ Mbps \quad (2)$$

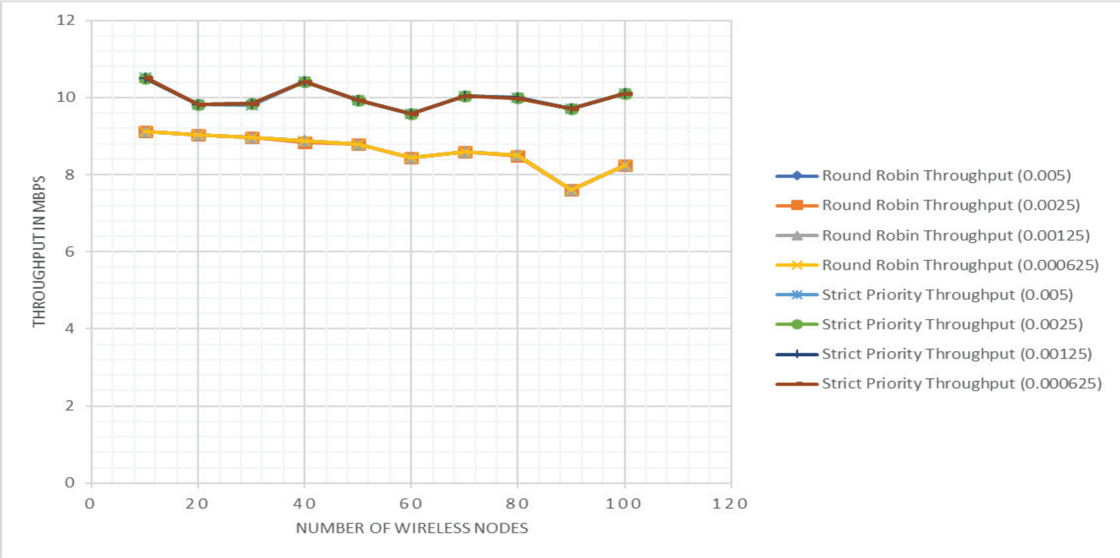

Figure 4. Throughput of frame period for round robin and strict priority

Where the,

Number of packets received: Total packets received by receiver machine of size 1024 Byte each.

Simulation Duration: The duration of data transfer in seconds.

3) Packet Drop: Total packets dropped during the communication duration.

$$Drop\ Rate = \frac{Number\ of\ Packets\ Dropped * 8}{Simulation\ Duration} * 10^{-6}\ Mbps \quad (3)$$

Where the,

Number of packets dropped: Total packets dropped of size 1024 Byte each.

Simulation Duration: The duration of data transfer in seconds.

5.3. Performance Analysis

It is evident from Figure 4 that a throughput of 9.12 Mbps for 10 nodes is observed in the Round Robin algorithm, which is much better than Strict Priority. Throughput also decreases with the increasing number of nodes. A comparative analysis reveals that Round Robin has an 88.4% higher Strict Priority for 20 nodes. The throughput for 50 subscriber stations is 8.79 Mbps and 9.92 Mbps for the RR and SP algorithms, respectively. Similarly, for Round Robin and Strict Priority, it is obtained at 8.59 Mbps and 10.04 Mbps for 70 nodes, respectively. Continuous degradation is observed as the number of nodes increases in the two algorithms. The same results are continuously observed as the number of nodes increases. Strict Priority is found to be 11.39% more efficient than Round Robin for 50 nodes and 18.33% better for 100 nodes. As the number of nodes increases, throughput decreases in both Round Robin and Strict Priority, due to the full utilization of the channel and maximum bandwidth utilizations. When subscriber station increases single orthogonal frequency division multiplexing symbol uses multiple bits which degrades the throughput of the channel. As the number of subscriber stations increases, multiple bits are carried in a single OFDM symbol. A shorter frame period uses the channel's maximum bandwidth, and throughput is higher for fewer nodes. The effect due to delay spread is minimized when a longer data symbol is used, and when delay spread is small, it becomes an insignificant fraction of the symbol length. On increasing subscriber stations, full utilization of the base station is used, which uses a wider channel.

Figure 5 shows that a smaller number of nodes per connection can also lead to higher goodput, that is, 9.51 Mbps obtained using the Round Robin algorithm for 10 subscriber stations. The observed goodput is 9.03 Mbps for 20 subscribers. It also obtained 8.39 Mbps and 6.75 Mbps goodput for 60 subscriber stations in round robin and Strict Priority. The obtained goodput for 80 subscriber stations is 8.45 Mbps and 8.3 Mbps for round robin and Strict Priority, respectively. The obtained goodput for 100 nodes is 8.19 Mbps and 10.15 Mbps for round robin and Strict Priority, respectively. When a comparative analysis is done, it is observed that round robin for relay performs 89.1% better for Strict Priority for 10 nodes, 87.4% better for 30 nodes, 81.8% better for 60 nodes, 82.4% better for 80 nodes, and 79.7% better for 100 nodes. This demonstrates that Strict Priority does not perform better in terms of throughput for stations with fewer subscribers. As the number of packets sent per second went up, so did the amount of data that could be sent through the channel. The most data is sent through channels with fewer subscribers [7]. When a comparative analysis is done, Round Robin performs much better than Strict Priority. When the number of nodes increases, the goodput in both cases decreases due to the dropping of packets occurring (busy channel). When the number of nodes increases, performance suffers as the channel is fully utilized, resulting in an increased drop rate.

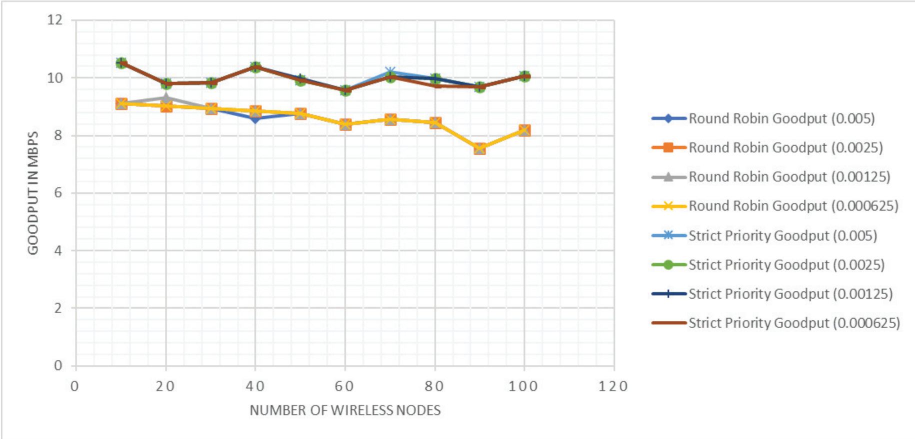

Figure 5. Goodput of frame period for round robin and strict priority

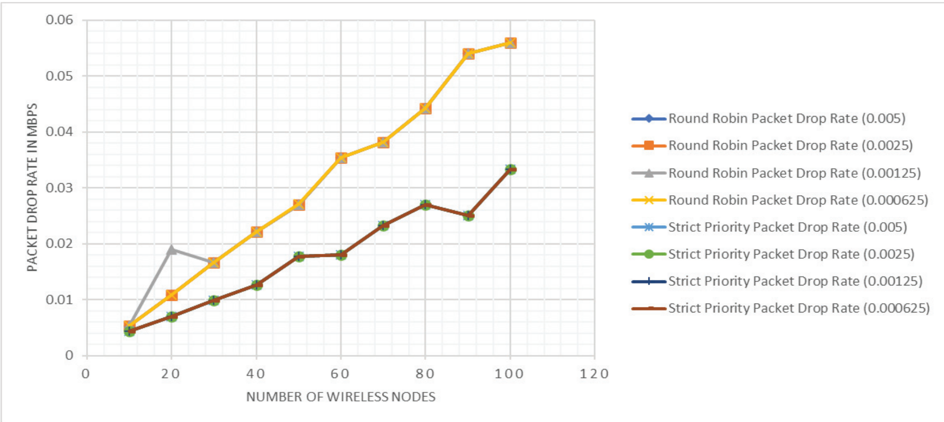

Figure 6. Drop rate of frame period for round robin and strict priority

Figure 4 shows that the dropped packets in Strict Priority are much higher as compared with round robin. The rate of packet drops increased as the number of subscriber stations increased because signals were initially transmitted with maximum power from base stations, reducing the likelihood of signal losses. Similarly, as traffic loads increase, it becomes difficult to maintain as many subscriber stations, and they are dropped after a long period of waiting [24]. Figure 4 shows that the drop rate also increased due to the unavailability of modulation over long distances. Initially, packet drop rates of 0.005, 0.016, 0.027, 0.032, and 0.056 Mbps are obtained for 10, 30, 50, 70, and 100 nodes, respectively, for Strict Priority and Round Robin, which is shown in Table 2. As the nodes increase, the packet drop rate also increases by 0.002, 0.007, 0.010, 0.014, 0.019, and 0.024 Mbps for 10, 30, 50, 70, and 100 nodes, respectively, for Strict Priority. The variation in data rate depends on whether the receiver is in line of sight or not [26]. In cases of non-line-of-sight (NLOS), the data rates drop significantly due to the adaptive modulation [30]. When comparing all three algorithms, the drop rate is higher in Strict Priority when the subscriber stations increase. It is observed that 37.2%, 42.15%, 41.7%, 49.9%, and 37.3% are higher than Strict Priority for, respectively, 10, 30, 50, 70, and 100 nodes.

Figure 7 shows that round robin and Strict Priority algorithms with a number of nodes equal to 10 in each case are compared with previously proposed EDF and DRRF on the basis of frame duration and channel bandwidth allocation. It is observed that Strict Priority and Round Robin perform much better in terms of throughput as compared to EDF, which is shown in Table 3 when taking 10 nodes in each case. It is observed from the analysis that Round Robin performs 83.8847 % better while Strict Priority performs 86.0220 % better in the case of a maximum of 10 subscriber stations.

Since previous algorithms have not mentioned the throughput for more than 10 nodes, hence the comparisons for 20,40,60, and 80 nodes are not shown in this work. So, for these nodes, comparisons between the two algorithms are available only. So, for the rest of the nodes, the comparisons of Strict Priority and Round Robin are done in this work. It is observed from the analysis that, for nodes, throughput is 7.84% higher than Round Robin in the case of 20 nodes. It is observed that 14.61% and 15.01% are higher than Round Robin for 40 and 80 nodes. The analysis shows that higher throughput is observed more in Strict Priority than the Round Robin algorithm in each case. Higher throughput is observed due to successful sending of packets from base station to subscriber station.

Table 2. Comparison of bandwidth allocation algorithm in WiMAX networks with throughput

Number of Nodes	Throughput (Round Robin)	Throughput (Strict Priority)	Throughput (EDF)	Throughput (DRRF)	Throughput (EDF-DRRF)	Throughput (Round Robin) Percent Higher than EDF	Throughput (Strict Priority) Percent Higher than EDF	Throughput (Strict Priority) Percent Higher than Round Robin
10	9.12179	10.5166	1.47	1.47	1.47	83.8847%	86.0220%	–
20	9.04207	9.81998	–	–	–	–	–	7.84%
40	8.88284	10.4029	–	–	–	–	–	14.61%
80	8.49475	9.99818	–	–	–	–	–	15.04%

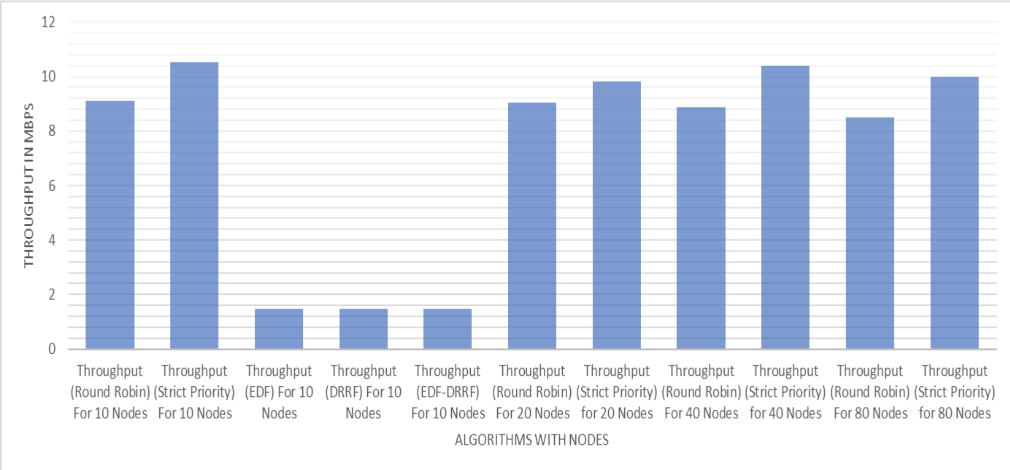

Figure 7. Throughput comparison of proposed algorithm with existing algorithms

Table 3. Comparison of bandwidth allocation algorithm in WiMAX networks with goodput

Number of Nodes	Goodput (Round Robin)	Goodput (Strict Priority)	Goodput (EDF)	Goodput (DRRF)	Goodput (EDF-DRRF)	Goodput (Round Robin) Percent Higher than EDF	Goodput (Strict Priority) Percent Higher than EDF	Goodput (Strict Priority) Percent Higher than Round Robin
10	9.11642	10.5123	1.47	1.47	1.47	83.8752%	86.0163%	–
20	9.03117	9.81304	–	–	–	–	–	7.95%
40	8.6067	10.3903	–	–	–	–	–	17.16%
80	8.45051	9.97117	–	–	–	–	–	15.25%

Throughput is generally considered as aggregate since it is dependent on many factors like interference including radio, physical, and electrical signals. Another factor that impacts throughput is distance between the base station and subscriber stations. Various other obstacles like geographical infrastructure of Earth is also a parameter through which throughput receive impacts in 2.4 GHz band in wireless communication systems.

Figure 8 shows that round robin and Strict Priority algorithms with numbers of nodes equal to 10 in each case are compared with previously proposed EDF and DRRF on the basis of frame duration and channel bandwidth allocation. It is observed that Strict Priority and Round Robin perform much better in terms of goodput as compared to EDF. Based on the analysis, Round Robin works better for up to 10 subscribers by 83.8752%, while Strict Priority works better by 86.0163%.

Since previous algorithms have not mentioned the goodput for more than 10 nodes, hence the comparisons for 20,40,60, and 80 nodes are not shown in this work. So, for these nodes, goodput comparisons between the proposed two algorithms are available only. So, for the rest of the nodes, the comparisons of Strict Priority and Round Robin are done in this work. It is observed from the analysis that for nodes, goodput is observed to be 7.95% higher than Round Robin in the case of 20 nodes, while it is observed to be 17.16% and 15.25% higher than Round Robin for 40 and 80 nodes. The analysis shows that higher goodput is observed in Strict Priority than Round Robin algorithm in each case. Higher goodput is observed due to the successful sending of packets from the base station to the subscriber station.

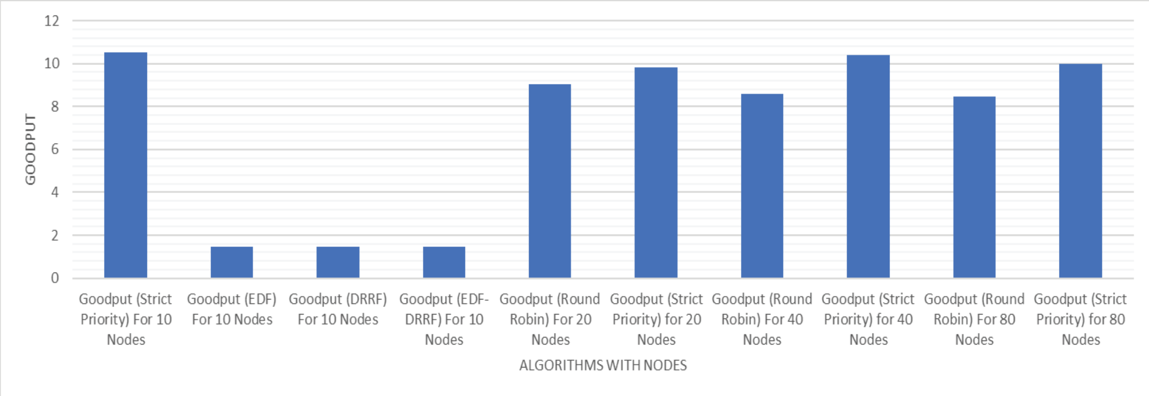

Figure 8. Goodput comparison of proposed algorithm with existing algorithms

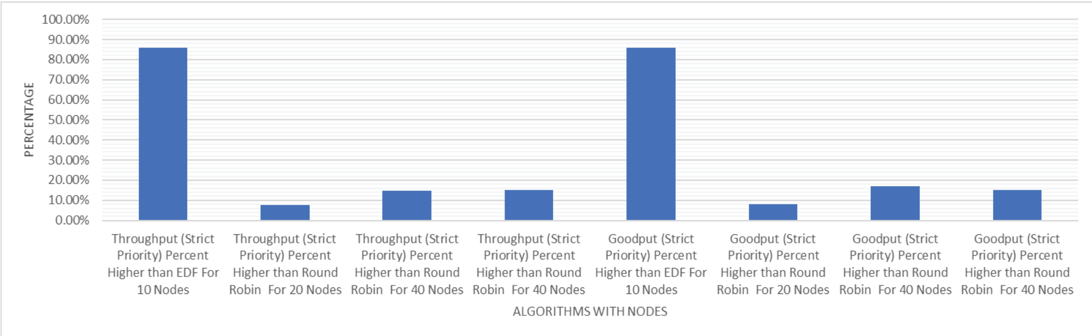

Figure 9. Comparative analysis (% wise) of throughput and goodput in round robin and strict priority nodes and EDF

Goodput is also dependent on many factors like interference, including radio, physical, and electrical signals. Another factor that impacts goodput is the distance between the base station and subscriber stations. Various other obstacles like the geographical infrastructure of the earth are also a parameter through which goodput receive impacts in the 2.4GHz band in wireless communication systems.

Figure 9 shows a percentwise comparative analysis in terms of throughput and goodput for 10 nodes of EDF with Strict Priority and Round Robin. It also shows a comparison of Strict Priority and Round Robin algorithms for 20,40, and 80 nodes since previous work for a greater number of nodes is not mentioned in the referenced papers. Overall, it is observed that Strict Priority performs much better among all three algorithms in terms of throughput and goodput.

6. Conclusion

The work is used to enhance the performance of WiMAX networks with various frame periods. Also, this work is done to enhance the performance by varying frame periods in the algorithms, and it is observed from the analysis that varying the frame period in the algorithm really enhances the performance of WiMAX networks. The enhancement is done by changing the existing algorithm and adding the new frame periods. This analysis also shows that during the bandwidth allocation, if the frame period is varied, then somehow a Strict Priority algorithm gives better results in the form of throughput, goodput, and packet drop rate.

The Strict Priority bandwidth allocation algorithms give better results as compared to round robin algorithms for all frame periods. When the frame period is 0.005 milliseconds, round robin and Strict Priority perform much better than the Earliest Deadline First Algorithm (EDFA) in WiMAX networks. It is observed from the analysis that Round Robin performs 83.8%, while Strict Priority gives 86.2% better throughput than the "earliest deadline first" algorithm for 10 subscriber stations. Similarly, it is also observed that Goodput performs 83.60% and Strict Priority 86.01% better for 10 subscriber stations than the traditional Round Robin algorithm and 90% better than Strict Priority in forms of throughput. A smaller frame period gives better results for efficient data transmission. The study also found that when the number of nodes is reduced, the throughput increases [24, 31–33].

7. Future Work

The whole work can be carried out with various quality of service parameters which may include best effort, real time poling service, non-real time poling service, unsolicited grant service and extended real time poling services. Different channel allocations can also be done for analysis. This whole analysis could also be done with 5G networks.

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