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Improved Bandwidth Allocation based on History in BWA Networks

M. Deva Priya
Assoc. Professor, Sri Eshwar College of Engineering/CSE Department, Coimbatore, Tamilnadu, India
Email: devapriya.m@sece.ac.in

Abstract: **WiMAX is a wireless technology that supports several applications. To efficiently assign resources to different kinds of traffic, Bandwidth Allocation (BA) module is included in MAC layer. The key goal is to reduce delay and make efficient use of available frame space, thereby reducing Information Element (IE) overheads. In this paper, Bandwidth Allocation based on History (BAH) is proposed for allocating bursts in WiMAX networks. BAH scheme focuses on assigning bandwidth depending on Expended as well as Fairness levels. Performance of the propounded mechanism is analyzed based on Throughput, Packet Loss Ratio (PLR) and Average Delay.**

Index Terms: **WiMAX, bandwidth, Expended and Fairness levels,**

I. Introduction

Worldwide Interoperability for Microwave Access (WiMAX), IEEE Std 802.16-2005 is a telecommunication protocol which offers fixed as well as mobile access to internet [1]. Broadband Wireless Access (BWA) technology is based on IEEE 802.16 standard [2]. WiMAX network includes comparatively reduced cost in contrast to DSL, GSM or Fiber-Optics [3]. WiMAX replaces cellular technologies like GSM and CDMA. It involves 2 modes namely, Point-to-Multipoint (PMP) or mesh mode based on applications [4]. It offers increased coverage as well as bandwidth supporting last-mile access to the Internet.

WiMAX supports real-time as well as non-real time communications. Real-time traffic flows include Unsolicited Grant Service (UGS) as well as real-time-Polling Services (rtPS). Non-real time services include non-real-time-Polling Services (nrtPS) as well as Best Effort (BE) services [5]. Traffic from a Mobile Subscriber Station (MSS) should be scheduled and essential bandwidth must be assigned to every flow dynamically [6]. Every MSS shares a dynamic Burst Profile (BP) with the Base Station (BS). BPs are determined depending on Quality of Service (QoS) demands as well as channel conditions.

BS allocates bandwidth depending on diverse factors like demanded bandwidth, QoS and available resources. Grants are represented using an Uplink (UL)-MAP. MSS forwards BW-REQs to the BS using any one of ensuing methods.

- ✓ It may forward a BW-REQ in the granted slot assigned through polling.
- ✓ When polled by BS, it may use contention request interval based on broadcast or multicast poll.
- ✓ It may piggyback BW-REQ on packets containing data.

The BW-REQs are incremental [7]. When an MSS is in short of bandwidth, it sends incremental requests. BS adds the demanded bandwidth to the requirement observed for MSS [8]. An MSS establishes connections with BS for connection-based BW-REQs. The fundamental schemes for sending BW-REQs in WiMAX include:

- ✓ **Contention-based Random Access:** The MSS forwards a BW-REQ during contention period.
- ✓ **Contention-free based Polling Access:** BS preserves details of registered MSSs and every MSS forwards a BW-REQ only after polling.
- ✓ **Grouping mode:** Random access scheme is linked with polling. On polling a group, MSSs contend for sending BW-REQs. This is appropriate when BS do not have sufficient bandwidth to independently poll every MSS.

In this paper, Bandwidth Allocation based on History (BAH) scheme is proposed which assigns bandwidth to flows in present round depending on requests' Arrival Rate (λ), Expended as well as Fairness levels of assigned bandwidth.

II. Related Work

Gakhar et al (2006) [9] have proposed a dynamic resource reservation scheme which varies the quantity of resources reserved depending on actual amount of active connections. Park et al. (2008) [10] have proposed a dynamic bandwidth allocation mechanism for handling real-time services by predicting the quantity of requested bandwidth depending on backlogged traffic and rate mismatch amid packet arrival and service rates. De Rango & Malfitano (2009) [11] have proposed Greedy Choice with Bandwidth Availability aware Defragmentation (GCAD-CAC) which preempts accepted calls on arrival of calls with high priority. Defragmentation of gaps between data sub-frames takes place. Lakshmanan et al (2009) [12] have considered bandwidth allocation and call admission based on possibility of handover as well as call arrival at the MSS. Chuck & Chang (2010) [13] have performed bandwidth recycling for reclaiming unused bandwidth from MSs without altering the present bandwidth reservation, thus ensuring QoS. Antonopoulos et al. (2010) [14] have designed a call admission mechanism based on bandwidth reservation for peak hour traffic to offer increased priority to VoIP calls.

Nasser et al. (2011) [15] have proposed Utility Optimized QoS (UOQoS) mechanism for mobile WiMAX which focuses on bandwidth utilization as well as acceptance of fresh as well as handover calls by linking a utility function to every connection. Sheu et al (2011) [16] have proposed

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Greedy Weighted Algorithm (GWA) to assign bandwidth for video multicast in relay networks so as to circumvent duplicate bandwidth allocation. Bounded GWA (BGWA) is also propounded. Gupta et al (2012) [17] have designed Efficient Bandwidth Management (EBM) to deal with efficient bandwidth allocation to increase bandwidth in ensuing time frame if there is inadequacy in the present time frame and vice-versa. Sheu et al. (2013) [18] have proposed approximation based resource allocation mechanism that focusses on improving utilization of DL bandwidth by sorting requests and dynamically assigning bandwidth.

Pillappaiah et al (2013) [19] have classified users depending on priority and dependency or independency of networks for resource allocation. Chern & Xu (2013) [20] have designed a mechanism wherein, bandwidth is reserved for every connection and Weighted Fair Queuing (WFQ) algorithm is used for scheduling the requests. Based on lengths of queues and connection classes, weights are assigned. Furqan & Hoang (2013) [21] have proposed WiMAX Fair Intelligent Congestion Control (WFICC) which finds the network load depending on borrowing of bandwidth and degradation of highly provisioned connections.

El Bouchti et al (2014) [22] have propounded a scheme for dynamically allocating bandwidth and admitting calls for polling services by using game theory. Non-cooperative 2-person common-sum game is framed, where BS and a fresh connection acts as players. Accepting or declining a connection along with quantity of bandwidth assigned to a connection is considered. Queuing model based on Adaptive Modulation and Coding (AMC) in physical layer is involved in analyzing the QoS of rtPS and nrtPS services.

El-Hammani et al (2017) [23] have focused on link variations while designing call admission schemes for handling real-time traffic. Diverse scenarios for splitting bandwidth as well as handling mobility are considered. Low and high mobility classes are focused on.

Niyato & Hossain (2018) [24] have designed a fuzzy logic-based admission controller for OFDMA-based networks. Factors like peak traffic rate, quality of channel, traffic load are considered for estimating intensity of traffic arrival, allocating available radio resources and admitting or blocking connections. A queueing model is used and packet-level QoS obtained aids in establishing inference rules for resource-allocation. Ahmed et al (2019) [25] have proposed a 2-level scheduling scheme for Base Station (BS) UL scheduler to ensure Quality of Service (QoS) to several traffic classes. It guarantees effectual and reasonable transmission of multimedia.

Ibrahim et al (2022) [26] have dealt with the additional bandwidth which is not utilized. It is recycled so as to improve QoS and conserve the present bandwidth reservation. Bandwidth may be available with the subscribers in addition to that of Downlink (DL) and UL. A suitable scheduling mechanism related to Round Robin (RR) is proposed. Idle bandwidth is reused.

Hindumathi et al (2023) [27] have concentrated on using optimized bandwidth and rejecting ongoing calls in addition to freshly connected calls. A unique and appropriate utility function is assigned to every connection. The proposed framework guarantees high-quality service to both real-time and non-real-time traffic. 2-level scheduling scheme is proposed for BS schedulers involved at UL so as to render service with improved quality to diverse traffic flows.

III. Proposed Model

The proposed BAH scheme allocates bandwidth to every flow in the present round by taking the consistency of assignment and bandwidth usage in previous round into consideration.

A. Bandwidth Allocation based on History (BAH)

BAH dynamically allocates bandwidth to flows depending on diverse factors from former round. It considers the ensuing factors:

- ✓ Traffic Arrival Rate (λ_{Pres})
- ✓ Bandwidth assigned in former round (B^{Prev}_{Alloc})
- ✓ Fairness level (F_{Prev})
- ✓ Expended level (E_{Prev})
- ✓ Available bandwidth (B^{Prev}_{Avail})
- ✓ Extra bandwidth (B^{Prev}_{Add})

BAH computes the Fairness level by taking the quantity of demanded and assigned bandwidth for every flow in previous round into consideration. Service flows request for some amount of bandwidth (B^i_{Req}). BAH module focuses on allocating a portion of whole volume of demanded bandwidth. Let bandwidth required by every flow be 'B^i_{Need}'. The amount of bandwidth demanded is the difference between requested and assigned bandwidth.

$$B^i_{Need} = B^i_{Req} - B^i_{Alloc} \quad (1)$$

Available bandwidth (BW^i_{Avail}) is evenly distributed to degraded flows as assigned to every MSS during handover. Every flow gets a share depending on the need.

$$\gamma = \frac{B^T_{Avail}}{\sum_{i=1}^{n} B^i_{Need}} \quad (2)$$

where,

n - Number of degraded flows

B^i_{Need} - Quantity of bandwidth needed by every flow

B^i_{Add} - Extra bandwidth which is allotted to every flow for upgrading

Every flow gets the share.

$$B^i_{Add} = \gamma * BW^i_{Need} \quad (3)$$

The additional bandwidth assigned to every flow in former round, '$B^{i,Prev}_{Add}$' is computed as:

$$B^{i,Prev}_{Add} = \frac{B^i_{Need}}{\sum_{i=1}^{n} B^i_{Need}} * B^{0,Prev}_{Avail} \quad (4)$$

For a flow (i),

$$\delta_i = \frac{B^i_{Need}}{\sum_{i=1}^{n} B^i_{Need}} \quad (5)$$

Where,

δ_i - Ratio of demanded bandwidth to total need

Then,

$$BW^{i,Prev}_{Add} = \delta_i * BW^{0,Prev}_{Avail} \quad (6)$$

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Depending on quantity of bandwidth required by every flow, ‘δ_i’ varies. Overall Fairness level (F^{O}_{Pres}) is computed as,

$$\beta_i = \frac{B^{i}_{Add,Prev}}{B^{i,Prev}_{Need} * \delta_i} \quad (7)$$

$$F^{O}_{Pres} = \sum_{i=1}^{n} \frac{B^{i,Prev}_{Alloc}}{B^{i,Prev}_{Req}} * \beta_i \quad (8)$$

$$F^{O}_{Pres} = \sum_{i=1}^{n} \frac{B^{i,Prev}_{Req} - B^{i,Prev}_{Need}}{B^{i,Prev}_{Req}} * \beta_i \quad (9)$$

$$F^{O}_{Pres} = \sum_{i=1}^{n} 1 - \frac{B^{i,Prev}_{Need}}{B^{i,Prev}_{Req}} * \beta_i \quad (10)$$

When less quantity of bandwidth is needed, fair bandwidth allocation contributes to increased Fairness level.

Besides Fairness level, overall Expended level is the level of use of assigned bandwidth. It is the proportion of throughput got in former round to assigned bandwidth.

$$E^{O}_{Pres} = \sum_{i=1}^{n} \frac{Th^{i}_{Prev}}{B^{i,Prev}_{Alloc} + B^{i,Prev}_{Add}} \quad (11)$$

$$B^{i}_{Tot} = B^{i}_{Alloc} + BW^{i}_{Add} \quad (12)$$

$$E^{O}_{Pres} = \sum_{i=1}^{n} \frac{Th^{i}_{Prev}}{B^{i}_{Tot}} \quad (13)$$

Sum of Fairness as well as Expended levels is given by,

$$D = F_{Pres} + E_{Pres} \quad (14)$$

As already mentioned, bandwidth is assigned to each flow in present round in terms of Fairness as well as Expended levels.

If bandwidth is assigned more than the essential, then these levels will have high values. In that case, assigned bandwidth is directly based on Arrival Rate (λ_{PREV}) of former round. A portion of available bandwidth is assigned for a flow ‘N’ depending on demanded additional bandwidth.

$$B^{Next}_{Alloc} = \left(\frac{\lambda_{Pres}{}^{N}}{\lambda_{Pres}{}^{O}}\right) \quad (15)$$

If bandwidth allocated to a flow is less than demanded, then both levels represent minimum values. The possible maximum bandwidth should be assigned.

$$B^{Next}_{Alloc} = \left(\frac{((1+D)\lambda_{Pres})^{N}}{((1+D)\lambda_{Pres})^{O}}\right) * BW^{O,Pres}_{Avail} \quad (16)$$

If bandwidth is not justly allocated, then Fairness level shows a lesser value. It is assigned depending on Fairness level.

$$B^{Next}_{Alloc} = \left(\frac{((1+F_{Pres})\lambda_{Pres})^{N}}{((1+F_{Pres})\lambda_{Pres})^{O}}\right) \times B^{O,Pres}_{Avail} \quad (17)$$

If bandwidth is not properly used, then Expended level indicates a lesser value. Bandwidth is assigned depending on Expended level.

$$B^{Next}_{Alloc} = \left(\frac{((1+E_{Pres})\lambda_{Pres})^{N}}{((1+E_{Pres})\lambda_{Pres})^{O}}\right) \times B^{O,Pres}_{Avail} \quad (18)$$

Variance of CD (VCD) varies with the number of connections currently established. Connections are accepted only when VCD is less than the threshold. After repeated iterations, it was decided to set the threshold to 0.8.

IV. RESULTS AND DISCUSSION

The system is implemented using Ns2. Parameters involved in simulation are shown in Table 1.

TABLE I.
SIMULATION PARAMETERS

PARAMETER	VALUE
MAC	IEEE 802.16e
Routing Protocol	DSDV
Frame Length	0.004
Queue length	50
Packet Size	1492 bytes
Number of MSSs	50
Start Time/ Stop Time	20 sec / 120 sec

The proposed BAH scheme yields better results. The performance of BAH is compared with Bandwidth Allocation scheme Without History (BAWH) depending on Dynamic QoS-based Bandwidth Allocation (DQBA).

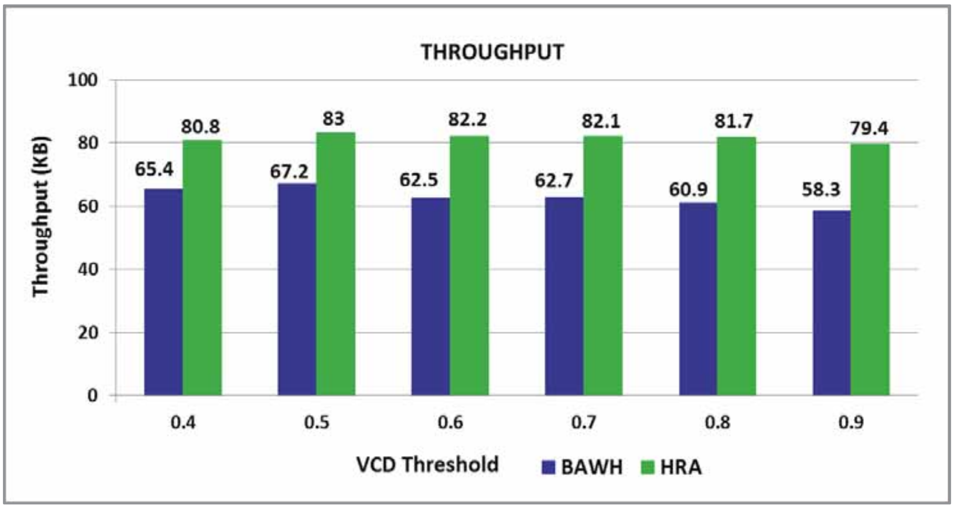

Figure 1. Throughput

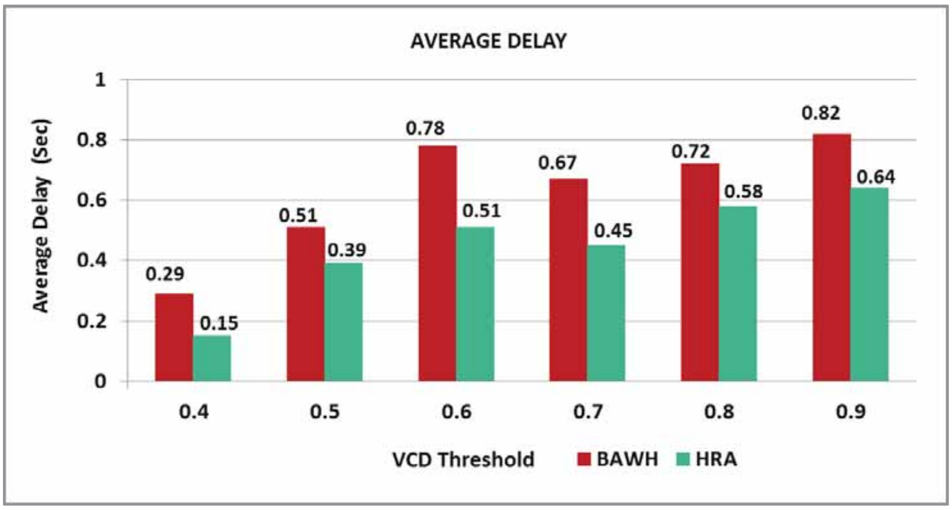

Figure 2. Average Delay

Fig. 1 shows the Throughput. BAH offers 18.7% better Throughput when compared to BAWH.

Fig. 2 shows the Average Delay. BAH involves 39.34% reduced Average Delay in contrast to BAWH.

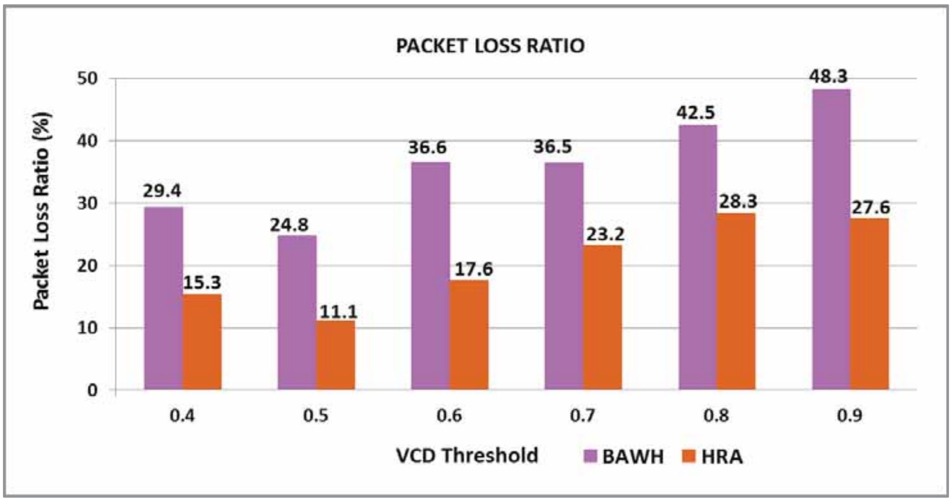

Figure 3. Packet Loss Ratio

Fig. 3 shows the Packet Loss Ratio (PLR). Similarly, BAH involves 15.8% less PLR in contrast to BAWH.

V. CONCLUSIONS

The proposed Bandwidth Allocation based on History (BAH) accepts calls only when the new incoming call does not affect the current QoS. This avoids QoS degradation to a better extent when compared to present mechanisms. The proposed scheme offers improved outcomes based on Throughput, Packet Loss Ratio (PLR) and Average Delay.

REFERENCES

1. IEEE Standard for Local and Metropolitan Area Networks, IEEE Std 802.16-2005, Dec. 2005, Part16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems.
2. Qassem, Y., Al-Hemyari, A., Ng, C., Noordin, N., & Rasid, M. (2009). Review of network routing in IEEE 802.16 WiMAX mesh networks. Australian Journal of Basic and Applied Sciences, 3(4), 3980-3996.
3. Priya, M. D., Valarmathi, M. L., Bharathi, K. J., & Deepa, M. (2013). BAC: Bandwidth based Admission Control Scheme for Gateway Relocation in IEEE 802.16e Networks, 4(1), pp. 699-705
4. Ohrtman, F. (2005). WiMAX handbook. McGraw-Hill Professional Publishing.
5. Guice, R. J., & Munoz, R. J. (2004). IEEE 802.16 commercial off the shelf (cots) technologies as a compliment to ship to objective maneuver (stom) communications. Naval Postgraduate School Monterey CA.
6. Chu, G., Wang, D., & Mei, S. (2002). A QoS architecture for the MAC protocol of IEEE 802.16 BWA system. In IEEE International Conference on Communications, Circuits and Systems and West Sino Expositions, 1, 435-439.
7. Ohrtman, F 2005, WiMAX Handbook, McGraw-Hill, Inc. ISBN: 0-07-145401-2.
8. Guice, R.J., & Munoz, R.J. (2004). IEEE 802.16 Commercial Off The Shelf (COTS) technologies as a compliment to Ship To Objective Maneuver (STOM) communications, Published Thesis, Naval Postgraduate School.
9. Gakhar, K., Achir, M., & Gravey, A. (2006). Dynamic resource reservation in IEEE 802.16 broadband wireless networks. In14th IEEE International Workshop on Quality of Service, pp. 140-148.
10. Park, E. C., Kim, H., Kim, J. Y., & Kim, H. S. (2008). Dynamic bandwidth request-allocation algorithm for real-time

services in IEEE 802.16 broadband wireless access networks. In IEEE INFOCOM 2008-The 27th Conference on Computer Communications, pp. 852-860.
11. De Rango, F., & Malfitano, A. (2009). Bandwidth availability aware defragmentation based CAC algorithm for IEEE 802.16 distributed mesh networks. In IEEE International Symposium on Performance Evaluation of Computer & Telecommunication Systems, Vol. 41, pp. 146-153.
12. Lakshmanan, M., Mohammed, V. N., & Nandakumar, S. (2009). QoS provisioning for mobile and fixed wireless real time multimedia services. In IEEE International Conference on Internet Multimedia Services Architecture and Applications (IMSAA), pp. 1-6.
13. Chuck, D., & Chang, J. M. (2010). Bandwidth recycling in IEEE 802.16 networks. IEEE Transactions on Mobile Computing, 9(10), 1451-1464.
14. Antonopoulos, A., Skianis, C., & Verikoukis, C. (2010). Traffic-aware connection admission control scheme for broadband mobile systems. In IEEE Global Telecommunications Conference GLOBECOM 2010, pp. 1-5.
15. Nasser, N., Miller, R., Esmailpour, A., & Taha, A. E. M. (2011). Utility optimized bandwidth allocation in WiMAX networks. In 7th IEEE International Wireless Communications and Mobile Computing Conference, pp. 540-545.
16. Sheu, J. P., Kao, C. C., Yang, S. R., & Chang, L. F. (2011). A resource allocation scheme for scalable video multicast in WiMAX relay networks. IEEE Transactions on Mobile Computing, 12(1), 90-104.
17. Gupta, A., & Chandavarkar, B. R. (2012). An Efficient Bandwidth Management algorithm for WiMAX (IEEE 802.16) wireless network: EBM allocation algorithm. In 7th IEEE International Conference on Industrial and Information Systems (ICIIS), pp. 1-5.
18. Sheu, J. P., Ko, C. H., & Ma, C. (2013). An approximation downlink bandwidth allocation scheme for IEEE 802.16 OFDMA system. In IEEE Wireless Communications and Networking Conference (WCNC), pp. 327-332.
19. Pillappaiah, S., Sarkar, M., Nagaraj, S., & Paolini, C. (2013). Auction based resource allocation in WiMAX. In 9th IEEE International Wireless Communications and Mobile Computing Conference (IWCMC), pp. 288-293.
20. Chern, H., & Xu, B. (2013). The bandwidth allocation by queue length (BA-QL) for WiMAX network. In 3rd IEEE International Conference on Information Science and Technology (ICIST), pp. 1076-1080.
21. Furqan, F., & Hoang, D. B. (2013). Wireless Fair Intelligent Admission Control-WFIAC. In 27th IEEE International Conference on Advanced Information Networking and Applications (AINA), pp. 1001-1008.
22. El Bouchti, A., Haqiq, A., & Benjelloun, A. (2014). Non-cooperative game for admission control and bandwidth allocation in WiMAX networks. In 4th edition of the IEEE International Conference on the Innovative Computing Technology (INTECH 2014), pp. 225-230.
23. El-Hammani, S., Ibrahimi, K., Bouyakhf, E. H., & El-Azouzi, R. (2017). Mobility management schemes for real-time traffic and resource allocation in IEEE 802.16 e mobile network. International Journal of Communication Systems, 30(1), e2926.
24. Niyato, D., & Hossain, E. (2018). Resource allocation and admission control using fuzzy logic for OFDMA-based IEEE 802.16 broadband wireless networks. In WiMAX (pp. 249-280). CRC Press.
25. Ahmed, Z., Hamma, S., & Nasir, Z. (2019). An optimal bandwidth allocation algorithm for improving QoS in WiMAX. Multimedia Tools and Applications, 78(18), 25937-25976.
26. Ibrahim, A. A., Salsabil, S. I., & Lawal, I. A. (2022). Effective Utilization of An Unused Bandwidth in IEEE 802.16 Network. Journal of Telecommunication, Electronic and Computer Engineering (JTEC), 14(2), 15-22.
27. Hindumathi, V., Veeramalla, S. K., & Vasudeva Reddy, T. (2023). Adaptive Resource Allocation in WiMAX Networks for Improved Quality of Service (QoS). In Intelligent Data Engineering and Analytics: Proceedings of the 10th International Conference on Frontiers in Intelligent Computing: Theory and Applications (FICTA 2022) (pp. 625-633). Singapore: Springer Nature Singapore.