IAES International Journal of Artificial Intelligence (IJ-AI)
Vol. 11, No. 2, June 2022, pp. 687~698
ISSN: 2252-8938, DOI: 10.11591/ijai.v11.i2.pp687-698

Evolutionary model to guarantee quality of service for tactical worldwide interoperability for microwave access networks

Ravishankar Huchappa, Kiran Kumari Patil
School of Computing and Information Technology, REVA University, Bangalore, India

Article Info

Article history:

Received Aug 7, 2021
Revised Jan 7, 2022
Accepted Jan 23, 2022

Keywords:

Evolutionary computing
IEEE 802.16
Tactical network
Worldwide interoperability for microwave access

ABSTRACT

The smart phone industries evolution had made the growth in wireless communication. The increase in social media usage led to huge increase of network traffic as sharing of data for multimedia like video conferencing, and voice over internet protocol (VoIP). Majority of services like this requires network resources and real-time strict quality of service (QoS). However high cost of network deployment is included. All the major service providers are currently being adopted to the WiMAX 802.16 network. Therefore, the worldwide interoperability for microwave access (WiMAX) network must have different supply policies and QoS for various applications. The implementation of these QoS policies was not provided by WiMAX for various needs of application. Recently development of various scheduling mechanism for QoS provisioning has been made. However, users improper synchronization made these models inefficient. To address this, uplink scheduling with feedback is considered to provision QoS. However, it induces delay in accessing slots, as result the bandwidth is wasted. To utilize bandwidth efficiently evolutionary computing is adopted by various existing model. However, these models induce computation overhead and may not be suitable for provisioning real-time services. The evolutionary computing model is used to compute ideal threshold.

Corresponding Author:

Ravishankar Huchappa
School of Computing and Information Technology, REVA University
Bangalore, India
Email: ravishankar.h@reva.edu.in

1. INTRODUCTION

In the rural, remote area and battle field, access to wired network configuration possess a big challenge because of economically and the unfeasibility. Therefore for long transmission worldwide interoperability for microwave access (WiMAX) [1], [2] gives better solution in wireless communication. WiMAX provides faster transmission rate and pre-defined quality of service (QoS) in compared with other traditional wireless access technology. WiMAX is on the basis of IEEE 802.11 standard that provides the facility to the mobile users. Because of increase in popularity of the wireless network WiMAX gives better service than any other because QoS the key issue. The services of WiMAX are broadly classified as. Unsolicited grant service (UGS): it supports the constant beat rate (CBR) such as voice application. Real time polling services (rtPS): it supports flexible size of data packets which contains the real time data streams which are issued periodically like MPEG video extended real-time polling service (ertPS): ertPS is applicable for this case as real time variable data requires data rate guarantee and delay. Non-real-time polling service (nrtPS): here the real time network system protocol (RTNSP) support the minimum data rate of delay tolerance such as file transfer protocol (FTP) where it has data streams contains data packets of variable size. Best effort (BE): BE supports data streams which does not require QoS guarantee, such as http. To enhance operation tactical network [3] provides facilities like data exchange and information sharing to military forces. Using WiMAX tactical communication network can be designed for effective data exchange and communication. There is need of clear understanding for operating environment characteristics, application data exchange profiles and communication media limitations with structured approach. To define relevant values and parameters of network design of basic tactical network are considered. Different data exchange network levels are needed to support subordinate tactical-level force units and to allow for higher on-the-ground battlefield status command. The WiMAX Group Architecture is demonstrated in Figure 1.

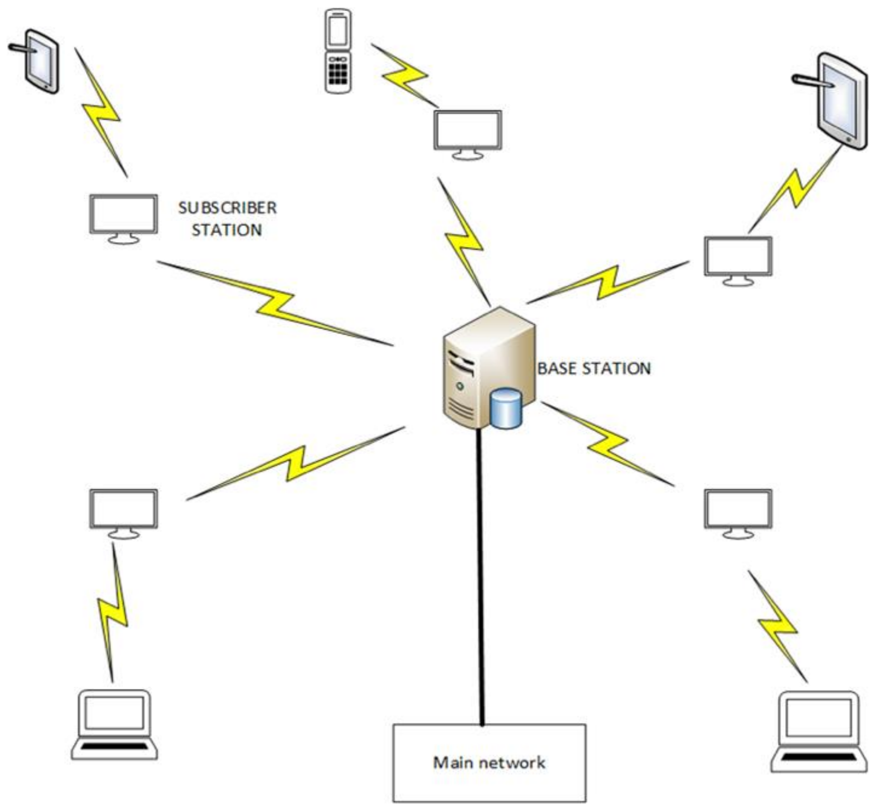

Figure 1. Architecture of WiMAX network

The tactical communication network's bandwidth allocation [4] depends on what can be assisted by the communication media. A fundamental component scheduling of wireless network resource management and plays a major role in the provision of QoS specifications such as latency, Packet failure and throughput for various service groups of 802.16. The traditional model presented in [4], [5] is not efficient in utilizing bandwidth efficiently and is the number of can't predict subscribed user and the time varying traffic of the network. As a result, the reliability of WiMAX network performance and QoS are affected. In order to correct this evolutionary computation, [6], [7] was adopted to improve WiMAX QoS. In [6], [7], an evolutionary model was presented to maximize time and adequate allocation of bandwidth for network users. It does, however, incur overhead computation in user synchronization, as a consequence of which real-time application might not be applicable. An significant parameter for efficient service delivery is the coordination of the customer and its application demand.

Slotted time based channel access between users was presented in [8]. Here, the channel set is shared and a transmission slot is given to each user. The model described here is invariant in performance, i.e. synchronized time. Synchronization failure, however, it leads to packet failure and varied WiMAX network service prioritization criteria have not been considered. Their sample in [9] uplink-scheduling algorithm is given with dual feedback. It is used for delay control and better bandwidth utilization; they provide the notion of target delay and for better QoS. The dual feedback system is used to reduce wastage of bandwidth. However, by using the dual feedback system, it experience the more delay. Therefore, there is need to give the feedback system that will give less delay and better QoS. In [8] to provide a better QoS, a Meta heuristic particle swarm optimization is provided with the uplink scheduling to compute time duration of frame that will give the better allocation and in [10] a genetic algorithm is used to optimize the throughput of the network in the downlink scheduling, but they did not consider optimizing uplink scheduling and are not suitable for solving multi-objective problem.

Scheduling and resource management are critical factors in ensuring QoS competitiveness in WiMAX network requirements, and they remain open research challenges. In the direction of uplink traffic, a new model for the base station (BS) scheduler has been suggested. The model's main goal is to provide QoS for WiMAX-specified service classes, with the promise of sufficient resources for real-time traffic classes and guaranteed minimum resources for real-time traffic-free classes.

For uplink bandwidth allocation in WiMAX network class B services, an adaptive buffer optimized and buffer optimized thresholding approach for subscriber stations is proposed in this work. The first step is to present a buffer-optimized bandwidth assignment. Second, buffer configured thresholds are presented for class B and class C service provisioning.

Thirdly, for better slot distribution, the probability of transmission failure is determined. In order to optimize delay and bandwidth, new adaptive genetic algorithms are then presented. The suggested model would dynamically allocate bandwidth for Class B service in terms of existing traffic, channel quality, and user. The probability of failure of packets is used to have QoS dependent on the level of packets and the latency of the delay optimized unit (DOU), as shown in Figure 2. The adaptive genetic algorithm is presented to optimize the buffer allocation threshold parameter.

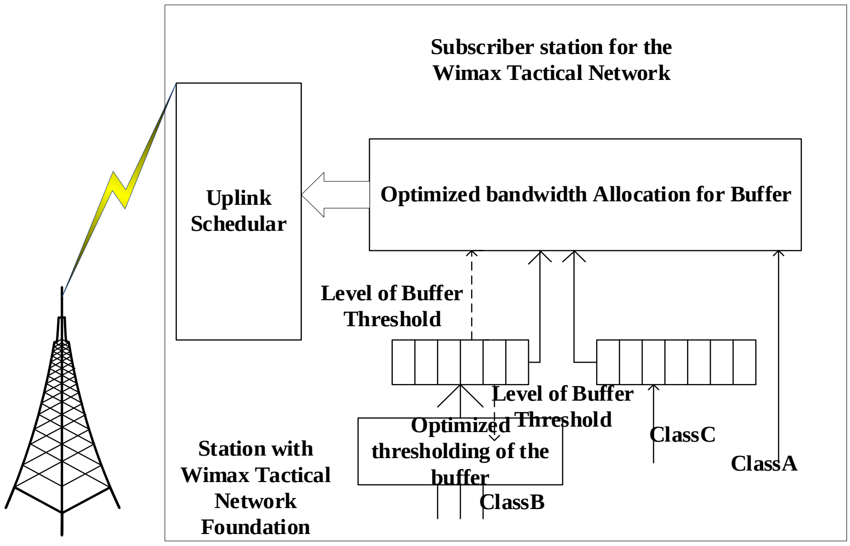

Figure 2. Architecture of proposed adaptive resource allocation scheme for tactical WiMax network

2. LITERATURE SURVEY

Scheduling (i.e., bandwidth allocation) and admission control play a critical factor in utilizing radio resource (bandwidth) efficiently for provisioning QoS in WiMAX network. Many scheduling and access control schemes have been proposed in recent times to improve the QoS of WiMAX network. In [11] evaluated the performance of the uplink scheduler that design for the onu-base station. They addressed the issue pertaining channel bandwith variability. To address this, they presented a deficit-based QoS uplink scheduler (DBQUS). Their model overcomes issues of existing scheduling strategy migration-based scheduler for QoS provisioning (MBQoS) [12]. They considered three types of priorities and bandwidth allocation is done based on prioritization of service flow. A queue is maintained to provision QoS. Experiment evaluation is done using integrated simulator for the WiMAX and also for the ethernet passive optical network (EPON) component. The outcome achieved shows better QoS to the SS. However their model is not efficient and induces queue storage overhead, since it maintain static queue.

To improve the communication performance and the network coverage, the architecture of WiMAX network is defined in IEEE 802.16 standard. To solve the scheduling problems in WiMAX many heuristic algorithms is presented. The performance of the algorithm is depends on the network structure and the bandwidth request but they do not achieve the optimal performance. In [13] an optimal scheduling algorithm with dynamic programming approaches (SADP) that will increase the probability of the spatial reuses and also increase the throughput of the network on the basis of network throughput and the uplink bandwidth request. To reduce the compute complexity a heuristic scheduling algorithm is presented. The outcome of their model achieves better result than exiting model interm of throughput, drop rate and time complexity. However performance evaluation of bandwidth utilization is not presented. In the communication network, guarantee of QoS is major factor for the performance for this traffic policing, call admission control and the scheduling mechanism should be present. In [14] presented various homogenous and hybrid scheduling strategy such as weighted fair queuing scheduling algorithm (WFQ) and deficit round robin (DRR) which are homogenous strategy merge these two strategy. In [15] presented a dynamic uplink-scheduling algorithm that is based on the variably weighted round robin (VWRR) algorithm for the WiMAX network for the allocation of bandwidth. In [16] presented an random early detection based deficit fair priority queue (RED-based DFPQ) scheme for the WiMAX. Their model improves throughput but induces delay for real-time polling services. In [17] presented a simple scheduling algorithm to improve access fairness. The outcome achieved shows better performance in term of throughput, but packet drop is not considered in their scheduling scheme.

In [7] presented a scheduler for better QOS by adopting meta-heuristic swarm optimization. The optimization for provisioning QoS is done at frame level. The model addressed the packet drop by computing the time duration of the frame and tries to find the optimal value to provide the better resource allocation for the network users. In [18] analyzed the saturation throughput of the cognitive wireless local area network (WLAN) overlaid that based on orthogonal frequency-division multiple-access (OFDMA) time division D network like WiMAX. The data packet is transmitted to the to the external empty resource block after the contention between the secondary nodes. To the empty resource block of the primary network, in the primary network the time duration for the secondary network, follows the simple exponential on-off pattern. For this, they presented an analytical model to comprise of discrete Markov chain and two inter-related open multi-class queuing network to model the dynamic behavior of the secondary nodes. Due to the random number of empty resource block at different frame the random number of upload and download data packet is transmitted on the WLAN. Here they also included the different resource allocation in primary network. Experiment outcome shows, accuracy is proven for different condition. However scalabity performance is not evaluated considering varied subscribed user. In [19] presented a new adaptive resource allocation scheme (ARAS) to construct the OFDMA based frame. ARAS integrates two approaches, the adaptive cyclic prefix (CP) length and dynamic frequency allocation. These two approaches are implemented, analyzed and evaluated based on the simulation of WiMAX frames in a dynamic manner resulting in a new frame pattern within each down link connection. The resulting frame shows the contribution of the time domain approach which represented by adaptive CP in mitigation ISI and ICI which improves the network performance in term of bit error rate (BER), outcome show, their model will provide better scalability, QOS and scalability when the number of user is increase on subscriber station.

In [10] presented evolutionary model using genetic algorithm (GA). The model presented aims to improve throughput for downlink scheduler in WiMAX network. In [20] presented optimization model for resource allocation of OFDMA system for real-time service. Up-link scheduler is optimized using genetic algorithm. They presented dynamic resource allocation scheme based on rate assignment strategy namely, GA with SS groping for resource allocation (GGRA). To avoid interference among user, different slots are assigned to each user. They also presented an optimal assignment strategy by using GA. GGRA aim to maximize system throughput and ensure QoS. Experimental outcomes of their model show better performance than existing model maximum largest weight delay first (MLWDF). However, their model induces bandwidth wastages. Since each user is allocated a separate slot to avoid interference. The genetic model adopted by their model may not suitable to support large population initialization.

The extensive research survey carried out in this work shows that there is a need to develop an efficient resource allocation scheme for WiMAX network. The scheduling model design should improve bandwidth utilization and reduce service delivery delay. To achieve this, here we present an adaptive resource allocation scheme. A new genetic algorithm is presented to improve search speed, space for better convergence and to support large population initialization [21]-[25].

3. PROPOSED ADAPTIVE RESORCE ALLOCATION SCHEME

Here, we consider the orthogonal frequency division multiplexing tube (OFDMA). In addition, these channels are grouped into frequency channels and time slots (frequency division multiplexing access (FDMA)) time division multiple access (TDMA). Relevant QoS criteria for the application decide both the channel’s frequency spectrum and the time slot length. There are three categories of service classes we consider here, namely class A, B and C.

– Class A: Traffic with multi-media and continuous traffic are enabled by this service and constant bit rate (CBRR). The bandwidth is statistically distributed in fixed amounts for this operation.

- Class B: The supporting traffic for which QoS requires an operational assurance. The real-time and non-real-time sub-types of this service class are further divided. These two are variants on the basis of QoS. The bandwidth for this type of service for the corresponding connection is calculated based on the appropriate QoS and the traffic arrival rate.
- Class C: Where no QoS assurance is required, this service is used. The basis of the above two process means is accomplished here after assigning bandwidth to class A and class B remains allocated to class C. The data is transmitted from the subscriber station to the base station using FDMA/TDMA, which considers three types of services, namely class A, B, and C, and the orthogonal frequency carrier modulation technique, as shown in Figure 2 for the uplink algorithm.

In Class B, a buffer is retained for the delay optimized unit (DOU) for subsequent transmission. For the SSS class GPSS, the BS reserves a certain amount of bandwidth (grant per SS) (subscriber station). A service category for same SS shares the reserved bandwidth. Based on priority bandwidth is allocated, the highest priority is given to class A and the lowest priority is given to class C. For scalability from any class B relation, the DOU is aggregated into a single buffer of size X. Traffic control is applied at the packet level to the class B buffer traffic rate. Class B would have the same QoS efficiency as class A if the rate control parameter for the entire connection is the same. Since there is no guarantee of output, traffic in class C was thought to have an infinite buffer capacity.

3.1. Optimized bandwidth allocation for buffer

The maximum number of DOU MACs denoted by $r_{\uparrow}$. is the sub-frame transmitted per transmission by SS. Two kinds of bandwidth allocation schemes are considered here, namely type A and B. In bandwidth allocation type A, a fixed amount of bandwidth $r_{\uparrow}$. is allocated to class A from a specified SS bandwidth and the remaining bandwidth ($r_{\uparrow} - r_A$) is allocated to class B and class C. If the bandwidth allowance for class A is less than r_A in the type B bandwidth allocation, the remaining bandwidth will be allocated to class B. The excess bandwidth will be allocated to the class C operation after the class A and class B bandwidth allocations are completed. We're simulating the method of allocating uplink bandwidth so that we can account for the existing number of class B buffer DOUs. The amount of bandwidth allocated to each communication frame is calculated separately, and bandwidth allocation is carried out frame by frame. The required bandwidth quantity is achieved by the threshold value in uplink's sub frame. The threshold is therefore as shown in (1):

$$\boldsymbol{\beta} = \beta_1, \beta_2, \dots, \beta_r, \dots, \beta_{\uparrow - r_A} \tag{1}$$

where $\beta_r\{1, \dots, I\}$, and $r \in \{1, \dots, r_{\uparrow} - r_A\}$. This set of thresholds specifies the quantum of bandwidth required for each sub frame of an uplink. For bandwidth allocation systems of type A and type B, the bandwidth is determined as an evolutionary computing function of the number of DOUs in the class A operation which is illustrated as (2), (3).

$$R_{T_A}(i) = \begin{cases} 0, & i = 0 \\ r, & \beta_r \leq i < \beta_{r+1} \\ r_{\uparrow} - r_A & \beta_{r_{\uparrow}} - r_A \leq i. \end{cases} \tag{2}$$

$$R_{T_A}(i) = \begin{cases} 0, & i = 0 \\ r, & \beta_r \leq i < \beta_{r+1} \\ r_{\uparrow} & \beta_{r_{\uparrow}} - r_A \leq i. \end{cases} \tag{3}$$

3.2. Buffer optimized thresholding model

The rate of DOUs in class B buffers is tracked using optimized buffer model thresholding. This technique can be applied to either the traffic source or the class B buffer. Instead of SS reminding the source of the buffer status flow, we use an arbitrary early detection model in which DOUs obtained from the class B buffer are dropped arbitrarily.

Let us consider the optimized threshold buffer $k_{\downarrow}$,$k_{\uparrow} \in \mathcal{M}$ guaranteed rate for the amount of DOUs on the buffer and minimum arrival $\alpha_{\downarrow}$. The rate of transmission can not be below $\alpha_{\downarrow}$. in class A. For the DOU arrival rate for the DOU, the buffer optimized threshold policy is given as (4):

$$\tilde{\alpha}(i, \alpha_o, \alpha_{\downarrow}) = \begin{cases} \alpha_o, & i < k_{\downarrow} \\ L(\alpha_o, i), & k_{\downarrow} \leq i \leq k_{\uparrow} \\ \alpha_{\downarrow}, & k_{\uparrow} \leq i \end{cases} \tag{4}$$

where, $L(\alpha_o, i)$ is A non-increased parameter of i with limit $\alpha_\downarrow \le L(\alpha, i) \le \alpha_o$ and $\tilde{\alpha}(\cdot)$ is optimized arrival rate threshold. The optimization of (4) to determine threshold is computed using genetic algorithm (GA). The rate control mechanism is implemented per-flow or aggregation on the basis of. On the basis of traditional model $k_\downarrow$,$k_\uparrow$ $\alpha_\downarrow$ for all connections under class B, rate control is carried out. For all connections, different parameters are used for regulation of the threshold in our model (i.e. $k_\downarrow(x), k_\uparrow(x)$ and $\alpha_\downarrow(x)$ for connection x).

3.3. Failure optimization for transmission

Ensuring DOU transmission quality between subscriber stations and base stations. The DOU is relayed until the base station effectively recalls it. The propagation fault of the DOU φ is as (5):

$$\varphi_{m,n} = \binom{n}{m}(1-\varphi)^m(\varphi)^{n-m}, \ \ m \in \{o, 1, 2, \dots, n\} \quad (5)$$

where m is likelihood out of n transmission of successful transmission.

3.4. Adaptive genetic algorithm

To solve the optimization problem of (4), we present a new adaptive genetic algorithm and fitness computing function which is presented (6). Let there be a total number of $\mathcal{N}$ base station and number of $\mathcal{K}$ subscriber station in each $\mathcal{N}$. Each chromosome consists of $(\mathcal{N} + \mathcal{K})$ sub chromosome feasible solution. Then each of the resultant sub chromosome consist of sub genes $\mathcal{D}_1 \colon (\mathcal{D}_1, \mathcal{D}_2, \mathcal{D}_3, \dots, \mathcal{D}_{\mathcal{K}})$ which denotes the bandwidth parameter allocated for different subscriber station and $\mathcal{P}_1 \colon (\mathcal{P}_1, \mathcal{P}_2, \mathcal{P}_3, \dots, \mathcal{P}_{\mathcal{K}})$ is the number of DOU for each $\mathcal{K}$ connection. The objective of proposed fitness function is to reduce the number of DOU queue required and maximize bandwidth efficiency. Hence, the following weighted fitness function is presented (6).

$$\mathbb{F} = \beta_1 \mathcal{F}_\downarrow^{\mathcal{P}} + \beta_2 \mathcal{F}_\uparrow^{\mathcal{D}} \quad (6)$$

Such that,

$$\mathcal{F}_\downarrow^{\mathcal{P}} = 1 - {}^{\mathcal{P}_k}\!/_{\mathcal{H}\cdot\mathcal{P}_\uparrow} \qquad \mathcal{F}_\uparrow^{\mathcal{D}} = 1 - {}^{\mathcal{D}_k}\!/_{\mathcal{H}\cdot\mathcal{D}_\uparrow}$$

where $\mathcal{F}_\downarrow^{\mathcal{P}}$ and $\mathcal{F}_\uparrow^{\mathcal{D}}$ are the sub fitness function parameter to minimize the DOU queue size and maximize bandwidth efficiency respectively, β_1 and β_2 are the weights to minimize the DOU queue size and maximize bandwidth efficiency respectively, $\mathcal{P}_k$ DOU queue size of sub channel k, $\mathcal{H}$ is the number of sub-channel, $\mathcal{P}_\uparrow$ is the maximum DOU queue size of a single channel, $\mathcal{D}_\uparrow$ is the maximum bandwidth for a single channel, $\mathcal{D}_k$ is the bandwidth of sub-channel k. For easiness we consider β_1 and β_2 parameter to be 0.5.

Let consider that the initial population be generated arbitrarily. Therefore, it can be acquired arbitrarily within stipulated parameter bound. Then based on the fitness parameter of next population, the chromosomes are chosen. The chromosomes with higher fitness parameter have a greater chance of chromosome being selected.in our case we adopt roulette wheel selection methodology. Therefore, based on fitness parameter the chromosomes are placed in a roulette wheel. As a result, the selection regeneration likelihood of each chromosome is computed based on following fitness function;

$$\mathcal{L}_x = \frac{\mathbb{F}(x)}{\sum_{y}^{\mathcal{M}} \mathbb{F}(y)} \quad (7)$$

where $\mathcal{L}_x$ depicts the selection regeneration likelihood of x^{th} chromosomes, which is an arbitrary parameter between zero and one, $\mathbb{F}(x)$is the fitness function computed for the x^{th} chromosomes, and $\mathcal{M}$ represent the population size. The arbitrary parameter of $\mathcal{L}_x$ is compared with selection likelihood of each chromosomes, a smaller chromosome will be selected and others are removed. As a result, a new population is again formed.

The evolutionary process (crossover and mutation) are very crucial in genetic algorithm. However, the existing genetic algorithm presented so far are not efficient. Since the likelihood are fixed in evolutionary process. As a result, it is not suitable for multi-objective fitness optimization. This model presents an adaptive evolutionary scheme. The scheme adaptively updates the likelihood based on fitness parameter. The likelihood, if $\mathcal{F}_\uparrow > \mathcal{F}_\downarrow$ is computed as (8),

$$\alpha_1 = \alpha_2 = 0.01 \frac{\mathcal{F}_\uparrow - \mathcal{F}_\rightarrow}{\mathcal{F}_\uparrow - \mathcal{F}_\downarrow} \quad (8)$$

The likelihood, if $\mathcal{F}_{\uparrow} = \mathcal{F}_{\downarrow}$ is computed,

$$\alpha_1 = \alpha_2 = 0.01 \tag{9}$$

where $\mathcal{F}_{\downarrow}$, $\mathcal{F}_{\uparrow}$ and $\mathcal{F}_{\rightarrow}$ denotes the minimum, maximum and average likelihood of fitness parameter respectively, α_1 and α_2 denotes the likelihood updated parameter of mutation and crossover. The crossover operation is a critical factor in identify an optimal solution. The exiting crossover operation is not efficient and it is time consuming. To address, this work presents an efficient and fast adaptive crossover selection schemes. Namely, single level crossover (SLC) and two-level crossover (TLC). In SLC, two chromosomes are chosen to carryout crossover and likelihood of crossover is computed using (8) and (9). Except interior of sub-chromosomes, the point of crossover is arbitrarily selected from two parent chromosome. The SLC permits the individual crossover as shown in Figure 3. Similarly, let also consider for a given sub chromosome, the TLC process is required to increase search speed and range. Each individual chromosome takes decision whether to carryout TLC based on likelihood of TLC. Only one sub-chromosome is chosen and gene order is changed, if TLC is performed as shown in Figure 4. This aid in improving the search range of TLC in assuring chromosome satisfies optimization parameter constraint. The proposed adaptive crossover scheme (SLC and TLC) enhances the search space and convergence speed. Subsequently, in the next population, ideal genes are searched as stable chromosomes.

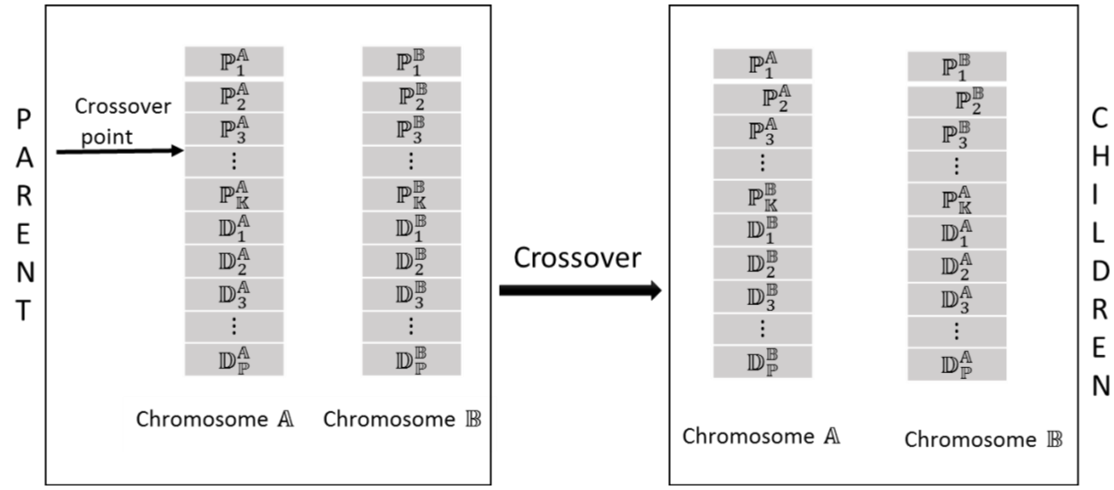

Figure. 3. Single level crossover

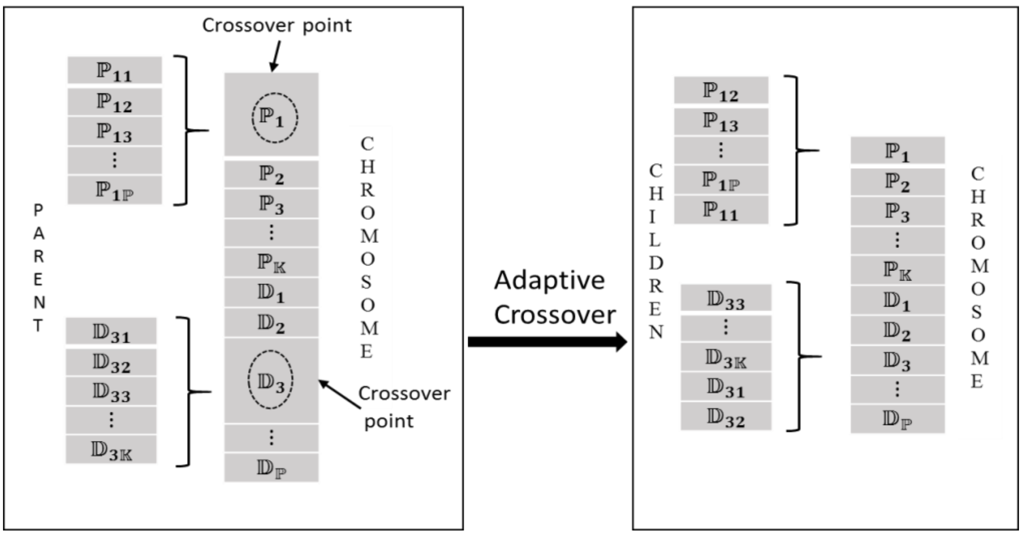

Figure 4. Two level crossovers

Mutation process plays an important role in avoiding selecting sub optimal solution and finds optimal solution. To represent a gene, the adaptive crossover searching model adopts decimal encoding technique. Here, we adopt Mutation based on per-bit basis. As a result, the chromosomes chosen for mutation have an arbitrarily chosen bit that is changed from 1 to 0 or 0 to 1. This aid the proposed scheme reduces computation complexity and thus we can set large size of population for initialization. The flow of proposed adaptive crossover searching scheme is presented.

The algorithm flow of proposed adaptive crossover searching scheme

The model takes **input**, population size $\mathcal{R}$, Mutation rate φ, crossover rate $\omega$and number of iteration n

The model gives the **output** solution $\mathcal{A}$

Start

Step 1. First sense the area for the set of inputs. (*Initial Phase*)

Step 2. The inputs are encoded to convert it into chromosomes.

Step 3. Generate $\mathcal{R}$ arbitrary feasible solution.

Step 4. Add them in population $\mathbb{R}$.

Step 5. $\forall[1,\mathcal{H}]$ do (*Looping is done till termination condition is met*)

Step 6. Find and choose the finest individual in $\mathbb{R}$. (*Selection is done based on fitness function*)

Step 7. Add them in $\mathbb{R}_1$

Step 8. End for loop.

Step 9. Choose 2 parent from $\mathbb{R}_1$. (*Looping of crossover and mutation is started*)

Step 10. Start adaptive crossover process.

Step 11. Collect the crossover processing parameter.

Step 12. Start mutation process.

Step 13. Offspring parameter in $\mathbb{R}_2$ is updated.

Step 14. Collect the mutation processing parameter. (Looping *is ended*)

Step 15. Compute crossover processing parameter and update crossover rate ω. (*Parameter updation is done*)

Step 16. Compute mutation processing parameter and update mutation rate φ.

Step 17. $\mathbb{R}_1 = \mathbb{R}_1 + \mathbb{R}_2$. (*Updation of* $\mathbb{R}$ *is done and loop is terminated*)

Step 18. Return the finest solution $\mathcal{A}$ in $\mathbb{R}$. (*Best solution are identified*)

End

3.5. QoS PROVISIONING METRIC MEASUREMENT

The QoS in provisioning of services of our model is measured for following metric. Buffer throughput: represent the mean amount of DOU transmitted per unit frame time. Here we are giving the method for computing the throughput considering there is no DOU blocked on its arrival, hence all packet is considered to be transmitted eventually. So, the buffer throughput for type A and type B is given by following equation:

$$P^{type\ A} = \bar{\rho}^{type\ A}\left(1 - \eta_D^{type\ A}\right) \tag{10}$$

$$P^{type\ B} = \bar{\rho}^{type\ B}\left(1 - \eta_D^{type\ B}\right) \tag{11}$$

Mean bandwidth allocation: We present a method to compute mean bandwidth allocation of the type A and type B of the buffer optimized bandwidth allocation. Slot utilization (bandwidth utilization): The performance of slot utilization is measured on the basis of amount of bandwidth allocated is used and is given by the (14) and (15). In the next section, the efficiency efficacy of the proposed model over the exit model [8] is measured.

$$\bar{r}^{(type\ A)} = \sum_{i=0}^{I}\left(R_{T_{type\ A}}(i)\right)\left(\sum_{p=1}^{\mathcal{P}\times M}\pi^{type\ A}(p,i)\right) \tag{12}$$

$$\bar{r}^{(type\ B)} = \sum_{i=0}^{I}\sum_{d=1}^{r_A+1}\left(\sum_{p=1}^{\mathcal{P}\times M}\left(R_{type\ B}(i) - (d-1)\right)\pi^{type\ B}(p,d,i)\right) \tag{13}$$

$$\delta^{type\ A} = \frac{P^{type\ A}}{\bar{r}^{type\ A}} \tag{14}$$

$$\delta^{type\ B} = \frac{P^{type\ B}}{\bar{r}^{type\ B}} \tag{15}$$

4. RESULT AND ANALYSIS ON SIMULATION

For simulation, it considers the following scenario. The proposed and current models' algorithms are written in C#, and the simulator is designed in visual studio 20100 with dot net framework 4.0. Three types of structures, A, B, and C, were given consideration. There are 5 subscriber stations, 10 subscriber stations, 15 subscriber stations, and 20 subscriber stations. The radio fading parameter is set to 4db and the wireless transceiver is set to 320 m. The arrival rate of the poisson packet is taken into account. Due to the different subscriber statistics, the tests are carried out to determine the reliability of the proposed model in terms of throughput efficiency and slot success ratio compared to the current model [8].

4.1. Slot utilization performance

The experiment is carried out to evaluate the performance in term of slot utilization for both the alternative solution and the actual one. The slot utilization performance is computed using (16). The number of subscribers varies between 5 and 15, and there are three categories of service classes to consider: class A, class B, and class C. Figure 5 depicts the performance ratio of slots for various services for five subscribers' stations. Figure 6 depicts the performance ratio of slots for various services for ten subscribers' stations. Figure 7 depicts the performance ratio of slots for various services for 15 subscriber stations. As can be seen from the graph, class A services have the highest QoS, whereas class C services have the lowest QoS. The overall result shows that the proposed (PS) model outperforms the current (ES) model in terms of slot usage for all service classes and for a number of subscriber stations. When the number of subscriber stations is equal to 5, an average increase in slot usage efficiency of 11.04%, 13.04 percent, and the proposed model over the existing system achieves 13.04% for class A, class B, and class C respectively, as shown in Figure 8. When the number of subscriber stations is equivalent to 10, the proposed model achieves an average slot utilization efficiency gain of 04.22%, 10.99%, and 13.04% over the current method for class A, class B, and class C, respectively, which is shown in Figure 8. When the number of subscriber stations is equivalent to 15, an average slot usage efficiency gains of 0.14%, 08.98%, and the proposed model over the existing system achieves 13.04% for class A, class B, and class C, respectively, as shown in Figure 8. When the number of subscriber stations is equal to 15, an average performance gain in slot use of 0.14%, 08.98%, and the proposed model reaches 13.04% for class A, class B, and class C over the current system, respectively, is seen in Figure 8. The final result shows that the proposed model is efficient in slot use, taking into account the subscriber station's scalability.

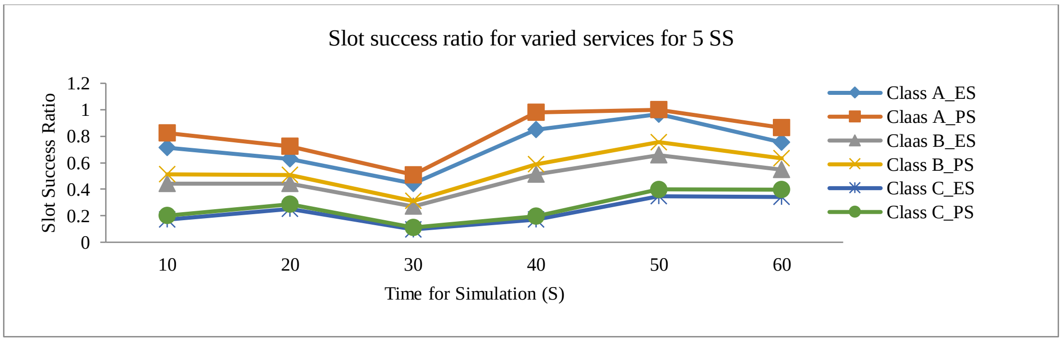

Figure 5. Subscriber 5's slot efficiency ratio stations for different service classes

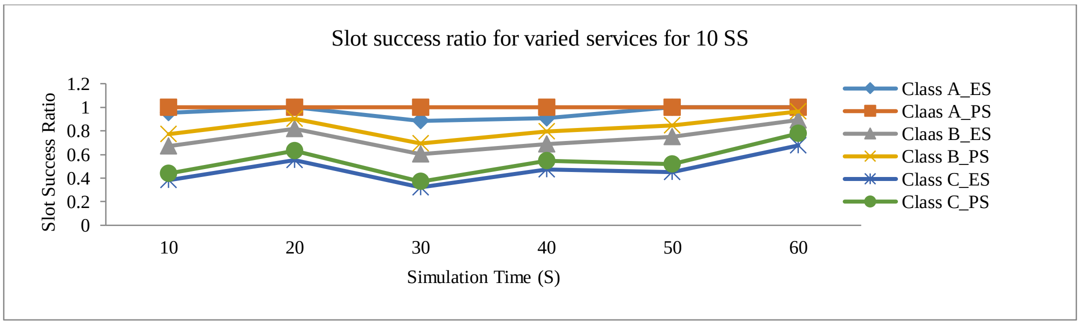

Figure 6. Slot efficiency ratio for 10 subscriber stations for different service classes

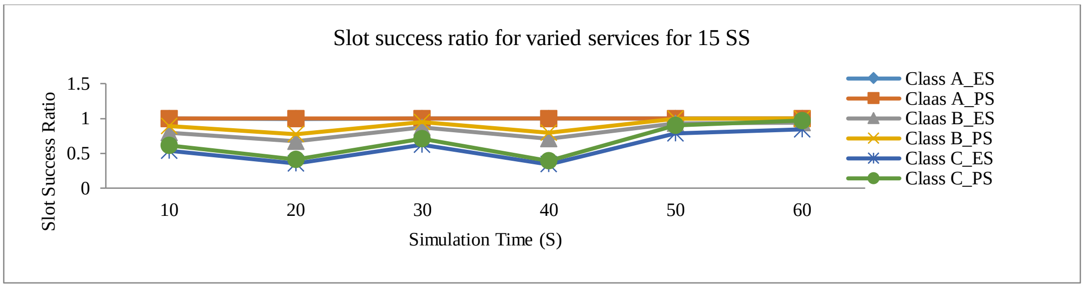

Figure 7. Slot efficiency ratio for 15 subscriber stations for different service classes

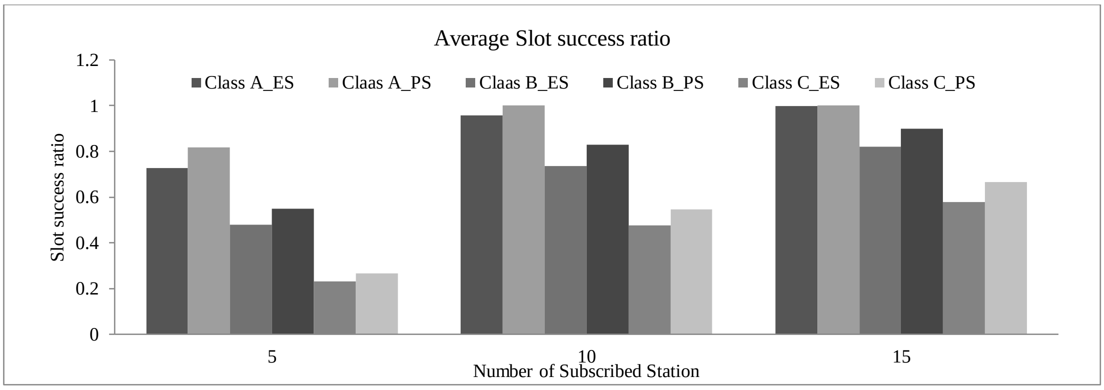

Figure 8. Average slot success ratio for varied subscriber station and services classes

4.2. Throughput performance

The experiment is carried out to evaluate the performance in term of throughput achieved for both proposed and existing approach. The throughput performance is computed using (12) which is a normalized throughput (i.e. between 0 to 1). The subscriber stations range from 5, 10, 15 and 20 and three types of levels of operation, class A, B and C, are considered. Just in Figure 9, for different subscriber stations, the output efficiency of the suggested and current model is shown as 5, 10, 15 and 20. The proposed model achieves higher performance than the current model. In both the expected and current approaches, the throughput increases as the number of subscriber stations increases, as seen in the table. High QoS for class A providers, both inferred and existing by the model delivery. The provision of a high priority connection operation requiring strict QoS degrades the efficiency of class B and class C throughput. The model suggested produces better results throughput efficiency than the current model in all situations. The proposed model achieves an average performance gain of 11.39 and 13.04% over the current model for class B and class C, as shown in Figure 10.

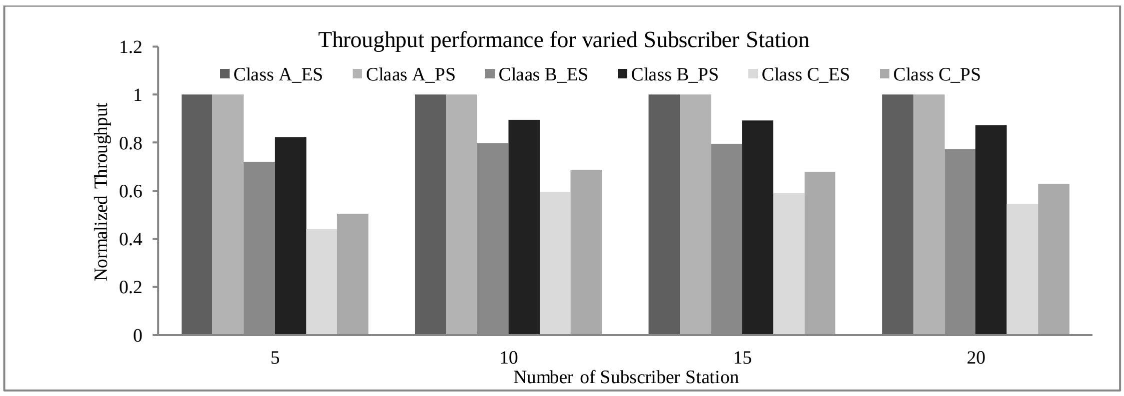

Figure 9. Achievement of varied subscriber station throughput

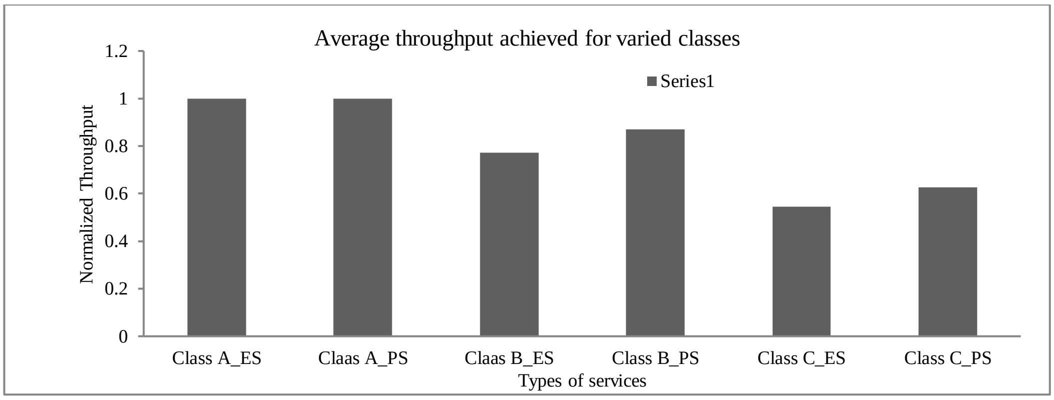

Figure 10. Average throughput achieved for varied service classes

5. CONCLUSION

The wide growth of smart phone usage has led to tremendous growth application services delivery through internet. Majority of these applications requires strict QoS. The limited availability of bandwidth and cost involved in occupying the spectrum for provider makes resource provisioning a challenge. Therefore developing a model that utilizes bandwidth efficiently with minimum delay is most desired. Here we presented the provisioning of QoS for different service classes. Different types of facilities require different criteria for QoS. Therefore, based on their priorities, bandwidth allocation is allocated for each service. The high-priority link bandwidth assignment affects the low-priority connection throughput. Improper user synchronization can lead to a waste of bandwidth. The presentation of this work is a successful Allocation of bandwidth and threshold policy for class B and class C networks using sophisticated computation to overcome all these study problems. The tests are carried out to test the efficiency of the suggested model over the current interm model of performance and slot utilization performance. Considering various subscriber stations, the result indicates substantial efficiency enhancement. For the proposed model, an average increase in production and slot utilization efficiency of 9.49% and 8.14% over the current model is achieved. Performance assessment considering various fading parameters and radio ranges will be considered for future work and an effective downlink scheduling would also be built to further boost performance.

REFERENCES

[1] F. S. Hamid, "The difference between IEEE 802.16 / WiMAX and IEEE 802.11 / Wi-Fi networks for telemedicine applications," *International Journal of Recent Technology and Engineering (IJRTE)*, vol. 2, no. 5, pp. 27–35, 2013.

[2] A. K. Gangwar and M. S. Alam, "A miniaturized quad-band antenna with slotted patch for WiMAX/WLAN/GSM applications," *AEU-International Journal of Electronics and Communications*, vol. 112, p. 152911, Dec. 2019, doi: 10.1016/j.aeue.2019.152911.

[3] M. Esteve, C. E. Palau, I. Perez-Llopis, I. Pérez-Llopis, and L. E. Hernandez-Blanco, "Tactical use of WiMAX-based networks for anti-aircraft artillery units," in *2011-MILCOM 2011 Military Communications Conference*, Nov. 2011, pp. 2117–2122, doi: 10.1109/MILCOM.2011.6127632.

[4] D. Naik, S. Dora, Nikita, and T. De, "Normalized uplink bandwidth scheduling algorithm for WiMAX networks," in *Advances in Computer, Communication and Control*, Springer Singapore, 2019, pp. 311–325.

[5] A. L. Yadav, P. Vyavahare, and P. Bansod, "QoS in WiMAX hybrid schedulers for heterogeneous traffic and their performance comparison," *International Journal of Electronics*, vol. 107, no. 4, pp. 561–575, Apr. 2020, doi: 10.1080/00207217.2019.1672213.

[6] E. R. Dosciatti and A. Foronda, "Time frame optimization using PSO to guarantee QoS in IEEE 802.16 networks," in *2015 Science and Information Conference (SAI)*, Jul. 2015, pp. 506–513, doi: 10.1109/SAI.2015.7237190.

[7] E. R. Dosciatti, W. Godoy Junior, and A. Foronda, "TQ/PSO-a new scheduler to optimize the time frame with PSO in WiMAX networks," *IEEE Latin America Transactions*, vol. 13, no. 1, pp. 365–376, Jan. 2015, doi: 10.1109/TLA.2015.7040671.

[8] Y. Zhang, Y.-H. Lo, W. S. Wong, and F. Shu, "Protocol sequences for the multiple-packet reception channel without feedback," *IEEE Transactions on Communications*, vol. 64, no. 4, pp. 1687–1698, Apr. 2016, doi: 10.1109/TCOMM.2016.2538259.

[9] Eun-chan Park and Hwangnam Kim, "A dual feedback approach of request-based bandwidth allocation for real-time service in broadband wireless access networks," *IEEE Transactions on Communications*, vol. 57, no. 3, pp. 610–613, Mar. 2009, doi: 10.1109/TCOMM.2009.03.070040.

[10] A. W. Vishal, V. J. Gond, A. Wagh, and U. Dalal, "Genetic algorithm for resource allocation in WiMAX network," *International Journal of Computer Applications*, vol. 35, no. 2, 2011.

[11] M. Piquet Dias and N. L. Saldanha Fonseca, "Performance evaluation of a scheduler for the ONU-BS of integrated EPON-WiMAX networks," *IEEE Latin America Transactions*, vol. 10, no. 3, pp. 1838–1843, Apr. 2012, doi: 10.1109/TLA.2012.6222591.

[12] J. F. Borin and N. L. S. da Fonseca, "Uplink scheduler and admission control for the IEEE 802.16 standard," in *GLOBECOM 2009-2009 IEEE Global Telecommunications Conference*, Nov. 2009, pp. 1–6, doi: 10.1109/GLOCOM.2009.5425779.

[13] C.-Y. Chang, M.-H. Li, W.-C. Huang, and S.-C. Lee, "An optimal scheduling algorithm for maximizing throughput in WiMAX mesh networks," *IEEE Systems Journal*, vol. 9, no. 2, pp. 542–555, Jun. 2015, doi: 10.1109/JSYST.2013.2271386.

[14] D. Pranindito, R. Munadi, and M. R. Rumani, "A performance analysis of packet scheduling algorithms between homogeneous algorithm and hybrid algorithm in point to multipoint WiMAX networks," in *2016 1st International Conference on Information Technology, Information Systems and Electrical Engineering (ICITISEE)*, Aug. 2016, pp. 63–68, doi: 10.1109/ICITISEE.2016.7803049.

[15] N. M. El-Shennawy, M. N. El-Derini, M. A. Youssef, and M. M. Fahmy, "A dynamic uplink scheduling scheme for WiMAX networks," in *2013 8th International Conference on Computer Engineering and Systems (ICCES)*, Nov. 2013, pp. 111–115, doi: 10.1109/ICCES.2013.6707183.

[16] P.-C. Ting, C.-Y. Yu, N. Chilamkurti, W. Tung-Hsien, and C.-K. Shieh, "A proposed RED-based scheduling scheme for QoS in WiMAX networks," in *2009 4th International Symposium on Wireless Pervasive Computing*, Feb. 2009, pp. 1–5, doi: 10.1109/ISWPC.2009.4800558.

[17] R. R. Prasad, N. Narendra, Y. S. Rao, and P. Chaporkar, "Slot fair scheduling for real-time applications on uplink of WiMAX networks," in *2013 IEEE International Conference on Communications (ICC)*, Jun. 2013, pp. 6250–6254, doi: 10.1109/ICC.2013.6655608.

[18] P. Rahimzadeh and F. Ashtiani, "Analytical evaluation of saturation throughput of a cognitive WLAN overlaid on a time-scheduled OFDMA network," *IEEE Transactions on Mobile Computing*, vol. 16, no. 3, pp. 634–647, Mar. 2017, doi: 10.1109/TMC.2016.2567387.

[19] H. Alyasiri, A. K. Al-Samarrie, and A. H. Al-Nakkash, "Performance enhancement by adaptive resource allocation in WiMAX networks," in *2015 3rd International Conference on Artificial Intelligence, Modelling and Simulation (AIMS)*, Dec. 2015, pp. 441–447, doi: 10.1109/AIMS.2015.75.

[20] Yin Chiu, Chung-Ju Chang, Kai-Ten Feng, and Fang-Ching Ren, "GGRA: a feasible resource-allocation scheme by optimization technique for IEEE 802.16 uplink systems," *IEEE Transactions on Vehicular Technology*, vol. 59, no. 3, pp. 1393–1401, Mar. 2010, doi: 10.1109/TVT.2009.2040005.

[21] C. Kai, L. Xu, J. Zhang, and M. Peng, "Joint uplink and downlink resource allocation for D2D communication underlying cellular networks," in *2018 10th International Conference on Wireless Communications and Signal Processing (WCSP)*, Oct. 2018, pp. 1–6, doi: 10.1109/WCSP.2018.8555896.

[22] S.-C. Hung, H. Hsu, S.-M. Cheng, Q. Cui, and K.-C. Chen, "Delay guaranteed network association for mobile machines in heterogeneous cloud radio access network," *IEEE Transactions on Mobile Computing*, vol. 17, no. 12, pp. 2744–2760, Dec. 2018, doi: 10.1109/TMC.2018.2815702.

[23] I. Sousa, M. P. Queluz, and A. Rodrigues, "A survey on QoE-oriented wireless resources scheduling," *Journal of Network and Computer Applications*, vol. 158, p. 102594, May 2020, doi: 10.1016/j.jnca.2020.102594.

[24] X. Tong, X. Li, and Y. Liu, "Research on resource efficiency optimization model of TDMA-based distributed wireless ad hoc networks," *IEEE Access*, vol. 8, pp. 96249–96260, 2020, doi: 10.1109/ACCESS.2020.2993339.

[25] M. Ozturk, M. Akram, S. Hussain, and M. A. Imran, "Novel QoS-aware proactive spectrum access techniques for cognitive radio using machine learning," *IEEE Access*, vol. 7, pp. 70811–70827, 2019, doi: 10.1109/ACCESS.2019.2918380.

BIOGRAPHIES OF AUTHORS

Ravishankar Huchappa Assistant professor, School of Computing and Information Technology, REVA University, Yelahanka, Bangalore, India. Curretly working as Assistant professor and having 15 years of experience in mentoring and conducted many social outreach activities. His area of expertise in wireless network. He can be contacted at email: ravishankar.h@reva.edu.in.

Dr. Kiran Kumari Patil Professor, School of Computing and Information Technology, REVA University, Yelahanka, Bangalore, India. Currently working as Director – University Industry Interaction Center at REVA University with 20 years of experience in mentoring, managing Software Product Design and Development Projects, Business Development and Business Incubation activities. Experienced in management, research and administration of Innovation and Entrepreneurship Development Activities. She can be contacted at email: kirankumari@reva.edu.in.