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Additional Resource Allocation for improving Fairness in WiMAX

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Abstract

IEEE 802.16 standard provides resources to both service classes Constant Bit Rate (CBR) and Variable Bit Rate (VBR). These services require enough resources to transmit data efficiently. In this paper, a Service Based Fair Resource Allocation (SBFRA) Mechanism is proposed, for assessing the required service from Subscriber (SS) along with the channel condition. The proposed model evaluates the required additional resources in order to provide the required service to SS. In this proposed model, a Priority Queue Scheduling Methodology is presented in order to provide additional resources as per channel condition. A comparison is made with and without the proposed model on both traffic, CBR and VBR. The experiments show that the proposed design manages the user request by providing them additional resources as per requirement. The requestsare handled in Priority Queue Scheduling based mechanism. Results show that an improvement is achieved by providing the additional resource on fair scheduling basis. To achieve the required performance for fairness there is a compromise on delay.

***Keywords**: Resource Allocation, SNR, CBR, VBR, Priority Queue*.

1. Introduction

WiMAX is a 4G wireless network technology. This system is designed for the metropolitan area network (MAN). Wireless network are generally less efficient and unpredictable as compared to a wired network due to limited resources. Management of available resources is a critical issue in WiMAX [1]. This research focuses on providing the quality of service (QoS) in a wireless environment. To handle this challenge WiMAX provides strong contender for broadband wireless technology.

In WiMAX when a new subscriber requests for the service a call admission control process is initiated. According to the procedure, Base Station (BS) monitors existing resources for the provision of service to new users. This ensures that the system has enough resources to accommodate the services required to newly requesting user. scheduling algorithms should be capable of providing minimum level for QoS [2],[3].

Scheduling is a critical process for allocating shared resources [4],[5]. The process involves allocating bandwidth among the contended users. Scheduling algorithms for a particular system is selected based on the type of service required by users in the network and its QoS requirements. In real-time application such as video conferencing, voice and streaming delay or jitter plays a vital role in QoS requirement. A task of the scheduling algorithm in a multi-class traffic is to categorize the users in one of the pre-defined classes. Each user is assigned a priority of class, as well as ensuring that fairness between the users is maintained [6].

Scheduling algorithm is implemented for both sides which are uplink and downlink in WiMAX network. The focus of the scheduling focuses on allocation of bandwidth to the subscriber. A subscriber may get separate resources for each application if the scheduling algorithm is not implemented at the SS side. If grant per Subscriber Station (SS) is applied then scheduling algorithm at SS needs to decide the allocation for each connection [7],[8].

To control the scheduling mechanism in WiMAX network it is necessary to maintain efficient mechanism on the BS. Number of issues arises at the time of uplink. To manage the resource optimally and efficiently the scheduling algorithm at BS coordinates with the scheduler on the Subscriber side [9].

In different scheduling mechanisms, various approaches are used for resource management. Most common schedulers are FIFO, WFQ, EDF and EDF which are used at SSs

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for rtPS class. To handle the scheduling of non-real time Polling Service Weighted Fair Queue is adopted. Whereas for providing the resource to Best Effort services FIFO method is adopted [10]. Taking into account the QoS framework, a low class priority service provides additional required resources in priority scheduling paradigm.

WiMAX is not only based on a static modulation scheme, various adaptive modulation and codding methodologies are used. In a wireless environment modulation, schemes synchronization plays an important role for additional resources with respect to the service and modulation scheme [11]. J. Lin et al proposed the uplink fair scheduling structure in WiMAX network [12]. This structure describes the factor of throughput and the delay handling in multi class's traffic. This structure presented the Modified Weighted Round Robin mechanism in BS. The method is to manage the scheduling problem at the subscriber side, and allocation is made based on the number of users. SS handles UGS and real-time polling service with MWFQ. To handle non real time Polling Service MWFQ is used and for BE traffic FIFO is used.

To allocate bandwidth on priority basis to all the subscribers in the system a hybrid scheduling mechanism is presented by M. Settember et al [13]. WRR based scheduling technique is used for bandwidth allocation to SSs, for rtPS and nrtPS classes on priority basis. Rest of resources allocated to BE classes by using round robin (RR) mechanism. Drawback of this method is if a low priority class requires additional resources then it will have to wait for a longer period of time [14].

In [15] WFQ approach is used for SS of both nrtPS and BE classes. The standard does not require any specific QoS requirement for the Best Effort traffic [16]. To apply a complex architecture for the management of resources for the BE traffic is not feasible for practical implementation due to resource hungry architecture. The overhead of the system will be more than the actual efficiency of the system. The main comparison in this paper is made based on the grant per subscriber and grant per connection. It is analysed and recommended that GPCC is better than GPC in terms of delay in the network traffic.

It is observed that there is a deficiency of an algorithm which can handle wireless traffic based on the fairness factor and allocates the resources based on user requirements. WiMAX have multiple classes, with respect to those classes multiple scheduling mechanism are required. To handle this situation an efficient algorithm is required to compute and allocate the existing resources based on requirements. The algorithm should be able to handle the mobile as well as the user in hard location.

In WiMAX minimum resource allocation can be made by slot permutation allocation methodology [18]. Four Types of permutation are used in WiMAX, partial usage sub channelization (PUSC), full usage sub channelization (FUSC), adaptive modulation and coding AMC and tile usage sub channelization TUSC. In [15] a new algorithm is proposed which is based on the channel condition and the buffer capacity. This cross layer approach in WiMAX shows that wireless link effects the performance of the system. To implement scheduling mechanism at the BS can produce better results. Main focus of this work is to get maximum throughput and fair scheduling among the service flows, but does not consider the channel status for scheduling.

2. Proposed Fairness Model

Figure 1 shows the proposed Service Based Fairness Resource Allocation (SBFRA) Mechanism; an adaptive resource allocation model is developed by evaluating the service. When user submits a request for a particular service, the proposed SBFRA Mechanism checks the required service along with the channel condition. In this model, two sub models are presented; Service Evaluator and Resource Manager.

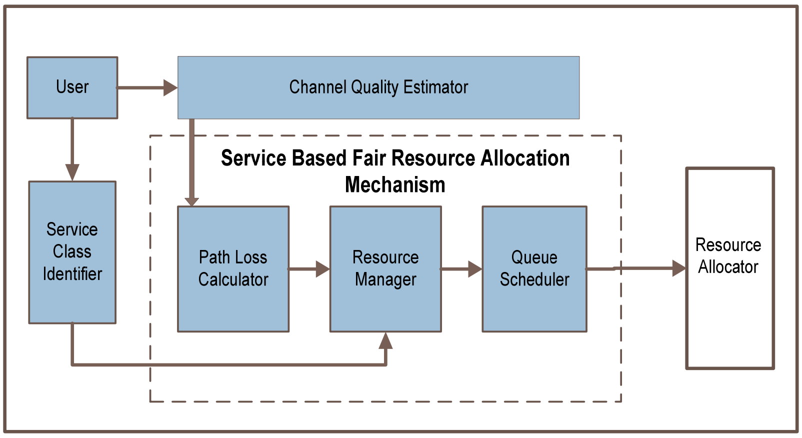

Figure 1. Fairness based resource allocation

In our proposed model we consider both services Constant Bit Rate (CBR) and variable Bit Rate (VBR).

2.1 Constant Bit Rate Service

CBR is traffic which keeps the bit rate same throughout the process, in real time data stream consisting of fixed size data packets. The QoS that requires the user to determine a fixed bandwidth requirement at the time the connection is setup. The data can be sent in a steady stream. CBR service is often used when transmitting fixed rate uncompressed video. A class of traffic that needs access to time slots at regular and precise interval. QoS parameter includes cell delay variation and cell transfer delay. We need to transfer uncompressed voice and video using CBR. CBR is designed for ATM virtual circuit where statistically constant amount of bandwidth is required for the duration of active connection. CBR service class is designed for real time application [20].

2.2 Variable Bit Rate Service

The term VBR is used in telecommunication and computing that relates to the bitrate used in the sound and video encoding. VBR files vary from the amount of output data per time segment. VBR allows a higher bitrate and therefore requires more storage to be allocated to complex segment of media files. The disadvantage of VBR is that it may take more time to encode as the process is more complex. VBR may also pose a problem during streaming when the instantaneous bit rate exceeds the data rate of the communication path. Bits available can use more flexibility to encode sound or video data [20].

2.3 Service Evaluator

WiMAX Services are usually categorizing in five main classes. In proposed model Service Evaluator is responsible for receiving user request for any of the five required services. Service Evaluator consists of two main features, which are Required Service R_s and Channel Condition C_c. When a user requests for a service R_s identify the required Service whereas C_c will assess the channel condition from where the service is required. After assessing these parameters final value for α is obtained.

2.4 Resource Manager

Resource Manager receives the value of α and estimates the additional resource required for providing the required service to the user. After finalizing the R_s the Resource Manager evaluates how much reserve resource it has and how much it can allocate the user for the R_s. Then Resource Manager forwards the result to Queue Scheduler Qs places the request in the three available queues, First Priority F_p, Second Priority S_p, and Third Priority T_p.

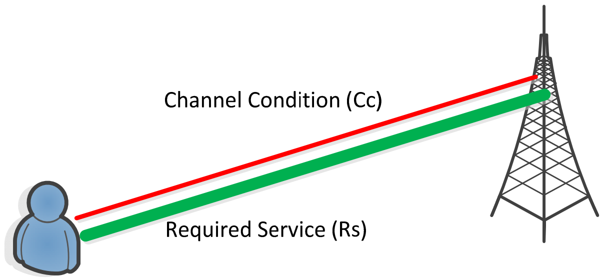

Figure 2. Service Evaluation

Let C_c and R_s be the random variables representing the input and output of the channel, respectively. Let$PR_s|C_c(R_s|C_c)$ be the conditional distribution function of Rs given Cc, which is an inherent fixed property of the communications channel. Then the choice of the marginal distribution $P\,C_c\,(C_c)$ completely determines the joint distribution$P\,C_c,R_s(C_c,R_s)$ due to the identity.

$$P\,C_c,R_s(C_c,R_s) = PR_s|C_c(R_s|C_c)PR_s(R_s) \quad (1)$$

Which, in turn, induces mutual information$I\,(R_s;\,C_s)$. The overall channel condition along with SNR is described as

$$O_{Channel} = {}_{P\,R_s(R_s)}^{SUP} I\,(R_s;\,C_c) \quad (2)$$

As per Shannon theorem for every required service there is a channel capacity. That is maximum requirement for providing required service. On the bases of this theorem our proposed model calculates the channel capacity.

$$O_{Channel} = {}_{P\,(R_s)}^{SUP} I\,(R_s;\,C_c) \quad (3)$$

Secondly every channel has some noise ratio which is called Signal to Noise Ratio (SNR). In this equation we denote it as with α, and $\alpha > 0$ and $R_c < C_c$ for the required service R_s, as per the existing code for Rs should be > Rs as per coding algorithm and for the $R_s$the maximal probability of the SNR should be $<\alpha$.

2.5 Queue Scheduler

In our proposed model we also introduced Priority Queue Scheduling methodology for providing resource as per the requirement of the user service. According to the channel status Queue Scheduler places the desired request in the first, second and third queue according to the required service and channel condition.

First Priority (F_p): Queue Scheduler evaluates and places all those requests which required 10% additional resources for fulfil the required request. All those request place in the F_p.

Second Priority (S_p): Our proposed model based queue scheduler place all those request in Sp which are required 20% additional resources for fulfilment to required service.

Third Priority (T_p): In the last queue all those request has been placed which required more than 30% additional resources.

Proposed queue scheduler is based on priority queue scheduling, so after certain period of time every required user got place in the next $S_p$and T_p.

3. Simulation and Results

To evaluate the proposed model a five node based WiMAX scenario is developed in NCTUns version 6.0 simulator. The simulation is executed for multiple times with respect to the services. Following parameters are used for both services.

Table 1. Simulation Parameters

Description	**Range / Model / Quantity**
Mobile Station	20 to 30
Base Station	01
Host	01
Number Channel	10 to 20
Bandwidth between Host and BS	10 MB
Base Station Antenna Height	30 m
Mobile Station Height	10 m
Protocol	802.16e
Fading Variance	10.0
Path loss Exponent	2.0
Ricean Factor	10.0 K(db)
Empirical Channel	Cost_231_Hata
Path loss Model	Ereg path loss
Frequency	2300 MHz
Transmission Power	43 dbm
Receive Sensitivity	-99 dbm

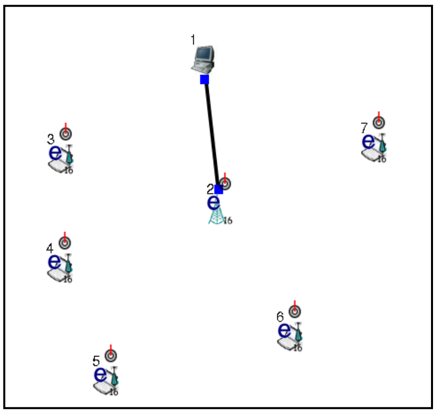

Figure 3. Five SS based scenario of WiMAX

The Figure 3 shows the real simulation screen shot of five nodes based SS scenario with one BS and one Host. In the first assumption, every node demands the CBR service from BS and BS which is equipped with SBFRA evaluates the demanded service and its channel. Then the proposed SBFRA initiates and receives the request from the user and provides the required service accordingly.

After executing simulation for 100susing proposed model. Base Station received the real time request from user form different services. Figure 4 shows the user demanding the CBR service from the base station.

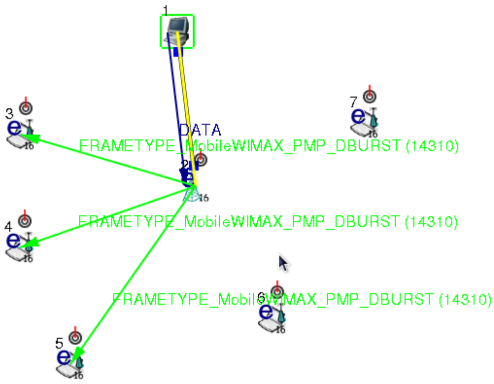

Figure 4. SS communication with Base Station for Required Service

3.1 Simulation Scenario 1.

In simulation scenario, the proposed model is applied on only five nodes based WiMAX network. In which the assumption was that every user demands CBR service with variable channel condition. It is observed that how proposed model places the user requests in the specified queue and how it manages the required resource.

In this simulation, every SS uses the 802.16e protocol along with some additional predefined parameters. In the first run has the capability to submit required for all of traffic i.e. UGS, rtPS nrtPS and BE. In this study, we evaluated the resource allocation to users with and without SBFRA and monitored the performance of SBFRA Mechanism.

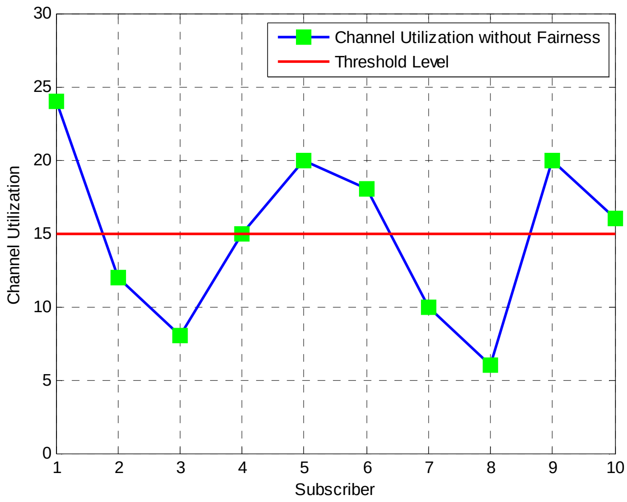

Figure 5.Channel utilization without fairness

Figure 5 shows the real simulation of the 10 SS along with their channel condition, below the red line explains on line user required extra resource to fulfil the required service whereas above the red line explains on line user has required the minimum resources. By evaluating the required resource the proposed model SBFRA Mechanism places the user requests according to the prescribed queue scheduler

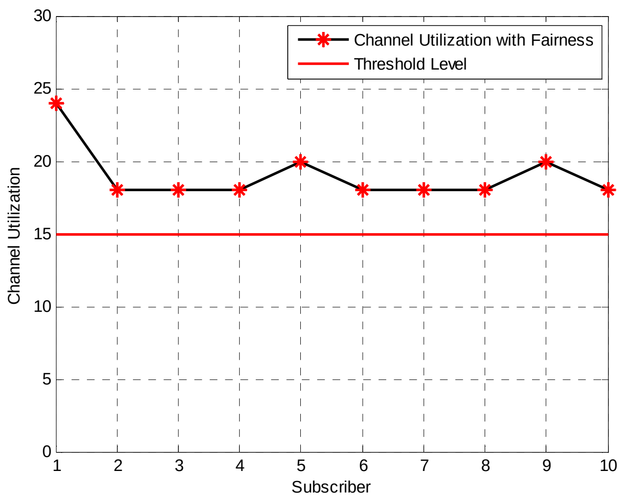

Figure 6.Channel utilization with fairness

Figure 6 presents the proposed model fairness resource methodology and according to the requirement SBFRA Mechanism provides the required resource and all users received the service with additional resource but with some delay. In this study, the prime focus is to provide the user required services but with a compromise on delay.

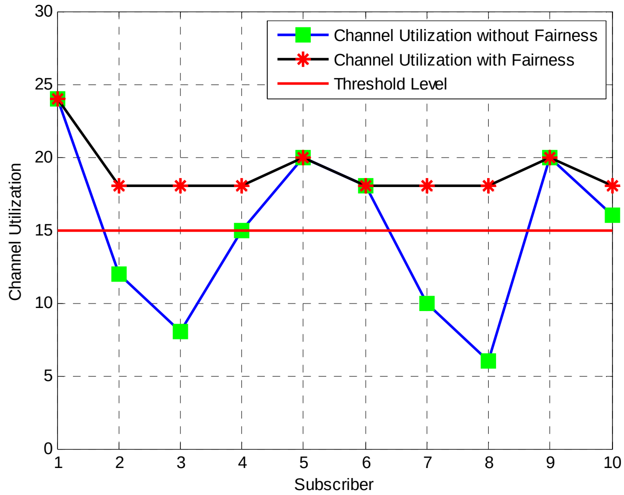

Figure 7. Comparison of channel utilization with and without SBFRAM

Figure 7 presents the overall performance of the SBFRA Mechanism, in which users 2, 3,4,7,8 and 10 require additional resource, whereas only 1, 5 and 9 channel condition is according to the required service, so without additional resource their required service is provided immediately. Whereas the rest of the users is placed in the F_p, S_p and T_p according to their channel condition, but after a certain period of time every user received its required service.

3.2 Simulation Scenario 2.

Figure 7 presents the overall performance of the SBFRA Mechanism, in which users 2, 3,4,7,8 and 10 require additional resource, whereas only 1, 5 and 9 channel condition is according to the required service, so without additional resource their required service is provided immediately. The rest of the users are placed in the F_p, S_p and T_p according to their channel condition, but after a certain period of time every user received its required service.

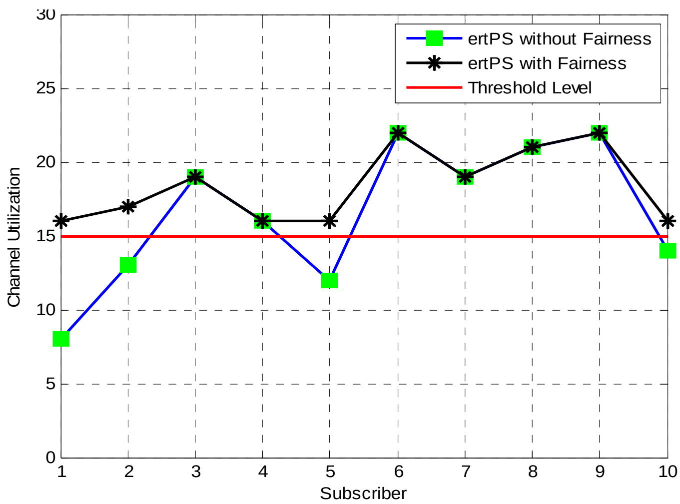

Figure 8.Comparison of channel utilization with and without fairness for ertPS class

Figure 8 shows that all 10 subscribers require the ertPS service, but 1,5 and 10 channel condition is not as per the required parameter, so users are placed in their respective queues for an additional resource, and when the required is provided by the Resource Manger then BS provides them the required service.

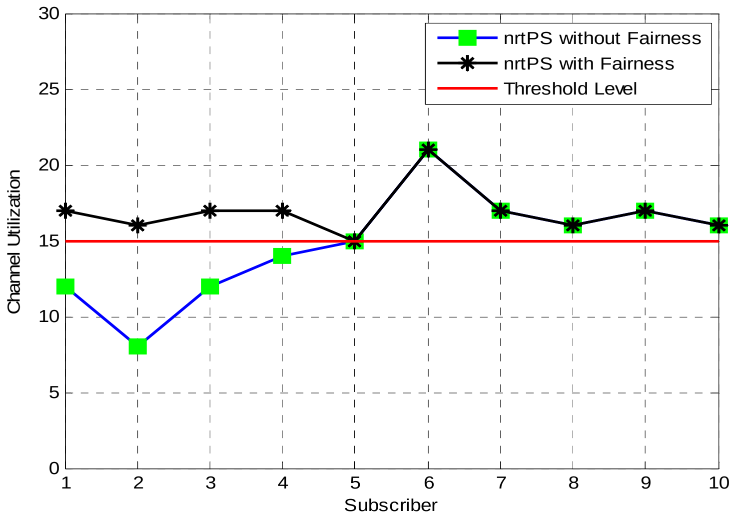

Figure 9.Comparison of channel utilization with and without fairness for nrtPS class

Using same channel condition, the experiments are performed by changing the other service nrtPS. Figure 9 presents that in proposed model users 1, 2, 3 and 4 require additional resources for providing the required service. The proposed model is applied on every service, and it is found that for different users require additional resources. In Figure 10, the proposed model is evaluated on rtPS service and marked 2, 5, 7 and 8 for requiring additional resources. Whereas in Figure 11 only 1, 8 and 9 require more resource for BE service.

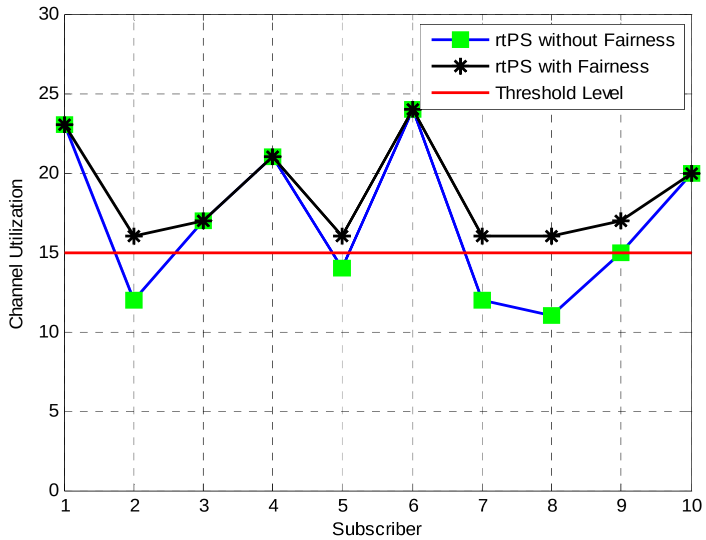

Figure 10.Resource utilization based on channel condition for rtPS Service

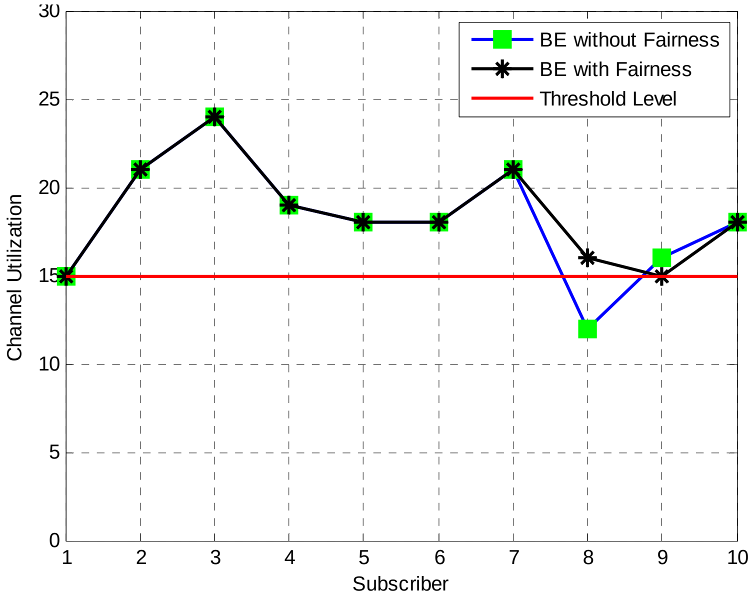

Figure 11.Resource utilization based on channel condition for BE service

Figure 12 presents the summary at BS level where multiple services are demanded by the SS, and SBFRA has queued all those services which require additional resources. After providing the required resource every SS entertains with that service. In this process those users which required more than 20% additional resource has been compromised on bit delay for providing the said service. The solid trend line presents that every service how many additional resources are required by every service and the proposed model provides the required resource as per the pre-set priority on the basis of the assumed service priority scheduling mechanism.

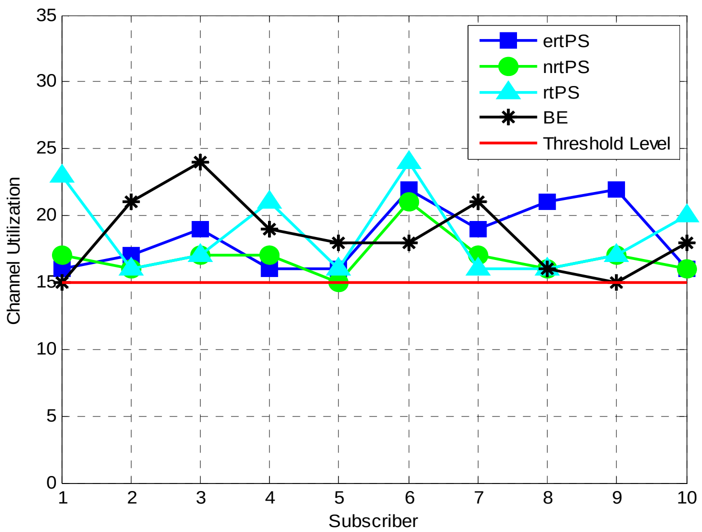

Figure 12.Comparison of channel utilization with fairness for different classes of VBR traffic

4. Conclusion

In this paper, a SBFRA Mechanism is proposed by using channel status. After studying the problem of fair resource management the proposed mechanism allocates based on the status of channel fairly and user satisfaction level is achieved. Simulation shows the improvement in the allocation of resources in terms of fairness which shows that the additional resource is allocated to the user with low SNR value in order to achieve the minimum satisfaction. The experiments show that both constant bit rate and variable bit rate traffic gets improvement in fairness and level of user acceptance. This mechanism also improves wait time for low priority classes to provide fair and desired service to all the users without affecting the QoS up to the maximum availability of resources. This mechanism does not perform efficiently if the users with low SNR will be greater in number.

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