# Channel Based Resource Allocation Mechanism (CBRAM) in WiMAX

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**Abstract:**WiMAX provides a wide range of growing requirements of services and mobility of user that has made allocation of resources a focusing area for the researcher. The goal of the WiMAX Network, based on IEEE 802.16e standard, is to provide the best available quality of service. Several parameters are considered to ensure QoS and efficient resource allocation in multi classes. Considering deficiency of standard policy for scheduling and resource allocation in IEEE standard. This paper focusees on key issues and the design factors of existing techniques. A new mechanism is proposed for allocation of resources, Channel Based Resource Allocation Mechanism (CBRAM). To achieve this objective an analytical technique is used to derive bounds on system capacity in channel distribution. The research gap is to analyze the performance of the existing resource allocation mechanisms based on channel condition or SNR ratio. To fill the gap an optimal hybrid resource allocation technique is proposed to ensureresource allocation efficiently.
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**Keywords:**Resource allocation, SNR, Quality of Service Classes

## I. Introduction

In telecommunication system the wireless networks have perceived tremendous growth. The current technological advancement in wireless communication has become the fundamental component of modern society. In next generation of network it requires attention to meet the demand and requirements of users. The implementation of these technologies depends on the requirements of the users. A user can use different applications to access the services over the LANs as well as WANs. Each of these applications has different set of complex requirements. For the last 10 years most of the research work in telecommunication system focuses on meeting user requirements and providing optimum level of services. WiMAX is a WAN technology that offers robust full duplex services (uplink and downlink channel) to users and provides identical services like DSL. WiMAX technology supports long range coverage with quality of service provided in the scalable architecture with high data throughput. WiMAX network architecture can be grouped into following three parts as shown in Figure 1.

- To access the network mobile station used by the end user.
- Access Service Network (ASN), consists of base station (BS/s) and gateways to make Radio Access Network (RAN) at the edge.
- Connectivity Service Network (CSN) is to provide core functions of the network and connectivity of IP.

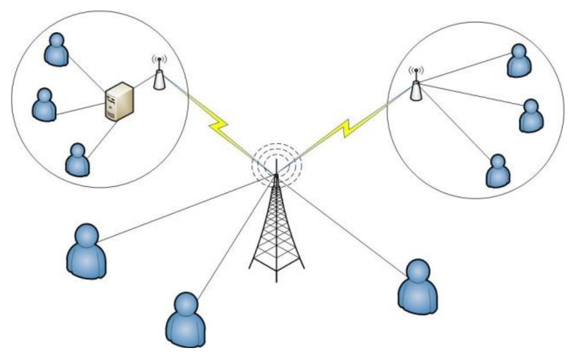

Figure 1. WiMAX Network Architecture

Current research focuses on enhancement of different aspects of WiMAX implementation such as resource allocation, QoS, scheduling, fairness, throughput, security and complexity of algorithms[1-2]. WiMAX forums are trying to establish the mature version of WiMAX mobile services. The experimental service of this technology is in progress and regular feedback is incorporated in the upcoming more mature standard, which helps in implementation and rolling out of WiMAX network [3]. Initially standard was released in 2001 which supports point to multipoint, later on enhancements were introduced and the updated version was released in 2009. This revision includes the mobility support and the required quality of service parameters [4].

WiMAX is one of the WAN categories which provide flexible and easy deployment solution to high speed communication and support a variety of services using advance multiple access techniques. This makes the network able to accommodate the users with different service classes. In IEEE802.16estandard, Orthogonal Frequency Division Multiple Access (OFDMA) supports broadband access infrastructure inwireless environment, which also increases the multiuser diversity [5].

Bandwidth in any network is an asset and is limited, so the performance of the system depends on an efficient resource utilization that improves spectrum efficiency and provides available resources to the users in an efficient way.

In wireless network environment different subcarrier have diverse channel gain, each subcarrier fades independently for different subscriber station (SS). Suchdiversity is a source of motivation for designing of some mechanism for the resource allocation in OFDMA network. Various researchers have worked out on the efficient utilization of resources in WiMAX network, scheduling for resource allocation and modulation based on channel condition [6]. Rest of the paper describes the detail of the work. In section II previous work has been described, in Section III Proposed Technology is presented, Section IV presentsDesign and Simulation of CBRAM. Section V describes Mathematical Model for Resource Allocation. The outcome of the proposed model is presented in section VI andlast section describes conclusion.

## II. Resource Allocation

Resource allocation is used to assign resources to different demanding entities in the system. It is an important part of resource management. In network, the resource allocation means scheduling the requests of different users in a well-organized manner.

Different areas of WiMAX have been intensively explored which reflects lot of work done. Current research on WiMAX focuses on mobility of subscriber which is specified in IEEE 802.16-2009 standards. These standards do not provide any specific technique for resource allocation. Focusing on the resource allocation, it is an open issue to derive anefficient mechanism, based on available literature. Considering the QoS in WiMAX and the scheduling of the resources, based on the channel, SNR and modulation scheme is to be selected along with the code rate[6]. The scheduling for resource allocation in wireless network is a critical problem [7].

In OFDMA system, the resource allocation is a process to allocate sub carrier with adequate resources.While to remain connected to the network SS can conveniently communicate with another SS or base station (BS). In [6] the resource allocation of sub carrier is proposed by assuming equal sub carrier allocation irrespective of the channel status and the data rate. The ideal channel state information is assumed by using fixed modulation for all subcarrier to all users [7, 8]. In Orthogonal Frequency Division Multiple Access (OFDMA) the bandwidth is divided into sub carriers [9], which are allocated to the subscriber and controlled by the BS.

In real scenario the subscribers have different data rate at different locations from base station so the approach in [10] don’t reflect the practical solution, but the practical approach in [11, 12] reflects the realscenario. Users are allowed to set their data rate based on the QoS and proportional rate constraint[11]. Each user can be satisfied with data rate constraint to the channel status of the user.

However the policy of resource allocation depends on the BS mechanism for allocation of resources. Grouping of these carriers is called as sub-channel and these sub-channels are represented by different OFDM symbols known as slots. In WiMAX standard, slot is defined as a minimum resource, which can be allocated to a SS [9]. Frame of WiMAX is further sub divided into two sub frames i.e. uplink and downlink sub frames. Both uplink and downlink supports duplexing using Time Division Duplexing (TDD) or Frequency Division Duplexing (FDD). In TDD, the communication is achieved by using the same channel in different time slots. In TDD, the downlink and uplink sub-frames are separated by receiver transmit transition gap (RTG). In FDD simultaneous communication is achieved by using different sub-channels. The throughput of uplink or downlink is proportional to the number of sub carriers allocated to the corresponding SS and the achievable rate of each subcarrier [4].

Theoretically all the users get the same service but due to mobility and load on the network, the service provider faces challenges in the fair allocation of resources to each user. If the service provider limits the number of slots and the user is in the odd area then service provider needs to allocate more resourcesso that user can get the same quality of service as compared to others user in the normal range, that raises the issues like fairness, throughput etc.

There are several algorithms that ensure allocation based on resource availability otherwise these algorithms drop the request. In [7] an Extra Bandwidth Granting (EBG) scheme is presented to improve the efficiency, based on the average packet size for the QoS classes. In [6] an optimization technique is presented considering the max carrier to interference ratio. In [9] the time frequency allocation is proposed with the channel condition for ensuring the QoS based on priority. There is special attention on scheduling for WiMAX to cope with key issues and design factor. Till now the work done regarding resource allocation is normally based on the scheduling of existing resources and applying the modulation technique on the basis of node distance and the SNR of the channel. For the best utilization of existing resources such as capacity, channel assignment and bandwidth allocation in WiMAX networks, there is need to consider, the required class for QoS and SNR of the channel, simultaneously. Resource Allocation and Management is a critical research issue in WiMAX networks [13]. The convolution has enlarged on the basis of numerous causes, for example the obtainable synthesis of various changed and uncommon network channels. Due to increase in traffic, users and demanding applications burden on the network has exponentially increased. To handle this situation it is required to manage the network resources properly.

Resource allocation in mobile WiMAX can be improved and made efficient by using the Artificial Intelligence (AI) techniques. Fairness among the users for getting the resource is another important aspect. Channel gain status is a major factor for deciding the allocation of resource. Two main techniques are used for the allocation of resources; one is Linear Search Technique [8] and the other is Root Finding Method [10]. In linear search technique, resources are allocated to the users by calculating the total bandwidth required and the data rate of the user. Then all sub-carriers are searched and sorted out in descending order according to their channel gain. Then the sub carriers are allocated to each user and this process is repeated until all the users have been served or the channels are occupied. In Route Finding Method the resources are allocated based on the target data rate. Each user gets the resources in a cyclic manner. This allocation remains continue in loop by finding the users with requirement and allocates any unused subcarrier. This process continues until fulfilling the user requirements or the allocation of all the resources. The problem with this method is; it does not find the number of resources required by each user. Second issue with this method is; it does not consider the channel quality (SNR) of the user [8, 10].

Following points are the limitations to resolve the concerned issues:

- QoS is not an optimum parameter for resource allocation.
- To allocate resources on the basis of quality of service classes is not enough and efficient to give optimum throughput.
- The allocation of resources based on the service channel status is unable to distribute resources fairly being a user at poor SNR location.

This research presents a new technique, for scheduling the resource allocation in WiMAX networks.The work is in extension of approach used inNetwork Utility Maximization (NUM) concept for QoS class based resource allocation [12]. The existing techniques are used for improvement, and better utilization of resources. Process of resource allocation can be enhanced using QoS with combination of channel status.

## III. Proposed Technique

The proposed mechanism has been shown in Figure 2. According to the proposed mechanism, a mobile user submits a request for a specific application to the Base Station. The CBRAM will evaluate the required application along with the adopted channel conditionfor providing the required services. CBRAM is mainly divided into two main sub-modules.

1. Service Identifier. 2. Algorithm Selector / Initiator.

**Service Identifier:**

WiMAX have five types of the services and CBRAM is also based on same services like: UGS, rtPS, ertPS, nrtPS and BE. Service Identifier will overall evaluate the required service of the user and along with it from which channel that user initiate the request. So Service Identifier will evaluate the condition of the used channel, weather required service can be provided on the used path or not is based on the SNR value. So by evaluating the both parameters the Service Identifier will response to Algorithm Selector / Initiator.

**Algorithm Selector /Initiator**

The second module of the CBRAM is Algorithm Selector / Initiator, for efficient service providing and fair resource allocation we have design and develop five algorithms according to the specified services. This Algorithm is initiating relevant algorithm on the bases of information provided by the Service Identifier. Service Identifier will provide the Algorithm Selector required service and channel condition bases on this information the module initiate the specified or appropriate algorithm. The details of the algorithms are mentioned in Simulation and Evaluation Section VI.

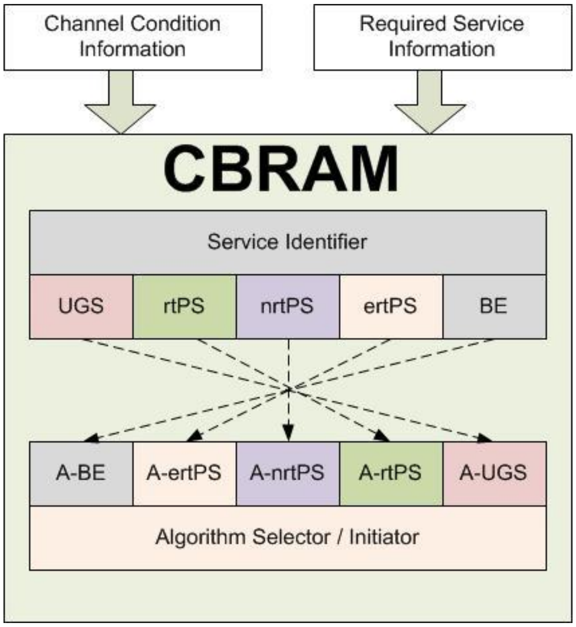

Figure2. Proposed CBRAM Mechanism

## IV. Design and Simulation

To evaluate the proposed mechanism we used NCTUNs version6.0Insimulatortwo scenarios with 10 and 20 mobile stations are used. In first scenario there are 10 mobile stations with one host and one Base Station. For initial evaluation the overall parameters are described in Table 1.

Table 1.Simulation Parameters

| Description | Range / Model / Quantity |
|---|---|
| Mobile Station | 10 to 20 |
| Base Station | 01 |
| Host | 01 |
| Channel | 10 to 20 |
| Bandwidth between Host and Base Station | 10 MB |
| Base Station Antenna Height | 30 Meter |
| Mobile Station Height | 10 Meter |
| 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 | Two_Ray_Ground |
| Frequency | 2300 MHz |
| Transmission Power | 43 dbm |
| Receive Sensitivity | -99 dbm |

Complete parameters for the 10 to 20 nodes simulation is defined in the Table1. The other parameters from host to Base Station and the internal mobile station parameters are described in Table 2 and Table 3 respectively.

Table 2. Host to Base Station Parameters

| | |
|---|---|
| Bandwidth | 50 MB |
| Sit Error Rate | 0.00 |
| Propagation Delay | 1.00 |
| Flush Time Interval | 3.000 ms |

Table 3. Base Station to Mobile Station Setting Parameters

| | |
|---|---|
| Channel | 10 to 20 |
| Frequency | 2300 MHz |
| Transmission Power | 43 dbm |
| Receive Sensitivity | -99 dbm |

Table 4. Mobile Station setting Parameters

| | |
|---|---|
| Fading Variance | 10.0 |
| Path Loss Exponent | 2.0 |
| Shadowing Deviation | 4.0 |
| System Loss | 1.0 |

When the user requests for service, the BS updates its status considering the demand of resource based on the quality of service class and the channel status of the user. In the proposed technique the user must go through the two processes after sending a service. In the first process all the users are divided into classes based on the demand of service class and the value for the priority of queues is assigned to each user along with other formalities like time of arrival, packet size etc. In the second process the users channel status (SNR) is calculated by the given formula.

$$NR= (Pt\ \beta t\ \beta r)/\ (l^*\ R\eta)$$

Where Pt is the total transmits power from the BS, βt is BS antenna gain, βr is SS antenna gain and Rn is the receiver sensitivity. The Table 1 indicates SNR values for modulation scheme used in this paper [13].

Table 5. SNR based Modulation scheme

| Modulation Scheme | Code Rate | SNR Range |
|---|---|---|
| No Transmission | 0 | 0-4 |
| QPSK | ½ | 4-10.5 |
| QPSK | 2/3 | 10.5-13.5 |
| QPSK | ¾ | 13.5-14.5 |
| 16QAM | 1/2 | 14.5-16 |
| 16QAM | 2/3 | 16-20 |
| 16QAM | 3/4 | 20-onward |

These calculated values are updated in the corresponding decision buffer. In this process all the current users for specific time span are treated. All the users are in the decision buffer with two parameters i.e. their service flow class and the channel status. It is assumed that packet arrives randomly from the different service classes. To decide the resource priority queues proposed algorithm checks the value of both the parameters in decision buffer and then populates the execution queues accordingly.

## V. Mathematical Model for Resource Allocation

The key parameters for a user $U_i$ to be selected for channel allocation on first priority are the services $U_{max}$ and Signal to Noise Ratio (SNR). The SNR is a numerical value ranging from 0 to 30. Since the service class is an attribute (a qualitative entity) not a normal value. To develop a mathematical formula the normal value is assigned to service classes on priority given in Table 2 bases as follows.

Table 6.Priority Classes

| Priority | Class |
|---|---|
| 1 | UGS |
| 2 | ertPS |
| 3 | rtPS |
| 4 | nrtPS |
| 5 | BE |

Let U be a space containing all users

$U_i = \{U_1, U_2, U_3 \ldots \ldots U_n\}$ (1)

In equation (1) n is the total number of users. This space U consists of order pairs as follows.

$U: \quad X \rightarrow Y$

$U_i: U_i\,(x_i, y_i) \quad x_i \in X, yi \in Y$

$U_i = U_1\,(x_i, y_i)$

The set x contains numerical value assigned to each attribute foreach service class and value ranges from 1 to 5.The set Y contains SNR value for each user and itsvalue ranges from 0 to 30. The rule for a user selection for channel allocation on priority bases is as follows.

Let $S_i$ be the sum of ordered pair $(x_i, y_i)$ then $S_i = (x_i, y_i)$ then the user $U_s$ will be selected based on max sum.

$U_s = \max(S_i)$

Then the users $U_s$ is compared to max S selected for channel allocation on priority bases.The bandwidth of the system can be mathematically formulated as [13]

$$\psi_{av} = \frac{BW_{eff}}{N_d} \frac{1}{N_{fr}} \sum_{f=1}^{N_{fr}} \psi_f \qquad (2)$$

The simulated average system throughput is evaluated for $N_{fr}$ = 1000 transmitted OFDMA frames with respect to the effective bandwidth,$BW_{eff}$ as above in equation (2).

$BW_{eff}$ can be mathematically computed as

$$BW_{eff} = N_d \frac{BW_{sys}}{N_F} \qquad (3)$$

In equation (3) $BW_{sys}$ indicates the total system channel bandwidth, which is 20 MHz for N_F=2048. Which is 20 MHz for high SNR, the performance of the system is increased due to the accurate theoretical evaluation of BER.

Proposed Algorithm for Resource Allocation

$T_i$=incoming traffic

$Q_c$=traffic class

$T_i \leftarrow$Input

Check $\rightarrow T_i{::}Q_c$

Set $Q_c$ according to $S_i$

$From_i \rightarrow$n

if $Q_c \in S_i$

Then set $T_i$ $S_i$ $(C_i)$

Else

Set accordingly i $\rightarrow$n

endif

## VI. Results and Evaluation

For evaluation the proposed mechanism we develop a 10 nodes simulation scenario on the bases of above mentioned parameters defined in Table 1, 2 and 3. The initial 10 nodes scenario is described in Figure 3.

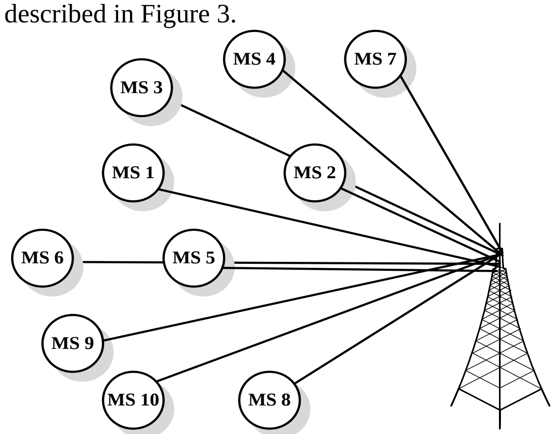


Figure 3 Simple WiMAX 10 Mobile Nodes based Scenario

In first experimental phase our assumption is based on that every mobile node is demanding the same priority service (UGS) from its available channel.

As per our assumption all nodes have the same parameters and the Base Station is set according to the above mentioned parameter defined in Table 2.

Complete functionality of the proposed model is described in the Figure 4. When a Mobile

Station requests for the UGS service then in parallel the proposed mechanism check the condition of the channel. We also introduced a Priority Queue Management w.r.t. channel condition for initiating the respective algorithm. The proposed Mechanism place the request according to the channel condition and respective algorithm provide the required service according to the required bandwidth.

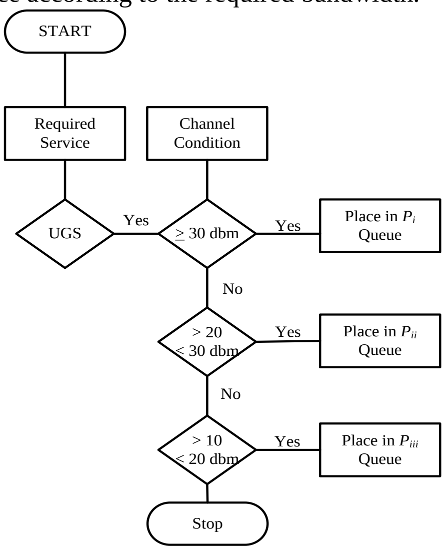


Figure 4 Appropriate Algorithm Selection Mechanism

According to the prescribed procedure when a user requires UGS service than the channel information will also be consider as the second main parameter. If the SNR value of the channel is more than the 30$d_{bm}$ than proposed mechanism will place the request at PQM at Priority Level 1 ($P_i$). If the channel condition will found more than 20 and less than 30$d_{bm}$ than place that request in Priority Level 2 ($P_{ii}$) and same as if the condition of the channel is up to 10$d_{bm}$than place it in Priority Level 3 ($P_{iii}$) as shown in Table 7.

Table 7. Priority Queue Management

| Node ID | $P_i$ | $P_{ii}$ | $P_{iii}$ |
|---|---|---|---|
| 5 | ✓ | | |
| 3 | | ✓ | |
| 1 | ✓ | | |
| 2 | | | ✓ |
| 6 | | ✓ | |
| 7 | | | ✓ |
| 8 | ✓ | | |
| 4 | | ✓ | |
| 9 | | | ✓ |
| 10 | ✓ | | |

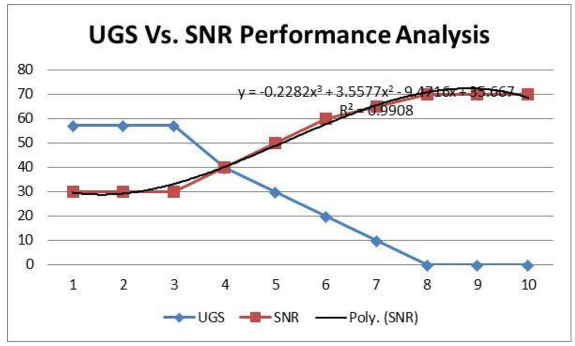


Figure 5 UGS Vs. SNR Performance Analysis

Figure 5 presented the analysis of single service based analysis performed by CBRAM. The proposed mechanism allocates the services of the demanding user by evaluating the condition of the channel. Which presents a 10 user based trend w.r.t. the SNR condition. As channel becomes more noisy than the required service becomes more difficult to provide to the required user.

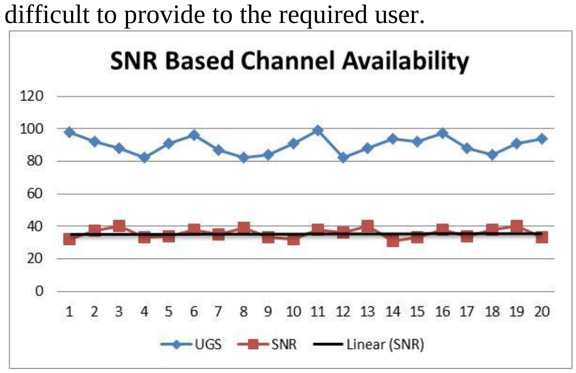


Figure 6 Ideal SNR Based Service Condition

In Figure 6 we have evaluated the proposed mechanism by controlling the SNR ratio at the ideal level and evaluate the overall performance, but in this condition we increased the number of user which are demanding the same service and the allocation of the channel sustained by the proposed mechanism.

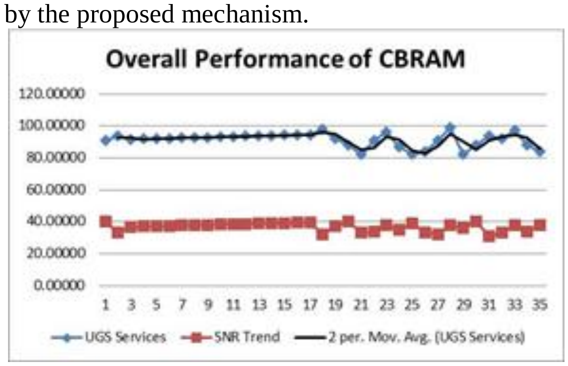


Figure 7 Overall Performance of CBRAM

Last but not least we have evaluated the proposed mechanism on more than 35 nodes

WiMAX network on the same service. The overall performance w.r.t. the SNR has been presented in Figure 7.

## VII. Conclusion

CBRAMmajor focus is on status of channel along with the quality of services classes. A prioritization scheme is introduced which provides consideration mechanism for both parameters (SNR and quality of service classes). To utilize system resources optimally this technique uses channel SNR as an indicator to perform allocation. Proposed technique is applied in different scenarios and it has the option to calculate the resources required to each priority queue and then allocates the resources on priority bases. The technique works in an efficient way for maximum utilization of available resources, but in some cases it may affect the allocation for the bottom queue while having the least priority for the execution of process. The results show that this technique has the capacity to increase the utilization of system resources with better quality of service indicators while it also gives the flexible results within parameters of the non-predictable channel status. Future research is based on how to manage the resources for the process in the bottom queue.

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