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Hybrid Channel Allocation with Priority on Bandwidth Sharing in Wireless Mobile Networks

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Abstract: The main objective of future wireless mobile multimedia networks is to provide services efficiently to the mobile users in all environments. In wireless mobile Communication the channel allocation and bandwidth sharing are the major factors and quality of service is the important issue to decide the system performance. In this work a Hybrid Channel Allocation(HCA)strategy for channel allocation and a novel bandwidth sharing technique applied to Hybrid Channel Allocation strategy for Quality of Service(QoS) provisioning are implemented. The proposed HCA strategy considers new calls in Fixed Channel Allocation (FCA) method and handoff calls in Dynamic Channel Allocation (DCA) method. In the bandwidth sharing of mobile multimedia calls, a multimedia call is considered as a combination of three classes namely voice of CBR, Voice with low rate video of CBR and Voice with high rate video of VBR. Priority of the above classes and a new bandwidth sharing method is implemented. When the required bandwidth is not available for a handoff (HO) call, it rejects a low Priority class and postpones bandwidth sharing to the class, that may cause delay, but it is not a major problem for the Quality of Service (QoS). Our method decreases the handoff call dropping probability (CDP) when compared with Without Control method (WCM). It also improves the communication quality of handoff calls in mobile multimedia networks.

Keywords: Fixed Channel Allocation (FCA), Dynamic Channel Allocation (DCA), Hybrid Channel Allocation (HCA), Quality of Service (QoS), Multimedia Call (MMC), Constant Bit Rate (CBR), Variable Bit Rate(VBR), Call Dropping Probability (CDP).

I. INTRODUCTION

The radio spectrum allocated to wireless cellular mobi*le communication* system is fixed one. Efficient use of available spectrum will produce an increased number of users. The fundamental operational principle of wireless cellular mobile networks(WCMN) is the reuse of frequencies at different places within the areas of service. Reusing the same frequency will not interfere, as it will be attenuated enough. In doing this, the carrier to interference ratio (CIR) and the radio spectrum reuse efficiency are improved. Channel allocation strategy is the technique used to make the most efficient and intelligent way of utilizing the available radio spectrum by the way in which channels are allocated to mobile multimedia calls. The third and future generation wireless mobile networks will support heterogeneous traffic, consisting of voice, video (JPEG & MPEG) and data as multimedia. The Quality of service (QoS) is the major issue for these applications in any kind of communication networking environment. The wireless QoS is the complex problem due to the time varying characteristics of the channel and user mobility. In this work, an efficient channel allocation strategy with QoS provisioning framework is applied to third and future generation wireless networks. Here Hybrid Channel Allocation (HCA) strategy [HCA is the combination of Fixed Channel Allocation (FCA) and Dynamic Channel Allocation (DCA) strategies] for channel allocation and bandwidth sharing to multimedia calls are implemented. Bandwidth sharing technique is the effective and efficient way to reduce the new call blocking and handoff call dropping probabilities. Implementation of HCA with bandwidth sharing effectively increases the channel utilization and thus providing QoS.

A. Introduction to Hybrid Channel Allocation (HCA) strategy

In HCA strategy, the total available set of channels is divided into two subsets. The first subset of channels is assigned to the cells of the system according to the FCA strategy. The second subset is kept in a central pool and assigned dynamically to the cells on demand to increase the flexibility. Therefore, there are two type of channel allocation strategy at the same time i.e., the combination of FCA and DCA strategy. For allocating channels, the fixed to dynamic ratio is very important one. This fixed to dynamic ratio depends upon the statistical nature of the cell i.e., depends on number of new calls and handoff calls initiated in peak hours and also in normal hours.

II. RELATED WORK

Variety of work has been done in the area of channel allocation strategies considering new calls and handoff calls. Minimizing the handoff occurrence is one possible solution. Virtual tree connection method [1] is the example solution. The model in [2] allocate bandwidth to a call in the cell where the call request originates and at the same time reserves the same amount of bandwidth in all neighboring cells for the call. A hierarchical cell model is proposed in [3] in which macro cells and micro cells are taken, and it allocates the bandwidth to appropriate cell according to the velocity of the mobile unit (MU). The scheme in [4] compares the model by assuming utilization and loss separately. The solution is to avoid the bandwidth shortage of the cell by reserving the bandwidth, in which direction the mobile user moves. The model in [5] considers the acceptance of new call according to an approximately calculated probability of a mobile unit induces handoff. By reserving some amount of bandwidth for new calls and handoff calls in advance, so that, the blocking and dropping probabilities can be reduced [6].In this bandwidth reservation is considered for reducing the dropping probability. To utilize the available spectrum effectively the 'Spectrum holes' i.e., prediction of bandwidth availability in advance is discussed in [7].Bandwidth prediction is also a method to reduce handoff call droppings.

In order to meet "anywhere and anytime" concept, the future wireless networks is converge into heterogeneous cellular network to support multimedia calls. For this, the good and bad threshold state method is examined in [8] to reduce the dropping probabilities. In real time traffic (example voice or video) with delay constraint, if a mobile unit is in a bad channel state for relatively long period, the multimedia call quality will be very much decreased and probably the call will be disconnected from the network. Since it only consider the threshold condition of a multimedia call. An analytical model of cellular mobile networks with instantaneous movement is investigated in [9].This is very much useful to cost analysis for updating location and paging in wireless mobile networks. In the bandwidth allocation, various requests of an MU for communication quality should be satisfied. It is widely recognized that future wireless networks will support an increased number of subscribers with more applications. It requires high bandwidth and huge amount of data transmission such as high resolution multimedia service. The limited radio spectrum used for mobile communication becomes the obstacle to provide these applications. Therefore, bandwidth allocation is the important issue in wireless networks. The adaptive resource allocation scheme proposed in [10] allocates connection resources to incoming calls depending on network conditions. In this the resources accumulated by bandwidth degradation for on-going calls are utilized to minimize dropping probability of handoff calls and blocking probability of new calls. Our work presents a new class of channel allocation strategy that overcomes some of the critical limitations of existing methods by considering hybrid channel allocation with bandwidth sharing. The proposed method is simple effective and especially suitable for micro and pico cellular wireless networks.

III. PROPOSED HYBRID CHANNEL ALLOCATION STRATEGY

Hybrid Channel Allocation (HCA) is the combination of Fixed Channel Allocation (FCA) and Dynamic Channel Allocation (DCA). Here a portion of total frequency channels will use FCA and the rest will use DCA. In HCA the channel allocation is done as follows. When a new or handoff call arrives at the cell base transceiver station (BTS), the first attempt to serve, it is by a nominal or fixed channel, if there is no fixed free channel, then a channel from a dynamic set is assigned to the calls. If this also fails, then the call is blocked. The ratio of fixed to dynamic channel is a significant parameter that determines and defines the performance of the system. In general, the fixed to dynamic ratio of the channel is a function of the traffic load and would vary over time according to the offered load distribution estimations. In HCA strategy, different methods are followed for channel allocation to multimedia mobile calls.

The first method is, when a new call or a handoff call arrives to the Base Transceiver Station (BTS), the channels are allocated first in FCA strategy, if there is no free channels available in FCA, then channels are taken from DCA pool and allocated in DCA strategy, The second is, our proposed strategy, in which whenever a new call arrivals at the BTS, the channels are allocated in FCA, and for the handoff call arrivals channels are allocated in DCA strategy. The simplified model of our proposed HCA strategy is shown in Figure 1.

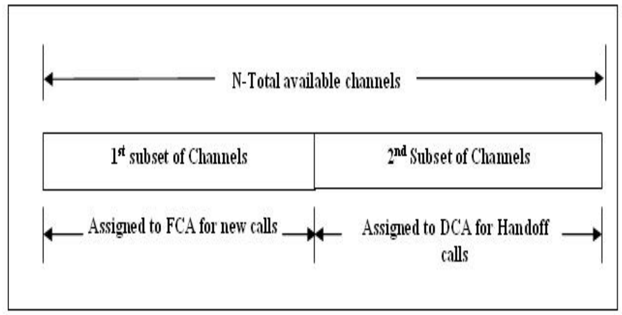

Figure 1. Channel Allocation in HCA Strategy

The first subset of channels is assigned to cell BTS, in FCA strategy for new calls, and the second subset of channels is assigned to the calls as DCA strategy for handoff calls. We consider FCA strategy for new calls because as far as new calls are considered delaying the call to provide the service or connection is better than blocking the call. But for handoff calls, providing continuous connection with minimum acceptable call quality is better than dropping a call in the middle of the service during handoff. Hence DCA strategy is proposed for handoff calls.

A.. Proposed HCA Strategy with Bandwidth Sharing Technique

The proposed hybrid channel allocation is shown in Figure 2. The bandwidth sharing analysis of multimedia call is presented in section 4. The flow chart shown in Figure 2 is self explanatory one. Whenever a new call arrives to BTS, the channels are allocated in fixed manner i.e. FCA method and for handoff call arrivals the channels are allocated dynamically i.e. DCA method. The fixed to dynamic ratio is the important factor and it varies according to the traffic conditions and cell site nature. All new and handoff calls are queued before channel allocation and then they are added. This gives the present traffic condition of a particular cell BTS.

B. Channel Allocation for New Calls and Handoff Calls in HCA Strategy

FCA method for new calls and DCA method for hand off calls in HCA strategy are shown in Figure 3 & 4 respectively. In the fixed channel allocation for new calls, if the BTS in the cell having channel capacity, then the call is accepted otherwise the call is blocked. In the dynamic channel allocation for handoff calls, the frequency reuse distance (D) and co-channel interference reduction factor (Q) are considered and then the channel is allocated to a call. In doing this both handoff reservation and handoff release calls are considered. If the above constrains are not satisfied, then the call is dropped. For handoff release calls the channel is released and kept in MSC or BSC pool for allocating channels to other handoff reservation requests.

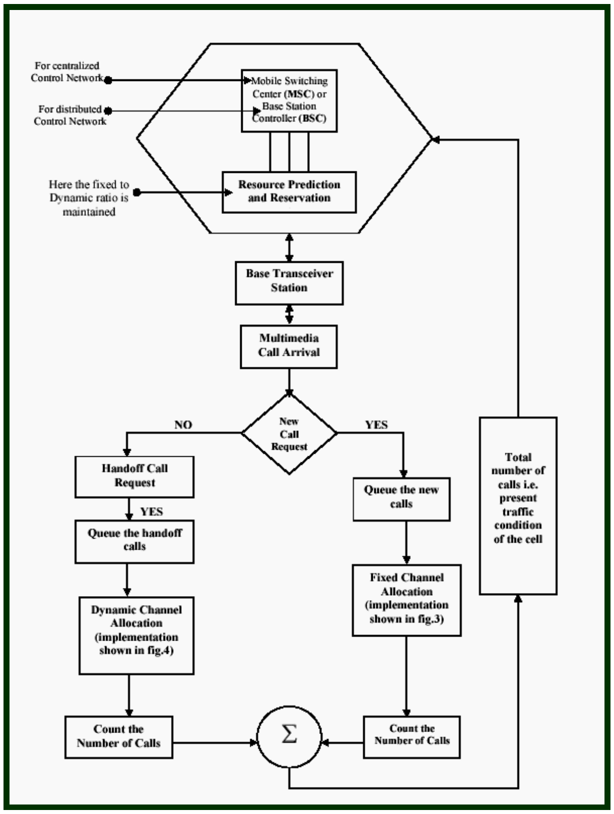

Figure 2. Proposed Hybrid Channel Allocation Strategy

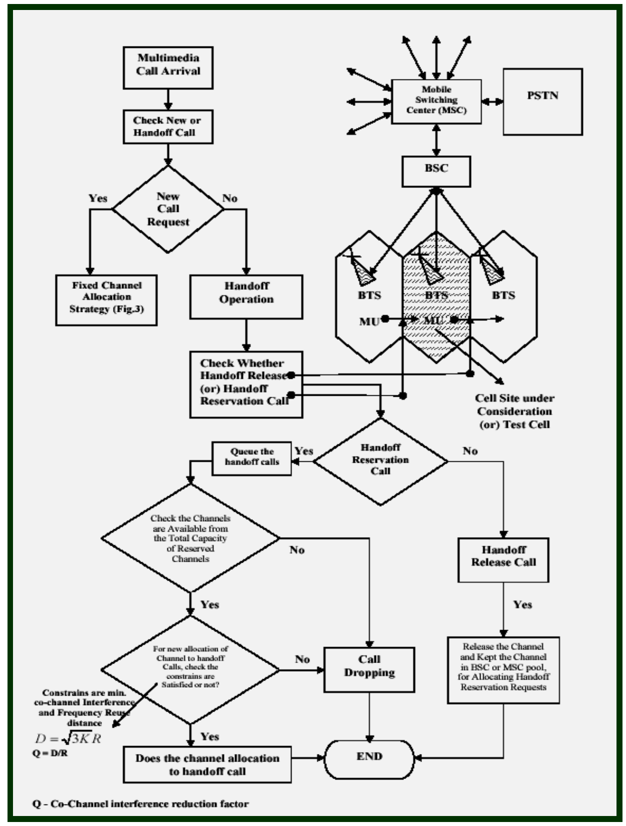

Figure 4. Dynamic Channel Allocation for Handoff Calls in HCA Strategy

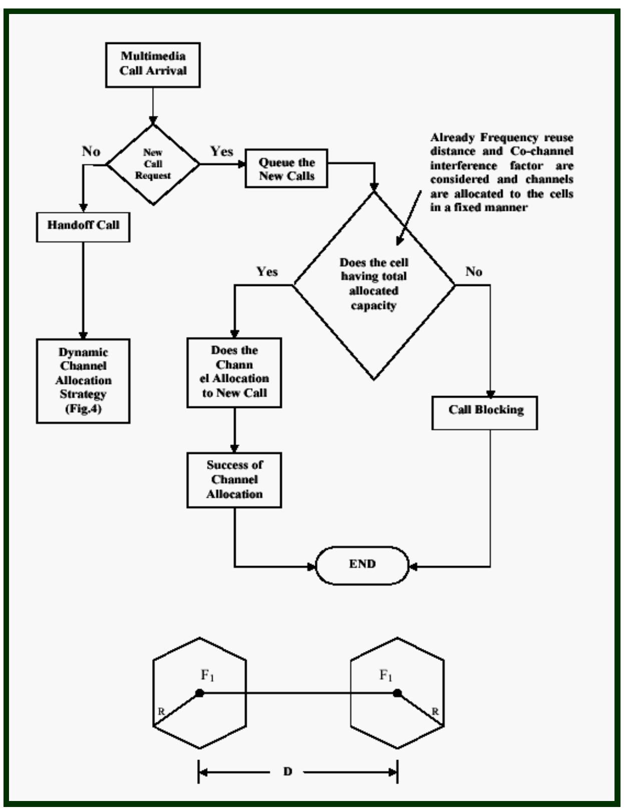

Figure 3. Fixed Channel Allocation for New Calls in HCA Strategy

IV. PROPOSED BANDWIDTH SHARING METHODOLOGY FOR MULTIMEDIA CALL

The demand for mobile multimedia networks is high. Handoff process is one of the most important and it occurs when a mobile unit (MU) moves from one cell to another cell. Suitable amount of Bandwidth should be allocated to the call of a MU in order to satisfy its QoS requirements. To satisfy the requirements of the MU for the communication quality, it is needed to control and modify the Bandwidth sharing according to the service class and the required QoS of the call.

In the proposed method, calls are considered as a collection of three-multimedia class calls. They are voice call of CBR class, and a low rate video call of CBR class and a high rate video call of VBR class. The first model, which is called model 1, consists of a voice call only. The application of a model 1 call is voice phone. Take the call as model 1 in a multimedia call. The second model (model 2) is a multimedia call, which consists of a voice call and a low rate video call. A videophone is an example of model 2. The final model (model 3) is a multimedia call having all the class including high rate video calls. Best example and application of model 3 call is videoconferencing, in which stored high rate video is distributed to attendees for the discussion. The voice call and the low rate video call are assumed to be voice and image, respectively, of the person attending the call. The high rate video call is taken as stored video of high quality, and it is assumed that the high rate video call (VBR call) has the minimum desired Bandwidth and the peak desired Bandwidth.

With videophone and videoconferencing, many persons can communicate with one another with voice and image. Generally, voice is essential for communication, i.e., an image without voice is of no use in videophone and videoconferencing. But voice without the image is useful for voice phone. Considering this feature, assume low rate video calls can be rejected according to the amount of available Bandwidth. That is, dropping the low rate video calls does not cause dropping the multimedia call, whereas dropping the voice call or high rate video call causes dropping the multimedia call. Normally, the high rate video call is a stored medium and the delay produced due to this call is not important compared with the voice call or the low rate video call and hence take the Bandwidth sharing to high rate video calls can be postponed.

A.. Bandwidth Sharing Methodology for New Call

For a new call, our method does not consider the priority of the class of a call and allocate the required bandwidth only when the amount of available bandwidth is equal to or greater than the maximum amount of required bandwidth of the new call.

The following assumptions are made in the below algorithm, let 'R_U' denote the used or utilized bandwidth, 'R_N' - the required bandwidth of a new call and 'R_T'- the threshold value of used or utilized bandwidth, which is used for estimating the admission conditions of a new call. let M[*y*] be the minimum and P[y] be the peak value of required bandwidth "y" of a model 3 call.

Bandwidth sharing algorithm for new call

IF new call arrival THEN
IF model 1 or model 2 THEN
IF $R_U + R_N \le R_T$ THEN
Admit the call and allocate the Bandwidth 'R_N'
ELSE/* $R_U + R_N > R_T$ */
Reject the call (call blocking)
ELSE/* model 3*/
IF $R_U + P(R_N) \le R_T$ THEN
Admit the call and allocate the Bandwidth $P[R_N]$
ELSE/* $R_U + P(R_N) > R_T$ */
Call blocking

B. Bandwidth Sharing Methodology for Handoff Call

For a handoff call, our method takes into the consideration of priority among the class of a call and restricts the bandwidth sharing according to the amount of available bandwidth. That is, when the desired bandwidth is not available, for a multimedia call it can reject the low rate video call and postpone the bandwidth sharing to high rate video call. Let 'HRV_P' be the required peak value of Bandwidth for a high rate video call. In the following algorithm, let 'R_H' be the bandwidth requested by the handoff call, 'R_{HV}' - Bandwidth requirement of a voice call in the handoff call and 'R_{HVL}' - total bandwidth requirement of the voice call and low rate video call in the handoff call. 'RC_{BS}' is the bandwidth capacity of a base station.

Bandwidth sharing algorithm for handoff call

IF arrival of a handoff call THEN
SWITCH (call model)
CASE model 1 or model 2 without low rate video call
IF $R_U + R_H \le RC_{BS}$ THEN
Admit the call and allocate the Bandwidth 'R_H'
ELSE/* $R_U + R_H > RC_{BS}$ */
Drop the call (call dropping)
CASE model 2 with low rate video call
IF $R_U + R_H \le RC_{BS}$ THEN
Admit the call and allocate the Bandwidth 'R_H'
ELSE/* $R_U + R_H > RC_{BS}$ */
IF $R_U + R_{HV} \le RC_{BS}$ THEN
Admit the call after rejecting low rate video and allocate the Bandwidth 'R_{HV}'
ELSE/* $R_U + R_{HV} > RC_{BS}$ */
Call dropping
CASE model 3 with low rate video call
IF $R_U + M[R_H] \le RC_{BS}$ THEN
Admit the call and share the required Bandwidth from RC_{BS}
ELSE /* $R_U + M[R_H] > RC_{BS}$ */
IF $R_U + R_{HVL} \le RC_{BS}$ THEN
Admit the call after Postpone the Bandwidth sharing to a high rate video and allocate the Bandwidth 'R_{HVL}'
ELSE/* $R_U + R_{HVL} > RC_{BS}$ */
IF $R_U + R_{HV} \le RC_{BS}$ THEN
Admit the call after Postpone the Bandwidth sharing to high rate video and rejecting the low rate video and allocate the Bandwidth 'R_{HV}'
ELSE/* $R_U + R_{HV} > RC_{BS}$ */
Call dropping
CASE model 3 without low rate video call
IF $R_U + M[R_H] \le RC_{BS}$ THEN
Admit the call and share the required Bandwidth from RC_{BS}
ELSE/* $R_U + M[R_H] > RC_{BS}$ */
IF $R_U + R_{HV} \le RC_{BS}$ THEN
Admit the call after Postpone the Bandwidth sharing to high rate video and allocate the Bandwidth 'R_{HV}'
ELSE/* $R_U + R_{HV} > RC_{BS}$ */
Call dropping

C. Bandwidth Sharing Methodology for a Postponed Call

Our proposed method can postpone the bandwidth sharing within a predetermined time interval to the class of a call. Let 'D_W'- be the time interval or time duration in which postponed call has to wait and 'D_M' - be the maximum possible time interval or time duration for sharing the available bandwidth. Take the bandwidth requirement of the postponed call as 'R_D'. The algorithm can be as shown below.

IF availability of Postponed call THEN
IF $D_W > D_M$ THEN
Drop the Postponed call and the corresponding multimedia call model (call dropped)
ELSE $D_W \le D_M$
IF $R_U + M[R_D] \le RC_{BS}$ THEN
Admit the Postponed call and share the required Bandwidth from RCBS
ELSE/* $R_U + M[R_D] > RC_{BS}$ */
Hold the Postponing operation of Bandwidth Sharing.

Table I. Bandwidth Requirements for Different Models of a Call

Model Of a call	*Class Of a call*	*Minimum Required Bandwidth*
Model 1.	CBR- Class voice call	16 kbps
Model 2.	CBR- Class voice Call & Low rate video Call	64 kbps
Model 3.	CBR- Class voice Call & Low rate video Call	64 kbps
	VBR- Class voice Call & high rate video Call	From 1.5 - 2.0 Mbps (peak Value) (minimum Value) = 0.7 x (peak Value)

V. SIMULATION MODEL AND PERFORMANCE EVALUATION

Proposed hybrid channel allocation strategy is shown in section 3. Bandwidth sharing of new calls and handoff calls is given in section 4. For simulation purpose, each cell having 78 channels and the call holding time of 101 seconds = 0.028 hours are taken. From the total available channels, the fixed to dynamic ratio of the channels is taken as 7 : 3 for new and handoff calls. For different multimedia call models, the bandwidth requirements are shown in Table 1. Various coding methods are used to code the multimedia calls. Here for voice call G.726 and for low rate video and high rate video calls H.261 and MPEG1 are taken respectively. The maximum required bandwidth (Peak Value) of a high rate video of VBR Class is taken as 2.0 Mbps, and it varies from 1.5Mbps to 2.0 Mbps. Generally the minimum required bandwidth of high rate video call is 70% of the peak or maximum value. If the new call initiated per second is taken as λ then λ_1, λ_2, λ_3 are the new calls of model 1, model 2 and model 3 respectively. For the purpose of simulation the new call arrival to the cell BTS per second is taken as 5-voice calls (model 1) 3-Low Rate Video (LRV) calls (model 2) and 1-High Rate Video (HRV)call (Model 3). Normally each base transceiver station has a bandwidth capacity of around 20 Mbps. For the purpose of simulation and comparison, a small amount of base transceiver station capacity is taken in this work.

A Without control method (WCM) is one, in which there is only one service class for each model, and there is no priority among the class of a call. Hence without control method shown in Figure.5. rejects the calls when the required bandwidth is not available in the base transceiver station irrespective of model and class of a call. Figure. 6 shows the bandwidth sharing of multimedia calls of model 1 & model 2 (i.e) for low rate video with voice of CBR class and high rate video with voice of VBR class calls. Here in our method, there is no Priority and class consideration for new multimedia calls and there is a consideration for priority and class for hand off multimedia calls. The handoff call bandwidth sharing is shown in Figure. 8. The call dropping probability comparison between proposed method and Without Control Method (WCM) are shown in Figure.9 & Figure 10.The Proposed Method (PM) does not consider the priority's among the classes of a call for new calls Bandwidth sharing, to provide QoS. The new call Bandwidth sharing is shown in Fig. 7. Since for new calls delaying a call to provide service is better than blocking a call. But for handoff calls, providing partial service to an ongoing call is better than dropping a call in the middle of the service.

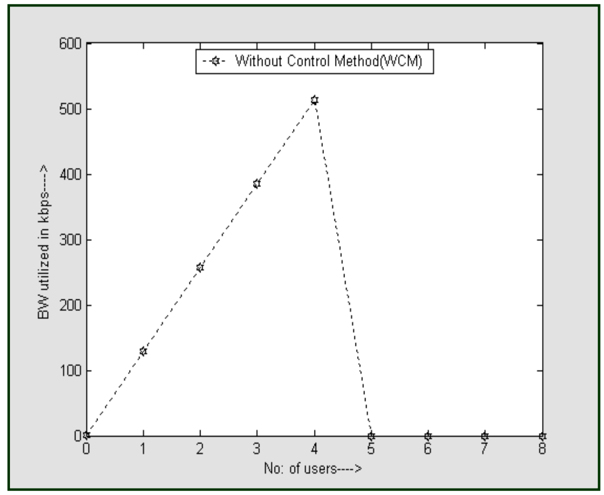

Figure 5. Multimedia Call Bandwidth Sharing Without Considering Classes of a Call (WCM Method)

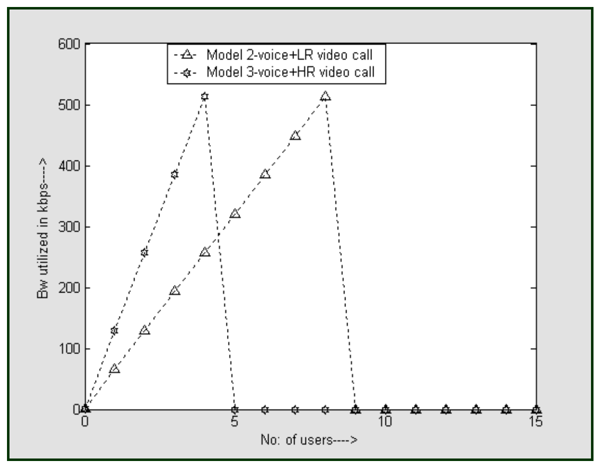

Figure 6. Multimedia Call Bandwidth Sharing For Low Rate Video with Voice Call and High Rate Video with Voice Call

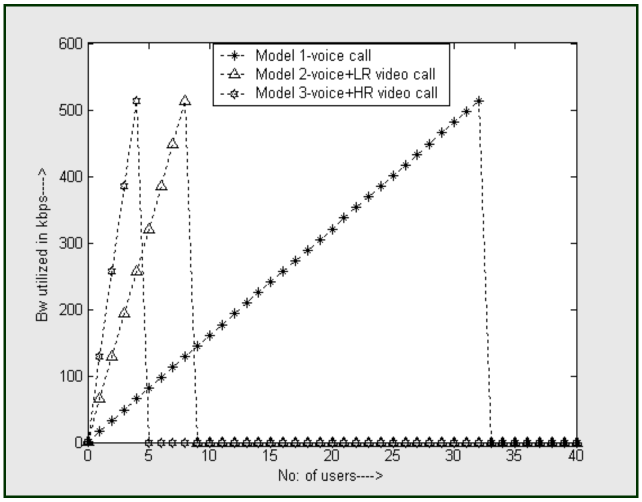

Figure 7. Multimedia Call Bandwidth Sharing for New Calls Without Considering Priority among Calls

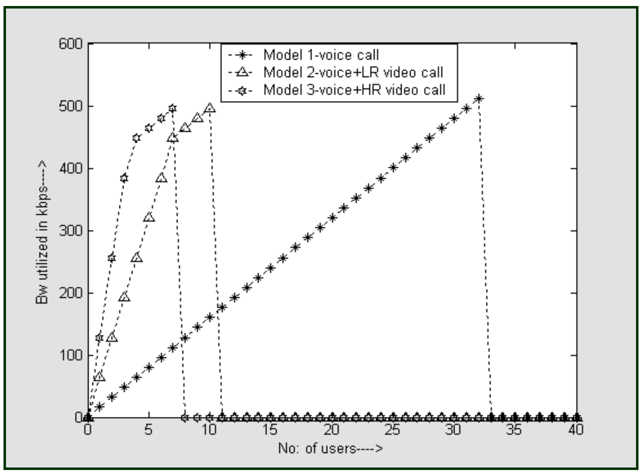

Figure 8. Multimedia Call Bandwidth Sharing For Handoff Call with Considering Priority among Calls

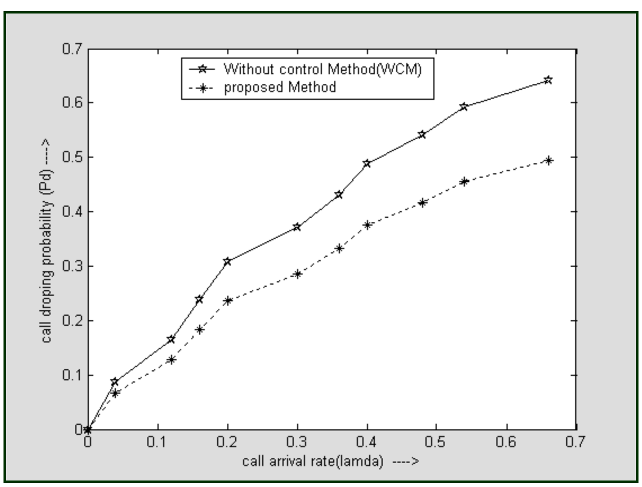

Figure 9. Call Dropping Probability Comparison between Proposed Method (PM) and Without Control Method (WCM) for model 2 calls

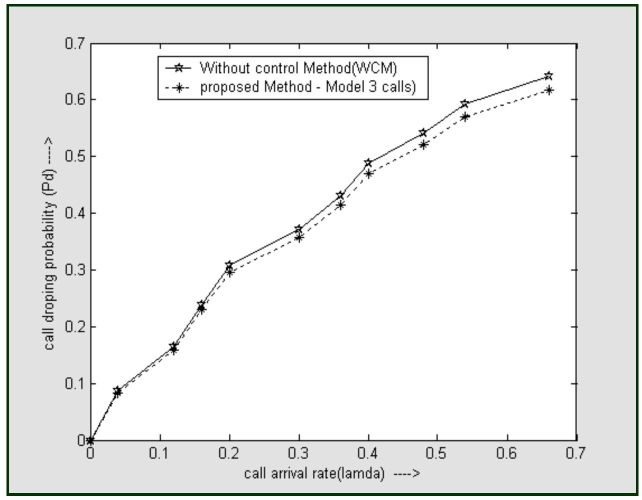

Figure 10. Call Dropping Probability Comparison between Proposed Method (PM) and Without Control Method (WCM) for model 3 calls

To compare the CDP between without control method(WCM) and proposed method, take model 2 and model 3 calls bandwidth sharing. The proposed method has better CDP performance than WCM, because rejecting a low rate video call can improve the CDP of model 2. But for model 3 calls a low rate video call is also included. Hence the CDP of model3 is not so different from WCM. This is because; the bandwidth requirement of low rate video call is much smaller than the required bandwidth of model 3 calls (High rate video of VBR class calls). This ensures that the required bandwidth of model 3 call does not change greatly even if the low rate video call is rejected. Allowing model 2 calls whose class of a call is rejected may cause the increase in number of call droppings of model 1. If we consider only model 1 calls in the handoff process our proposed method gives better performance than the without control method (WCM).

VI. CONCLUSION

The main aim of our work is to introduce an effective channel allocation strategy with bandwidth sharing technique for multimedia handoff calls in wireless cellular mobile networks. Wireless mobile networks will support multimedia traffic hence quality of service is very important one. Normally in wireless environment, QoS is very complicated one because of handoff calls and mobility of the mobile users. In our work an effective QoS methodology is utilized for bandwidth sharing of multimedia handoff calls. The results obtained from simulation shows, the communication quality of multimedia handoff calls are reasonably improved by considering class of a call and their priority.

VII. REFERENCES

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