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BANDWIDTH ADAPTATION FOR JOINT CALL ADMISSION CONTROL TO SUPPORT QOS IN HETEROGENEOUS NETWORKS

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Abstract: Call admission control (CAC) is one of the basic mechanisms which are used in the wireless networks for ensuring high quality of service (QoS) offered to the users. A bandwidth adaptation technique has been proposed for the Adaptive Joint CAC (AJCAC) algorithm, solution of congestion, where it degrades the basic bandwidth units of some ongoing users to make space for new incoming ones. Similarly a restoration process takes place when the network is underutilized and underperformed, where the algorithm restores the maximum bandwidth service to the degraded users. As the degradation in the bandwidth increases, the adaption required in the network also goes up and vise-versa. The drawback with this algorithm is that it is applicable only with homogeneous terminals. The presence of heterogeneous network leads to the necessity of multi-mode terminals i.e. single mode, dual mode, triple mode, quad mode etc. To overcome this issue of unfair allocation of radio resources (RRM), a terminal modality based joint call admission control (TJCAC) algorithm has been proposed and the resultant effect on call blocking and call dropping probabilities in the networks has been evaluated.

Keywords : Bandwidth adaption, Call admission control, QoS degradation, QoS restoration, congestion**.**

1. INTRODUCTION

The main objective of this paper is to analyze the call blocking and handoff probability in heterogeneous networks when the terminals are homogeneous and heterogeneous terminals using the AJCAC (Adaptive Joint Call Admission Control) and TJCAC (Terminal Joint Call Admission Control) and to generate results for them where different scenarios are compared to make sure that the WLAN can work to its best efficiency. The AJCAC algorithm degrades the bandwidth of some ongoing users to make room for new incoming ones so that new users can be included whenever there are new calls or handoffs call. A restoration process must take place when the network is underutilized and it restores the maximum bandwidth service to the degraded users, where the algorithm restores the maximum bandwidth service to the degraded users. When the terminals are heterogeneous the major drawback is the unfairness in allocation of radio resources among heterogeneous mobile terminals in heterogeneous wireless networks. Low-capability mobile terminals (such as single-mode terminals) suffer high call blocking probability whereas high-capability mobile terminals (such as quad-mode terminals) experience very low call blocking probability in the same heterogeneous wireless network. To overcome this problem TJCAC algorithm has been introduced which analyze the network at different subscription rate of these terminals and give the graphical analysis for blocking and handoff probability.

2. BACKGROUND

(a) Bandwidth Adaptation for Joint Call Admission Control to Support QoS in Heterogeneous Networks Call admission control (CAC) is one of the basic mechanisms for ensuring high quality of service (QoS) offered to the user in Wireless Networks. Based on the available network resources, it estimates

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the impact of accepting or blocking a new session request. Many CAC algorithms have been proposed in the literature but they were all limited by the available bandwidth. This paper proposes a bandwidth adaptation technique for the Adaptive Joint CAC (AJCAC) algorithm; it is proposed as a solution for congestion; where the AJCAC algorithm degrades the bandwidth of some ongoing users to make room for new incoming ones. A restoration process must take place when the network is underutilized; where the algorithm restores the maximum bandwidth service to the degraded users[1]-[4]. In this paper the bandwidth degradation process was investigated and evaluated. The results showed that as the degradation in the bandwidth increases, the adaption required in the network also increases. On the other hand, degradation in the QoS results in decreasing the blocking probability.

(b) Admission Control for QoS Support in Heterogeneous 4G wireless networks admission control plays a very important role in wireless systems, as it is one of the basic mechanisms for ensuring the quality of service offered to users. Based on the available network resources, it estimates the impact of adding or dropping a new session request. In both 2G and 3G systems, admission control refers to a single network. As we are moving towards heterogeneous wireless networks referred to as systems beyond 3G or 4G, admission control will need to deal with many heterogeneous networks and admit new sessions to a network that is most appropriate to supply the requested QoS [2]-[5]. In this article we present the fundamentals of access-network-based admission control, an overview of the existing admission control algorithms for 2G and 3G networks, and finally give the design of a new admission control algorithm suitable for future 4G networks.

III. ADAPTIVE JOINT CALL ADMISSION CONTROL (AJCAC)

In this system model, servers have been considered with no waiting room. Calls arrive in a Poisson process with rate λ. The service time of each call has an exponential distribution with mean 1/μ. Calls that arrive when all servers are busy are blocked and lost, so the system considered is a loss system. The state of the system is defined by the number of calls present in the system. The state space is finite and it follows a birth-and-death process. The blocking probability of the CAC algorithms is calculated using the Erlang-B formula or Erlang's loss formula;

$$Ps = \frac{\left(\frac{\alpha}{s_j}\right)}{\sum_{j=0}^{s}\left(\frac{\alpha J}{J_j}\right)}$$

The system model considers two different coexisting RATs, example of possible RATs are cellular global system for mobile communications (GSM), General Packet Radio Service (GPRS), Universal Mobile Telecommunications System (UMTS) or wireless local area networks (WLANs).The system considers a complete partitioning policy where the entire available bandwidth of the two different coexisting RATs is partitioned into pools. Each pool is dedicated to a particular traffic class of calls [4]-[8]. Two types of call classes have also been considered: calls class 1 (voice) and call class 2 (video), both having a service time μ = 0.5. Both RATs are capable of serving the two types of calls but with different percentages. Let the total number of BBU available for call class 1 be 30 and that for call class 2 be 60 as shown in Table1. Each class of call has two possible basic bandwidth units (BBu), maximum bandwidth unit (BBumax) and minimum bandwidth unit (BBumin). Table 2 shows the min and max BB for each class of calls and call class 2(video calls) with max BBu 7 and min BBu 3.

Table 1.
Partition Bandwidth-In BBU Unit-For AJCAC

	(Calls Class 1)	*(Calls Class 2)*	*Bandwidth of RAT*
RAT 1 Bandwidth	25	5	30
RAT 1 Bandwidth	5	55	60
Total Bandwidth of Partition	30	60	N/A

Table 2.
Basic Bandwidth Units BBU

Basic Bandwidth Unit BBu	*Calls Class 1 (Voice)*	*Calls Class 2 (Video)*
BBu_{max}	2	7
BBu_{min}	1	3

Since the partition of calls class 2 is of size 60 BBu, and has a maximum BBu of 7, this provides the RAT partition with 8 maximum BBu channels and 4 extra unused BBus. Using an Adaption Threshold of 75% provides 6 channels where each channel is assumed to serve one call (75% of 8 channels = 6). When the traffic exceeded 75% of the maximum bandwidth, one channel will be degraded from 7 BBumax to 3 BBumin releasing 4 BBu. Using these released BBus together with the 4 extra unused BBus a new channel of 7 BBu is created, leaving one extra BBu unused in this stage. This process is repeated until there are no more channels to degrade. At the end of the adaption process 4 new channels with BBumax are created. The network now has a total of 12 channels instead of only 8 channels. The adaption produced 50% extra channels to the network.

4. RESTORATION PROCESS

The restoration process must take place when the network is underutilized, where the algorithm restores the maximum bandwidth service to the degraded users. In this case study, restoration thresholds at 75% was evaluated to examine the reallocation of the BBu back to the channels. The restoration thresholds used for calls class 2 is 75% The restoration process for calls class 2 when a threshold of 75% has been examined. The calls are upgraded from 3 BBumin to 7 BBumax (75% *12 total channels = 9 channels). When the traffic is below 75% of the total bandwidth one adapted channel is released (releasing 7 BBu). Three BBu of the released 7 BBu are used to upgrade one current call from 3 BBumin to 7 BBumax the remaining 3 BBus are used in the next stage as shown in Table 3. The process continues until all adapted channels are released. At the end of the restoration process the network would have its 8 original maximum-bandwidth channels. the optimal restoration threshold for calls class 2 is around 75%. This threshold provides both low blocking probabilities and good restoration percentage.

5. DEGRADATION PROCESS

The model and the process of degrading the QoS during the adaption process for calls class 2 is investigated. The BBumin was varied while the BBumax remained fixed. Fig.4 evaluates the blocking probability with varyingBBumin while the BBu max remains fixed. A lower minimum bandwidth BBumin value results in a poorer QoS for ongoing calls. Ongoing calls will release most of its bandwidth during the adaption process to make space for incoming calls. This also results in a lower blocking probability which is desired by the service provider.

Table 3.
Maximum and minimum bandwidth values

Parameter	*Value (BBu)*
BBu_{max}	7
BBu_{min}	3
	4
	5

On the other hand a higher minimum bandwidth BBumin value results in a more convenient QoS for ongoing calls. Ongoing calls in this case will release only a small portion of their bandwidth to free space for new incoming calls.

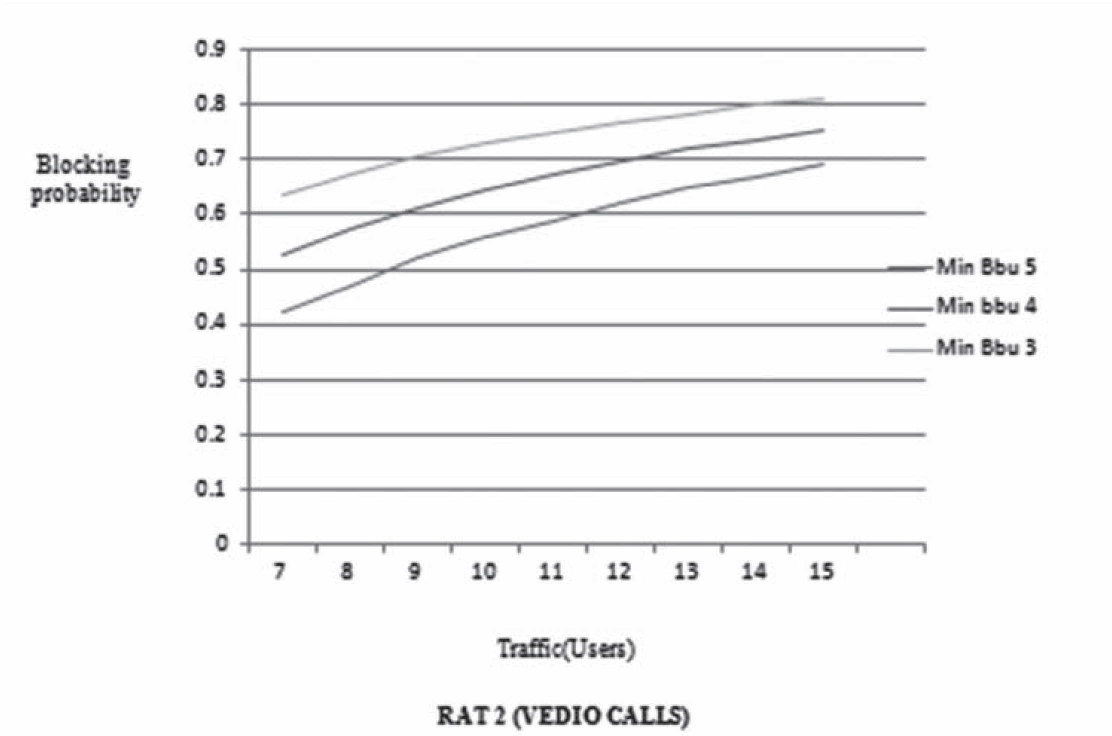

Figure 1. Blocking probability vs Traffic for RAT 2 video calls

This results in a higher blocking probability which is not desired by the service provider. Hence when BBu min is 4 the user can relate best for its use After modeling and evaluating the result for call class 2 , audio calls which are call class 1 has been evaluated where BBUmax has been set up as 2 and BBUmin has been has setup as 1,2.

Table 4.
Different values of BBUs

Parameter	*Value (BBu)*
BBu_{max}	2
BBu_{min}	1,2

With the following values given in table 4, the earlang b formula has been applied and the blocking probability corresponding to different traffic signals was evaluated. Later the two systems were compared given in Fig.2 and the most favorable system was chosen.

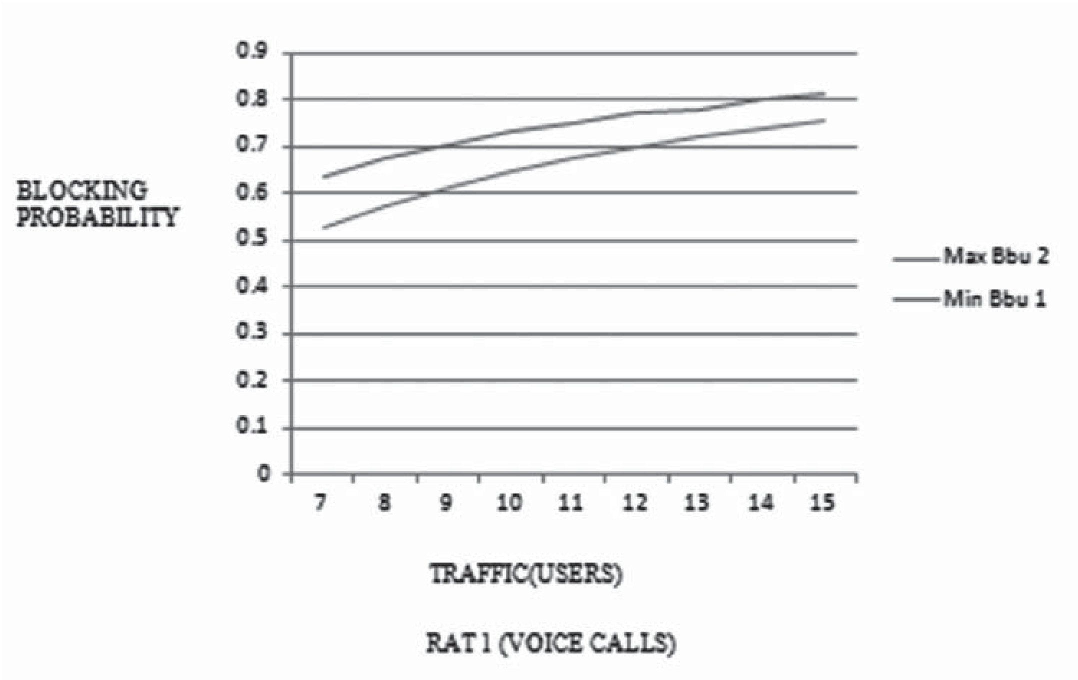

Figure 2. Blocking probability vs Traffic for RAT1audio Calls

A lower minimum bandwidth BBumin value results in a poorer QoS for ongoing calls. Ongoing calls will release most of its bandwidth during the adaption process to make space for incoming calls. This also results in a lower blocking probability which is desired by the service provider. On the other hand, a higher minimum bandwidth BBumin value results in a more convenient QoS for ongoing calls. Ongoing calls in this case will release only a small portion of their bandwidth to free space for new incoming calls. This results in a higher blocking probability which is not desired by the service provider.

6. MODELING

(a) ***Mathematical modeling for TJCAC (Terminal Joint Call Admission Control):*** We consider heterogeneous mobile terminals ranging from single-mode terminals to J -mode terminals, where J is the total number of RATs in the heterogeneous wireless network. The heterogeneous terminals can be broadly categorized into J groups based on the number of RATs supported by each terminal. For example, in a three-RAT heterogeneous wireless network, there will be a maximum of three categories of mobile terminals namely: 1-mode (single mode), 2-mode (dual-mode), and 3-mode (triple-mode) terminals. This categorization is based on the number of usable network interfaces possessed by each terminal in the heterogeneous network.For instance, a 4-mode (quad-mode) terminal in a three-RAT heterogeneous wireless network will have a maximum of three usable interfaces in the heterogeneous network because there is a maximum of three RATs available. Therefore, the 4-mode terminal will be categorized as a 3-modeterminal in a three-RAT heterogeneous network provided all the three-RATs are supported by the terminal. The fore going implies that in a J -RAT heterogeneous wireless network, a subscriber’s terminal can only have a maximum of J usable interfaces (J -mode terminals).

(b) ***Markov Model:*** A markov process is memory less process .Any process can be modeled as markov process if predictions for the future can be made based solely on its present state. A stochastic process that is defined using a separate argument can be mathematically shown to have the markov property . One can process any model in markov, and consider it as the bases for a construction. In modeling processes this is one of the simple ways of introducing statistically dependence into a model for a stochastic process. Markov chain is a random process with a markov property. A markov process with the discrete (finite or countable) state space is called as markov chain . Usually a markov chain is defined for a discrete set of times. A discrete time random process of a system is that it is in a certain state at each step and the state changes randomly between steps. The steps can be moments in time, physical distance or any other discreet measurement. The distance may be integers or natural numbers, and the random process is a mapping of these two steps or state. The markov property states that the conditional probability distribution of the system for the next state and all future states depend only on the current state of the system and not on the state of the system at previous steps.

7. RESULTS

The proposed model has been implemented using MATLAB to analyze the blocking probability in the homogenous and heterogeneous terminals of the heterogeneous networks and to find the blocking probability of each RAT using the Markov Model.

7.1 Video Calls

The table given below contains the value of max BBu , the channel can accommodate and it's relation when BBu min is varying .

Table 5.
BBu Distribution

Parameter	*Value (BBu)*
BBu_{max}	7
BBu_{min}	3
	4
	5

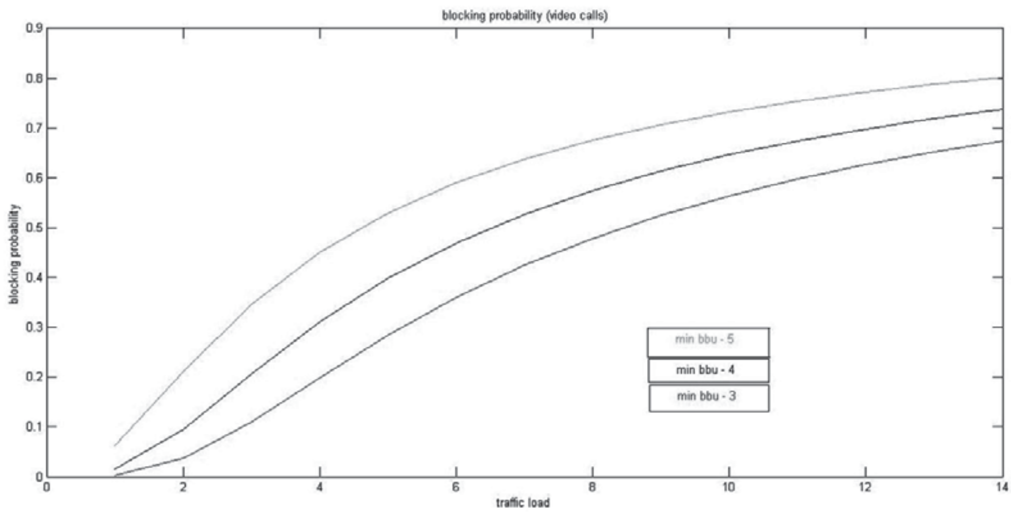

Figure 3. Blocking probability vs Traffic for RAT 2 video Calls

Figure 3 demonstrates the different aspects used in choosing an optimal value for the BBumin. A lower minimum bandwidth BBumin value results in a poorer QoS for ongoing calls. Ongoing calls releases bandwidth for new calls which results in lower blocking probability as shown in fig when min BBu is 3. But when min BBu is 5 ongoing calls releases just some BBu for new calls. This results in a higher blocking probability. The best case would be when min BBu is 4, everything is balanced.

7.2 Audio Calls

The similar analysis has been done for audio calls too , where there max BBu has been set up as 2 and the minimum BBu is varying 1 and 2.

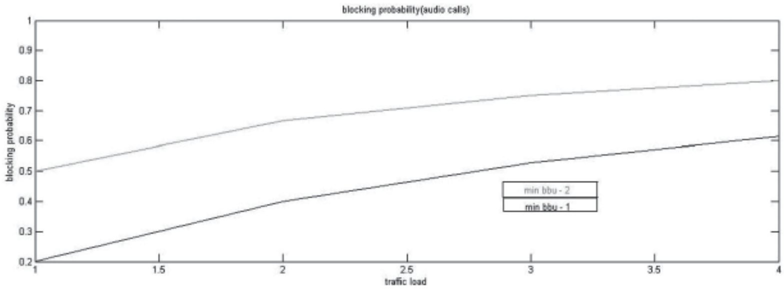

Figure 4. Blocking probability vs Traffic for RAT 1 audio Calls

When min BBu is 1, call dropping probability is low means it releases more BBu for incoming calls but the quality of services degrades but in the case of min BBu 2 the call quality is good but the blocking probability is high. This analysis helps the service providers to decide which part they want to focus on.

Table 6.
Rate of Subscription

Scenario	*Subscribers using 1-modes terminals (%)*	*Subscribers using 2-modes terminals (%)*	*Subscribers using 3-modes terminals (%)*
1	100	0	0
2	0	100	0
3	0	0	100
4	33.33	33.33	33.33
5	50	50	0
6	50	0	50
7	0	50	50
8	50	25	25
9	25	50	25
10	25	25	50
11	75	25	0
12	75	0	25
13	25	75	0
14	25	0	75
15	0	75	25
16	0	25	75

The Fig.5 shows the different blocking probabilities at different rate of subscription given in the table 5. It contains the level of subscription of single mode , dual mode ,and triple mode simultaneously .This graph analysis helps us to decide which will the best combination of subscription so it allows minimum blocking probability. The Fig. 5 above shows the best rate of subscribers for minimum blocking probability would be single mode 75%, dual mode 25 %, triple mode 0.

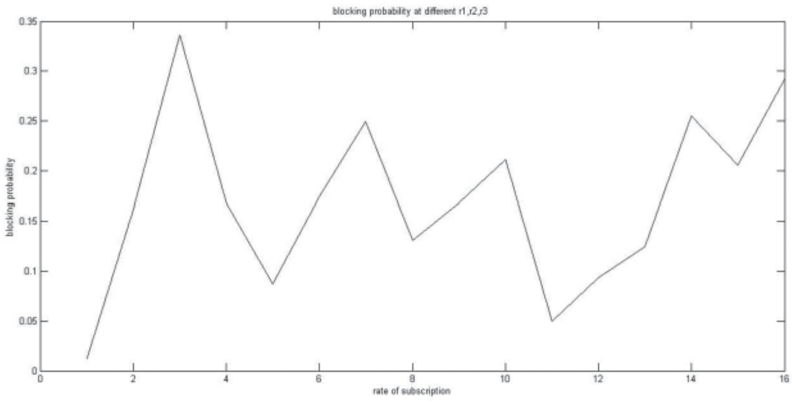

Figure 5. Blocking Probability at Different Rate of Subscription

7.3 Markov Model

Table 7.
Splitting of an incoming call with a bandwidth requirement of 8

Scenario	*Incoming bandwidth*	*Splitting*
5	8	4:4
6	8	5:3
7	8	6:2
8	8	7:1
9	8	No splitting

Assumptions:

BBU of Class-1 calls (b1) =8

BBU of Class-2 calls (b2) =3

Handoff Threshold (Cj) = 35

Newcall Threshold (Toj) = 28 (Since, Toj=0.8*Cj)

The incoming new/handoff call is considered as a class1 call with 6 bbu. The session splitting is implemented on the incoming call and the result of the blocking/dropping probability for the new call/handoff call is compared with the blocking/dropping probability of the call without session splitting. The result is summarized to get a clear view of the effect of session splitting on NCBP and HCDP of class-1 calls.

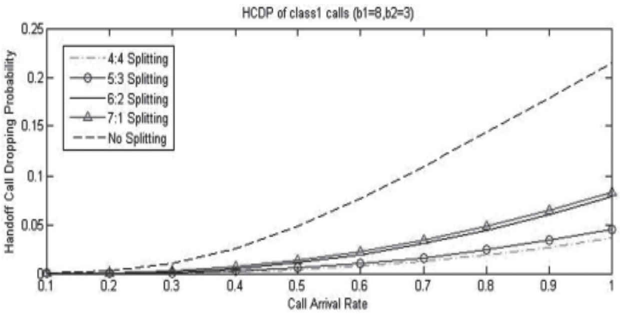

Figure 6. Variation of NCBP, b1 = 8 b2 = 3

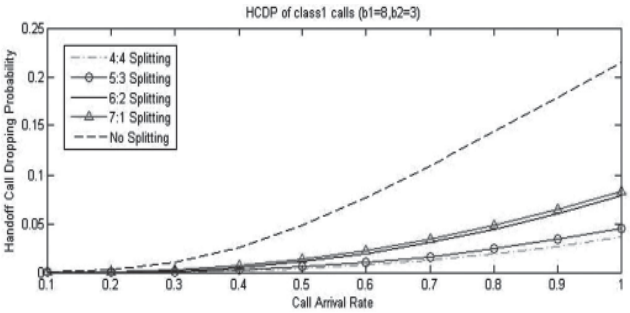

Figure 7. Variation of HCDP, b1 = 8 b2 = 3

Based on the obtained results, the NCBP (Pb1) and HCDP (Pd1) increases with increase in call arrival rate for the 9 scenarios. However, the Pb1 and Pd1 of scenarios 1-3 and 5–8 are much less than the Pb1 of scenarios 1 and 9 respectively. Thus, layer splitting reduces NCBP and HCDP in heterogeneous wireless networks.

6. CONCLUSION

A bandwidth adaptation technique for the Adaptive Joint CAC (AJCAC) is proposed when the terminals are homogeneous and similarly the Terminal – modality based Joint Call Admission Control (TJCAC) has been introduced when the terminals are heterogeneous. The main objective of the proposed Joint Call Admission Control algorithm is to ensure that there is fairness in radio resources allocation among the heterogeneous mobile networks. , the concept of session splitting via multiple RATs (here two RATs) to reduce call dropping/blocking probability has been implemented using MATLAB simulation and the result has been used to analyze the best splitting ratio for different scenarios The algorithm uses multiple RAT selection and splitting of scalable call to reduce call blocking/dropping probability in heterogeneous wireless networks. An analytical model has been developed for the proposed JCAC scheme and two performance metrics namely call blocking probability and call dropping probability have been derived. Simulation results show that the proposed JCAC scheme reduces call blocking/dropping probability for both new and handoff calls in heterogeneous wireless networks.

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