Radio Resource Management in CDMA 4G Networks, Based on Mutual Frequency Assignment

Alam N. Shaikh†, and Dr. S. K. Bodhe††

Research Scholar, NMIMS, HOD, Dept. of EXTC, DRIEMS, Mumbai, INDIA
Principal, College of Engineering, Pandharpur, INDIA

Summary
As 3G is launched and 4G is about to launch, there is incessant growth in number of mobile users. [1], [2].We telescope cell size to swell system capacity. Handoff rate is increased by contract cell size. To surmount these tribulations, mutual frequency assignment (MFA) is proposed. Because efficient use of radio resources is very important, utilization of all resources have to be maximized. Thus, in mutual frequency assignment, how to assign available radio resources to each user is significant question. Hitherto, several studies have been made on static radio resource management in CDMA. Nevertheless, in order to adapt to changes of traffic, it is necessary to consider adaptive radio resource management. Thus, in this study, we propose an adaptive radio resource management in CDMA. The performance of proposed scheme is evaluated by means of matlab simulation. The results show that proposed scheme improves call blocking, call dropping and utilization of radio resource compared with conventional schemes.

Keywords:
Mutual frequency Assignment; Common Frequency Assignment; FBRA ; HCS.

1.Introduction

For scores of years, there has been rapid swell in the number of mobile users. Though CDMA system is able to provide large Capacity compared with other systems, other methods to satisfy with this increase are needed. Sectorization and microcell concept are the most universally used methods for capacity increase. But annoyance of these methods is to increase the number of handoff. So, mutual frequency assignment (MFA) has been proposed in order to overcome these problems [16]. In hierarchical cellular system, because mobile users select appropriate cell layer in accordance with their speed, increase in handoff by fast users, who select macrocell with large cell size, is solved and capacity is increased by lessening cell size for low speed users [16], [18]. In this paper, we have studied three schemes: Scheme 1: Radio Resource Management using teletraffic modeling. (Passive) [19].Scheme 2: Variable Threshold Velocity Scheme. Scheme 3: Frequency Borrowing Resource Allocation. After studying three schemes, new scheme, Mutual Frequency Assignment (MFA) is developed. Hierarchical Cell Structures with Adaptive Radio Resource Management. Spectrum allocation is very important. There is problem if each layer uses its own radio frequency. Because available spectrum is inadequate in HCS (hierarchical cellular system), load balancing or resource sharing is needed in order to avert each layer from being overloaded. So far, several studies have been made on static radio resource management in hierarchical cell structure [4], [4]. It is necessary to consider adaptive resource management in order to adapt to changes of traffic. Load of each layer in hierarchical cellular system can be balanced by controlling threshold velocity by which appropriate cell layer is selected [5]. And a resource which can be shared between layers in CDMA based HCS is only FA (Frequency Assignment) [6]. Load of each layer is balanced by changing threshold velocity according to traffic condition, but when several adjacent microcells are overloaded in rush-hour, overload of those cells can't be solved because macrocell doesn't have enough resources to serve all overflowed mobile users. In order to overcome this problem, FBRA (Frequency Borrowing Resource Allocation) scheme is proposed in [6], The IMT-2000 system uses a microcell with diameter of a few hundred meters. we can increase the system capacity using such a microcell. on the other hand, in a microcell system, the number of handoffs increases significantly and the traffic load distribution is nonuniform. The hierarchical cellular structure, which consists of microcell clusters superimposed on a macrocell, can solve this handoff problem. In this hierarchical structure, high speed mobile terminals are serviced in the macrocell while low speed mobile terminals are serviced in the microcells to minimize the number of handoffs.

Few steps of traffic handling in hierarchical cell architectures are discussed here.

- In idle mode, cell selection and reselection of mobile stations for camping on a cell may be speed sensitive or insensitive
- A speed-sensitive handoff algorithm uses the estimated mean speed of the mobile station to decide on the target Cell layer where the call has to be handed off. Thus, in this cram we would like to propose an mutual frequency assignment scheme in CDMA based HCS by which overload of each layer can be solved. The performance of proposed scheme

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is evaluated by means of matlab simulation and the results show that our proposed scheme improves call blocking, call dropping and utilization of radio resource compared with other schemes. This paper is structured as follows. Section II illustrates numerous adaptive radio resource management schemes which can used in CDMA based HCS. Section III presents a new mutual frequency assignment scheme. In Section IV, we discuss the performance of our scheme and in Section V, we would make a conclusion.

2. Adaptive radio resource Management in HCS

It is necessary to balance loads of each layer and share resources in CDMA.

2.1. Scheme 1: Passive Radio Resource Management

In this scheme, mobile users select layer in accordance with their speed, and both threshold velocity and the number of FA in each layer are designed based on the estimation of traffic load of each layer. If load of some layers is larger than estimated load, many calls are blocked or dropped. In this case, if overflow of new calls and handoff calls, and take-back mechanism are used, performance can be improved [1] , but those schemes cannot adapt to dynamic changes of traffic. So, operator needs to assign enough FAs to solve unexpected overload. In this case, radio resource allocation scheme is very simple but utilization of resource is decreased. When we consider the same number of FA as other schemes, the worst performance is expected. That is, in our paper, this scheme is not considered as one of adaptive radio resource management schemes, but is considered as reference scheme. The operation of the system can be demonstrated as follows (refer Fig. 1).

- A new call generated by a slow mobile station is first directed to the camped-on microcell. If the number of traffic channels in use in the microcells equal to, this new call may be overflowed to the overlaying macrocell. A new call generated by a fast mobile station is first directed to the camped on macrocell. If the number of traffic channels in use in the macrocell is equal to this new call may be overflowed to that overlaid microcell which provides radio coverage to the mobile station. This new call will be served by the microcell if the number of traffic channels occupied in this microcell is otherwise, it will be lost.
- A handoff request of a slow mobile station is first directed to the target microcell independent of whether the current serving cell is a neighboring microcell or an overlaying macrocell. If all traffic channels in the target microcell are busy, the handoff request may be overflowed to the overlaying macrocell.

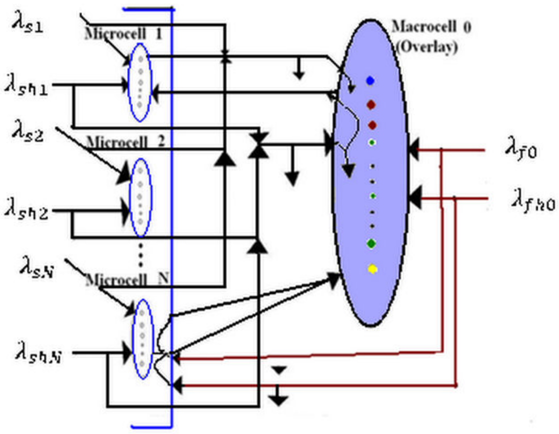


Fig. 1. Hierarchical Cell: Flow of new and handoff traffic, their overflow, and take-back traffic.

- A handoff request of a fast mobile station is first directed to the target macrocell independent of whether the current serving cell is a neighboring macrocell or a neighboring microcell. If all traffic channels in the target macrocell are busy, the handoff request may be overflowed to the neighboring microcell, which will provide radio coverage for the mobile station. The overflowed handoff request will be served by the microcell if there is any idle traffic channel; otherwise, the handoff request will fail and the call will be forced to terminate (dropped).
- While a slow mobile station is roaming within a macro ell, it monitors continuously the microcell it is traversing. If this slow mobile station is engaged in a new or handoff call that has been successfully overflowed to the macrocell, a take-back request is directed to the entered target microcell at each border crossing of a microcell. This take-back request will be accommodated by the target microcell if there is any idle traffic channel in the microcell. If all traffic channels in the target microcell are busy, the slow mobile station will continue to be served in the macrocell. This algorithm makes the simplifying as summation that the take-back process, normally expected to take place as soon as a channel in the microcell becomes available, is delayed until microcell border crossings.
- If a fast mobile station is engaged in a new or handoff call that has been successfully overflowed to a microcell, a take-back request is directed to the overlaying macrocell at the border crossing of the microcell. This take-back

request will be accommodated by the target macrocell if there is any idle traffic channel in the macrocell. If all traffic channels in the target macrocell are busy, the fast mobile station initiates a handoff request to a neighboring microcell, which will provide radio coverage. This algorithm takes into account the practical considerations on the use of handoff and delays the take-back process until the border-crossing epochs (as opposed to whenever a channel in the microcell becomes available). This reasonable simplifying assumption renders a tractable solution. In our system, all microcells of the lower cell layer are treated equivalently to simplify the understanding of the overflow and take-back mechanisms.

2.1.1 .Performance Measures

1) The handoff probability of calls of slow and fast mobile stations in a macrocell is given by [2]

$$P_{h0} = \frac{n_0}{\mu + n_0}$$
$$P'_{h0} = \frac{n'_0}{\mu + n'_0} \quad (1)$$

2) The session duration of slow and fast mobile stations in macrocell is given by

$$\frac{1}{\mu_0} = \frac{1}{\mu + n_0}$$
$$\frac{1}{\mu'_0} = \frac{1}{\mu + n'_0} \quad (2)$$

Correspondingly, in a microcell, we can write,

$$n_1 = \frac{2V_s}{\pi r_1}$$
$$n'_1 = \frac{2V_f}{\pi r_1} = n_1 \frac{V_f}{V_s} \quad (3)$$

3) The aggregate traffic rate into a microcell due to slow mobile stations is as follows:

$$\lambda_{t1} = \lambda_{s1} + \lambda_{sh1} + \lambda_{sb1} \quad (4)$$

4) The take-back traffic rate component is given as

$$\lambda_{sb1} = (\lambda_{s1} + \lambda_{sh1} + \lambda_{sb1})P_{b1}(1 - p_{b0})\zeta_n \quad (5)$$

5) The aggregate traffic rate into a microcell due to fast mobile stations is given as

$$\lambda'_{t1} = \frac{1}{N}(\lambda_{f0} + \lambda_{fh0} + \lambda_{fb0})P_{b0} + \lambda'_{fh1} \quad (6)$$

6) The generation rate of slow mobile stations handoff traffic in a microcell is as follows:

$$\lambda_{sh1} = P_{h1}(\lambda_{s1} + \lambda_{sh1} + \lambda_{sb1})(1 - p_{b1}) \quad (7)$$

7) The generation rate of fast mobile stations' handoff traffic in a microcell is as follows:

$$\lambda'_{fh1} = P'_{h1}\left\{\frac{1}{N}[\lambda_{f0} + \lambda_{fh0} + \lambda_{fb0}]P_{b0}(1 - pb1 + \lambda'fh11 - pb1 \quad (8)$$

8) The aggregate traffic rate due to fast mobile stations into a macrocell is as follows:

$$\lambda_{t0} = \lambda_{f0} + \lambda_{fh0} + \lambda_{fb0} \quad (9)$$

9) The take-back traffic rate component is given as:

$$\lambda_{fb0} = (\lambda_{f0} + \lambda_{fb0} + \lambda_{fh0})P_{b0}(1 - p_{b1})\zeta_f \quad (10)$$

10) The aggregate traffic rate due to slow mobile stations into a macrocell is given as :

$$\lambda'_{t0} = N(\lambda_{s1} + \lambda_{sh1} + \lambda_{sb1})P_{b1} + \lambda'_{sh0} \quad (11)$$

11) The generation rate of fast mobile stations' handoff traffic in a macrocell is as follows:

$$\lambda_{fh0} = P_{h0}(\lambda_{f0} + \lambda_{fh0} + \lambda_{fb0})(1 - p_{b0}) \quad (12)$$

2.2 Scheme 2: Variable Threshold Velocity Scheme

We are concerned with the performance parameters in our exploration are the traffic capacity of the system. The traffic capacity is fundamentally determined by the teletraffic which is carried by the system. However, the definition of carried traffic only makes sense if Quality of Service (QoS) parameters are taken into consideration. The different kinds of handovers as well as their triggering events are depicted in Fig. 2.

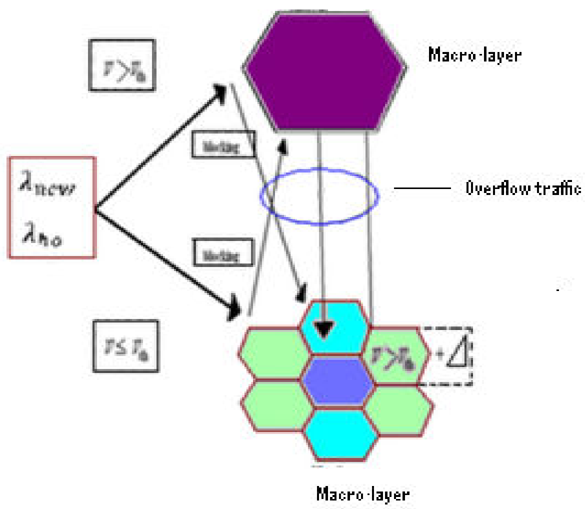
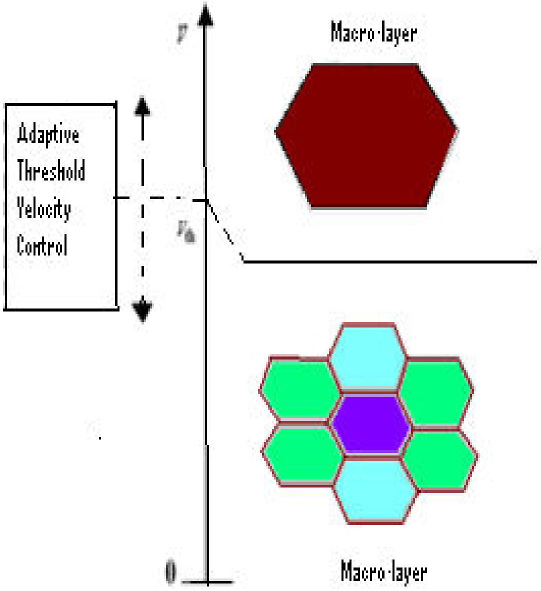


Fig. 2. Variable threshold velocity scheme.

The basic principle of the v_{th} control is explained in fig 3. It gives us an idea of principle of Velocity Control



threshold.

Fig 3. Velocity Control threshold's principle

In order to become accustomed the dynamic changes of traffic, the control scheme of v_{th} is proposed in [5]. Load of microcell is decreased by decreasing v_{th} when microcell is overloaded and load of macrocell is decreased by increasing v_{th} when macrocell is overloaded. Also, when overload of each layer isn't solved, capacity enhancement algorithm is proposed in [5]. But, [5] don't consider CDMA system which is most popular in the future communication systems. We consider scheme 2 to investigate the effect by the control of v_{th}. In scheme 2, load of each layer is balanced by changing threshold velocity according to traffic condition, but when several adjacent microcells are overloaded in rush-hour, overload of those cells can't be solved because macrocell doesn't have enough resources to serve all overflowed mobile users. In other words, in general one macrocell covers every microcell regions and so decrease of v_{th} causes abrupt load increase of macrocell. Of course, increase of v_{th} doesn't cause problems except for increase in the number of handoff in contrast to decrease.

2.3. Scheme 3: Frequency Borrowing Resource Allocation

In order to solve hot spot problem occurred in rush-hour, FBRA (Frequency Borrowing Resource Allocation) is proposed in [6]. In this scheme, FA's in macrocell are classified into two groups: dedicated FA and common FA. Dedicated FAs are only used in a macrocell and common FAs are ordinarily used in a macrocell but used in microcell for rush-hour. According to [6], one FA in macrocell can serve up to 36 users and one FA in microcell can serve up to 30 users. Disadvantage of this scheme is that this scheme is effective when fast users can be served by only dedicated FA in macro- cell, i.e. FBRA cannot unfortunately be applied when the number of user in macrocell is more than pole capacity of dedicated FA in macrocell. Though the number of fast user is decreased during rush-hour, we need to consider other scheme which can solve this problem. Of course, allocation of more FA solve this problem but we must efficiently use limited resources.

2.4. Scheme 4: Proposed Scheme

Our proposed scheme can solve two problems.. Fig 6 shows our proposed scheme.

First, when several adjacent microcells are overloaded in rush-hour, over-loads of those cells can be solved. Second, when more fast users than pole capacity of all dedicated FAs request service in macrocell, we decrease load of macrocell by increasing and then microcells use MFA (Mutual Frequency Assignment).

In this case, handoff between layers occur and this is MFA called connect-after-break. When microcells are overloaded, we expect for macrocell to lend microcells MFA. Like scheme 3, FAs in macrocell are classified into dedicated FA (DFA) and mutual FA (MFA). When a call is originated, resource in DFA is preferentially assigned and if all resources in DFA is exhausted, resource in CFA is assigned. If macro- cell isn't busy (regardless of use of MFA), macrocell decrease its load by increasing v_{th} and then lends microcells MFA. Also, macrocell can control decrease of load.

One of the notable features of our scheme is increasing v_{th} instead of decreasing v_{th} when most channels in microcell are busy. Thus, abrupt increase in load of macrocell caused by decreasing v_{th} when microcell is overloaded can be solved. If loads of microcells are decreased, CFA is returned to the macrocell and v_{th} is returned to original value.

From fig 4, utilization of resource is given by U and defined as,

$$U = \frac{N}{C} \tag{13}$$

Where,

N= The number of user.
C= Pole capacity of cell

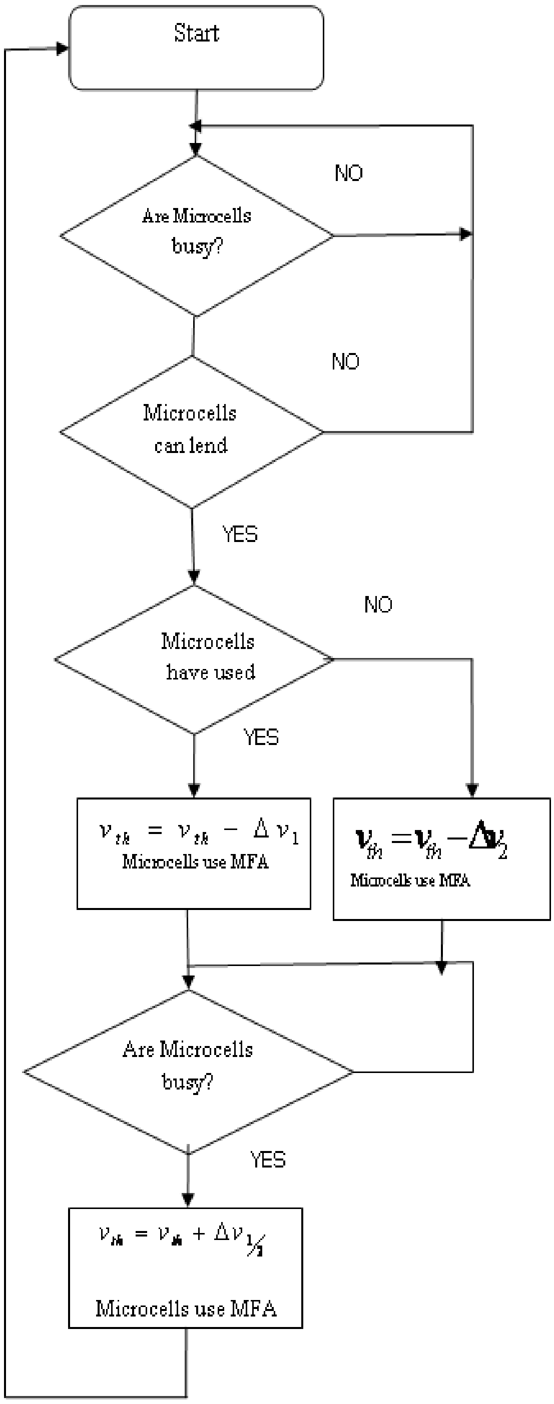


Fig.6. Flowchart of MFA

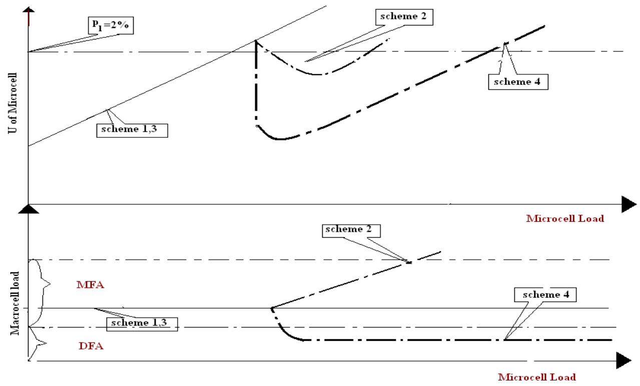


Fig.4 . Output of each scheme when MFA is not used in macrocell

Fig.4 and Fig. 5, explains conceptual operation of each scheme when some calls in microcell are assigned to MFA.

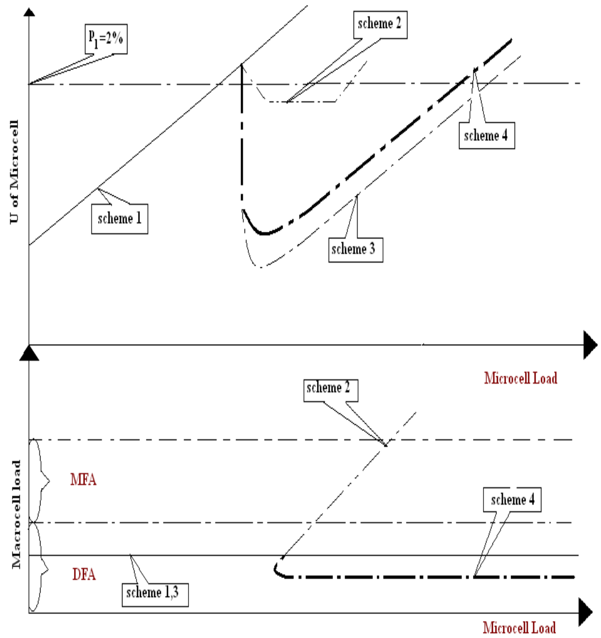


Fig. 5. Operation of each scheme when MFA is used.

Above fig. explains conceptual operation of each scheme when some calls in microcell are assigned to MFA.

3. Statistical Results and Discussion

3.1. Simulation milieu

We have considered 1 macrocell and 6 microcells (6 micro-cells are embedded in a macrocell) and additionally 5 neighboring macrocells and 10 neighboring microcells in order to consider handoff call. The radius of microcell is 500 m. Each layer uses two FAs. One of FAs in macrocell is DFA and an-other is MFA. According to [6], one FA in macrocell support up to 36 calls and one FA in microcell supports up to 30 calls. The number of user per FA in microcell is smaller than that in macrocell since neighboring macrocell can use the same FA as that in microcell and transmission power in macrocell is bigger than that in microcell. The initial velocity of each mobile user is uniformly distributed from 0 km/h to 60 km/h and all directions are possible. Both speed and direction of each user are constant during call duration time or a considered macrocell dwell time.

Following graphs gives us an idea as Systems overall Dropping Probability increases, Dropping Probability also increases for all schemes.

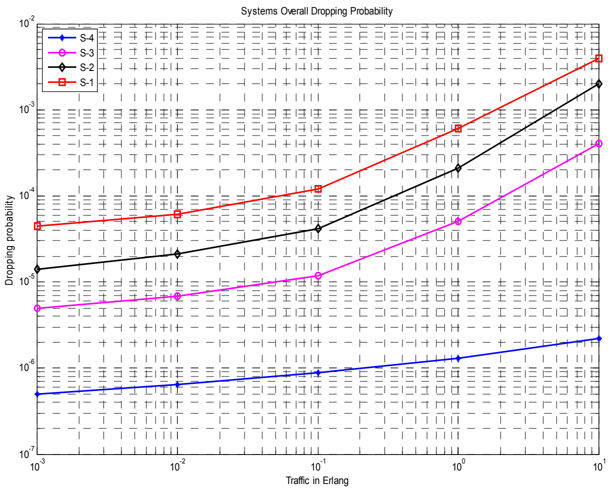


Fig.7. Systems overall Dropping Probability vs. Dropping Probability

In Fig. 7, Blue graph shows Dropping Probability for RRM, Passive. Pink graph shows Dropping Probability for VTVS

Table 1. Dropping Probability of overall System.

Systems overall Dropping probability					
Traffic in Erlang	0.001	0.01	0.1	1	10
RRM, PASSIVE	0.000044	0.000061	0.00012	0.00061	0.004
VTVS	0.000014	0.000021	0.000042	0.00021	0.002
FBRA	0.000005	0.0000068	0.000012	0.00005	0.00041
MFA	0.0000005	0.00000065	0.00000088	0.0000013	0.0000022

It is observed from Table 1. that for scheme-1, RRM , passive Systems overall Dropping probability is more as compared to MFA

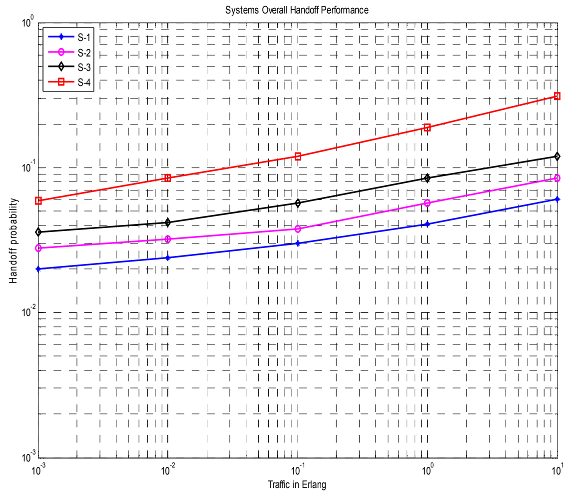


Fig 8. Systems overall Handoff Performance vs. Handoff Probability

In Fig. 8. Black graph shows Handoff Probability for FBRA. RED graph shows Handoff Probability for MFA, new Scheme developed by us.

Systems overall Handoff Performance					
Traffic in Erlang	0.001	0.01	0.1	1	10
RRM, PASSIVE	0.020	0.024	0.030	0.041	0.061
VTVS	0.028	0.032	0.038	0.057	0.085
FBRA	0.036	0.042	0.057	0.085	0.12
MFA	0.059	0.085	0.12	0.19	0.31

Table 2. Handoff Performance of overall System.

From Simulation results Systems overall Handoff Performance is shown in Table 1. For 10 Erlang traffic in MFA, Systems overall Handoff Performance is 0.31 and for 0.001 Erlang traffic it is 0.059.

Above Fig.9. Illustrates Blocking probability of Macro and Micro cell vs. blocking Probability. As traffic increases, blocking probability also increases

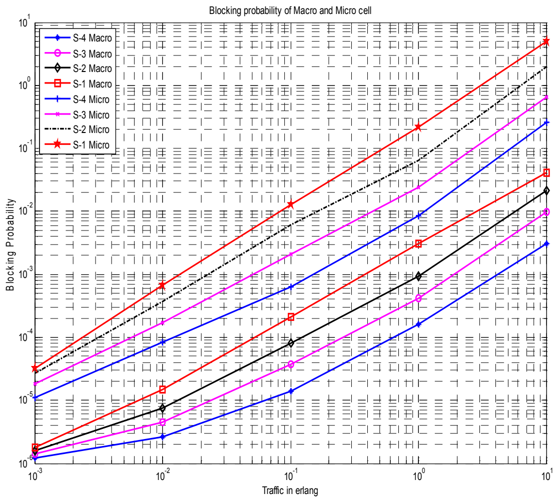


Fig 9. Blocking probability of Macro and Micro cell vs. Blocking Probability

Table 3. Blocking Probability of Macrocell and Microcell

Blocking Probability of Macro Cell					
Traffic in Erlang	0.001	0.01	0.1	1	10
RRM, PASSIVE	0.0000018	0.000015	0.00021	0.0031	0.041
VTVS	0.0000016	0.0000075	0.000081	0.00092	0.021
FBRA	0.0000014	0.0000045	0.000037	0.00042	0.0097
MFA	0.0000012	0.0000026	0.000014	0.00016	0.0031
Blocking Probability of Micro Cell					
RRM, PASSIVE	0.000032	0.00068	0.013	0.22	5
VTVS	0.000027	0.00037	0.0061	0.064	2
FBRA	0.000018	0.00017	0.0021	0.024	0.66
MFA	0.000011	0.000084	0.00063	0.0084	0.26

Scheme 1: Radio Resource Management using teletraffic modeling. (Passive)
Scheme 2: Variable Threshold Velocity Scheme.
Scheme 3: Frequency Borrowing Resource Allocation
Scheme 4: Mutual Frequency Assignment (MFA)

4. Summary of Results

(1) If we compare Scheme 1,2,3 to scheme 4 in macrocell , it is observed that blocking probability goes on reducing in our new scheme, MFA
(2) Also in microcell if we compare Scheme 1, 2, 3 to scheme 4, it is observed that blocking probability goes on decreasing in our new scheme, MFA
(3) Systems overall Handoff Performance increases in our new scheme MFA

5. Conclusion and Future Works

In this paper, we proposed a new adaptive radio resource management scheme in CDMA based hierarchical cell structure i.e. MFA. In our scheme, the resource shortage in microcell is solved by increasing the number of resource and the resource shortage in macrocell is solved by decreasing traffic in macrocell. One of the notable features in our proposed scheme is to increase threshold velocity rather than to decrease threshold velocity when most channels in microcell are busy. Thus, abrupt increase of macrocell load caused by decreasing threshold velocity when microcell is overloaded can be solved. Although the number of handoff is increased in this case, we can decrease the number of call loss since this problem occurs during only rush-hour. In other words, we could prevent call from dropping or blocking although handoff rate is increased slightly.
Using matlab simulation, we have revealed that this proposed simple scheme considerably improves call dropping, call locking and utilization of resource.

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Alam N. Shaikh received B.E. (Electronics) and M.E. (Electronics) in 1994 and 2007 respectively from Shivaji University Kolhapur; Currently he is pursuing Ph. D. in Electronics and Telecommunications at NMIMS University, Mumbai. He has been working as H.O.D., and A.P., Dept. of EXTC, DRIEMS, Mumbai. He has Guided 9 Post Graduate students .His research interests are Wireless Networks, Mobile Communication. He has published over 18 papers in national/international journals/Conferences. He is life member of ISTE.

Dr. Shrikant Bodhe was born in September 19, 1959. He completed his Bachelors degree in Electronics and Telecommunication in 1983 from Pune University. He completed his Masters Degree in Electronics Engineering from Shivaji University, Kolhapur, in 1989. He received his Ph. D., in Mobile Communication from Shivaji University, Kolhapur, in 1999. He is working as a Principal; at College of Engineering Pandharpur, INDIA He has many national and International publications on his name. His research interests include Mobile Communication, Wireless ad hoc networking Wireless Sensor Networks. He has Guided 40 post Graduate students. Under his Supervision 8students have completed their Ph.D. work in the field of mobile communication. He is a member of IEEE. He has published over 80 papers in national/international journals/Conferences.