Variable Guard Channels for Efficient Traffic Management

G. M. Mir, N. A. Shah, Moinuddin

***Abstract*—**Guard channels improve the probability of successful handoffs by reserving a number of channels exclusively for handoffs. This concept has the risk of underutilization of radio spectrum due to the fact that fewer channels are granted to originating calls even if these guard channels are not always used, when originating calls are starving for the want of channels. The penalty is the reduction of total carried traffic. The optimum number of guard channels can help reduce this problem. This paper presents fuzzy logic based guard channel scheme wherein guard channels are reorganized on the basis of traffic density, so that guard channels are provided on need basis. This will help in incorporating more originating calls and hence high throughput of the radio spectrum

***Keywords*—**Free channels, fuzzy logic, guard channels, Handoff

I. INTRODUCTION

CONTINUATION of an active call is one of the most important qualities of measurements in cellular systems. Handoff process enables a cellular system to provide such a facility by transferring an active call from one cell to another. The current trend of exponential growth in the use of personal communication services is causing the industry to examine ways to use the available bandwidth more efficiently. In wireless cellular network, a fixed number of channels are assigned to a given cell. If a channel is used by a call, no other call can use the channel again in the same cell at the same time. With the decrease in size of cells, the system capacity increases because of the more efficient reuse of frequencies in a given area. However, there is also an increase in the number of cell boundaries that a mobile unit crosses. It is desired that a handoff call be given high priority than an originating call. Guard channels offers a generic means of improving the probability of successful handoffs by simply reserving a number of channels exclusively for handoffs [1, 2]. The remaining channels are shared equally between handoffs and originating calls. For example, priority can be given to handoffs by reserving N channels for handoffs among C channels in the cell. The remaining (C-N) channels are shared by both new calls and handoff calls. A new call is blocked if the number of channels available is less than(C-N). Handoff fails if no channel is available in the candidate cell.

G. M. Mir is Assistant Professor (Senior Scale) in the Division of Agricultural Engineering, S. K. University of Agricultural Sciences and Technology-Kashmir, Srinagar-191 121, India (Contact:91-9419076882; fax:91-2461326; e-mail: mir_ae@hotmail.com).

N. A. Shah was Dean Academic Colleges University of Kashmir, He is now Dean Faculty of Applied Sciences University of Kashmir Srinagar-190 006, India (e-mail:nashah2007@rediffmail.com)

Moinuddin was Head and Dean Faculty of Engineering, Jamia Millia Islamia, NewDelhi, India. He is now Director in Dr. B. R. Ambedkar National Institute of Technology Jalandhar-144 011, India (e-mail:prof_moin@yahoo.com)

Prioritization schemes provide improved performance at the expense of reduction in total admitted traffic [3-5]. Efficient utilization of the scarce spectrum allocated for cellular communications is certainly one of the major challenges in cellular system design. Figure 1 illustrates the decrease in total carried traffic as a function of number of guard channels.

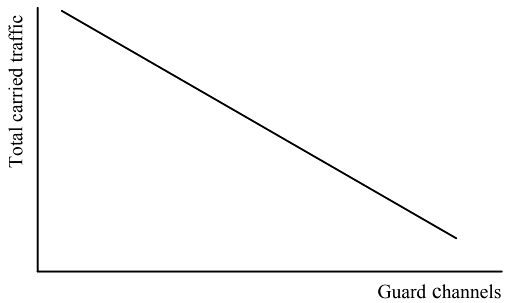


Fig. 1 Total traffic as a function of number of guard channels

Mobility oriented and fuzzy adaptive guard channel assignment for personal communication system has been reported in [6-8]. Thus there is a need of reorganizing these guard channels in accordance with the variations and nature of traffic. In other wards some intelligence is required for efficient utilization of guard channels. In heavy traffic conditions, the allocation of channels will improve the performance of the network. An attempt has been made for accommodating more traffic by efficient usage of guard channels [9].

Fuzzy logic control has been successful in various applications; fuzzy algorithms have also been employed to improve the cellular system performance [10], [11]. Mir et al [12] presented efficient handoffs, between microcells using variable hysteresis as an effective parameter. [13] presents decentralized handoffs between microcells due to corner effects. The mobile velocity based call bidirectional scheme is presented in [14]. The major contribution of our paper is selection of guard channels in accordance with density of traffic in the cell, so that efficient utilization of the available radio spectrum is obtained.

II. Analytical Method

The total channels (T_C) of the system comprises of free channels (F_C), and guard channels (G_C). The free channels comprises of channels for originating calls (C_{OC}), and channels for handoff calls (C_{HOC}). The need of guard channels increases for high density of traffic particularly at peak hours. We define T_{Self} as traffic contained in the cell T_{In} as traffic entering into the cell and T_{Out} as traffic going out from the cell as shown in Figure 2.

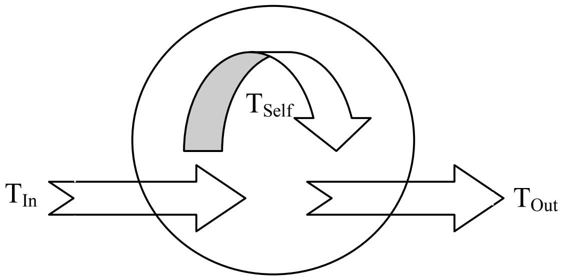


Fig. 2 Total traffic in the cell

The prioritization of handoff calls over originating calls needs ensured guard channels reserved exclusively for handoff calls. But at the same time if the selection of guard channels are made on demand basis, the efficiency of the system to handle both originating, ongoing and handoff calls will definitely increase. We have provided three partitions in guard channels which are used in accordance with traffic situation. The use of these partitions is decided by various thresholds. The algorithm describes selection of guard channels on the basis of nature of traffic in the cell and gives conditions for queuing of handoff calls and originating calls on the exhaust of channels. The more partitioning of guard channels will provide more efficient and linear selection of guard channels. Figure 3 illustrates the allocation of guard channels with various thresholds corresponding to the intensity of handoff calls and originating calls. For simplicity we have chosen linear variations in graph. On the exhaust of free channels, the originating calls are queued and, on the exhaust of guard channels, handoff calls are queued.

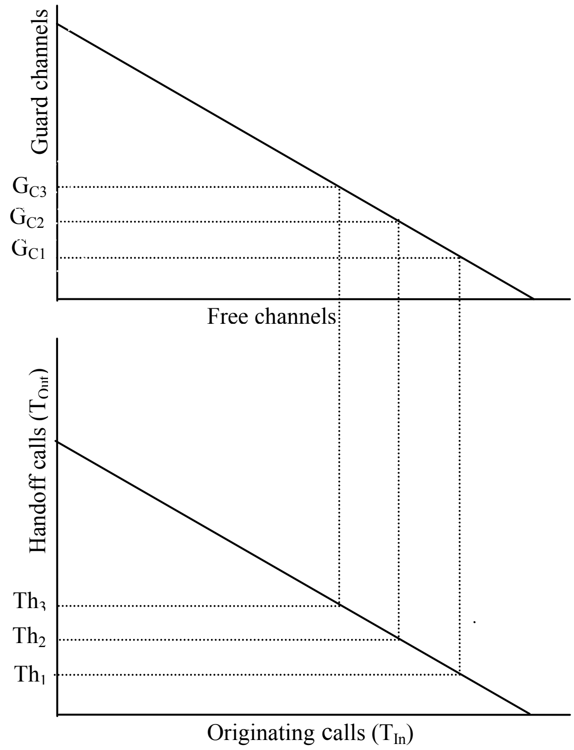


Fig. 3 Reorganizing of guard channels

Algorithm

T_C = Free channels + Guard channels

$(F_C)_{New} = (F_C)_{Old} – T_{Self} – (T_{In} – T_{Out})$

$F_C = C_{HOC} + C_{OC}$

For $(T_{In} – T_{Out}) \geq Th_1$

$T_C = (F_C)_{Old} – T_{Self} + G_{C1}$

For $(T_{In} – T_{Out}) \geq Th_2$

$T_C = (F_C)_{Old} – T_{Self} + G_{C1} + G_{C2}$

For $(T_{In} – T_{Out}) \geq Th_3$

$T_C = (F_C)_{Old} – T_{Self} + G_{C1} + G_{C2} + G_{C3}$

In general

$$T_C = (F_C)_{Old} – T_{Self} + \sum_{i=1}^{n} G_{Ci} \text{ ; for } T_{In} – T_{Out} = Th_i, \quad i=1,2,\ldots,n$$

For $(F_C)_{New} = (F_C)_{Old} - T_{Self} – (T_{In} – T_{Out}) = 0$

Originating calls are queued

For $G_C = 0$

Handoff calls are queued

where T_C = Total channels in the cell

F_C = Free channels in the cell

G_C = Guard channels

T_{In} = Originating calls

T_{Out} = Handoff calls

III. Fuzzy Logic for Guard Channels

The proposed solution to prioritize channels on the basis of density of traffic and mobility of mobile stations use fuzzy logic concept. The theory of fuzzy logic is based upon the notion of relative graded membership and so are the functions of mentation and cognitive processes. The utility of fuzzy sets lies in their ability to model uncertain or ambiguous data. The fuzzy logic concerns the principles of approximate reasoning. The block diagram describing the methodology and criteria used in selection of guard channels is shown in Figure 4. For obtaining QoS for handoff and originating calls by reorganizing guard channels with variations in traffic density, three parameters, free channels, originating calls, and handoff calls are used. These parameters are fed into fuzzifier, which transforms the real time measurements into fuzzy sets. The output variable is the guard channels.

Fuzzy sets contain elements that have a varying degree of membership in a set. Therefore, it is different from an ordinary or crisp set, where element will only be considered members of a class if they have full membership in the class. The fuzzy sets have varying degrees of membership functions such as quite weak, not so strong, or medium. This indicates that an element in a fuzzy set can have a membership in more than one set. The membership values are obtained by mapping the values obtained for a particular parameter onto a membership function. This function is a curve or a straight line that defines how each data or value is mapped onto a membership value.

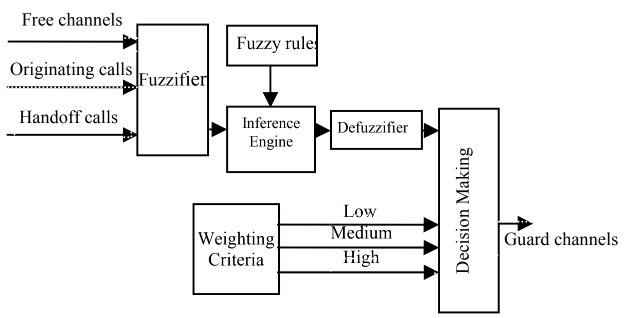


Fig. 4 Block diagram describing methodology and criteria used in allocation of guard channels

The perceived quality of service (QoS) may vary in accordance with different applications or user requirements. The simulation results have shown improved performance over already existing methods. Table 1 shows relationship between various membership values of different parameters. This data is obtained by applying fuzzy-IF-THEN rules to the Mamdani Fuzzy inference system.

Table I Various membership values of guard channels to the corresponding changes of originating calls, handoff calls and available free channels

Free channels	Originating calls	Handof f calls	Guard channels
0.5	0.946	0.0542	0.133
0.5	0.849	0.151	0.272
0.5	0.753	0.259	0.418
0.5	0.645	0.355	0.483
0.5	0.548	0.452	0.5
0.5	0.452	0.548	0.5
0.5	0.355	0.645	0.5
0.5	0.259	0.753	0.508
0.5	0.151	0.849	0.5
0.5	0.0542	0.946	0.5
0.705	0.946	0.0542	0.154
0.705	0.849	0.151	0.294
0.705	0.753	0.259	0.418
0.705	0.645	0.355	0.448
0.705	0.548	0.452	0.448
0.705	0.452	0.548	0.448
0.705	0.355	0.645	0.468
0.705	0.259	0.753	0.508
0.705	0.151	0.849	0.5
0.705	0.0542	0.946	0.5
0.91	0.946	0.0542	0.136
0.91	0.849	0.151	0.144
0.91	0.753	0.259	0.162
0.91	0.645	0.355	0.143
0.91	0.548	0.452	0.136
0.91	0.452	0.548	0.136
0.91	0.355	0.645	0.259
0.91	0.259	0.753	0.414
0.91	0.151	0.849	0.48
0.91	0.0542	0.946	0.5
0.5	0.0542	0.0542	0.133
0.5	0.151	0.151	0.272
0.5	0.259	0.259	0.419
0.5	0.355	0.355	0.483
0.5	0.452	0.452	0.5
0.5	0.548	0.548	0.5
0.5	0.645	0.645	0.517
0.5	0.753	0.753	0.592
0.5	0.849	0.849	0.728
0.5	0.946	0.946	0.867

0.705	0.0542	0.0542	0.154
0.705	0.151	0.151	0.294
0.705	0.259	0.259	0.419
0.705	0.355	0.355	0.448
0.705	0.452	0.452	0.448
0.705	0.548	0.548	0.448
0.705	0.645	0.645	0.468
0.705	0.753	0.753	0.531
0.705	0.849	0.849	0.607
0.705	0.946	0.946	0.839
0.91	0.0542	0.0542	0.136
0.91	0.151	0.151	0.144
0.91	0.259	0.259	0.1161
0.91	0.355	0.355	0.143
0.91	0.452	0.452	0.136
0.91	0.548	0.548	0.136
0.91	0.645	0.645	0.259
0.91	0.753	0.753	0.414
0.91	0.849	0.849	0.48
0.91	0.946	0.946	0.5

Fig. 5 and Fig. 6 shows demand of guard channels for various values of originating calls, handoff calls, and the availability of free channels.

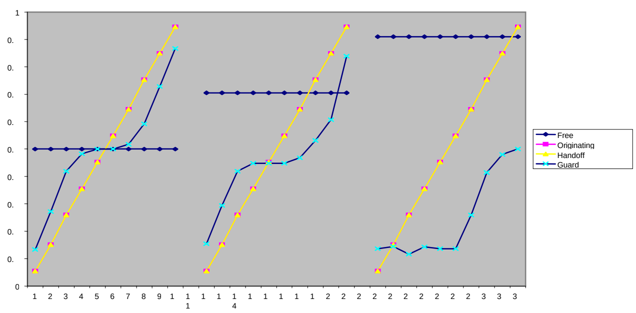


Fig. 5 Demand of guard channels for increasing of originating and handoff calls

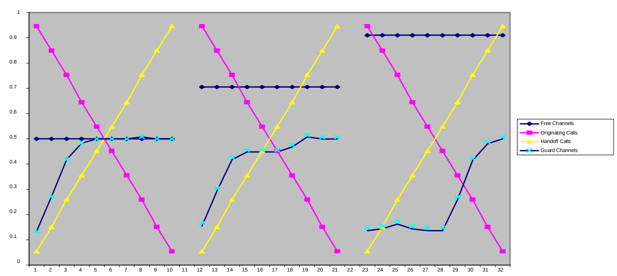
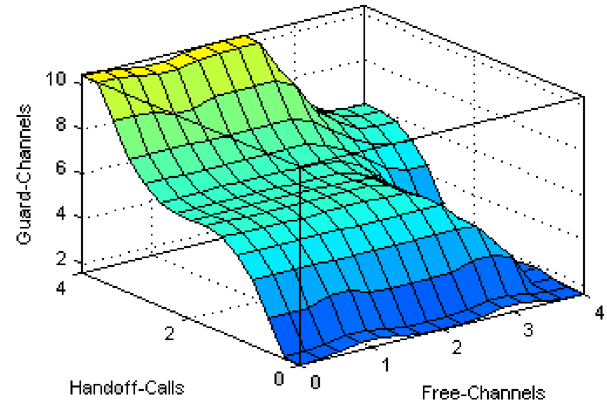
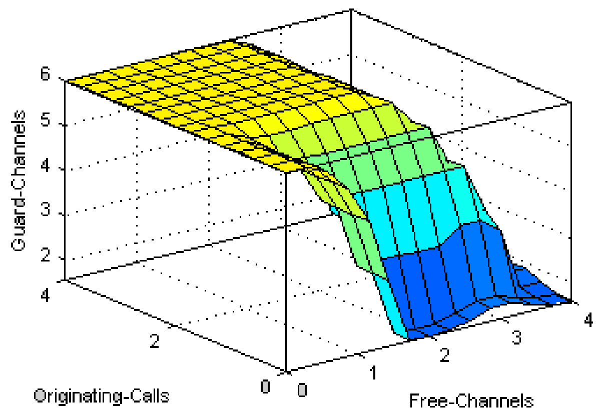


Fig. 6 Demand of guard channels for increasing of handoff calls and decreasing of originating calls

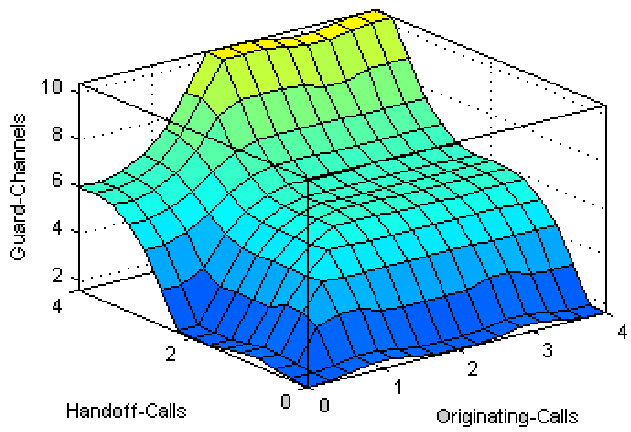
The three dimensional view of guard channels versus handoff calls and free channels, guard channels versus originating calls and free channels and guard channels verses originating calls and handoff calls is shown in Figure 7(a), (b) and (c) respectively .



(a)



(b)



(c)

Fig. 7 (a) Guard channels versus handoff calls and free channels (b) Guard channels versus Originating calls and free channels (c) Guard channels originating calls and Handoff calls

IV. Conclusion

Although variable guard channels presented in this paper will enhance traffic handling capability, there is also a scope to modify selection of guard channels on the basis of traffic density and mobile velocity as other parameters.

References

[1] S. Tekinay and B. Jabbari, "A measurement-based prioritization scheme for handovers in mobile cellular networks," IEEE JSAC, vol. 10, no. 8, Oct. 1992.
[2] Mikael Gudmundson, "Analysis of Handover Algorithms.", IEEE Vehicular Technology Conference July 1991, pp537-542
[3] Y-B. Lin, S. Mohan, and A. Noerpel, "Pcs channel assignment strategies for handoff and initial access," in IEEE Personal Communications, pp. 47–56. 1994.
[4] H. Balakrishnan, S. Seshan, and R. Katz. "Improving reliable transport and handoff performance in cellular wireless networks", ACM Wireless Networks Vol. 1, No. 4, December 1995.
[5] R. Guerin, "Queueing-Blocking System with Two Arrival Streams and Guard Channels," IEEE Trans. Comm., vol. 36, no. 2, pp. 153-163, 1988.
[6] Yan Jian, Vijay K. Bhargava, "Mobility Oriented Guard Channel Assignment for Personal Communication Systems" IIEEE ICPWC, 1997, pp 15-18.
[7] P. M. Ichan, R. E. Sheriff, Y. F. hu, P. Conferto, C. Tocci, "Mobility Management incorporating fuzzy Logic for a Heterogeneous IP environment" IEEE Commun. Mag. Dec. 2001, pp 42-50.
[8] A. S. Acampora and M. Naghshineh, "Control and Quality of Service Provisioning in High-Speed Micro-Cellular Networks," IEEE Pers. Commun., vol. 1, 1994.
[9] N. A. Shah, G. M. Mir, Moinuddin "Efficient Guard Channels for Accommodating More Traffic in Microcellular Mobile Communication" 4th JK Science Congress, Dept. of Science and Technology Govt. of India, 2008
[10] K.R. Lo, C.J. Chang, C. Chang, and C.B. Shung, "A QoS Guaranteed Fuzzy Channel Allocation Controller for Hierarchical Cellular Systems," IEEE Trans. Vehicular Technology, vol. 49, pp. 1588- 1597, Sept. 2000.
[11] K. Shum and C.W. Sung, "Fuzzy Layer Selection Method in Hierarchical Cellular Systems," IEEE Trans. Vehicular Technology, vol. 48, pp. 1840-1849, Nov. 1999.
[12] G. M. Mir, N. A. Shah, "Realization of QoS in Handoffs by hysteresis using Fuzzy Logic" Journal of Mass Communicator, vol 2, issue 2, pp 13-20, June 2008.
[13] G. M. Mir, N. A. Shah, Moinuddin, "Decentralized Handoff for Microcellular Mobile Communication System using Fuzzy Logic" World Acadamy of Science, Engineering and Technology, vol 50, pp 866-870, Feb 2009.
[14] G. M. Mir, Moinuddin, N. A. Shah "Mobile Velocity Based Bidirectional Call Overflow Scheme in Hierarchical Cellular System" World Acadamy of Science, Engineering and Technology, vol 58, pp 827-830, Oct 2009.

G. M. Mir received Post Graduate degree from the Department of Electronics and Computer Sciences, University of Kashmir in 1992.He has submitted his Ph.D thesis on the topic captioned as "Realization of QoS on Wireless Mobile Networks Using Fuzzy Logic" He has worked as Lecturer in the Department of Electronics University of Kashmir form 1993 to 2001. He is now working as Assistant Professor (Senior Scale) in the Division of Agricultural Engineering, S. K. University of Agricultural Sciences and Technology–Kashmir, Srinagar since 2001. His research interests include Cellular Automata, Cellular Mobile Communication, Fuzzy Modeling, and Control Systems.

N. A. Shah is Professor and Head in the Department of Electronics and Instrumentation Technology University of Kashmir. He is also Dean Faculty of Applied Sciences University of Kashmir. He was Dean Academic Colleges University of Kashmir. There are large numbers of publications in National and International Journals to his credit. His research interests include Circuit Modeling, Fuzzy Design Techniques, and Active Filters.

Moinuddin was Head Department of Electrical Engineering and Dean Faculty of Engineering Jamia Millia Islamia New Delhi, He is now Director in Dr. B. R. Ambedkar National Institute of Technology Jalandhar. He has large number of publications in National and International Journals. His research interests include Routing in Mobile Adhoc Networks, Fuzzy Logic, and Artificial Intelligence.