Heuristic based Negotiation in Multi-Agent System for Cellular Network

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ABSTRACT
Radio resource is scarce for cellular network and application of this network is increasing. We assume radio resources here are complete frequency carriers. Different traffic load conditions generate hot and low traffic areas. We are assuming a macro-cellular scenario where base stations communicate by exchange of information. To maintain performance of the whole network, load sharing in distributive manner is required.To achieve this, the paper describes a framework of multi agent system and heuristic approach for negotiation of base stations. Results stated at every step are showing enhancements in the performance of the network.

General Terms
Wireless Network, Multi Agent System

Keywords
Cellular Network, Multi Agent System, Heuristic Search, Call dropping probability

1. INTRODUCTION
We consider in a cellular mobile network, the geographical area served by the system is divided into several hexagonal-shaped cells. The mobile hosts in each cell are served by a base station (BS) located in the cell and the BSs are interconnected via a wired network. We assume macro cellular scenario for simulation which presents moderate traffic load and base stations can communicate to each other using interprocess communication thru messages.

A mobile host can communicate only with the base station in its cell directly. For this communication, the available wireless bandwidth is divided into channels, where each channel is capable of supporting a communication session. The call can be set up only if a channel is assigned to support the communication between the mobile host and the base station. Central pool of channels is available at Mobile Switching Center (MSC). No two cells in the system can use the same channel at the same time if they are within minimum channel reuse distance; otherwise, channel interference will occur. So resource management is a key problem in cellular network. Resource management is consisting of two phases- call admission control and resource allocation. There are different strategies for channel allocation in Cellular Networks as described in the literature[2][5][8]. This paper implements distributed hybrid channel allocation (combination of fixed and dynamic channel allocation) using a multi-agent system(MAS) virtually ported at Base station[1][3]. The agents here are software agents, available in the form of software modules that manage the radio resource of individual cell(local scenario) as well as heavily loaded regions(global scenario) of the cellular network.

2. EXISTING WORK
Parag Pendharkar[7] had implemented MAS using DCA and the results can be improved using HCA in place of DCA. E.L. Bodanase[1] had presented one of the early research about MAS in cellular network. Bigham, Lin [2] had focused on negotiation for changing the antenna patterns of the network so as to decrease call dropping probability. Papazoglou,karras[9[had presented a novel simulation approach, evaluated the research usinf two negotiations i) thread delay negotiation which is implemented using central control agent and has the drawback of centralized controlling ii) performance based negotiation needs rigorous testing for scalability of network.

The framework presented in the literature was missing call admission decision at entry level so as to enhance QoS. The negotiation suggested in this work is again based on heuristic approach in distributive manner which increases efficiency of problem solving.

3. PROPOSED WORK
3.1 Distributed Multi Agent System (DMAS)

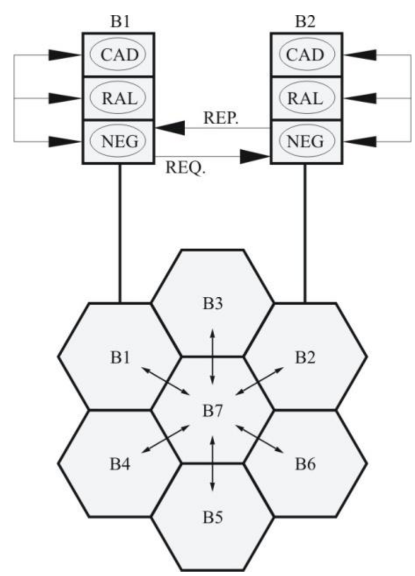


Fig. 1:Processes participating in DMAS

DMAS consists of a collection of interacting agents connected to form a communications network and physically remote. Each

agent is a problem solver that can solve resource allocation issues in a cellular data network. Such an environment must interoperate to share knowledge/data and cooperate to achieve problem solutions.
The proposed framework is a system composed of multiple interacting intelligent agents. MAS is suitable in this scenario as it can be used to solve problems that are difficult for an individual agent to solve. Intelligence includes algorithmic search and processing approach. Agents may reside in wait status, run status and do not require interaction, may invoke their communication. Figure 2 from [11] represents DMAS and each agent's architecture adapted from [1] is shown in Figure 1[11].

The layers are further involved in resource management using a set of processes {CAD,RAL,NEG} stands for Call Admission Decision, Resource Allocation and Negotiation respectively as shown in the diagram Figure 1.

3.2 Reactive Layer Call Admission Control

The work of Reactive Layer is to resolve the resource allocation problem locally. There are two ways- allocate any channel from locally available free channel set to originating call, reorganize the channel to allocate low ordered channel to hand-off calls. In this paper, proposed work of Reactive Layer includes fuzzy control[4][6] to call admission so as to reduce call dropping which can occur at later stage because of heavy traffic condition. The detail implementation of reactive layer and Fuzzy CAC scheme is explained in Figure 3[11].

3.3 Local Planning Layer

Local planning layer is working with the help of hybrid channel allocation which is combination of Fixed Channel allocation and Dynamic Channel Allocation scheme. We are using 70 channels for simulation purpose in which 21:49 is the ratio for static and dynamic channels[6]. For dynamic allotment distributed borrowing scheme should be implemented. Existing literature works for borrowing using either search or update method. This work proposes identification of promising neighbor that is effective lender with the help of soft computing approach [6]. Membership function for Fuzzy output for decision of the efficient lender is applied to get a cell to borrow the channels.

3.4 Cooperative Layer

3.4.1 Process of Negotiation

Negotiation is a key technique to resolve conflicts in cooperative scenario[3]. This paper concentrates on a negotiation approach to balance the network performance. Co-operative layer functions for balancing of the network where process of negotiation of agent is used[1][9].

After every simulation step completion, each agent checks its current status in terms of traffic load. If traffic load > threshold (value is assumed based on data set at the time of simulation), the cell is treated as hot cell or it is marked as cold cell. When cell state changes to hot, software agent at base station invokes the negotiation. It collects the data and heuristic approach is applied to get the less occupied cell for negotiation.

3.4.2 A Heuristic Approach*

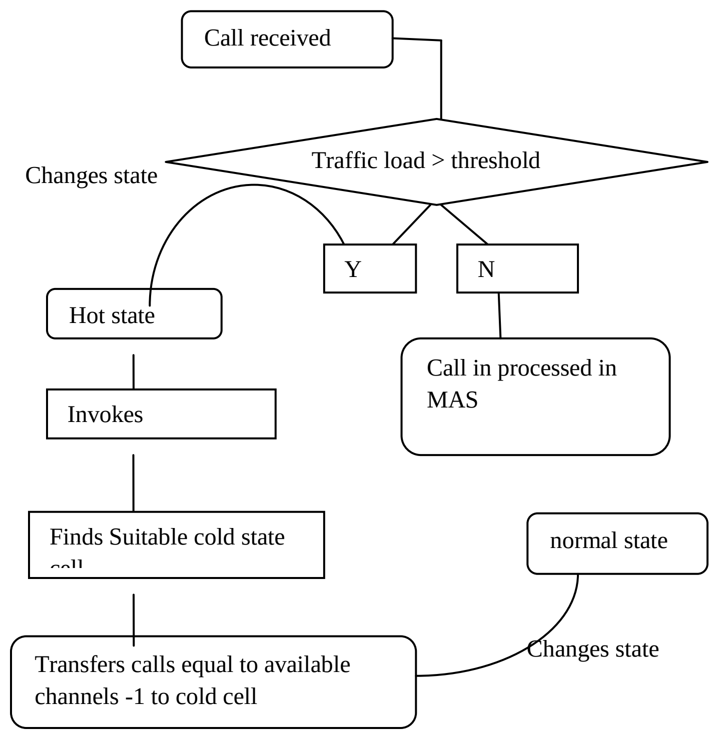
Refer to Figure 1. Let's assume B7 is a hot cell which invoked negotiation. 7 cell cluster and wrap around structure of cellular network is assumed. So when scarcity of channels is there in hot cell, the possible channel set to support the session will be available not in adjacent cells but cell repeated after 1,2 or 3 hops distance. The concept is illustrated the cell cluster in Figure 1.

B7 calculates heuristic evaluation function as F(x)=g(x)+h(x)

where g(x)=traffic load in a cell, h(x)=no. of hops

Heuristic evaluation function is evaluated and compared to negotiate with cell to transfer the calls.

3.4.3 State Transition during Negotiation



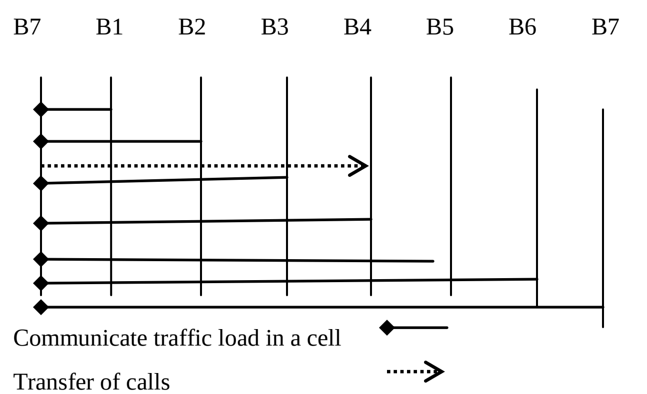


Fig. 2. Message Exchange during Negotiation mechanism

4. EXPERIMAL RESULTS

The simulation parameters used in this paper are quite similar to the ones used in [11]. The simulated cellular network consists of a 2D structure of 7 x 7 hexagonal cells - a wrapped-around layout with cells, with each cell having six neighbors. There are 70 channels in total in the system. A frequency reuse factor of 3 is assumed (i.e., $N = 3$).The dynamic channel ratio is 21:49.

The arrival of calls at any cell is assumed to be a Poisson process and that the call duration is exponentially distributed with a mean of 3 minutes. We are considering uniform traffic scenario.

4.1 Performance Analysis

The QoS parameter call dropping probability has been observed for call arrival rate 20-200 calls/hr. Simulation is done using Omnet+ Network Simulator. By applying fuzzy CAC[10], handoff calls can be buffered for small delay at low call arrival rate as well as this decreases rate of dropping and blocking. Call dropping is observed using Fixed Channel Allocation (FCA) as per Erlang B Formulae[12] at reactive layer. At local planning layer, combined approach of FCA and dynamic channel allocation(DCA) [11] is applied. At third layer, negotiation will improve the performance by transferring cells to cold cell. Threshold to determine hot cell is assumed as 120 calls/hr in this sample data set.

4.1.1 Statistics for sample traffic load chart

The network load is determined using the equation eq. (1) [4] and call dropping rate[8] is calculated using equation eq(2).

$$network\ load = \frac{no. of\ new\ callst * weight(1)\ +\ \text{no. of handoff calls} * \text{weight}(2)}{total\ no.\ channels\ available\ for\ data\ traffic}$$

eq.(1)

$$Call\ dropping\ rate = \frac{no. of\ \ calls\ dropped}{no. of\ total\ calls - no. of\ blocked\ calls}$$ eq.(2

)**Table 1. Call dropping data in different steps**

Traffic load in Erlang s(calls/ hr)	**Network Load**	**Calls dropped as per Erlang B formula with FCA**	**Calls drpped (reduced) with FCA+DCA**	**Calls dropped after Heuristic approach of Negotiati on**
140	5.10	80	20	0
180	6.54	116	56	7
80	2.99	44	0	0
120	4.43	76	16	0
140	5.10	80	20	2
60	2.19	0	0	0
140	5.10	80	20	2

4.1.2 Message Complexity

Assume the message transmission delay between any two cells to be T. The message complexity and channel acquisition delay can be analyzed as follows:

Assume that in most cases, it takes only one search to acquire a channel; this assumption is not unrealistic because the cell is in search for a channel attempts to collect the most-recent channel usage information before launching a search. The message complexity and acquisition delay for acquiring a primary channel are both zero. For simulation purpose we can consider, the message complexity for acquiring and releasing a secondary channel is 6d^2+9, where d=a+b, Simulation considers a grid structure say 7 * 7 , every cell is identified by row(a) and column number(b). In conventional approach of search or update, message transmission delay is 6T or more. The proposed work is negotiating on the basis of heuristic approach and transferring the calls from one region to other. Negotiationwill require communicating only 3 to 4 neighbors, not all 6 and one additional request to transfer the call, so message transmission delay will be maximum 5T.

5. CONCLUSION

A flexible scheme using intelligent agents is proposed. The agent architecture adopted is able to provide greater autonomy to the base stations and allows co-operation and negotiation among them. MAS is suitable in this scenario to support the difficulty of involvement of multiple participants in the decision making. The simulation results have shown the improvement of the proposed approach.

6. REFERENCE

[1] E.L. Bodanese And L.G. Cuthbert, "Application Of Intelligent Agents In Channel Allocation Strategies For Mobile Networks", *IEEE International Conference On Communications*, Vol. 1, Pp. 18–22, June 2000

[2] Guohong Cao, Associate Member, IEEE, And Mukesh Singhal, Senior Member, IEEE, "Distributed Fault-tolerant Channel Allocation For Cellular Networks", Ieee Journal On Selected Areas In Communications, Vol. 18, No. 7, July 2000 Pp. 1326-1337

[3] John Bigham, Lin Du, "Cooperative Negotiation in a MultiAgent

System for RealTime Load Balancing of a Mobile Cellular Network", *AAMAS'03,* July 14–18, 2003, Melbourne, Australia.

Copyright 2003 ACM 1581136838/3/2007

[4] Doru Todinca, Stefan Holban, Philip Perry & John Murphy, "Fuzzy Logic Based Admission Control for GPRS/EGPRS Networks", Transaction on Automobile Control & Computer Science. Vol. 49(63), 2004, ISSN 1224 – 600.

[5] Jianchang Yang, D. Manivannan, " An Efficient Fault-tolerant Distributed Channel Allocation Algorithm For Cellular Networks", IEEE Transactions On Mobile Computing, VOL. 4, No. 6, November/December 2005

[6] Jun Ye, Xuemin (Sherman) Shen, Senior Member, IEEE, and Jon W. Mark, Fellow, IEEE, "Call Admission Control in Wideband CDMA Cellular Networks by Using Fuzzy

Logic", IEEE Trans. on Mobile Computing, Vol. 4, No. 2, Mar/Apr 2005

[7] Parag C. Pendharkar, Penn State Harrisburg, "A Multi-agent Distributed Channel Allocation Approach For Wireless Networks", International Transactions In Operation Research, Vol. 15, Issue 3, Pages 325-337, APR 2006

[8] Jamal Raiyn, "Development And Comparison Between Resource Allocation Strategies Based On Intelligent Scheme And Traditional Distributed Dynamic Resource Allocation Strategiesn Mobile Communication Networks", Wireless Personal Communications (2007) 40: 495–509

[9] Panagiotis Minas Papazoglou, Dimitrios Alexios Karras, "An Improved Multi-agent Simulation Methodology For Modelling And Evaluating Wireless Communication Systems Resource Allocation Algorithms", Journal Of Universal Computer Science, Vol. 14, No. 7 (2008), 1061-1079 .

[10] M. Ravichandran, P. Sengottuvelan , Dr. A. Shanmugam, "An Approach For Admission Control And Bandwidth Allocation In Mobile Multimedia Network Using Fuzzy Logic", International Journal Of Recent Trends In Engineering, Vol 1, No. 1, May 2009

[11] Kamble M., Gupta R., "A new framework for call admission control in wireless cellular network", IEEE Int.Conf.ETNCC, 978-1-4577-0239-6/178-181, Apr 2011.

[12] [15]W.C.Y.Lee: Mobile Cellular Telecommunication Systems (New York: McGraw-Hill,1989)