World Academy of Science, Engineering and Technology
International Journal of Mathematical and Computational Sciences
Vol:7, No:6, 2013

Optimization of Fuzzy Cluster Nodes in Cellular Multimedia Networks

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Open Science Index, Mathematical and Computational Sciences Vol:7, No:6, 2013 publications.waset.org/12049/pdf

***Abstract*—**The cellular network is one of the emerging areas of communication, in which the mobile nodes act as member for one base station. The cluster based communication is now an emerging area of wireless cellular multimedia networks. The cluster renders fast communication and also a convenient way to work with connectivity. In our scheme we have proposed an optimization technique for the fuzzy cluster nodes, by categorizing the group members into three categories like long refreshable member, medium refreshable member and short refreshable member. By considering long refreshable nodes as static nodes, we compute the new membership values for the other nodes in the cluster. We compare their previous and present membership value with the threshold value to categorize them into three different members. By which, we optimize the nodes in the fuzzy clusters. The simulation results show that there is reduction in the cluster computational time and iterational time after optimization.

***Keywords*—**Clusters, fuzzy and optimization.

I. Introduction

CELLULAR communication has experienced explosive growth over past two decades. It is supported by infrastructure called cellular network, which integrates cellular phone into public switched telephone network. The service coverage area of cellular is divided into many smaller areas, referred to as cell. A cellular network has a hierarchical structure and is formed by connecting the components like Mobile Phones, Base Station, Mobile Switching centre, etc. The base station serves a cell, which could be a few kilometers in diameter. The cells when grouped together form a cluster each of which is served by base station. The recent survey insists that there is huge growth in mobile node population for single base station. The mobile node under each base station does different transaction with other base station; hence it becomes very difficult to increase computational speed along with the growth of mobile nodes. Thus there will be more call drops, call blocking and call errors.

To decrease the computational speed, we have reduced the mobile node population which is very uncertain and not possible with present scenario. So the solution may be to keep some of the nodes in the base station tertiary out of computation. This can be done using technique called node number optimization using clustering, rather maintaining the individual nodes. If there is group maintenance in the cellular network it is faster and efficient.

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A. Hard Clustering

Hard clustering is used to classify data in a crisp sense. By this we mean that each data point will be assigned to one and only one data cluster. In this sense these clusters are also called partitions that are partition of the data.

B. Fuzzy 'C' Means Clustering

This step determines the fuzzy 'C' partition matrix for grouping a collection of 'n' data sets into 'C' clusters [13]. The clustering is based on the distance matrix, which is fixed on the basis of network (comprising of base stations and wireless nodes) topology and the number of clusters to be formed. To determine the fuzzy C-partition matrix-U for grouping a collection of 'n' data sets into 'C' cluster, we define an objective function as given in (1) and (2).

$$J_m(u,v)=\sum_{k=1}^{n}\sum_{i=1}^{c}(\mu^m{}_{ik})*(d^2{}_{ik}) \quad (1)$$

$$dik=d(x_k-v_i)=\sum_{j=1}^{m}\sqrt{(x_{kj}-v_{ij})^2} \quad (2)$$

where μ_{ik} is membership of the base station with respect to each cluster i.e. it is membership function of the Kth node in the ith cluster. The distance measure, dik in the above equation is euclidean distance between the ith cluster center and kth base station that we considered and v_i is the ith cluster center. Each of the cluster coordinate for each cluster center can be calculated in the manner shown in (3). Where m and m′ is between $(1,\infty)$. This parameter controls the amount of fuzziness in the classification process.

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$$v_{ij} = \sum_{k=1}^{n} (\mu^{m}{}_{ik} * x_{kj}) / \sum_{k=1}^{n} (\mu_{ik}) \quad (3)$$

The partition matrix is calculated using equation as follows.

$$\mu^{r+1}{}_{ik} = [\sum_{j=1}^{c} \frac{d^{r}{}_{ik}{}^{(2/m-1)}}{d^{r}{}_{jk}}]^{-1} \quad (4)$$

The fuzzy rules are computed at different instant of time to form the cluster. Once the clusters are formed, cluster head is computed to have communication. The cluster head act as master of all the nodes in that cluster. In fuzzy cluster system cluster head will change as and when there is movement of nodes inside the cluster, the cluster computation time and head selection time become more complex as well as longer. Hence there is a requirement for the optimization of these mobile nodes.

In optimization scheme we can have single or multiple dimension optimizations. The optimization method we use here is one dimension optimization which finds the optimal solution from a family of reasonable solution according to an optimization criterion. There are different methods of one dimensional optimization. In which we have considered classical optimization for one dimension relationship which can be formulated as follows. Suppose we wish to find the optimum solution x*, which maximizes/minimizes the objective function y = f(x) subject to the constraints.

The one dimensional optimization technique used in this scheme involves numerical method using interval halving approach and elimination approach. In elimination technique near optimum is obtained by comparing the values of the objective function at a sequence of selected points and gradually eliminating the points which do not give the best in the comparison, where in the interval having the technique of initial interval of uncertainty is divided into three equal parts and exactly one half of the current interval of uncertainty is deleted in every stage.

In this work we evaluated the objective function f(x) by combining both the approaches. The f(x) is divided into three interior points to obtain three membership nodes as long refreshable node, medium refreshable node and short refreshable node which are compared with threshold at different interval of time and after comparison the member node which gives the best comparison with the threshold at that interval of time is selected and other nodes are assumed to be static. Such comparison procedure is done for the entire three membership node at every interval of time until the new objective function is assigned for next incoming nodes.

$$g_i(x) \leq 0, i = 1, m \quad (5)$$

Each of the constraint functions gi(x) can be aggregated as the intersection of all the constraints. The functions gi(x) defines the membership functions of three categories considered in our proposed system.

$$c_i = x / g_i(x) \leq = 0$$
$$Then\ c = c_1 \bigcap ..c_2 .. \bigcap ... \bigcap c_3$$
$$= x / g_1(x) \leq = 0, g_2(x) \leq = 0, g_3 \leq = 0$$

which is feasible domain described by the constraint Ci. In our scheme the Ci(x) defines the maximum to minimum limits membership function. Thus the solution is,

$$f(x^*) = \max_{x \in c} f(x) \quad (6)$$

Rest of the paper is organized as follows. Section II explains the related works in optimization technique and fuzzy clustering. In Section III, explanation of optimization of fuzzy cluster nodes is given. Section IV describes the simulation and results. Section V concludes the paper.

II. Related Work

In paper [1] idea of hierarchical clustering is considered, the author proposes a new adaptive fuzzy clustering algorithm A-FCM that can determine the optimal cluster number automatically and efficiently. The numerical experiments demonstrate that the A-FCM achieves better performance than other adaptive fuzzy clustering algorithms. The work presented in [2] paper outlines a real-world industrial problem for product-mix selection involving 8 decision variables and 21 constraints with fuzzy coefficients. On one hand, a multiobjective optimization approach to solve the fuzzy problem is proposed. This paper [3], introduces a new method for cross-layer design in mobile ad hoc networks. It uses fuzzy logic system (FLS) to coordinate physical layer, data-link layer and application layer for cross-layer design, ground speed, average delay. Packets' successful transmission ratio is selected as antecedents for the FLS. Simulation results show that cross-layer design can reduce the average delay, increase the throughput and extend the network lifetime.

The main objective of paper [4] is with optimizing by routing in Adhoc networks and also suggest a new method for reducing the complexity of routing algorithm, a new algorithm is introduced that reduces the number of times that routing protocols are being repeated. After a few repetition of routing the nodes themselves know where they should send the data.

The aim of the paper [5] is to use the subtractive clustering algorithm to provide the optimal number of clusters needed by FCM algorithm by optimizing the parameters of subtractive clustering algorithm by an iterative search approach and then to find an optimal weighting exponent for the FCM algorithm. Once the number of clusters is optimized then two approaches are proposed to optimize the weighting component in FCM algorithm, namely, the iterative search approach and the genetic algorithm. This paper infers the time needed for the genetic algorithm to optimize an objective function that depends on the number and the length of the individual in the population and the number of the parameters to be optimized. The scheme in paper [6] explains us the use of multiobjective genetic algorithm by fuzzy logic on the optimization problem

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to meet all the constraints and also failed to bring the solution to global optimal point. Hence multi-objective method has proved to be more practical and efficient method fuzzy optimization. A fuzzy optimization is presented in [7] the summary is made on aspects of fuzzy modeling and fuzzy optimization, classification and formulation for the fuzzy optimization problems, models and methods. The importance of interpretation of the problem and formulation of the optimal solution in fuzzy sense are emphasized in the summary of the fuzzy optimization. A paper [8] for optimization of fuzzy if then rules for approximation is an area of research that has received much attention in the last years. The present paper adds a new possibility by proposing a method for data-driven reshaping or designing the uncertainty transitions of piecewise linear fuzzy sets representing the linguistic terms of the fuzzy rules.

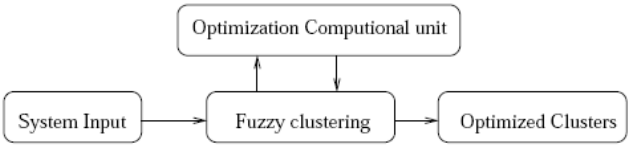


Fig. 1 System Block Diagram

Generalized fuzzy logic based approach for energy aware routing in wireless sensor networks is proposed in paper [9]. The approach is soft and tunable and hence it can accommodate sensor network compromising of different types of sensor nodes having different energy metrics. The disadvantage of this work is not being easily adaptive to changes in sensor types because energy metrics vary widely with the types of sensor node implementation platform.

The scheme presented in paper [10] analyses and compares some of the existing work on clustering in MANET's. It categorizes the works as location based, mobility based and weight based. It also presents the advantages and disadvantages of these techniques and suggests a best clustering approach based on the observation. It suggested the need of artificial intelligence technique like fuzzy logic to select the appropriate weight parameters for cluster head thereby minimizing the overhead and maximizing the throughput. The proposed paper [11] presents ant colony optimization based hierarchical clustering algorithm to reduce the number of participating nodes in routing. This clustering scheme considers various system parameters such as distance between neighbor nodes mobility to form and maintain clusters. The performance of this scheme has been evaluated in terms of end to end delay, packet delivery ratio and throughput. The paper [12] deals with the multiple prototype fuzzy clustering models. This scheme proposes a frame work for partitional fuzzy clustering which suggest the model of how data are generated from cluster structure to be identified. They also extended the frame work to a number of clustering criterion, and study the FCMP properties. In their work they consider different way for pertaining observed entities to the prototypes.

III. Proposed Work

In our scheme we have worked on one dimensional node optimization for the cluster nodes. The work aims at reduction of time required for computation of the cluster and cluster\ head formation in mobile node environment. When the nodes of the cluster are mobile, then it becomes very complex every time to calculate and declare the head and cluster members. Hence a proposed system block diagram is given in Fig. 1. Where the system input provides the information about the total number of nodes and the number of cluster required to be formed to the fuzzy clustering system. The fuzzy clustering unit will cluster the nodes according to the fuzzy cluster rules. The output unit will give the clusters and their cluster heads. Each cluster is well defined with membership value of its members as well as its head membership. In the second iteration the fuzzy system unit will send the information about the membership to optimization unit, which in turn compute the below equations.

$$T=\sum_{i=1}^{n}(C_t+CH_t+\tau) \tag{7}$$

- T = Total cluster computational time
- C_t = Cluster formation time
- CH_t = Cluster head selection time
- τ = Membership assignment time

The total time 'T' consist three time components that is time taken for cluster formation, time taken for cluster head selection and time taken for membership assignment for each member in each cluster. The total time has major share of value for membership assignment rather than other two components. Hence in this scheme we have planned to optimize the time by considering the membership assignment time rather than other two values. Equation (8) defines the total time required for computation of membership values for cluster members as well as cluster head.

$$\tau=\sum_{i=1}^{n}((L_t)+(M_t)+(S_t)) \tag{8}$$

- L_t = Long refreshable node membership assignment time
- M_t = Medium refreshable node membership assignment time
- S_t = Short refreshable node membership assignment time

Where in this scheme we have members with short, medium and long refreshable nodes times, where short refreshable node will change its position very frequently, medium refreshable will change at medium instant of time where as long refreshable node will change the position after long time. The short refreshable nodes such as four wheeler mobile node and medium refreshable such as two wheelers and long refreshable node such as walker is considered. The mobile node in the hands of the walker do not change its position very frequently, hence by assuming them as static node, we can compute the computation time as follows.

$$L_t = (L_{t-1}) + (L_{t-2})$$
$$M_t = (M_{t-1}) + (M_{t-2})$$
$$S_t = (S_{t-1}) + (S_{t-2})$$

where the value of Lt, Mt, St are the values to be measured to distinguish every time their class values. The values computed are compared with the threshold values so as to continue in the same membership value or to change to the new value depending on its value calculated by the above equation. If the above computed value of Lt, Mt, St is approximately zero then their membership is continued with existing value else they will change their membership according to threshold values. The below algorithm defines the procedure for conducting the simulation.

A. Algorithms

Nomenclature

n= number of nodes, xk and vi are distance values of the base station and cluster center of kth base station and ith center, U_r and U_r+1 are the 'C' partition matrix at the rth and r + 1th steps. E= edge list, N= vertices list, k= first selected edge, u= vertex of the edge, v= vertex of the edge, c= center of the cluster, m= weighing parameters. Lt, St and Mt are the time value of the nodes.

Algorithm 1: Main Program
Begin
• Consider the topology comprising of 'n' number of nodes;
• Form a 'C' number of clusters;
• Define cluster head H for each clusters;
• Call algorithm 2 for fuzzy clustering;
• Compute threshold value for each type;
• Call algorithm 3 for optimization of nodes;
• Compute the time and percentage of optimized node for the output parameter.
End.

Algorithm 2: Fuzzy Clustering
Begin
• Choose the number of clusters 'K', 2 _ c _ n;
• Select weighting parameter 'm";
• Initialize the partition matrix U with all '0's;
• Calculate the centers for each cluster by using U matrix value using (3);
• For i= 1 to c do For k= 1 to n do; /*initialize matrix with fuzzy value*/
Begin
$$d_{ik} = d(x_k - v_i)$$
End
• Update the partition matrix for the rth step using (4);
• If $(U(r+1) - U(r)) \le 0.001$ then stop else go to step 4;
• Stop
End.

Algorithm 3: Optimization of Nodes
Begin
• Choose nodes with long refreshable time;
• Compare the value long refreshable time of the node with its threshold value:
• If it is more than threshold keep its membership same.
• else assign with short or medium membership value.
• The same is carried for short and medium refreshable time nodes.
• Return the value of nodes whose membership should be changed
End.

B. Simulation Input

The simulation is done using Qualnet 4.5 simulator and MatLab 7.7, on Pentium IV machine. The simulation networks we have considered is cellular network with 'n' number of mobile nodes in each base station. Each 'n' numbers of nodes are further classified into three types such as long ('Lt'), medium ('Mt'), and short ('St') refreshable nodes. The time instant 't-1' and 't-2' are considered as two consecutive refreshable time instants. The 'T' is defined as total computational time instant. This is defined as the total time taken for membership assignment.

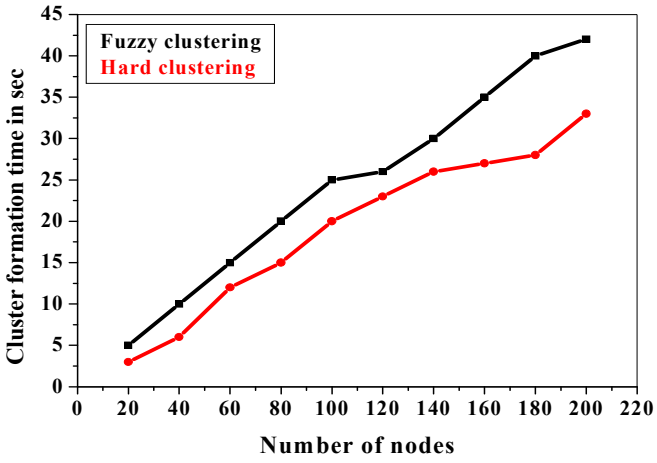


Fig. 2 Hard Clustering vs. Soft Clustering

C. Performance Parameters

1. Cluster Computational Time

It is the time taken for group of nodes to form clusters using hard and soft cluster formation techniques.

2. Time Computation for Every Iteration

It is the time taken by the group of nodes to form fuzzy clusters in different iterations using after optimization and before optimization techniques.

3. Time Computation for Every Node Group

It is the time taken by the every group of nodes to form fuzzy clusters using after optimization and before optimization techniques.

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4. Percentage of Optimized Nodes

It is defined as the percentage of optimized nodes in the every node groups.

IV. Results and Discussions

The following are the simulation results which show that the optimization of time can be done in fuzzy cluster formation using one dimensional optimization technique. Fig. 2 gives the time taken to form clusters using hard and soft clustering techniques. It shows that soft clustering needs more time compared to hard cluster. Therefore there is need for soft cluster optimization. In Fig. 3, we have considered a group of nodes in each iteration and applied soft cluster formation technique after and before optimization. The result shows that, time after optimization is less as compared to before optimization and this is the required result for our experiment. Fig. 4 shows simulation carried out for different group size of nodes, still it is found that the time taken after optimization is less compared to before optimization. The Fig. 5 shows that the percentage of optimized value of cluster members. The zigzag shape of the graph indicates that numbers of nodes optimized at different instant of time are different, which in turn saves lot of computational time.

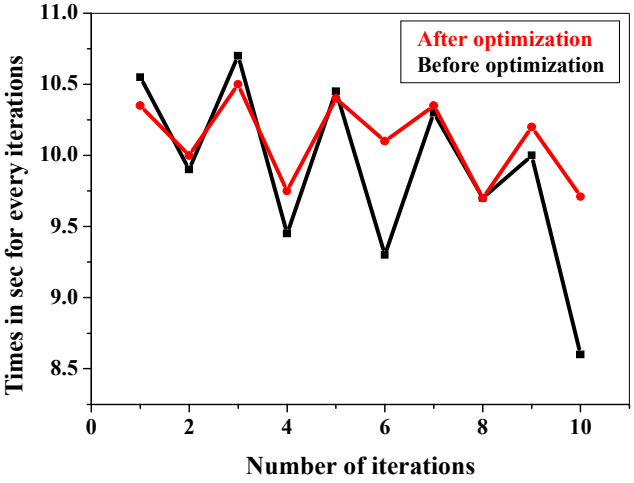


Fig. 3 Time Vs Number of iterations

V. Conclusions and Future Work

In this paper we have proposed a scheme for optimization of nodes in fuzzy clusters. The main objective is to suggest optimization of cluster members which will help to reduce the computational time and increase the efficiency of the system. The novelty of our scheme resides in the optimization of long refreshable nodes to reduce the computational time. Extensive simulation results reveal that our scheme features reduced computational time for every iteration and for different group of nodes. The scheme also presents different percentage of optimization at different instant of time, which helps to maintain dynamism of fuzzy clusters. Further work can be carried out by considering storage fuzzy cluster members and retrieval with respect to wireless nodes. The retrival of nodes takes longer time as the number of nodes in each cluster becomes more and the storage requirement also increases. Hence we adopt other soft computing tools and minimize these time requirement in these two applications.

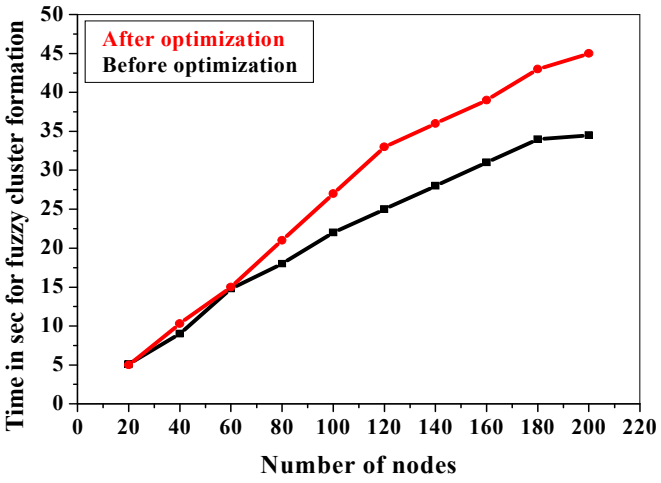


Fig. 4 Time Vs Number of nodes

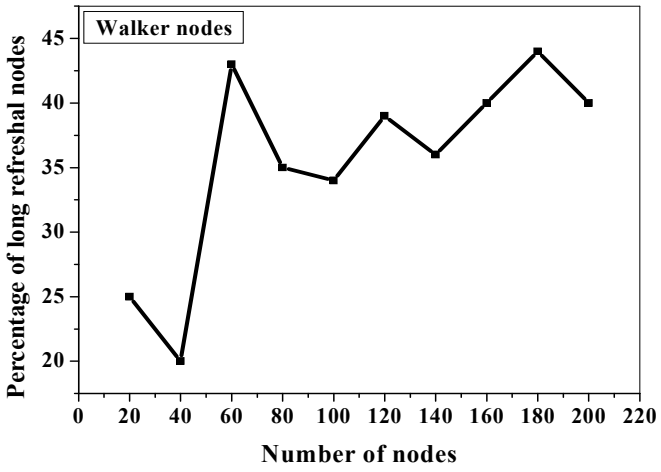


Fig. 5 Percentage of Long Refreshable Nodes

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