Smart Implementation of Cluster Head Responsibilities in Wireless Sensor Network

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Abstract

This study is similar to the our earlier work in that the selection process of the cluster head was depending on Fuzzy input, but adding more to that our this paper deem on dissemination of distributed works between the backup cluster head and main cluster head. This is entirely novel idea in the networks which are based on cluster. In conventional cluster based networks, the cluster head is major or important object which serve the task of the data communication as a single object. The cluster head works as the backbone of the whole cluster, which can be regarded as the single point of failure for the whole chosen network. This procedure brings uplift in the consumption of power and that affects directly on the total life of the network. Considering our earlier work this study deem the selection of cluster head depending on fuzzy login but this study considers backup system sharing of recourses mechanism, in return of that demonstrates effective usage of resources. The results of simulation demonstrates that, our proposed method Fuzzy-based Smart Cluster-head Selection and Task Distribution with Backup System (FSCS-TD) which uses 20 equivalent to 30 percent less messages traffic for the equal number of nodes as compare to LEACH and V-LEACH protocols which brings decline in the consumption of power in the nodes and uplifts the life of the whole network.

Keywords: Wireless sensor network, Cluster Head selection, Hierarchical clustering, fuzzy based clustering, FCA-BS.

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INTRODUCTION

Wireless sensor network is a emerging field which is used to gather data from the location which are remotely located with the deployment of wide number of less expensive devices based on tiny circuits. The most important components of sensor are: external memory, microcontroller, power source, transceiver and other sensors. The sensor node after deployment is able to carry out a variety of tasks. The wireless sensor network performance is rapidly increasing and embedded computing systems, Converged Sensor Network Architecture which provides connection between sensor, the storage of data and image display units and the sensor data is sent on a IP based network.

The most important issue in the WSN is the energy constraints. In the hostile area, where it is complicated or even not possible to reinstate the battery, one has to consider the solution for maximizing the life time of the nodes. Sensor node consumes most of its energy in the transmission phase, i.e. data from sensor node towards base station which can be located to a distant location. If whole the nodes which are sensor have to establish communication along with the base station, then it is very easily to deplete all their energy in a short time cycle. So much research is in progress to make to the energy efficient protocols and systems so that it can prevent the easily depletion of battery and maximizes the life of the system.

Previous customized network architectures pertaining to wireless sensor networks consists of solitary central processing station which was associated to many different nodes (Bonivento et al.,). But the demand is to migrate to distributed architecture system

which can prevent the energy issues. So to overcome these issues routing protocols have been developed like LEACH (Heinzelman et al., 2000), ACE (Chan and Perrig), HEED (Younis and Fahmy) and LEACH-C (Heinzelman et al., 2002).
In recent research, clustering technique has come into existence as popular architecture (Younis et al., 2006) in WSN Figure 1. The objective of providing cluster is to minimize the total communication power by aggregating into single path for enhancing the life span of the network.

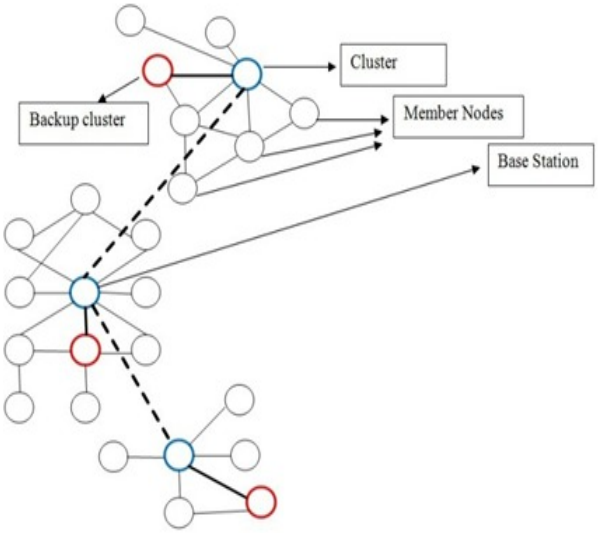


Figure 1: Clustering formation in wireless sensor network

This paper introduces a new approach for cluster–head selection FCA-BS based on Fuzzy Logic. Much of the work is done on the selection of cluster head but in this study we also introduce the backup support. The reason behind this approach is that, in case of emergency, like in battlefield or in hostile area if cluster head destroyed all the nodes have to look to the base station for data communication and then re-selection of cluster head will start. This will make cumbersome and can cause lose of energy and hence affect the overall life of the system.
The other body of this paper is made as following. Section II presented the related work. Proposed Model is introduced in section III. In section IV back up cluster approach is presented. Simulation and conclusion are available in section V and VI correspondingly.

Background

Clustering in sensor network is hot issue in research community. Many of the algorithms are presented to determine the feasible cluster node. The first well known protocol presented by Heinzelman is LEACH (Low Energy Adaptive Clustering Hierarchy). LEACH is basically works on clustering mechanism by which cluster head is selected by optimal probability. This protocol works on periodic randomized regular change of the cluster head within the cluster range between zero and one. In case the number is less as compare to the value of threshold, the node acts as cluster head for the in progress round. By using LEACH, one can achieve a significant reduction in energy dissipation (Kumar et al., 2011) by a factor of 7 to 8 as compare to direct communication and transmission energy routing protocol.
The LEACH protocol provides efficiency in terms of energy but the expected number of clusters is fixed or already defined. Also LEACH do not provide guarantee of good distribution of CH and believe homogeneous energy utilization for CHs. Yet another drawback of LEACH is that it cannot support to deploy the network in a large region.
To overcome the LEACH protocol that do not guarantee the number of cluster heads, a new modified version LEACH-C was presented. LEACH-C protocol is a central clustering protocol that has the ability to decide the number of cluster heads. Once the cluster broadcast the message to the sink and if it contests its own ID, the node is CH; if not node uses TDMA transmission for data transfer and went into sleep mode. Each node through the set-up phase transmits its present location information to the sink. But the steady state phase of LEACH-C protocol is alike to the LEACH protocol.
Another version of LEACH was presented named as V-LEACH. In the existing LEACH protocol CH is responsible for sending aggregated data to the base station that can be positioned far away. In some situation this CH can have short of energy or due to any other reason die, which makes the whole system unstable. But due to vice-CH the node get the responsibility and become the cluster head (Yassein et al., 2009).

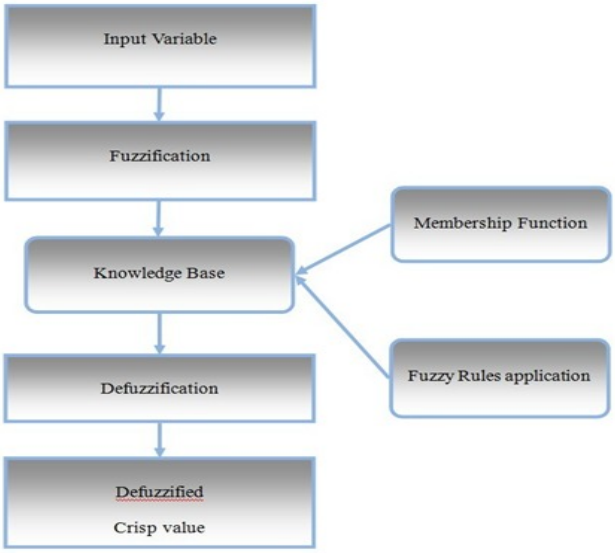
Another popular protocol, Hybrid Energy Efficient Distributed Protocol (HEED) can form single-hop clusters devoid of the knowing density and size related to the sensor network. The primary parameter in HEED is residual energy which sporadically chooses cluster heads regarding a hybrid of the node lasting power and an inferior factor, like node immediacy along with neighbors or degree of node. HEED expires in O(1) iterations, acquire less overhead of message, and accomplishes reasonably consistent cluster head allocation to the entire network. Ding et al., 2003 reported a distributed weight-based energy efficient hierarchical clustering protocol (DWEHC). The DWEHC protocol was mainly intended to improve HEED by generating non-overlapping balanced size clusters. The HEED and DWEHC both are sharing a few resemblances as well as no supposition regarding density and size of network, and taking into account outstanding power in the CH determination process. Fast Local Clustering (FLOC) (Bandyopadhyay and Coyle, 2003) generates non-overlapping and more or less equivalent size clusters. The clustering is like every node inside one hop as of a CH fit in to its cluster, and no node m hops far from the CH may fit in to its cluster. Another protocol named as Energy Efficient Clustering Scheme (EECS)(Ye et al., 2007) suggested by Mao Ye et al. that focuses on the unbalanced power debauchery. In EECS, through the cluster development phase nodes come to a decision to connect with a CH depending on a weighted cost aspect which is made of three tasks. A faintly customized version of the EECS is shown in(Ye et al.,) as energy efficient unequal clustering (EEUC).

Proposed Model

This section initiates an investigation about FCA-BS. This algorithm is decentralized, growing and vibrant aimed to extend the life time of the WSN. Below is the step by step procedure for the fuzzy based clustering scheme.

Design of Fuzzy Inference based cluster head selection.

Fuzzy logic is a process of decision making depending on the input variable and member functions and collection of fuzzy rules. Here for the selection of cluster head, we used the important input functions degree, distance and energy which with the help of rules give us the output function result. As shown in the Fig. 2, the fuzzy inference system made of fuzzification, defuzzification and knowledge base.



The initial step to design a fuzzy inference system is to decide membership functions to the input and output fuzzy variables depending pre-defined range. After this the constructed rules for the fuzzy inference system are included. This whole development is related to estimate the most preferred cluster head which is explained below.

Fuzzification of inputs and outputs

The three (03) input member functions to be fuzzified are Degree, Distance and energy as shown in Fig. 3. The membership functions which are Low (L), Medium (M) and High (H) are used for the input variable "degree". Same as Far (F), Medium (M) and Near (N) are the membership functions used for the input variable "Distance". For input variable Energy, we used three membership functions named as Low (L), Medium (M) and High (H).

The output function as shown in the Fig. 4 consists of five membership functions which are named as Excellent (EXC), Good (G), Likely (LK), less likely (LLK) and ignore (IGN). This result is carried out by applying the Mamdani's fuzzy inference method(Mamdani 1977).

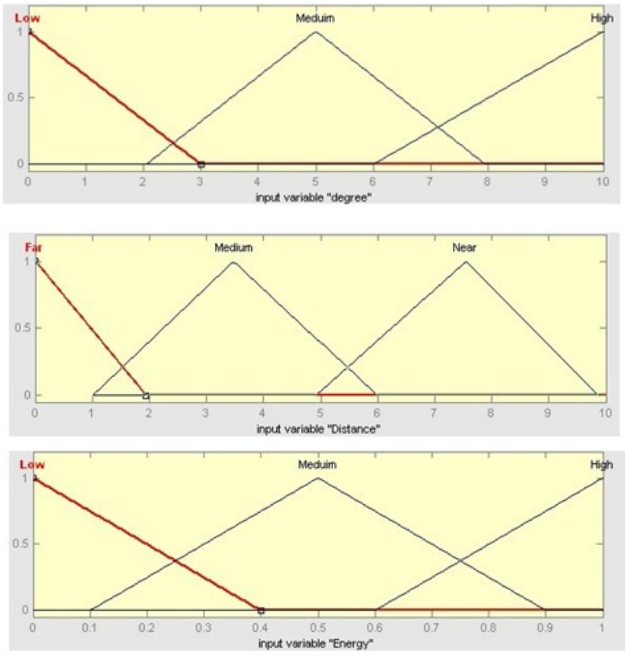


Figure 3: Fuzzy membership functions for Degree, Distance and energy.

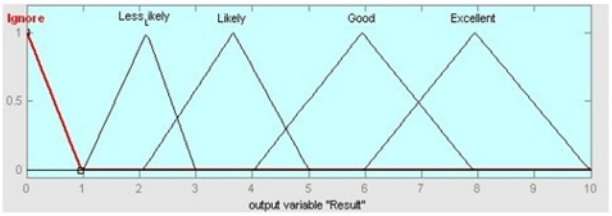


Figure 4: Fuzzy membership fuction for Result.

Fuzzy Inference Engine

Thefuzzy inference engine is a collection of rules made using knowledge of expert which is known as expert knowledge. In our system we got twenty seven rules. These knowledge based rules are connects the inputs and outputs depending on vigilant perception of the philosophy of cluster head selection in wires less sensor network.

Table I depicted the rules used in the fuzzy based complete system.

In the Figure 5, the trend shows the Fuzzy Relationship between input membership functions distance and degree with the output fuzzy variable Result. In this trend it shows clearly, the output variable is high when degree is high and distance is near. The selection of cluster head probability is high in this area as compare to the other region. Same as in Figure 6, which shows the relationship between input membership functions (Energy and distance) and output membership function (Result). The area marked as yellow has the highest chance of selecting the cluster head as it is depends on the near distance and High energy contents.

Table 1: Knowledge Structure Based on Fuzzy Rules

RULES	Degree	Distance	Energy	RESULT
1	H	N	H	EXC
2	H	N	M	EXC
3	H	N	L	LLK
4	H	M	H	EXC
5	H	M	M	GD
6	H	M	L	LLK
7	H	F	H	GD
8	H	F	M	LK
9	H	F	L	IGN
10	M	N	H	EXC
11	M	N	M	GD
12	M	N	L	IGN
13	M	M	H	LK
14	M	M	M	LLK
15	M	M	L	IGN
16	M	F	H	GD
17	M	F	M	LK
18	M	F	L	IGN
19	L	H	H	GD
20	L	H	M	LK
21	L	H	L	IGN
22	L	M	H	LK
23	L	M	M	LK
24	L	M	L	IGN
25	L	F	H	LK
26	L	F	M	LLK
27	L	F	L	IGN

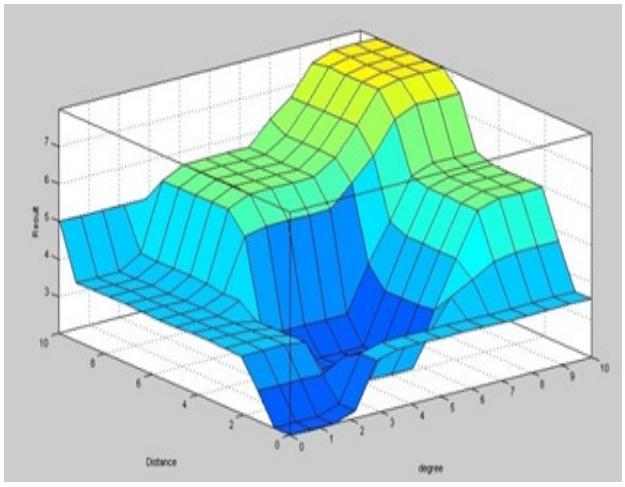


Figure 5: Fuzzy Relationship between input membership functions (Distance and Degree) and output fuzzy variable Result.

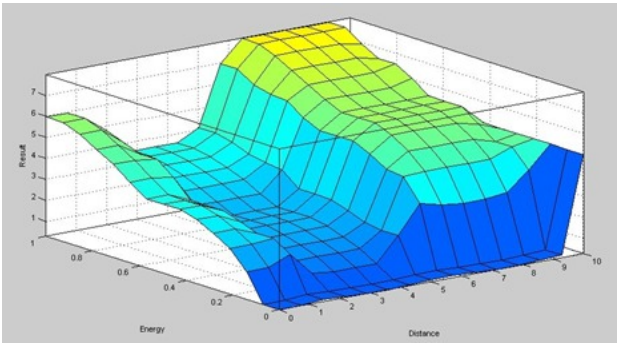


Figure 6: Fuzzy Relationship between input membership functions (Energy and Distance) and output fuzzy variable Result.

Defuzzification

Defuzzification is the method of making a quantifiable outcome in fuzzy logic, specified fuzzy sets and related membership degree. It is related to the way a crisp value is extracted from the fuzzy set as a demonstration value. In our work we used the popular defuzzification method known is centroid of area strategy. How to get the output membership variable is given in the below mentioned equation.

$$Fuzzy\_Result = [\Sigma_{Fuzzy\_Rules}\, xi * \mu(xi)] / [\Sigma_{Fuzzy\_Rules}\, \mu(xi)]$$

Here, fuzzy_result is used to specify the decision for cluster head selection. Xi denote the fuzzy variable and μ(xi) is membership function.

Cluster backup approach

This section defines the cluster backup approach. Most of the research considers the cluster head selection with many different methods. Though only with the cluster head selection we can save the residual power of entire system to a great extent but with keeping up the backup cluster we can improve the life time of entire network. As it is known, cluster heads are making as the single point of failure for the whole cluster. And while the cluster head fails to perform, the nodes (cluster members) have to make communication direct to the base station. That increases the energy usage for the members of cluster. We proposed a method in which the node which has the maximum score acts as the cluster head and the runner up performs the dual duties, like as a node and as a backup cluster head. Cluster head periodically shares the cluster nodes data along with the present condition of cluster head like as the battery power and base station connectivity information with the backup cluster node. In the below mentioned Figure 7, blue node functions as CH, and red functions as B-CH (backup cluster head).

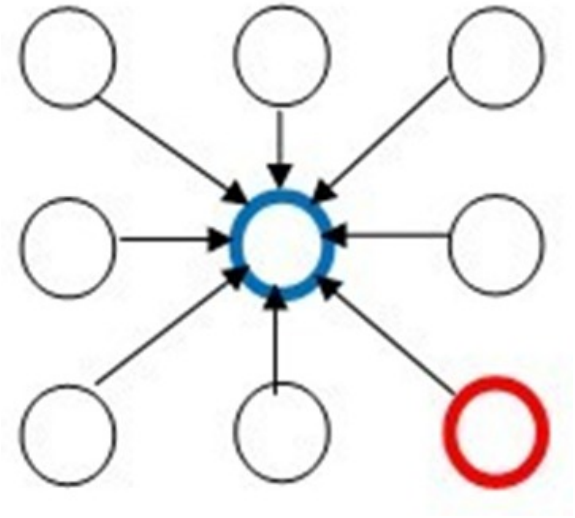


Figure 7: Selected Cluster head

After the blue is lost, red becomes CH and purple become B-CH. This is how rest of the nodes with respect to their scores will be prepared to take responsibility of CHs. This process is demonstrated in Figure 8.

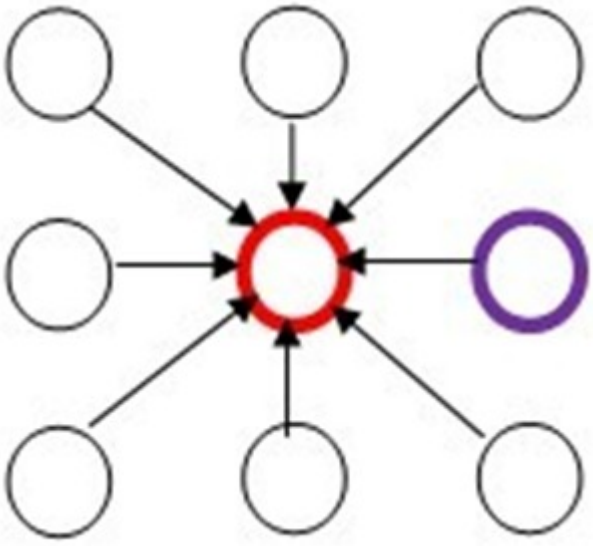


Figure 8: Selection of backup Cluster

Simulation

In this section we compared the FCA-BS with the available cluster based sensor network protocol. The simulation is implemented in the MATLAB platform. We compared the results on the basis of messages overhead, Data rate and power dissipation. As shown

in the Fig.9, messages overhead by the proposed method is about 17~20% lower than the LEACH and VLEACH protocol which in turn saves the energy of the system and gives the entire system longer life. Next, in Fig. 10, FCA-BS is compared for the power debauchery of the relevant nodes in a certain cluster. FCA-BS shows the important development in the power debauchery of the nodes in a certain period of the time.

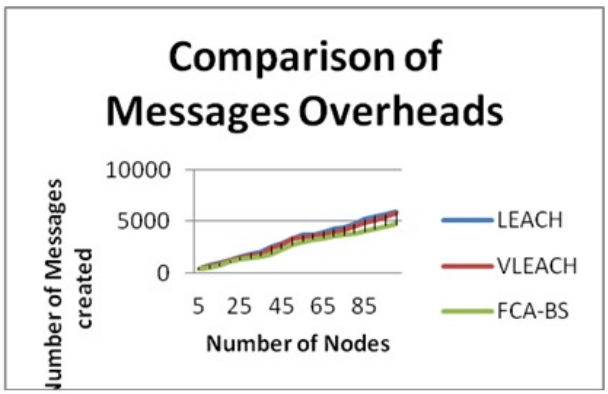


Figure 9: Messages Overhead in the cluster

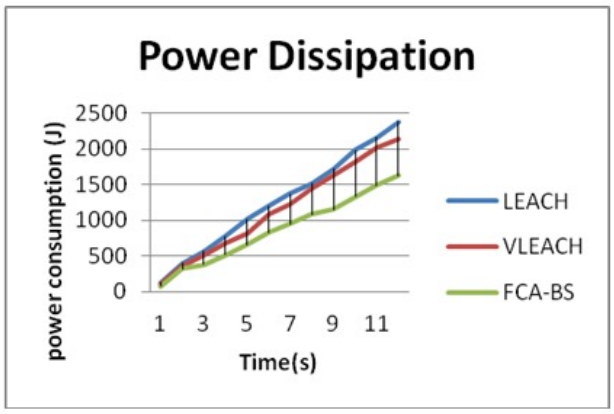


Figure 10: Power dissipation in the cluster

Simulation Results

Numerous above mentioned services are required to support back end infrastructure and OBU. This platform can be used to standardize among the various vehicle manufacturing organizations to create a collective market and making it easy entry for the new service providers into the market. The important car manufacturers backed a development of standardization method for the system platform made inside the European Project GST. The open high level platform architecture is given, which provides the details of the entities of system along with its interactions. In relation to that a latest method for the improving the scalability for reducing the count of messages, which are to be sent with the evaluation of relevancy of the relevant content of message. The selection of the message depends on the relevancy of the content and uses the information of the context in the vehicle and calculates the benefit of the message can be given to the vehicles nearby. In case whole vehicles use same method that can improve whole utility, resulting in the some extent utilization of global optimized network.The figuresin belowdemonstrate advantage curvature of an occurrence is plotted. The advantage declines over the distance from the source ofinformation, restricting the distribution neighborhood. Various VANETspecific simulation scenariosare published in the recent years. GrooveSim and CARISMA can be taken as two examples. Many of these simulators used digital maps as a foundation for the mobility model of node. The information related to node location and wireless links are used as input to moreover are incorporated or an external network simulator (e.g. ns-2). This paper also suggests few comprehensive information the procedure of combining the simulators for wireless network and mobility resourcefully whereas producing consistent results of simulation depending on practical mobility patterns. In this section we have provided the results of our simulations performed. We have taken End to End Delay and Packet loss as performance metric under the proposed framework and performed our simulations under three mobility scenarios as demonstrated in figure (11-22).

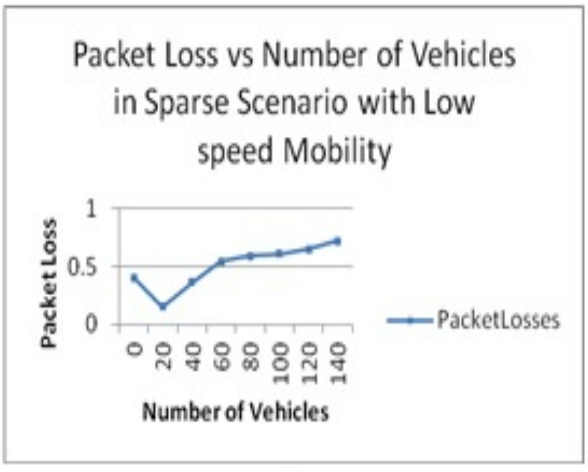
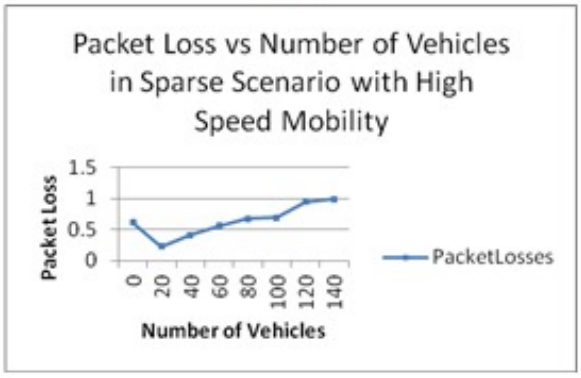


Figure 11



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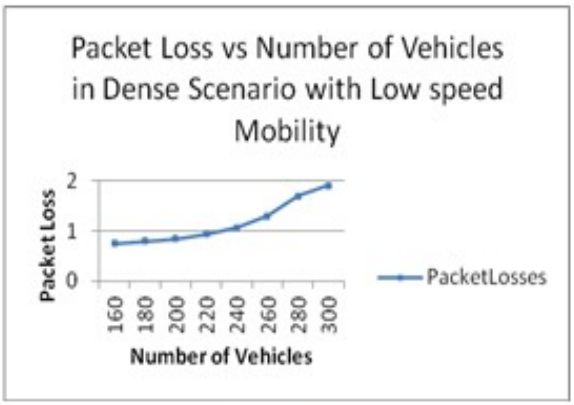
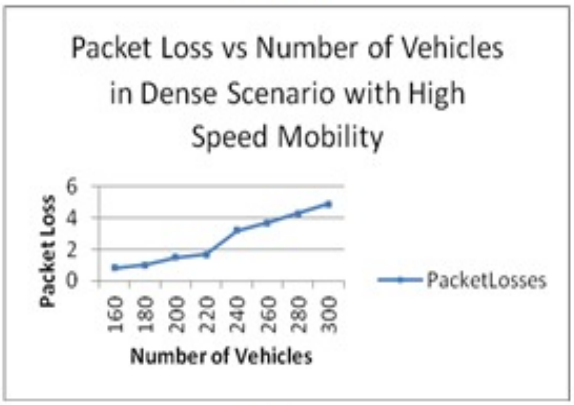


Fig 13



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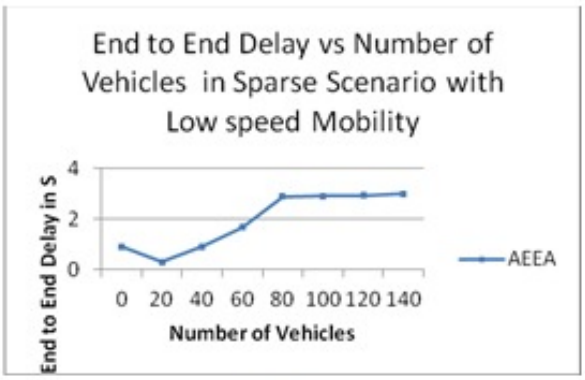

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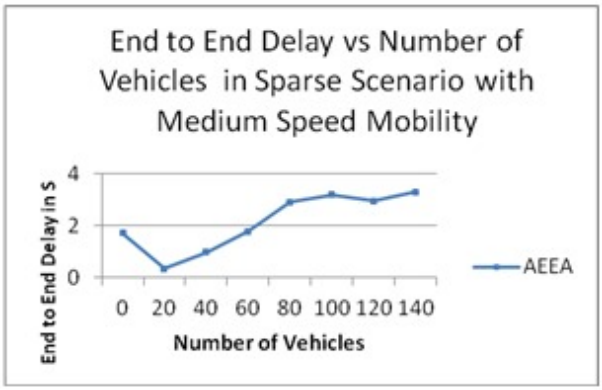

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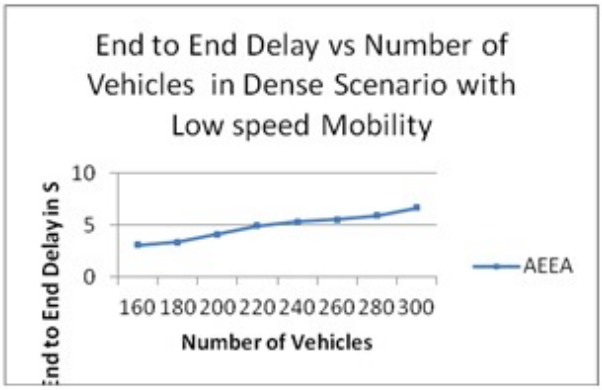

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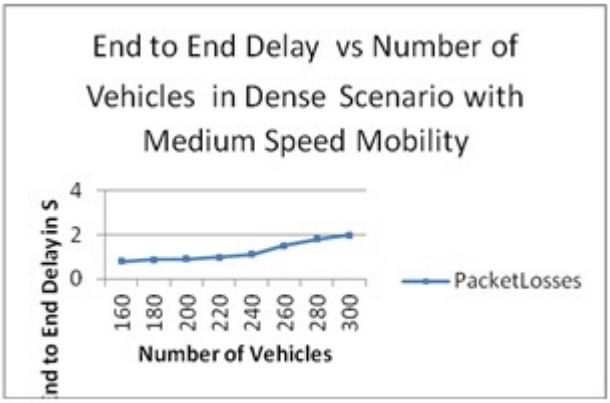

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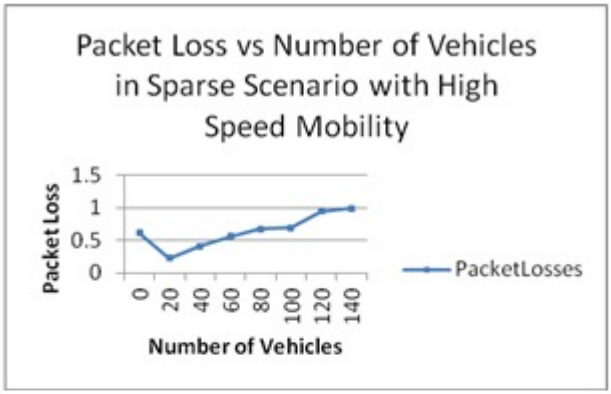

Fig 19

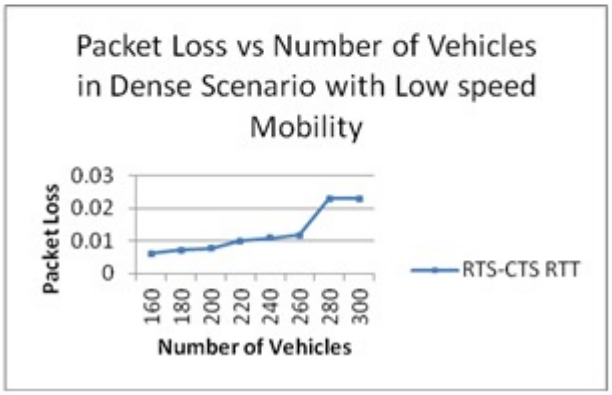

Fig 20

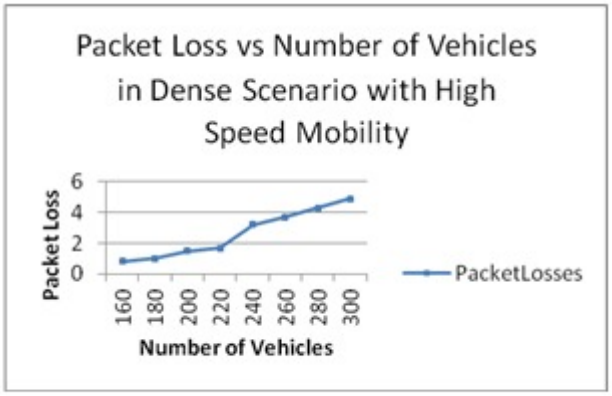

Fig 21

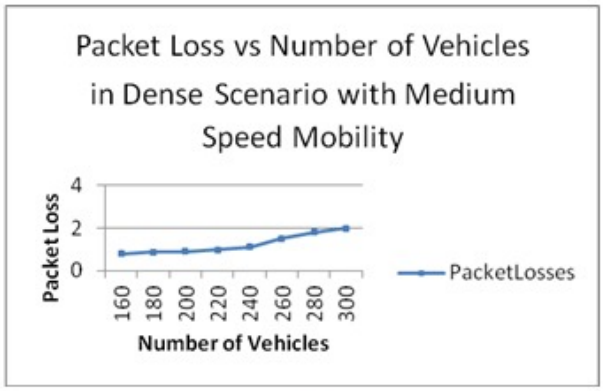

Fig 22

CONCLUSION

In this study we proposed a novel method for the selection of cluster head named Fuzzy Clustering Algorithm with backup support (FCA-BS). This algorithm is decentralized, dynamic and emergent aimed to make longer the life time of the WSN. In the cluster formation,if the cluster head fails to accomplish his function, all the nodes of the concerned cluster makes direct communication to the base station; this causes the burden on the network and reduces life time of the system. We proposed a reliable backup scheme in which if the cluster head fails to perform its duties, there remains always a backup cluster head which takes control of the cluster. FCA-BS is compared with well recognized wireless sensor network LEACH protocol and its improved version of V-LEACH. Simulation results show that, in FCA-BS messages overhead are lowered by 17~20% than the LEACH and VLEACH protocol which in turn saves the power of the system and gives the entire system longer life time.

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