A NOVEL WEIGHTED CLUSTERING ARCHITECTURE FOR INTRA AND INTER CLUSTER ROUTING IN WIRELESS MOBILE AD HOC SENSOR NETWORKS (WIICRP) FOR DISASTER MANAGEMENT

Gomathi K.[1], Meera Gandhi[2], Parvathavarthini B.[3]

[1]Research Scholar, Sathyabama University
[2]Dept of CSE, Sathyabama University
[3]Dept of Comp. Applns., St. Joseph Engg. college

ABSTRACT

Wireless Mobile Ad hoc Sensor Networks (WMASNs) are deployed in difficult environments where failures of sensor nodes and interruption of connectivity are habitual occurrences. On the other hand, energy-utilisation in (WMASNs) remains the main factor to achieve a longer network lifetime. Wireless Mobile Ad hoc Sensor Networks (WMASNs) are infrastructureless, multi-hop, dynamic networks for a collection of mobile nodes. This paper reviewed technological solutions for managing disaster using Wireless Mobile Ad hoc Sensor Networks via cluster management system by providing data sensing and aggregation for search and rescue operations. A clustering architecture provides network scalability and fault tolerance, and results in more efficient use of network resources. In each cluster, a Cluster Head (CH) is elected and responsible for cluster maintenance and inter-cluster and intra-cluster communication is also considered in our work. A Secondary Cluster Head (SCH) is also elected to avoid the CH from becoming a bottleneck. The SCH stores backup routing and cluster information. For this purpose, a Novel Weighted Intra and Inter Cluster Routing Protocol for WMASNs (WIICRP) for disaster recovery and management has been proposed. This approach is based on combined weight metric that takes into account of several system parameters like the degree difference of the node, transmission range, battery power and mobility of the sensor node. For intra cluster communication well known concept TDMA (Time Division Multiple Access) is used. For inter-cluster communication, AODV protocol is used in order to get the routes On Demand and to minimize the memory usage in sensor nodes. The performance of the system is evaluated based on the few metrics like Fault tolerance, delay, Quality of Service, Packet Delivery Ratio (PDR), network life time and data accuracy. As demonstrated, our algorithm reduces control messages overhead by having SCH and Gateway node thus improving overall performance and reducing energy utilization.

Keywords: WMASNs, Cluster Head, inter-cluster, intra-cluster, Secondary Cluster Head, TDMA, WIICRP

I. INTRODUCTION

Wireless Mobile Adhoc Sensor Networks (WMASNs) usually contains thousands or hundreds of sensors which are randomly deployed. Sensors are powered by battery, which is an important issue in sensor networks, since routing consumes a lot of energy. Wireless Mobile Ad hoc Sensor Networks (WMASNs) [1-3] are infrastructureless, multi-hop, dynamic networks for a collection of mobile nodes. WMASNs consist of mobile sensor nodes that form the networks without any fixed infrastructure or centralized administration. Each node communicates with the other nodes via intermediate nodes. Such factors might improve the network stability, scalability, bandwidth utilization, and resource sharing and management efficiency. Networking unattended sensor nodes are expected to have significant impact on the efficiency of many military and civil applications [3] such as combat field surveillance, security and disaster management. These systems process data gathered from multiple sensors to monitor events in an area of interest. For example, in a disaster management's setup, a large number of sensors can be dropped by a helicopter. Global climate change is increasing the occurrence of extreme climate phenomenon with increasing severity, both in terms of human casualty as well as economic losses. Authorities need to be better equipped to face these global truths. In the event of disaster, another important issue is a good search and rescue system with high level of precision, timeliness and safety for both the victims and the rescuers. This paper reviewed technological solutions for managing disaster using wireless Mobile Ad hoc Sensor Networks sensor networks (WSN) via disaster detection and cluster management system by providing data sensing and aggregation for search and rescue operations.

Networking these sensors can assist rescue operations by locating survivors, identifying risky areas and making the rescue crew more aware of the overall situation. Such application of sensor networks not only increases the efficiency of rescue operations but also ensure the safety of the rescue crew. On the military side, applications of sensor networks are numerous. For example, the use of networked set of sensors can be limiting the need for personnel involvement in the usually dangerous reconnaissance missions. Security applications of sensor networks include intrusion detection and criminal hunting.

The clustering architecture of Sensor nodes are given in the figure 1 provides three useful features in a WAMSN environment: network scalability, fault tolerance and reduction of communication overheads. Most existing clustering algorithms use either geographical regions as clusters or form new clusters proactively even if their function is not needed [2, 3, and 9].

It can be used for resource management, routing and location management to reduce communication and Computational Overhead .For this purpose, a Novel Weighted Intra and Inter Cluster Routing Protocol for Wireless mobile adhoc sensor networks (WMASNs) (WIICRP) has been proposed for disaster recovery and management. This approach is based on combined weight metric that takes into account several system parameters like the degree difference of the node, transmission range, and battery power and mobility of the sensor node.

The remainder of this paper is organized as follows. Section 2 presents related work done in cluster formation and cluster head election mechanisms. Section 3 presents the proposed data transmission architecture and routing schemes in both intra cluster and inter cluster. Section 4 presents performance evaluation and finally, Section 5 presents conclusions and future work.

II. RELATED WORK

Various cluster based routing schemes have been proposed in the literature. Some examples are:

A. Highest Degree Heuristic:

The Highest Degree heuristic uses the degree of a node as a metric for the selection of cluster heads. The degree of a node is the number of neighbor nodes. The node with maximum degree is chosen as a cluster head. Any tie is broken by the node identifiers. In this scheme, as the number of ordinary nodes in a cluster is increased, the throughput drops and system performance degrades [10].

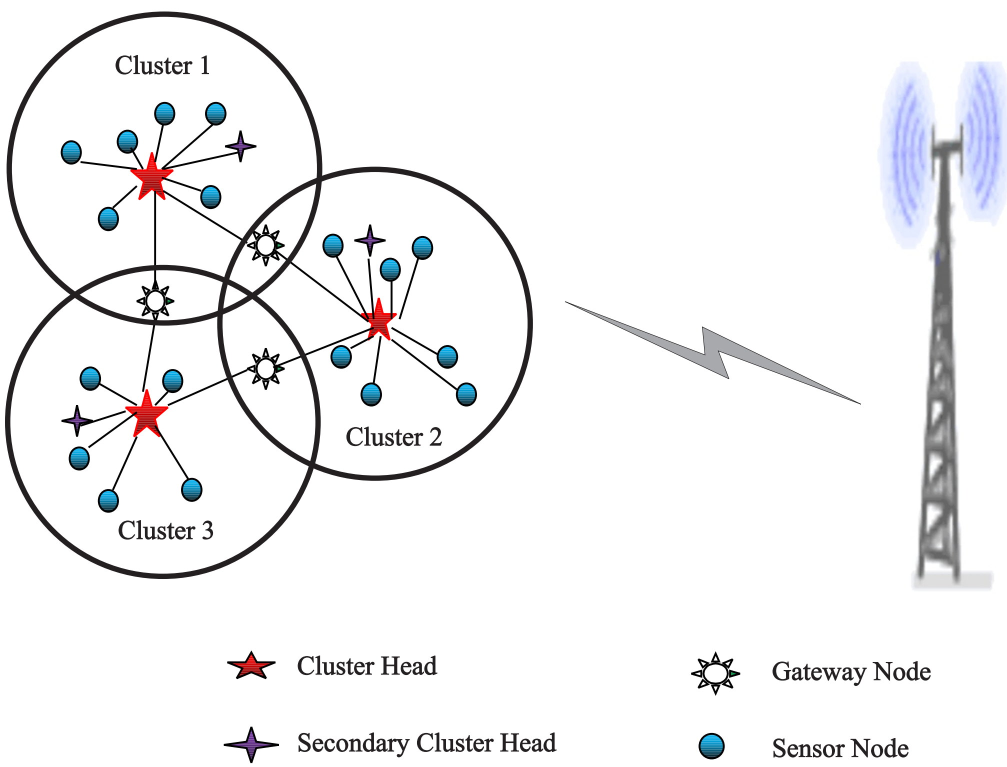

Fig. 1. Clustering Architecture of Sensor nodes

B. Weighted Clustering Algorithm (WCA):

The WCA is based on the use of a combined weight metric that takes into account several system parameters like the node-degree, distances with all its neighbors, node speed and the time spent as a cluster head. Each node obtains the weight values of all other nodes and information of other cluster heads in the system through rebroadcasting. As a result, the overhead induced by WCA is very high. If a node moves into a region that is not covered by any cluster head, then the cluster set-up procedure is invoked throughout the whole system. This leads to overheads. [10,12].

C. Distributed Weighted Clustering Algorithm:

This algorithm is an enhanced version of WCA to achieve distributed clustering set up and to extend lifetime span of the system. This algorithm differs from WCA in which it localizes configuration and reconfiguration of clusters and poses restriction on the power requirement on the cluster heads. This algorithm provides better performance than WCA in terms of the number of reaffiliations, end-to-end throughput, overheads during the initial clustering set up phase, and the minimum lifespan of nodes [13].

D. Low-Energy Adaptive Clustering Hierarchy Protocol:

LEACH (Low-Energy Adaptive Clustering Hierarchy) is one of the popular cluster-based structures. It has been regard as a relatively perfect routing protocol in wireless networks (WSN) [5]. In this protocol, the nodes organize themselves into local clusters, with one node acting as the local cluster-head. If the cluster-heads were chosen a priori and fixed throughout the system lifetime, as in conventional clustering algorithms, it is easy to see that the unlucky sensors chosen to be cluster-heads would die quickly, ending the useful lifetime of all nodes belonging to those clusters. Thus LEACH includes randomized rotation of the high-energy cluster-head position such that it rotates among the various sensors in order to not drain the battery of a single sensor. The method to elect clusters is using random. Each sensor chooses a number between 0 and 1. If the number is less than a threshold, the node broadcasts itself as the leader.

III. PROPOSED ALGORITHM

Our proposed work consists of following modules like Initialization phase, Data transmission phase and Maintenance phase.

A. Initialization phase

Initially weight will be computed for every node based on the factors like degree difference of the node, transmission range, and battery power and mobility of the sensor node. This module consists of following sub modules like Cluster Head election and cluster formation.

Weight Computation

Initially each node is assigned a random ID value (1) It broadcasts its ID value to its neighbors and builds its neighborhood table. Each node calculates its own weight based on the following factors like Node degree difference, **Energy remaining**, Mobility, distance from all other neighboring nodes. The distance between nodes and mobility is considered to keep the balance between clusters. The WIICRP performs clustering based on parameters described above and selects the Cluster Head for efficient clustering. The weight computation W for all the weights is given as follows in equation

$$W_n = W_1 * \Delta_n + W_2 * E_n - W_3 * M_n + W_4 * D_n \quad ...(1)$$

Where Δ_n - Degree Difference of node

E_n - Energy in each node represented by Joules

M_n - Mobility of each node. (Less mobility nodes have more probability to become a CH)

D_n - Distance from all other neighboring nodes

The co-efficient used in weight calculations W_1, W_2, W_3, W_4 are assumed as follows $W_1 = 0.5$, $W_2 = 0.35$, $W_3 = 0.05$, $W_4 = 0.1$. The sum of these co-efficient is 1. The factors degree difference and energy are given more importance and assumed higher co-efficient values 0.5 and 0.35. The combined weight is calculated by using the parameters of $\Delta - E_n$, M_n, D_n from the equations 2,3,4,5 respectively. After finding its own weight, each node broadcasts its weight to its neighbors based on neighborhood table. The neighborhood table consists of one hop reachable nodes; its weights. It is maintained by the CH.

Degree difference

It is defined as the difference between the cluster size N and the actual number of neighbours d_n. From the equation (2), it is known that Δ_n Degree Difference of node '*n*'. In order to find the Degree d_n of the node '*n*' by counting its neighbors. Compute the Degree difference for the node '*n*', where *N* is a threshold for the cluster's size.

$$\Delta_n = |d_n - N| \quad ...(2)$$

Energy:

Energy in each node represented by Joules. It is represented by $E_n -$ Energy (Battery Power) of node '*n*'. Energy E_n is calculated as

$$E_n = E_0 - E_{residual} \quad ...(3)$$

E_0 and $E_{residual}$ are initial and remaining energy of node '*n*'

Mobility of each node:

Less mobility nodes have more probability to become a CH. It is represented by $M_n -$ Mobility (Speed) of each node. It is calculated as

$M_n -$ Mobility speed of every node by following formula

$$M_n = \frac{1}{T} \sum_{t=1}^{T} \sqrt{(X_t - X_{t-1})^2 + (Y_1 - Y_{t-1})^2} \quad ...(4)$$

Where (X_1, Y_1) and $(X_{t-1}\ Y_{t-1})$ are the co-ordinate positions of node '*n*' at time *t* and $t-1$, $T =$ cumulative time.

Distance:

Distance from all other neighboring nodes is represented by D_n. Here; the sum of the distance between member nodes and its neighbors *is* defined by the equation (5). In order to find the neighbor $N(n)$ of each node '*n*', the D_n is calculated as

$$D_n = \sum_{n \in N(n)} \{\text{distance}\ (n, n)\} \quad ...(5)$$

$D_n -$ The sum of the distances between node '*n*' with its entire neighbor.

B. Cluster Head Election

In the Cluster Head election, every node broadcasts a Hello packet within its transmission range This broadcast contains the node ID and Weight value of that node. When a node receives a predefined number (Np) of Hello packets, it compares all the weights received, the node with highest weight will be announced as a Cluster Head (CH),then the newly elected CH will broadcast a message that "I am a cluster-head (CH)". A failed CH may cause a cluster to remain isolated until the next re clustering. Meanwhile, important data from sensors cannot be reported and may be lost. To avoid this problem, a Secondary Cluster Head (SCH) is also elected based on next highest weight. The SCH stores backup routing and cluster information.

C. Cluster Formation

In this phase nodes send their joining message like "I am Cluster member" to CH within the one- hop distance. CH will maintain the member's list with member id and role (Ordinay node, SCH, Gateway node, neighbour CH). Suppose a node receives more than one CH message from different CH, then that will become a Gate Way node and it is responsible for inter-cluster communication.

D. Data transmission phase

This phase consists of sub modules like inter cluster and intra cluster communication .In intra cluster – TDMA is used in order to avoid the congestion in the cluster heads. In the inter cluster communication, AODV protocol is used in order to get the routes On demand and to minimize the memory usage in sensor nodes.

Inter Cluster Routing

CH uses a traditional AODV protocol and send RREQ message to search for a BS through a gateway to its neighbor clusters. To reduce the overhead caused by the RREQ flooding packet, only gateways and CHs are involved in forwarding the RREQ. No ordinary nodes are involved in RREQ packets in the inter-cluster communications will send RREP message to the concerned CH and neighborhood table is maintained. By using the routing information, aggregated data will be forwarded to the BS.

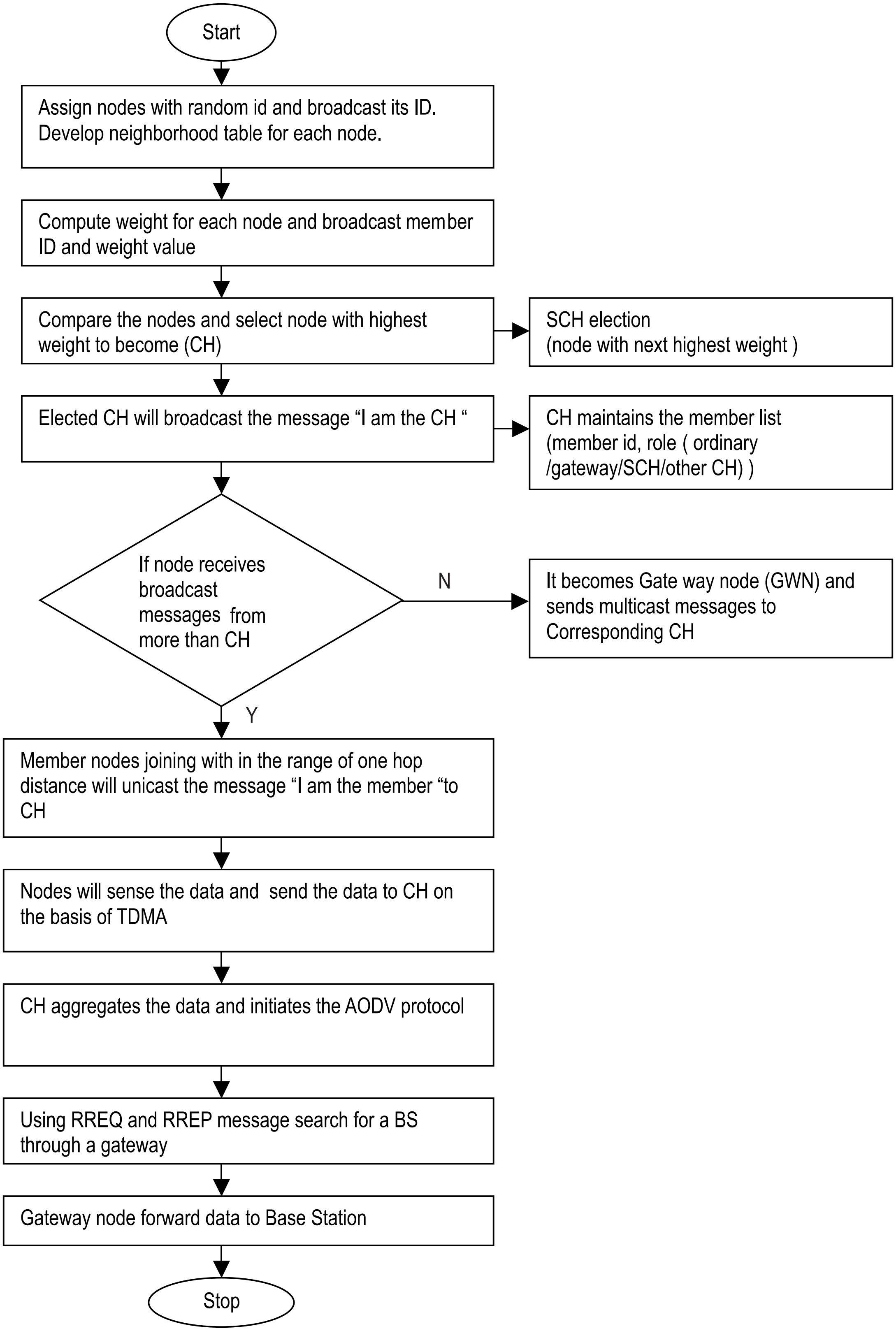

Fig. 2. Flow for Cluster formation and Data transmission

IV. SIMULATION RESULTS AND DISCUSSION

The number of nodes used in the simulation results varies between 20 and 100. The simulations were run for 300 seconds. The cluster size was fixed at 15. We depict some statistics on the formed clusters for different transmission ranges. In the first set of simulations, the scalability of the algorithm is measured in terms of nodes density and transmission range. In this paper, the NS-2 simulator [15] is used for the simulation to show the performance of the proposed method. In the simulation, the parameter values are selected at random and shown in Table 1. The parameters are network size, number of nodes, max speed, pause time, packet size, transmission area, hello packet interval, and simulation time, cluster size and protocol. The proposed method WIICRP is compared with AODV protocol for performance evaluation. The total energy consumption of entire network is compared between before cluster with AODV and proposed protocol WIICRP and the Packet Delivery Ratio of total network is compared with well known AODV protocol and our Weight based Routing protocol WIICRP.

A. Network model and parameter settings

In our proposal the following network mode and its parameter settings are considered: The Simulation Parameters are given in Table 1.

- All the nodes are capable of communicating directly with the BS.
- The BS is located far from the sensor network and fixed.
- All nodes are homogeneous, energy constrained and immobile. Initial energy 0 E is 4J in this paper.

Sensor nodes are densely deployed which might generate huge redundant data. Similar data from multiple nodes can be combined or fused together in order to reduce the required number of transmission to the BS [6,7]. We consider a 100-node network with randomly distributed nodes in a (300×300) meter area. The BS is located at $(x = 0, y = 0)$. The length of each signal is 4000 bits and the energy required for data aggregation is 5nJ/bit/signal [8]. The radio spends $E =$ 50nJ/bit energy to run receiver and transmitter electronics.

Table 1. Simulation Parameters

Parameters	Value
Network size	300 m × 300 m
Number of nodes	20 – 100 nodes
Mobility of the node (Speed)	3-30 m/s
Pause time	10 s
Packet size	100 bytes
TransmissionRange	30-300 m
Simulationtime	420 s
Hello packet interval	3 s
Frequencyband	5.4 Ghz
Cluster size with member nodes	15 nodes
Time of simulation	300 sec
AODV protocol (Inter cluster)	–
TDMA (Intra Cluster)	–

B. Packet Delivery Ratio (PDR):

Data Packet Delivery Ratio can be calculated as the ratio between the number of data packets that are sent by the source and the number of data packets that are received by the Base station.

PDR = No. of Packets received/No. of Packets sent

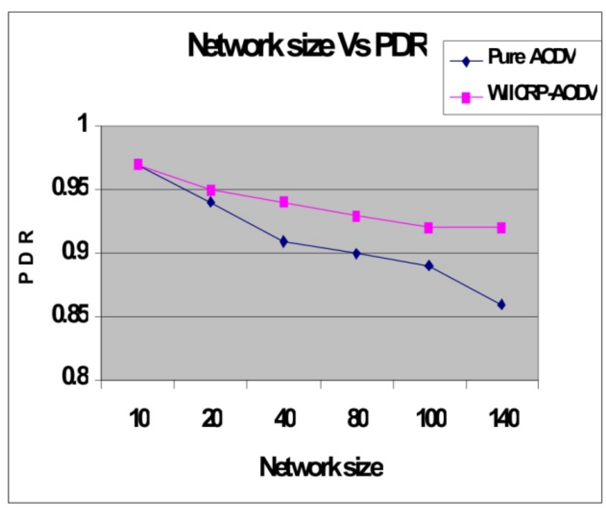

Fig. 3. Network size Vs PDR of Pure AODV and WIICRP-AODV

Figure. 3 is the total Packet Delivery Ratio (PDR) of entire Network nodes about Pure AODV and our proposed protocol WIICRP. Fig. 3 shows that the packet delivery ratio is higher for the Proposed protocol WIICRP than the pure AODV protocol. The difference in the delivery ratios increases as the network's size increases, which shows the performance gained because of Weight based routing scheme.

C. Total Energy consumption

Figure. 4 is the total energy consumption of entire network nodes, and our proposed protocol WIICRP. Initially both the protocols consuming energy almost the same but after time of 400, there is a change in energy consumption of two protocols. So, the proposed protocol WIICRP which can save more energy better than without cluster by using AODV protocol.

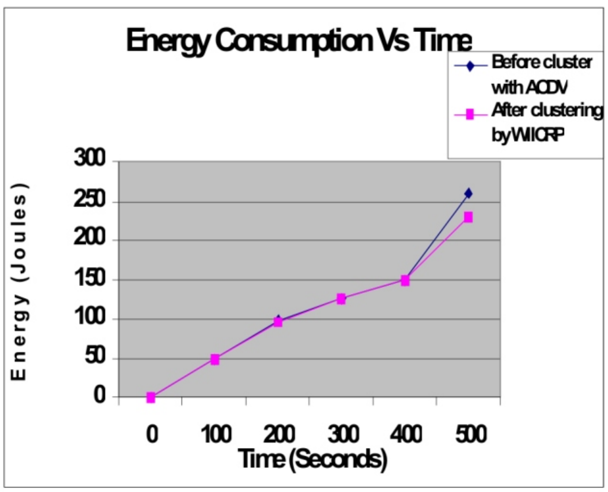

Fig. 4. Energy Consumption Vs Time of before cluster with AODV and after clustering by WIICRP

D. Total Number of alive Nodes

In Wireless Mobile Ad hoc Sensor Networks (WMASNs) every sensor node directly communicate with the BS, so it wastes its maximum energy for transmitting the data, but by applying weight based clustered hierarchy (WIICRP) sensor node directly send their data to its nearest CH and it consume only less transmission power. CHs then aggregate these data's and send them to BS. So this clustered architecture results energy saving for sensor nodes but at the same time, we consume the energy of CHs. To solve this problem, there is a Monitoring node for checking the energy level of CH, when it reaches minimum energy SCH will take part in the communication and it will act

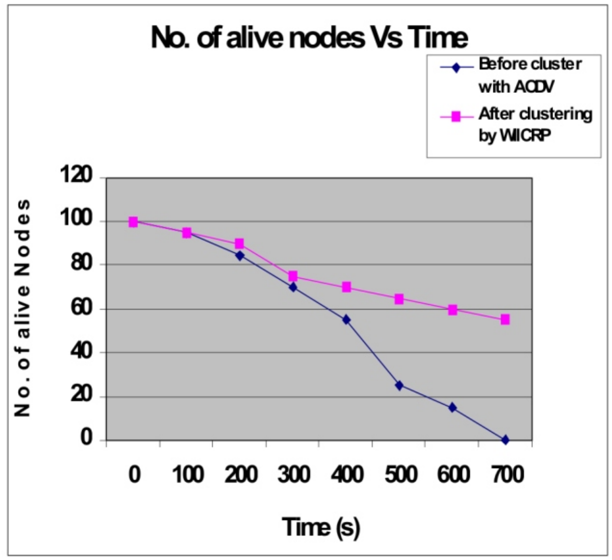

Fig. 5. No. of alive nodes Vs Time of before cluster with AODV and after clustering by WIICRP

as a CH and CH algorithm will be iniated for selecting new SCH. In the proposed protocol (WIICRP) which is having more number of alive nodes than before clustering with AODV protocol.

V. CONCLUSION

This paper presents a weight-based clustering and AODV based routing scheme in Wireless Mobile Adhoc Sensor networks (WMASNs) for efficient cluster management. The scheme is used for integrated routing and message delivery in clustered networks for disaster management. As demonstrated, our algorithm reduces control messages overhead by having SCH and Gateway node thus improving overall performance and reducing energy utilization. Since energy utilization is the most important criteria in cluster based routing schemes, our protocol provides better results than existing algorithm. A clustering architecture improves the network's scalability and results in a more efficient use of network resources. In the future, some other performance metrics like fault tolerance, network life time can be taken for performance evaluation and this protocol can be extended to include group key management among clusters to provide secure transmission of collected data. We also intend to extend the clustering architecture to support multi-hop clustering in Wireless mobile adhoc sensor networks (WMASNs). Effective utilization of power, Bandwidth wastage, Stable Clusters helps in improving the quality of service in WMASNs by applying the Weighted Clustering Algorithm. This paper applies cluster management system by providing data sensing and aggregation for search and rescue operations for disaster mangement. In the future solar energy system will be exercised for improving the battery life time and network life time.

REFERENCES

[1] Anitha, V.S., Sebastian, M.P.(2009), "SCAM: Scenario-based clustering algorithm for mobile *ad hoc* networks ", in Proceedings of the 13th IEEE/ACM International Symposium on Distributed Simulation and Real-Time Applications, pp. 97-104.

[2] Basagni, S. et al (2006), "Localized protocols for *ad hoc* Clustering and backbone formation: A performance comparison", IEEE Trans. Parall. Distrib. Sys. 2006, 17, pp. 292-306.

[3] Dhurandher, S.K., Singh, G.V (2005), "Weighted-based adaptive clustering algorithm in mobile ad hoc networks ". in Proceedings of ICPWC'2005, New Delhi, India, pp. 96-100.

[4] K. Akkaya and M. Younis, (2003) "A Survey of Routing Protocols in Wireless Sensor Networks", Elsevier Ad Hoc Network Journal, 3(3), pp .325-349.

[5] LI Fangmin et al (2008), "Power Control for Wireless Sensor Networks", Journal of Software Engineering, 19(3): pp. 716-732.

[6] Q. Jiang and D. Manivannan (2004), "Routing protocols for sensor networks", in Proc. 1st IEEE Consumer Comm. & Net. Conf. (CCNC), pp. 93-98.

[7] Zhang Jian-wu et al, (2008), "Weighted Clustering Algorithm Based Routing Protocol in Wireless mobile adhoc sensor networks (WMASNs)".

[8] Sanjay kumar padhi et al (2008), "Review of routing protocols in sensor and Adhoc networks", International journal of reviews in computing.

[9] Adeel Akhtar, Abid Ali Minhas, and Sohail Jabbar (2010) "Energy Aware Intra Cluster Routing for Wireless Mobile Adhoc Sensor Networks (WMASNs)", International Journal of Hybrid Information Technology Vol.3, No.1, pp. 29-48.

[10] Naveen chauhana (2011), "Distributed Weighted Cluster Based Routing Protocol for MANETS" *wireless Sensor Network*, 2011, 3, pp. 54-60.

[11] Tzung-Pei Hong et al (2011), "An Improved Weighted Clustering Algorithm for Determination of Application Nodes in Heterogeneous Sensor Networks", Journal of Information Hiding and Multimedia Signal Processing, Ubiquitous International, Volume 2, Number 2, pp. 173-184.

[12] R. Pandi Selvam et al (2011), "Stable and Flexible Weight based Clustering Algorithm in Mobile Ad hoc Networks", International Journal of Computer Science and Information Technologies, Vol. 2 (2), pp. 824-828.

[13] Jutao Hao et al (2011), "Energy Efficient Clustering Algorithm for Data Gathering in Wireless Sensor Networks", Journal of Networks, Vol. 6, no. 3, pp. 490 - 497.

[14] Huiheng Liu et al (2011), "Cooperative Spectrum Sensing and Weighted-Clustering Algorithm for Cognitive Radio Network", I.J. Information Engineering and Electronic Business, vol. 2, pp. 20-27.

[15] NS-2 simulator. Available online: http://www.isi.edu/nanam/ns (17 May 2011)