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Enhanced Geographic Adaptive Fidelity Algorithm in Cooperative Networks

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Abstract— **in cooperative networks, transmitting and receiving nodes recruit neighbouring nodes to assist in communication. A cooperative transmission link in wireless networks modeled as a transmitter cluster and a receiver cluster. A cooperative communication protocol proposed for establishment of these clusters and for cooperative transmission of data. We analyzed the end-to-end robustness of the protocol to data-packet loss, energy consumption and error rate. The analysis results are used to compare with two non-co operative schemes such as disjoint path, one path and cooperative scheme such as CAN protocol. We run two sets of experiments. In the first set nodes are placed on a grid topology and in the second set nodes are positioned randomly. The comparison results show that, when nodes are positioned on a grid, there is a reduction in the probability of packet delivery failure by two orders of magnitude for the values of parameters considered. Up to 80% in energy savings can be achieved for a grid topology, while for random node placement cooperative protocol can save up to 40% in energy consumption relative to the other protocols. The reduction in error rate and the energy savings translate into increased lifetime of cooperative sensor networks. In cooperative protocol, location based routing protocol is implemented which make use of nodes' location information, instead of links' information for routing. They are also known as position based routing. This algorithm makes use of nodes which are not active into sleeping state over a period of time. Thus making cooperative network more energy efficient and implemented using Geographic Adaptive Fidelity (GAF) algorithm.**

Keywords — ***Clustering, cooperative networks, Wireless sensor networks (WSN), geographic adaptive fidelity algorithm(GAF).***

1. INTRODUCTION

A wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions. The development of such networks was originally motivated by military applications such as battlefield surveillance. However, wireless sensor networks are now used in many civilian application areas, including environment and habitat monitoring,
Health care applications, home automation, and traffic control [1-2]. As depicted in Fig. 1, data collected by sensors is transmitted to a special node equipped with higher energy and processing capabilities called –Base Station‖ (BS) or –sink‖.
The BS collects filters and aggregates data sent by sensors in order to extract useful information. WSNs have the potential to become the dominant sensing technology in many civilian and military applications, such as intrusion detection, environmental monitoring, object tracking, traffic control, and inventory management. In many of these applications,

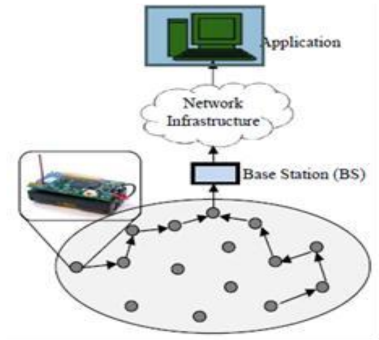

Fig-1 Wireless sensor networks

WSNs need to monitor the target field for detecting events of interest, e.g., the entrance of an intruder in intrusion detection applications. Widespread deployment of WSNs in target field monitoring is being deterred by the energy consumed in the monitoring process.

In wireless sensor networks, nodes have limited energy resources and, consequently, protocols designed for sensor networks should be energy efficient. One recent technology that allows energy saving is cooperative transmission. In cooperative transmission, multiple nodes simultaneously receive, decode and retransmit data packets.

In the model of cooperative transmission, every node on the path from the source node to the destination node becomes a cluster head, with the task of recruiting other nodes in its neighborhood and coordinating their transmissions. Consequently, the classical route from a source node to a sink node is replaced with a multi hop cooperative path, and the classical point-to-point communication is replaced with many-to-many cooperative communication. The path can then be described as –having a width,‖ where the –width‖ of a path at a particular hop is determined by the number of nodes on each end of a hop. For the example in **Fig.2.** the width of each intermediate hop is 3. Of course, this –width‖ does not need to be uniform along a path. Each hop on this path represents communication from many geographically close nodes, called a sending cluster, to another cluster of nodes, termed a receiving cluster. The nodes in each cluster cooperate in transmission of packets, which propagate along the path from one cluster to the next.

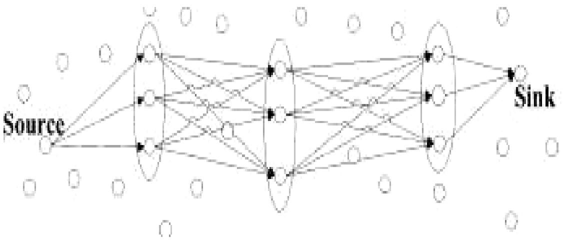

Fig 2- Cooperative transmission protocol

The model of cooperative transmission for a single hop is further depicted in **Fig. 3**. Every node in the receiving cluster receives from every node in the sending cluster. Sending nodes are synchronized, and the power level of the received signal at a receiving node is the sum of all the signal powers coming from all the sender nodes. This reduces the likelihood of a packet being received in error.

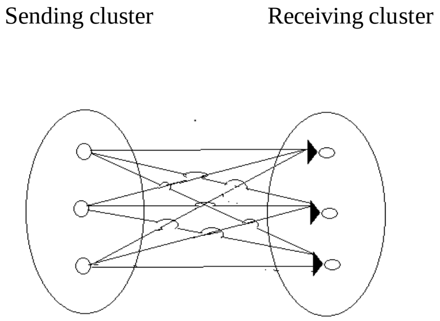

Fig 3. Cooperative reception model

The cooperative transmission protocol consists of two phases. In the routing phase, the initial path between the source and the sink nodes is discovered as an underlying –one-node-thick‖ path. Then, the path undergoes a thickening process in the –recruiting-and-transmitting‖ phase. In this phase, the nodes on the initial path become cluster heads which recruit additional adjacent nodes from their neighbourhood.

Recruiting is done dynamically and per packet as the packet traverses the path. When a packet is received by a cluster head of the receiving cluster, the cluster head initiates the recruiting by the next node on the –one-node-thick‖ path. Once this recruiting is completed and the receiving cluster is established, the packet is transmitted from the sending cluster to the newly established receiving cluster.

During the routing phase where the –one- node-thick‖ path is discovered, information about the energy required for transmission to neighbouring nodes is computed. This informationis then used for cluster establishment in the –recruiting-and-transmitting‖ phase by selecting nodes with lowest energy cost. Medium access control is done in the –recruiting-and-transmitting‖ phase through exchanges of short control packets between the nodes on the –one-node-thick‖ path and their neighbour nodes.

Routing in ad hoc and sensor networks is a challenging task due to the high dynamics and limited resources. There has been a large amount of non-geographic ad hoc routing protocols proposed in the literature that are either proactive (maintain routes continuously), reactive (create routes on demand)

Non geographic routing protocols suffer from a huge amount of overhead for route setup and maintenance due to the frequent topology changes and they typically depend on flooding for route discovery or link state updates, which limit their scalability and efficiency. On the other hand, geographic routing protocols require only local information and thus are very efficient in wireless networks. First, nodes need to know only the location information of their direct neighbours in order to forward packets and hence the state stored is least. Second, such protocols conserve energy and bandwidth since discovery floods and state propagation are not required beyond a single hop. Third, in mobile networks with frequent topology changes, geographic routing has fast response and can find new routes quickly by using only local topology information.

A key advantage of cooperative transmission is the increase of the received power at the receiving nodes. This decreases the probability of bit error and of packet loss. Alternatively, the sender nodes can use smaller transmission power for the same probability of bit error, thus reducing the energy consumption.

1.1. SYSTEM MODEL DESCRIPTION

We consider a wireless sensor networks composed of multiple clusters of nodes, as shown in Fig 2.The nodes within the same cluster are closely spaced and can cooperate in signal transmission and/or reception. The average distance between the adjacent clusters is much larger than the average distance between the intra-cluster nodes. Every node in our model only has an antenna. This scenario depicts a typical wireless sensor network and is widely analyzed.

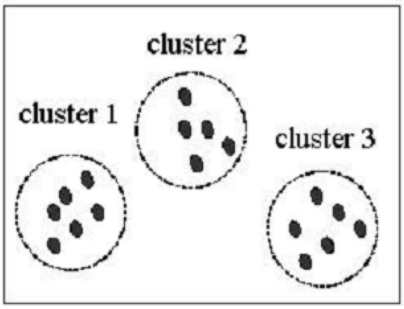

Fig-4 Clustering Model

The model works as follows. If a node has data to other adjacent clusters, it will first broadcast its data to the nodes in the same cluster. All the nodes in this cluster will receive the data simultaneously. Then, all nodes that have received the data correctly will transmit the data with the same energy to the destination simultaneously after some distributed space- time coding. These cooperative nodes work just as an antenna array. Because the inter-cluster distance is large, this model is expected to be much more energy efficient than the common direct communication.

2. COOPERATIVE PROTOCOL

The routing phase of the protocol, which is responsible for finding a –one-node-thick‖ route from the source node to the sink node, could be implemented using one of the many previously published routing protocols. For the purpose of performance evaluation chose to implement this phase using the Geographic Adaptive Fidelity protocol (GAF).

The main novelty of paper—the –recruiting-and-transmitting‖ phase is done dynamically per hop, starting from the source node and progressing, hop by hop, as the packet moves along the path to the sink node. Once a data packet is received at a receiving cluster of the previous hop along the path, the receiving cluster now becomes the sending cluster, and the new receiving cluster will start forming. The next node on the –one-node-thick-path‖ becomes the cluster head of the receiving cluster. The receiving cluster is formed by the cluster head recruiting neighbour nodes through exchange of short control packets. Then, the sending cluster head synchronizes its nodes at which time the nodes transmit the data packet to the nodes of the receiving cluster.

3. OPERATION OF THE –RECRUIT-AND TRANSMIT‖ PHASE

The example in Fig. 5(a)–(f) demonstrates the operation of the –recruiting-and-transmitting‖ phase. In the current hop node 2 is the sending cluster head and has a packet to be sent to node 5.

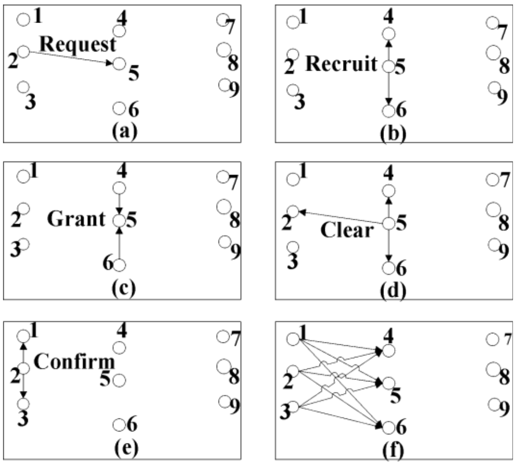

Fig 5 Example of recruiting phase operation

Node 2 sends a request-to-recruit (RR) packet to node 5 [Fig. 3(a)], causing node 5 to start the formation of the receiving cluster, with node 5 as the cluster head. From the routing phase, node 5 knows that the next-hop node is node 8. Node 5 broadcasts to its neighbours a recruit (REC) packet [Fig. 5(b)]. The REC packet contains: the id of the previous node (2), the id of the next node (8), and the maximum time to respond, denoted as T. Each node that receives the REC packet, which are potential recruits (nodes 4 and 6) computes the sum of the link costs of the following two links: a link from the sending cluster head to itself (the receiving link) and a link from itself to the next node, such as the receiving cluster head or the sink node (the sending link). In this example, node 4 computes the sums of the energy costs of the links (2,4) and (4,8), i.e., $C_{(2,4)}+C_{(4,8)}$, while node 6 computes the sum of the energy costs of the links (2,6) and (6,8), i.e., $C_{(2,6)}+C_{(6,8)}$. A potential recruit replies to the REC packet with a grant (GR) packet that contains the computed sum [Fig. 5(c)] after a random back off time drawn uniformly from (0, T). The GR packets inform the cluster head that the nodes are available to cooperate in receiving on the current hop and in sending on the next hop.

After waiting time and collecting a number of grants, the cluster head (node 5) selects cooperating nodes with the smallest reported cost ‗m‘ to form the receiving cluster of nodes.(The value of ‗m‘ is protocol selectable.) If the cluster head node received less than ‗m-1‘ grants, it forms a smaller receiving cluster with all the nodes that sent the grants. Node 5 then sends a clear (CL) packet [Fig. 3(d)] that contains the ids of the selected cooperating nodes (4 and 6). The CL packet serves two purposes:

1) It informs the sending cluster head (node 2) that the cluster has been formed; and

2) It informs the potential recruits whether they have or have not been chosen to cooperate.

Upon receiving the CL packet from node 5, node 2 sends a confirm (CF) packet to the nodes in its sending cluster (nodes 1 and 3) to synchronize their transmission of the data packet [Fig. 5(e)]. The CF packet contains the waiting- time-to-send P_t and the transmission power level. The transmission power level is the total transmission power (a protocol-selectable parameter) divided by the number of the nodes in the sending cluster. In the case of our example, the value of P_t is divided by 3 (nodes 1–3 are cooperating in sending). After the waiting-time-to-send expires, sending cluster nodes 1–3 send the data packet to the receiving cluster nodes 4–6 [Fig.5(f)]

4. GEOGRAPHIC ADAPTIVE FIDELITY ALGORITHM (GAF)

GAF: Geographic Adaptive Fidelity (GAF)[10] is an energy-aware location-based routing algorithm designed primarily for mobile ad hoc networks, but may be applicable to sensor networks as well. GAF conserves energy by turning off unnecessary nodes in the network without affecting the level of routing fidelity. GAF can substantially increase the network lifetime as the number of nodes increases. A *geographical adaptive fidelity* (GAF) algorithm that reduces energy consumption in ad hoc wireless networks. GAF conserves energy by identifying nodes that are equivalent from a routing perspective and turning off unnecessary nodes, keeping a constant level of routing *fidelity*. GAF moderates this policy using application- and system-level information; nodes that source or sink data remain on and intermediate nodes monitor and balance energy use. GAF is independent of the underlying ad hoc routing protocol; we simulate GAF over unmodified AODV and DSR. Analysis and simulation studies of GAF show that it can consume 40% to 60% less energy than an unmodified ad hoc routing protocol. Moreover, simulations of GAF suggest that network lifetime increases proportionally to node density; in one example, a four-fold increase in node density leads to network lifetime increase for 3 to 6 times (depending on the mobility pattern). More generally, GAF is an example of adaptive fidelity, a technique proposed for extending the lifetime of self-configuring systems by exploiting redundancy to conserve energy while maintaining application fidelity

In GAF protocol, each node uses location information based on GPS to associate itself with a –virtual grid‖ so that the entire area is divided into several square grids, and the node with the highest residual energy within each grid becomes the master of the grid. Two nodes are considered to be equivalent when they maintain the same set of neighbour nodes and so they can belong to the same communication routes. Source and destination in the application are excluded from this characterization.

Nodes use their GPS indicated location to associate itself with a point in the virtual grid. Inside each zone, nodes collaborate with each other to play different roles. For example, nodes will elect one sensor node to stay awake for a certain period of time and then they go to sleep. This node is responsible for monitoring and reporting data to the sink on behalf of the nodes in the zone and is known as the master node. Other nodes in the same grid can be regarded as redundant with respect to forwarding packets, and thus they can be safely put to sleep without sacrificing the –routing fidelity‖ i.e. routing efficiency.

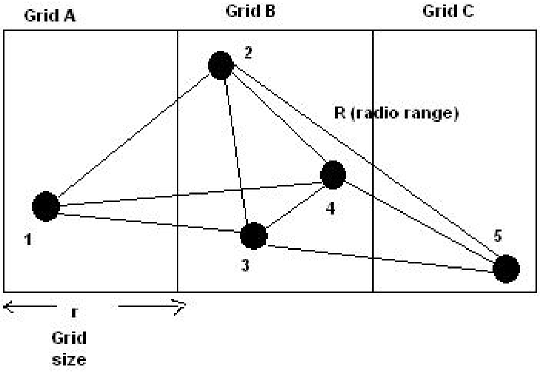

Fig 6 Virtual grid structure in the GAF protocol

The slave nodes switch between off and listening with the guarantee that one master node in each grid will stay awake to route packets. For example, nodes 2, 3 and 4 in the virtual grid B in Fig 2 are equivalent in the sense that one of them can forward packets between nodes 1 and 5 while the other two can sleep to conserve energy. Hence, GAF conserves energy by turning off unnecessary nodes in the network without affecting the level of routing fidelity. Each node uses its GPS-indicated location to associate itself with a point in the virtual grid.

The grid size r can be easily deduced from the relationship between r and the radio range R which is given by the formula:

$$r \le R/\sqrt{5}$$

There are three states defined in GAF. These states are discovery, for determining the neighbors, active reflecting participation in routing and sleep when the radio is turned off. Which node will sleep for how long is application dependent and the related parameters are tuned accordingly during the routing process. The sleeping neighbors adjust their sleeping time accordingly in order to keep the routing fidelity. Before the leaving time of the active node expires, sleeping nodes wake up and one of them becomes active. GAF strives to keep the network connected as in, by keeping a representative node always in active mode. The state transitions in GAF are depicted in Fig. 7.

$$A_{Jk} = \sum_{I=1}^{2^m-1} g^J_{v(I)} A_{v(I)k-1}$$

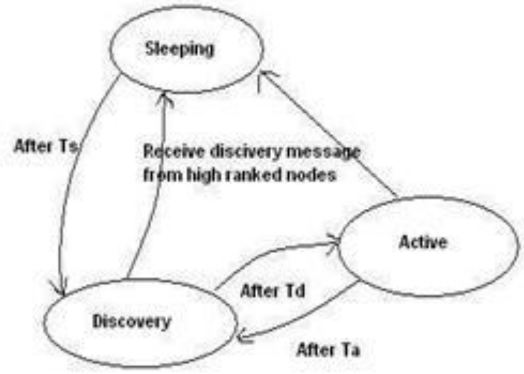

Fig 7 State transitions in GAF protocols

In our cooperative transmission protocol, cluster heads which are found during by routing phase will always be in active mode. During recruiting and transmitting phase, the nodes which are not recruited will turn into sleeping mode over a period of time. This algorithm saves the overall network energy.

5. PROTOCOL ROBUSTNESS

We compute the failure probability that a packet does not reach the sink due to reception error along the path. We then compare the failure probability of our cooperative transmission protocol to the failure probability using the CAN protocol, the disjoint-paths scheme, and the one-path scheme.

5.1. COOPERATIVE TRANSMISSION PROTOCOL

Let the nodes in the cluster be indexed from 0 to m-1 where m is the number of nodes in the sending cluster. We denote the transmission pattern of nodes in a sending cluster by a binary representation $b_{m-1......}b_1b_0$ according to which node j transmits if $b_j=1$ and does not transmit if $b_j=0$.Similarly the reception model in receiving cluster is get established.

Let g_I^J be the probability that nodes with binary representation I = $u_{m-1.....}u_1 u_0$ transmit a packet of length L bits to nodes with binary representation J = $b_{m-1....}b_1 b_0$ across a single hop, and let SNR_j be the SNR of the received signal at node j. Then

$$\mathrm{BER} = f\left(\mathrm{SNR}_j, \sum_{i=0}^{m-1} u_i\right)$$

$$g_I^J = \prod_{j=0}^{m-1} [(1-b_j)(1-(1-\mathrm{BER})^L) + b_j(1-\mathrm{BER})^L].$$

Let A_{JK} be the probability that a packet reaches the kth hop to nodes with binary representation J, ,then

$$A_{Jk} = \sum_{I=1}^{2^m-1} g^{J}_{v(I)} A_{v(I)k-1}$$

$$A_{J0} = \begin{cases} 1, & \text{for } J = v(2^{\lfloor m/2 \rfloor}) \\ 0, & \text{otherwise} \end{cases}$$

Let be B^h_{CwR} the probability of failure of a packet to reach any node by h^{th} hop then

$$B^h_{CwR} = \sum_{k=1}^{h} A_{v(0)k}.$$

5.2. DISJOINT-PATHS

The probability of a bit error at a receiver is computed as $f(\frac{P_t}{P_\eta d^\gamma \beta\gamma}, 1)$, Then, the probability that a packet of length L bits successfully reaches the sink over one path of h hops is $\left(1 - f\left(\frac{P_t}{P_\eta d^\gamma \beta^\gamma}, 1\right)\right)^{Lh}$ .If we let B^h_{IXC} be the probability of failure of a packet to reach any node by the hth hop of the disjoint-paths scheme, then

$$B^h_{\mathrm{IXC}} = \left(1 - \left(1 - f\left(\frac{P_t}{P_\eta d^\gamma \beta^\gamma}, 1\right)\right)^{Lh}\right)^m.$$

5.3. ONE-PATH

The analysis in this case is similar to the disjoint-paths case, but with one path only and each node transmitting with power of $\pounds_{j=1}^{m} P_t(j)$, where $P_t(j)$ is the transmission power of the j^{th} node. Let B^{h}_{one} be the probability of failure of a packet to reach the hth node of the one-path scheme, then

$$B^h_{\mathrm{One}} = 1 - \left(1 - f\left(\frac{mP_t}{P_\eta d^\gamma \beta^\gamma}, 1\right)\right)^{Lh}.$$

5.4. CAN

Let $X_i=0$ represent the event that a packet is not received at the i^{th} hop along the non-cooperative path, while $X_i=1$ is the complementary event. Let B^{h}_{Can} be the probability of failure of a packet of length L bits to reach the node at the hth hop

$$\begin{aligned} B^h_{\mathrm{CAN}} &= \Pr(X_h = 0) \\ &= \sum_{I=1}^{2^n-1} [\Pr(X_h = 0\, X_{h-1} = u_0, \ldots, X_{h-n} = u_{n-1}) \\ &\qquad \times \Pr(X_{h-1} = u_0, \ldots, X_{h-n} = u_{n-1})] \end{aligned}$$

Where n= min (m,h).

6. SIMULATION RESULTS

Medium Access Delay(s): is the average time spent between the time a packet is handed to the GAF layer and the time it is received at the next hop. This delay accounts for the contention delay in the case of contention-based protocols and scheduling delay in schedule-based protocols.

Packet Drop Rate: is the fraction of packets that is dropped during the medium access. It is calculated as the percentage of dropped packets to the total packets sent from the MAC layer throughout the simulation. This metric shows the performance of the GAP protocol in terms of medium access overhead introduced in terms of wasted number of packets.

Good put: is the ratio between the total number of packets received at the sink and the total number of packets generated by all sensor nodes. As a result, the efficiency of the GAF protocol is investigated.

Average Energy Consumption (J): is the average energy a sensor node consumes during the simulation. Exploiting spatial correlation at the GAF layer is a powerful means of reducing the energy consumption in WSN under collective performance limits. This can be achieved by collaboratively regulating medium access so that redundant transmissions Exploiting spatial correlation at the GAF layer is a powerful means of reducing the energy consumption in WSN under collective performance limits. This can be achieved by collaboratively regulating medium access so that redundant transmissions from correlation neighbors are suppressed. By allowing only a Subset of sensor nodes to transmit their data to the sink, the proposed GAF protocol not only conserves energy, but also minimizes unnecessary channel access contention and there by improves the packet drop rate without compromising the event detection latency. This is in contrast to the energy-latency tradeoffs that has been the main focus of many energy efficient in WSN.

When the simulation done and the numerical values collected for both the existing system and the proposed system for the performance parameters

1. Energy consumed
2. Bandwidth Utilized
3. Delay
4. Packet delivery ratio
5. Number of packets sent and the result was noted down

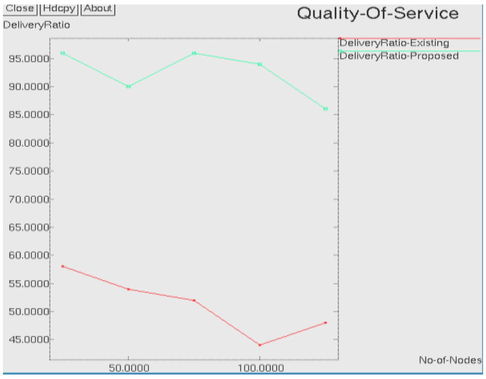

Fig 8 Comparing existing system and proposed based on packet delivery ratio

Fig. 9 Comparing existing system and proposed based on Bandwidth Utilization

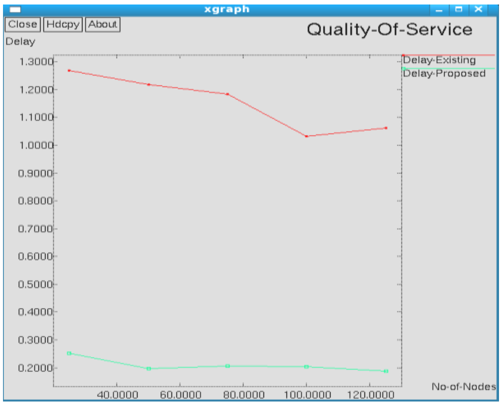

Figure 9 Comparing existing system and proposed system based on Delay

7. CONCLUSION

This paper, evaluated the performance of cooperative transmission, where nodes in a sending cluster are synchronized to communicate a packet to nodes in a receiving cluster. In this communication model, the power of the received signal at each node of the receiving cluster is a sum of the powers of the transmitted independent signals of the nodes in the sending cluster. The increased power of the received signal, leads to overall saving in network energy and to end-to-end robustness to data loss. The cooperative protocol is implemented using GAF algorithm to achieve more energy efficiency by using location information instead of link‘s information for outing.GAF is a hierarchical protocol, with limited power usage. As they operate on the basis of the geographic or location information for routing, data aggregation at any point is absent. Although GAF is highly scalable, it will not take care of QoS. Future direction may be conducted to enable QoS in the GAF algorithm during data submission.

REFERENCES

[1] A. Khandani, J. Abounadi, E. Modiano, and L. Zheng, ―Cooperative routing in static wireless networks,‖ IEEE Trans. Commun., vol. 55, no. 11, pp. 2185–2192, Nov. 2007.

[2] N. Shankar, C. Chun-Ting, and M. Ghosh, ―Cooperative communication MAC (CMAC)—A new MAC protocol for next generation wireless LANs,‖ in Proc. IEEE Int. Conf.Wireless Netw., Commun., Mobile Comput., Maui, HI, Jul. 2005, vol. 1, pp. 1–6.

[3] T. Korakis, S. Narayanan, A. Bagri, and S. Panwar, ―Implementing a cooperative MAC protocol for wireless LANs,‖ in Proc. IEEE ICC, Istanbul, Turkey, Jun. 2006, vol. 10, pp. 4805–4810.

[4] C. Chou, J. Yang, and D. Wang, ―Cooperative MAC protocol with automatic relay selection in distributed wireless networks,‖ in Proc. IEEE Int. Conf. Pervasive Comput. Commun. Workshops, White Plains, NY, Mar. 2007, pp. 526–531.

[5] J. Mirkovic, G. Orfanos, H. Reumerman, and D. Denteneer, ―A MAC protocol for MIMO based IEEE 802.11 wireless local area networks,‖ in Proc. IEEE WCNC, Hong Kong, Mar. 2007, pp. 2131–2136.

[6] A. Sendonaris, E. Erkip, and B. Aazhang, ―User cooperation diversity—Part I: System description,‖ IEEE Trans. Commun., vol. 51, no.11, pp. 1927–1938, Nov. 2003.

[7] X. Wang, G. Xing, Y. Zhang, C. Lu, R. Pless. And C. Gill, ―Integrated coverage and connectivity configuration in wireless sensor networks,‖ in Proc. ACM SenSys, Los Angeles, CA, Nov. 2003, pp. 28-39

[8] J. Laneman, D. Tse, and G. Wornell, ―Cooperative diversity in wireless networks: Efficient protocols and outage behavior,‖ *IEEE Trans.Inf. Theory*, vol. 50, no. 12, pp. 3062–3080, Dec. 2004.

[9] A. Stefanov and E. Erkip, ―Cooperative information transmission in wireless networks,‖ in *Proc. Asian–Eur. Workshop Inf. Theory*, Breisach, Germany, Jun. 2002, pp. 90–93.

[10] T. Hunter and A. Nosratinia, ―Diversity through coded cooperation,‖ *IEEE Trans. Wireless Commun.*, vol. 5, no. 2, pp. 283–289, Feb. 2006.

[11] J. Laneman and G. Wornell, ―Distributed space-time-coded protocols for exploiting cooperative diversity in wireless networks,‖ IEEE Trans.Inf. Theory, vol. 49, no. 10, pp. 2415–2425, Oct. 2003.

[12] P. Herhold, E. Zimmermann, and G. Fettweis, ―Cooperative multi-hop transmission in wireless networks,‖ Comput. Netw., vol. 49, no. 3, pp. 299–324, Oct. 2005.

[13] A. Nosratinia, T. E. Hunter, and A. Hedayat, ―Cooperative communi- cation in wireless networks,‖ IEEE Commun. Mag., vol. 42, no. 10, pp. 74–80, Oct. 2004.