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AN ENERGY EFFICIENT COOPERATIVE AND INCREMENTAL RELAY NODE SELECTION BASED ROUTING PROTOCOL FOR WSN

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ABSTRACT

Abstract- In wireless sensor cooperative networks, the cooperation among the neighboring nodes can significantly improve energy efficiency of a network. In this paper, energy efficient and load balanced cooperative relay selection for wireless sensor networks is proposed. By optimizing the total data transmission time and balanced load among various relay and cooperative nodes, network reliability is improved. It helps to make the network more energy efficient by forming coordination. During analysis of all the existing protocols, find out that protocol in which directly data transmission from Cluster Head to Base station depletes their energy earlier as compared to other ones. So, the proposed protocol equally distributes the load among all nodes. Mainly this approach is best suitable for the homogeneous network, in which all nodes deployed with same energy level, for the densely deployed area and nodes are considered as static. In this, data transmission time is minimized using the relay nodes. By considering the various parameters energy and scalability; Simulation results of proposed protocol shows the remarkable improvement in energy savings over non-cooperative routing LEACH, SEP, Z-SEP.

Keywords: Wireless Sensor Networks, Relay nodes, cooperative nodes, Data Transmission Time.

1. INTRODUCTION

Over the last few years, Wireless sensor network (WSN) set up new benchmarks in the wireless networks technology, because of its capability to work with less infrastructure and multi-hop transmission. A wireless network is an efficient way to reduce the requirement of hardware (cables) among any of the two or more communicating devices. Wireless networks administered this by the way of radio communication and it takes place at first layer of open source system interconnection (OSI) model i.e. at the physical layer which aims to provide hardware for the purpose of sending and receiving data on the wireless channel. In WSN, the increasing number of nodes is proportional to the total cost of the network, this problem is directly coupled to the performance of WSN's such as fault-tolerance and one of the most critical issue i.e. coverage problem in WSN area.

2.

The ad-hoc networks was existing from a very long period, but the requirement for WSN came into reality with military applications for target detection, but nowadays it is used to monitor the environment conditions like pressure, temperature, also used in health-care applications, agriculture and so on. From the past few years, wireless networks has been categorized into various kind of aspects like WSN's, wireless body area networks (WBANs), wireless micro sensor networks (WMNs) etc. Because of the distinctive nature of WSNs, sensor nodes communicating among themselves and forming a multi-hop network in which one sensor node is following the different paths for transmission of data packets to another nodes rather than one particular path [1],[3]. WSN has Base Station (BS) which is able to manage for all communication among nodes. Sensor or autonomous nodes are deployed in supervisor area to monitor the physical and environmental conditions. To create a network sensor nodes randomly wide spread in the monitoring area and after that all sensor nodes maintain the connectivity among themselves for the transmission of data. Some of them are used to know about environmental factors or changes. Sensor nodes are also known as mote, mote is always a node but it's not necessary that a node is always a mote and they are great to use in geographical areas. Sensor nodes are varying in size, how the sensor node works effectively in particular field is characterized upon its size only. Most of nodes are static but some are classify to mobility state also. Sensor nodes have limited battery and would not be rechargeable and replaceable in some cases. The transmission power of sensor nodes is very limited, thus there is a need to design an energy efficient protocol for these wireless devices to make the less energy consumption. In proposed protocol, instead of direct communication between nodes with CH or BS the sensor nodes communicate via cooperative nodes with other CH's and BS. The primary difference between the ad-hoc networks and WSNs can be described on the basis of some attributes:

- Central sink: There is one head or controller in WSN for transmitting and receiving data in network, it means there is only one access point. In case of MANETs, have no single controller. Each node acts as a controller till network do not have one fixed administrator

- Quality of service: WSN is not too much reliable due to the reason of QOS metrics is different, as sensor node batteries can't be replaced or recharged once it is deployed or finished so that the applications which are using WSNs must be more energy-efficient than others. On the other hand ad-hoc networks are more reliable, as reliability per node is must at fair level
- Type of network: WSNs are generally homogeneous because there is only one type of devices used in network i.e. sensors while on the other hand ad-hoc networks are heterogeneous network, different types of devices constitutes a network like mobile, laptop etc
- Fault tolerance: WSN maintenance is not easy in case fault occurrence, sensor nodes are very small in size so it's difficult to find them firstly and maintain it properly but this concept is avoided in case of ad-hoc networks, heterogeneous devices are used and easy to find fault in devices like mobile, laptops and correct it
- Packet size: In WSN as compare to standard size of packets, small size of sensor nodes is taken. So, energy consumed by the small size packets is less to reach its destination as well as there would be less chances of collision. In ad hoc networks, standard size of packets are taken which consumes more energy
- Data aggregation: In WSN, during data transmission time some of the sensor nodes are assigned for the routing purpose and rest for data aggregation in a network. In ad-hoc networks, data aggregation is partially required by network. Most of the time only routing is performed.

1.1 Network Architecture

Routing protocol algorithm depends upon network architecture; there are two types of architecture-

- Flat- In this, each and every node of a network takes the responsibility to transmit and senses the data to sink
- Hierarchical- All the nodes in network is distinguished. They can be classified on the basis of sensing, transmitting power and energy. Some of the nodes can be elected as the cluster head (CHs).

The variation between homogeneous and heterogeneous WSN is, heterogeneous network having the sensor nodes with different battery energy, sensing range and functionalities. It consists of more than two types of nodes and they are not identical with higher deployment cost. These type of networks have to work in a cooperative way by considering the different energy of nodes [8]. In case of homogeneous networks, it consists of identical nodes with lower deployment cost.

1.2 Sensor Node

Sensor node can classify into various categories: infra-red, radar and thermal visual [2]. Our Cooperative Relay Selection (CRS) approach is based on homogeneity in which all sensor nodes are homogeneous, having the same capabilities and energy. Due to the reason of small battery and more consumption of energy, the sensor nodes starts dying at the very first and second round or in some cases they don't remains with energy for the next round based on the distance and cluster hierarchy. To avoid this, energy efficient protocols are introduced. We distinguish the sensor networks into two categories:

- Category A: like the mesh-based systems along with multi-hop radio connectivity in whole deployment area. e.g. military-theatre
- Category B: like point to point and multipoint to point along with single-hop connectivity in whole deployment area. e.g. home control systems

In a cooperative communication scheme, every node transmits the data of its own or always be act like a cooperative agent for another users also[5]. Cooperative communication allows single-antenna mobiles to retrieve some advantages of Multiple Input Multiple Output (MIMO) system. In multi-user scenario, single-antenna mobiles organize its antennas in such a way that helps it to create a pragmatic MIMO system. By this allowance in cooperative communication, one antenna can be used for transmitting as well as receiving purpose also, like antenna in second level cluster would be used for receiving the data from first level cluster and further used for transmitting the same data to upper level cluster. In Cooperative communication, each CH depends on other CH or may be other node to forward data to BS by using relay nodes which aggregates data from sensor nodes. The source and destination are connected and communicating by means of relay nodes. In this network topology, because of the greater transmission range between source and destination, they are not able to communicate directly. Therefore, relay nodes are needed to act as an intermediate among both of them. By taking the relay nodes, it holds the advantages like prolong the network lifetime, increase data transmission range and so on. In our proposed protocol, sensor nodes forward data to the CH via direct link and also use relay nodes for transmitting. The sensor nodes are in the transmission range of relay nodes and relays are in range of CH, they can cooperate with each other to forwards data to BS. The half-duplex communication is considered in this scheme. CH forwards data to BS by forming a cooperation among all the CH and cooperative nodes. The cooperative nodes will receive data from CH and forwards it to other cooperative node for transmitting it to the BS.

The remaining section of this paper is organized as follows: Section 2 represents related work regarding this approach. Section 3 represents CRS and its working along with flow chart. In Section 4, energy consumption by sensor nodes are described. Section 5 includes the results and performance evaluation. Finally, we conclude the paper discussion and its future work.

2. RELATED WORK

LEE et. al, [1] proposed a protocol named as Energy Efficient Cooperative Communication (EECC) which form Clusters firstly and then initiate inter-cluster routes with the help of relay nodes or may be directly. In this, the exact selection of relay nodes would helps for the reduction of energy consumption in cluster heads. Relay nodes would also helps to maintain the load in network via inter cluster routing. They conclude from results that network lifetime of proposed protocol is 101.3% larger in case when energy of 1st sensor node is going to be exhaust and 6.3% larger in case when energy of 20th sensor node is going to be exhaust when compared with network lifetime of Hybrid energy efficient Deficiency protocol(HEED).

Muruganathan et. al, in 2005 proposed a protocol named as, Base Station Controlled Dynamic Clustering Protocol (BCDCP) [2], it is a clustering-based routing protocol having a centralized scenario. The aim of this approach is to set up cluster in such a way that each cluster in network is composed with equal number of cluster members, gain improvement in results over PEGASIS.

Jamil et. al, proposed COPE [3], Cooperative Power And Energy-Efficient Routing Protocol for WSN's in which this proposed cooperative protocol compared with the two non-cooperative routing protocols named as LEACH and Power-Efficient Gathering in Sensor Information System (PEGASIS) and find out that COPE gives better results in case of network lifetime as well as energy efficiency rather than other two non-cooperative routing protocols LEACH and PEGASIS because after every round in total iterations, number of dead nodes was decreasing. Ibrahim et. al, [4] The minimum Power Cooperative Routing algorithm (MPCR) has been proposed, while making the minimum power route, cooperative communication scheme is utilized. At the end comparison is made between cooperative routes and non-cooperative routes for selected routes and concludes that MPCR is 37.64% power saving than non-cooperative routes.

Ahn. et. al, proposed [5] Balanced Chain Based Routing Protocol For Energy-Efficient WSN (BCBRP) implements a chain based structure for balancing load among the all nodes in order to improve the lifetime of a network. The complete network firstly divides into various sub-areas and ensure that each sub-area is of equal size and in particular sub-area at least one chain of nodes would be formed which further connects to other chain via bridge node, finalize from simulation that proposed protocol has 7% more network lifetime when compared to PEGASIS and has 11% when compare to EBSCR approach.

BinLi et. al, [6] proposed Energy-Efficient Cooperative Geographic Routing in WSN (ECGR), using the scheme of Cooperative Diversity and Geographic Routing to make network stable and energy efficient. By considering the energy consumption and geographic information, this approach adaptively selects an appropriate cooperative node for the purpose of forwarding a packet. Simulation shows that when hop count will be dropped then automatically the average transmitting distance is increased of each hop. *Shalli rani et. al*, proposed Energy Efficient Protocol for Wireless Sensor Networks [7] used a multi-hop approach for the CH's and this novel EEICCP protocol equally distributes the load among all the sensor nodes. Author was trying to increase the scalability of a network via controlling topology in which respective CH's directly sends the data to BS and every node in particular cluster has the same responsibility to receive the data from other nodes and after aggregating, further forwards to the BS. They conclude from simulation that this protocol reduce energy consumption of 43% than Hierarchical Clustering Routing Protocol (HCR) and 50% than Low Energy Adaptive Clustering Hierarchy (LEACH) protocol.

[**10] Prashant Katoch et. al,** proposed a protocol by focusing CH selection process of LEACH by taking the concept of residual energy (energy left at node after completion of one round). Author proposed one data transmission algorithm in which firstly checks it out that particular node is CH or normal node, if it is a CH then data starts transmitting to the BS. If it is not a CH, then there is a condition that node which has energy greater than 10% of initial energy of node would be consider as normal node otherwise that particular node would be consider as a weak node. In case it is normal node, starts transmitting data to its respective CH and if it is a weak node then firstly sends data to its nearest node (nearest node may be CH or normal node).

P. Ding et. al, proposed LEACH C protocol[13] in which only base station decides the number of clusters available in network and evenly distribute overall load among clusters. It helps to increase overall network lifetime rather than

LEACH and Minimum Transmission Energy routing protocol (MTE), in this the nodes starts transmitting the data only when a small change is noticeable in the sensing attribute of particular node so that CH's don't have to check out among whole network that which node transmit at particular time.

Shalli rani et. al, [14] proposed an Energy Efficient Inter Cluster Coordination Protocol, follows an appropriate layered approach for communication among CH's and CCO. The results received by this particular strategy proved that this protocol works good even in case if nodes will be increased. This protocol transmits 70% data earlier than HCR approach and same 43% faster than LEACH approach. In 2005 [9] stable Election Protocol (SEP), Hybrid Energy-Efficient Distributed Clustering (HEED), LEACH and CODA protocols were proposed by *S. Hussain et. al*, in which HEED shows better network lifetime by two times and CODA shows 30% better network lifetime as compared to LEACH. In HEED, for data transmission the cluster get divided into two levels to reduce energy efficiency but still the distance travelled by CH's is large. As a result, SEP has a more stable region than LEACH.

Priya suri et. al,[15] reviewed on different clustering based protocols for WSN having the heterogeneous network. The scalability of a network can be increased by restricting the topology, thus clustering sensor node is one of them for particular energy constrained networks. Cooperative routing mechanism has the capability to reduce the effects from channel fading and on other hand increased energy efficiency of a network. Cooperative routing is an inter-operable layer technique, to make the communication more effective it utilizes the benefits of cooperative communication at physical layer and do routing at the network layer. This process helps us in reducing the power consumption of a network and delay.

3. COOPERATIVE ROUTING PROTOCOL

Cooperative communication seems to be the fastest growing research area but the term 'cooperation' is possible only whenever the communicating interface exceeds two. Communication among all the sensor nodes is the main reason behind an energy consumption that can restrict the network lifetime and the stability of network. In the CRS, an appropriate selection of the relay nodes will make the better cooperative communication. Relay nodes are being elected by considering the equal distance from all sensor nodes and CH. When one CH cooperates with cooperative nodes to transmit data to the BS, this effective way of communication helps to make the network more energy efficient. This form of communication, face many challenges and one of them is how to select an appropriate cooperative node that can transmits the data in an efficient manner [11].
As we compare the CRS with other non-cooperative approach, it requires single iteration for the selection of CH. So there would be less chances of complexity in this protocol. During initial phase, CH is randomly selected in particular cluster but during re- election clusters which was never be act like a CH, would be appointed. But the re-election done only when previous CH reach the threshold level. During re-election, if the node which has energy greater than 0.1J and lesser than 0.5J then that node would be selected as CH. The same process is followed during the selection of cooperative nodes [1].

There are the two phases under proposed protocol:-

- Setup phase- In this, the CH broadcasts its own status and location to other NON-CH nodes in particular cluster and at the same time nodes sends back acknowledgement to the respective CH. In this way CH knows about all the nodes available in a network. CH assigned Time Division Multiple Access (TDMA) slot to the nodes, it means the clock of both CH and node will be mutually sink. The nodes always be on sleep mode (no energy consumption by nodes) and wake up only when node knows that it's the time to transmit the packets. So with TDMA slotting, there is less chances of collision and less energy consumed by sensor nodes. Along with this scheduling, the initial phase is completed.
- Data Transfer phase- The data transmission begins from the cluster which is far away from BS and it is assumed that BS has a constant power supply. Firstly, relay nodes aggregate data from all the sensor nodes and forwards to their respective CH. CH further transmits data to cooperative node which resides at next level cluster and after that cooperative node further forwards to the next level cooperative node and so on until the data will be transmitted to Cluster Cooperative Head (CCH) which can directly communicate with all the cooperative nodes as well as BS. This process helps to reduce the effect from line of sight propagation (propagation in which sender and receiver starts transmitting or receiving data only at a situation in which both are in view of each other).

For this network set up, CRS starts by partitioning the area into sub-areas (clusters) with the fixed number of dimensions. From each cluster, one node is selected as CH randomly and its necessary that each cluster has CH. In Fig.2, the three relay nodes are selected in each cluster i.e. R_i, R_j and R_k in a cluster. In our proposed protocol, relay nodes has higher capabilities like battery energy, data aggregation and transmission range than sensor nodes Firstly, the source node transmits data packets to CH and CH checks that coming packets is valid and arrived successfully.

Then CH sends acknowledgement (ACK) to source, otherwise it sends negative acknowledgement (NACK) to source. At that time, relaying scheme is invoked. In second phase, if Relay R_i has received packets in first phase correctly then it forwards to CH. The packet arrives and validated by CH then CH send ACK to Relay R_i otherwise send NACK to R_i. During the

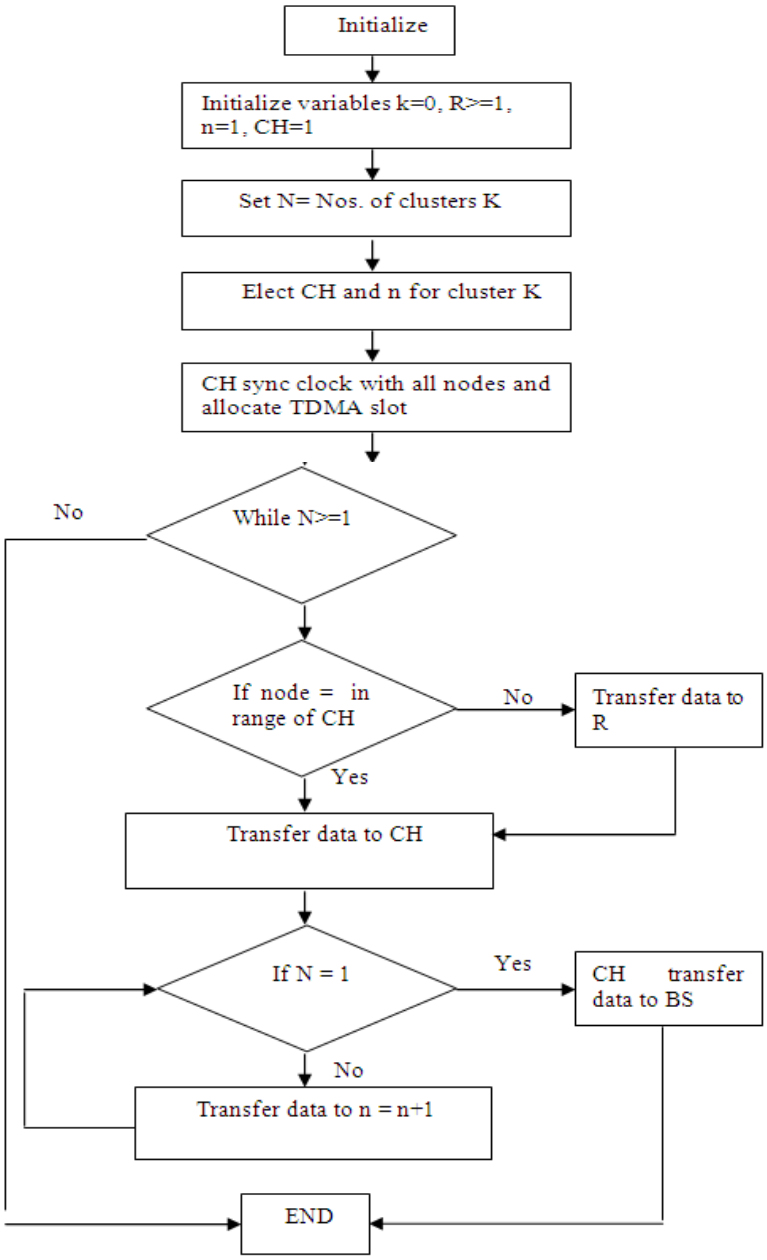

Fig. 1: Flow Chart for Data Transmission in CRS Approach

Third phase, Relay R_j forwards the packet to CH which was unsuccessful during R_i- CH transmission. If the packets are validated by CH then CH send ACK to R_j otherwise NACK. In the last phase, R_k starts forwarding the data to CH and it is the responsibility of Rk for successful delivery of packets then last phase is finished otherwise they can consider that packet was dropped [16]. The CH aggregates the data from sensor nodes or relay nodes and forwards to the node in next level, the receiving node would be act as a cooperative node for the first level cluster and this process continues until the data will be received by CCH. The CCH has the same capabilities like CH in terms of battery power and data gathering. At the last level which is near to BS, there is one CCH which aggregates the data from all the cooperative nodes and forward directly to the BS. Cooperative nodes in each cluster on basis:

$$x1 = y - 1 \qquad (1)$$

where x represents the cooperative nodes and y represent the cluster level in the network. e.g. if for second level cluster, y is supposed to be 2;

$$x2 = 2 - 1 \quad (2)$$

$$x2 = 1 \quad (3)$$

i.e. cooperative nodes in second cluster is 1 and so on.

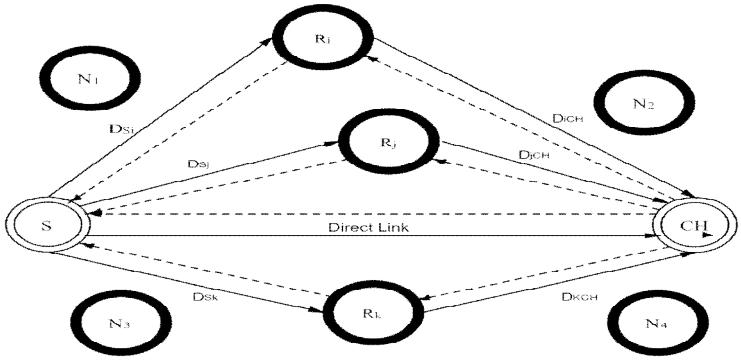

Fig. 2: Source Node Communicate with CH directly or via Relay Nodes [16]

4.ENERGY CONSUMPTION

In traditional non-cooperative routing, the bottle neck problem occurs when data is completely transmitted to that cluster which is nearby to BS, at that time the nearest cluster overloads with data under beneath it and dead earlier and can affect the routing path to the sink. Hence the complete network can be exhausted in this way [7]. In Fig.3, the lower level CH aggregates data from nodes and then forwards to cooperative node which resides at next cluster and data transmission continues till complete data reaches at BS. The problem in traditional routing, load was not distributed among the whole network partially. At lower clusters CH does not bother about the other ones, once data is transmitted by CH's the residual energy of that cluster was wasted. So, the energy consumption by this routing scheme is more. In proposed CRS approach, firstly the energy consumed at the initial level while election of CH among all nodes in cluster, election of cooperative nodes in each cluster. During the data transfer phase, energy is consumed by the relay nodes to aggregates the data from sensor nodes and forwards it to the CH and continues until the complete data is transmitted to BS.

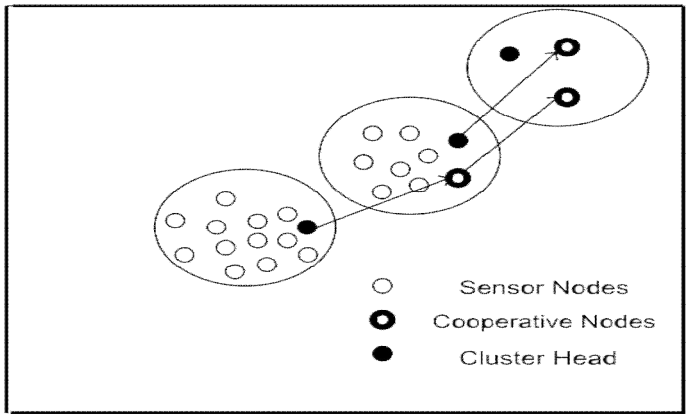

Fig. 3: Data Transmission among Clusters via CH and Cooperative Nodes

5.RESULTS AND PERFORMANCE EVALUATION

CRS approach is compared with LEACH, SEP and Z-SEP in MATLAB. In comparative protocols, CH is only the way to communicate with other clusters in a network. It means the entire load of network is on the CH only and selection of CH is based on number of nodes available, node having the highest energy among all. In Proposed approach, the CH and Cooperative nodes are being elected on basis of how many clusters available [1]. In this way, load is balanced among relay nodes, CCH and cooperative nodes. The traditional non cooperative routing protocols only consider the energy efficiency of network but this proposed approach also considered the network lifetime, reliability of network along with energy efficiency. It shows improved results in above considered terms.

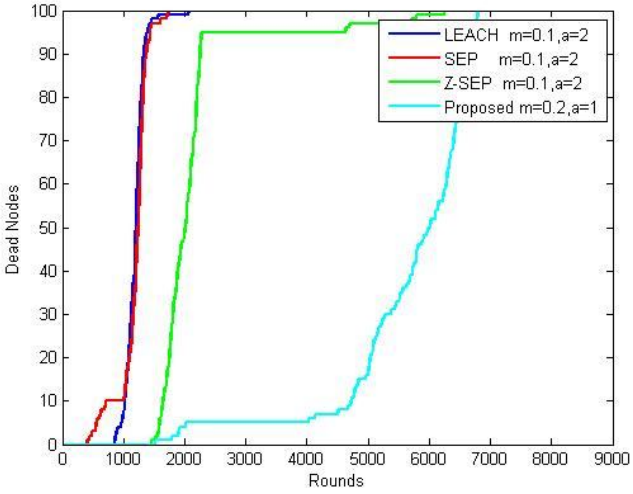

Fig. 4: Number of Dead Nodes versus Rounds

In Fig. 4, dead nodes are shown over 9000 rounds. In 500 rounds, 55 nodes are dead in SEP, 75 nodes are dead in LEACH. In Z-SEP, not a single node dead till 1000 rounds but 50 nodes dead in 1500 rounds. In CRS, only 30 nodes are dead in 1500 rounds. In Fig. 5, alive nodes are shown over 9000 rounds and observed that no node is alive after 2300 rounds in LEACH, no node alive in SEP after 5500 rounds and after 6700 in Z-SEP. Nodes are alive in CRS till 9000 rounds. The alive nodes remains in CRS at the end of transmission helps to improve reliability of a network. Fig. 6, In 6500 rounds CRS transmitted 5.5 * 10(5) packets and Z-SEP only transmitted 2 * 10(5) packets in 2000 rounds. In case LEACH and SEP shows worst performance. So, CRS proved itself better over comparative protocols, more reliable and energy efficient.

Table 1 depicts some of the relative distinctions of clustering based routing protocols. When we compare, CRS approach leads among all of them. It is more energy efficient even than LEACH, SEP and Z-SEP. By using this approach scalability of network is increased because it has ability to transmit data for a long time by forming the cooperation among all the nodes in a network. Z-SEP is also proved as an energy efficient protocol and have good QOS metric and more scalable than SEP but worst than CRS. But in case, SEP protocol is worst among all the parameters but moderate energy efficient.

TABLE 1: Comparison of routing Protocols.

Routing Protocol	Classification	Data Aggregation	QOS	Energy	Scalability	Power Usage
LEACH	Hierarchical /Node centric	Yes	No	Energy Efficient	Fair	Low
SEP	Hierarchical	No	No	Low than Z-SEP	Limited	Limited
Z-SEP	Hierarchical	No	Yes	Energy Efficient & Consumption	Fair	Limited
CRS	Hierarchical	Yes	Yes	Energy Efficient	Good	Limited

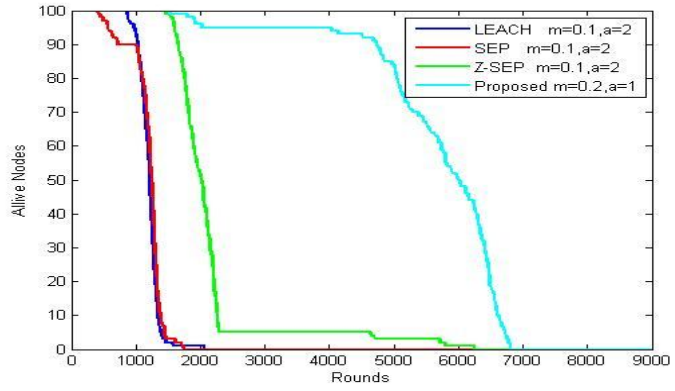

Fig. 5: Number of Alive Nodes versus Rounds

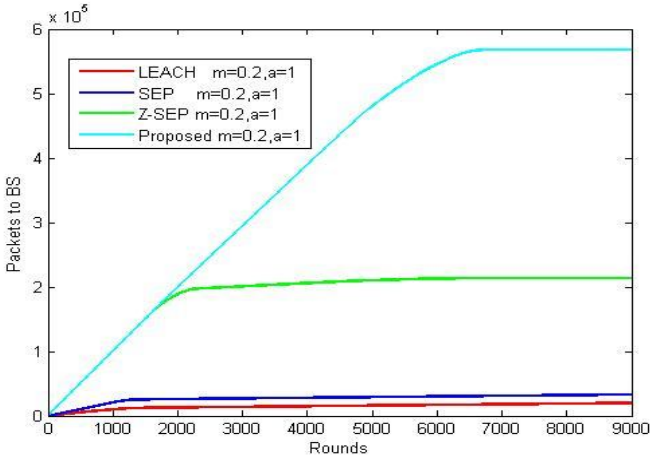

Fig. 6: Packets send to BS versus Rounds

TABLE 2: Simulation Parameters

PARAMETERS	VALUES
Network Size	200* 200
Packet Size	5000 bits
Base Station	At top most corner of network
Nodes	1000
R* Energy Consumption	50 nj/bit
T* Energy Consumption	50 nj/bit
Initial energy of node	0.5j/Node

6.CONCLUSION

The protocol named as CRS is addressed in this paper, by reducing the total transmission time of network helps to prolong network lifetime as well as balanced energy consumption among all the sensor nodes. Relay nodes (intra cluster communication) plays a significant role for speed up the communication among network. We analyze the results of CRS approach, LEACH, SEP and Z-SEP protocols and conclude that CRS approach improves the results over these protocols by considering the cooperative communication among all the clusters. Load balancing is one of the following techniques for energy savings by consuming same energy at each node; the load is partially distributed among relay nodes, cooperative nodes and CCH to increase reliability of a network. In this proposed protocol, the number of alive node are more at the end of transmission and dead nodes are relatively less as compared to other non-cooperative protocols. As future work, this cooperative diversity will be utilized in practical field of networks having the C-MAC protocol and combined beam forming.

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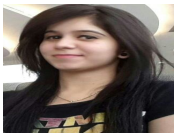

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