ISSN: 2321-9653

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

Optimal Sensor State Planning for CMIMO in Multi-Hop Wireless Sensor Networks

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Abstract*:Minimizing energy consumption and increase the network lifetime are important issues in the field of Wireless Sensor Networks (WSN). Energy efficient sensor state planning consists in finding an optimal assignment of states to sensors in order to maximize network lifetime. In this paper, addresses the optimal planning of sensor's state in Cooperative Multiple Input Multiple Output (MIMO) Protocol. Due to the two challenging aspects a tremendous research has been going on the field of Wireless Sensor Networks (i.e. energy consumption and efficient routing). For that a protocol called Cooperative Multi Input Multi Output (CMIMO). This protocol works well in terms of creating clusters. Finally the simulation result shows, this mechanism achieves better results compared to existing one.

***Keywords*: Cluster, Master Cluster Head, MIMO, Slave Cluster Head**

I. INTRODUCTION

Recent technology improvements that have been developed in small size nodes, low-cost, battery power devices, which are capable of local processing and efficient wireless communication. Such nodes are called as sensor nodes. These sensor nodes are efficient in computing in various applications, such as office building, industrial plants, and reading temperature of a particular region. Each sensor will be having a limited lifetime and hence the processing of data may loss some sensed data due to battery power, collision while communicating between the nodes and having multipath links to reach the destination. We can place the sensor nodes randomly in the environment or we can use a Grid based approach to place the sensor node [13].

Sensor networks will be having the knowledge to find the location of a high accuracy of sensing data in the particular environment; hence we will be using Location Finding System. The Mobilize will be an optional in the sensor node, since for some task the sensor node should be moved from one place to another to find the sensing data which is related to the application. The power unit for the sensor can either be a solar power cell or battery power cells, the more sensing data transmission the more battery it consumes.

In networking, the nodes in a cluster communicate with each other in a cooperative and non-cooperative way. To improve link throughput and minimizing energy consumption, a technique is called Multiple Input Multiple Output (MIMO). This MIMO can be done all above activities with help of three types of gains (i) Array (ii) Multiplexing (iii) Diversity [2].

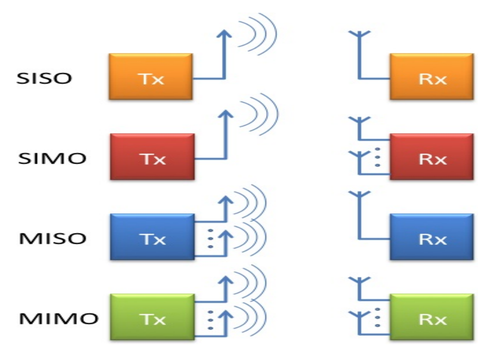

Fig. 1 Transmission Schemes

ISSN: 2321-9653

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

Normally in a Wireless Sensor Networks, each node holds with a single antenna, by using that possible to form group of antennas, which acted as the transmitting and receiving end of a MIMO link.In Figure(ii) shows that, different types of transmission schemes, that are Single Input Single Output(SISO), Single Input Multiple Output(SIMO), Multiple Input Single Output(MISO) and Multiple Input Multiple Output(MIMO). Based on the transmission diversity, any one of the above transmissions scheme will be choosen.

This paper is organized as follows. Section 2 includes a discussion about Related Work; section 3 gives us a background work; section 4 gives the proposal method; section 5 gives the performance metrics and result analysis. Finally section 6 gives conclusion of the paper.

II. RELATED WORK

In this section focus given to algorithms and protocols: Alamouti scheme techniques, CMIMO and Data Aggregation Technique,Semi-Analytic Technique, Heuristic algorithms, HEED Protocol. One of the transmission schemes is Alamouti, valid for frequency selective channels, where to find the suitable transmission scheme to reduce energy consumption and we derive an expression was shown Shuguang Cui et al (2004). Alamouti scheme used in wireless communications to transmit multiple copies of a data stream across a number of antennas and to exploit the various received versions of the data to improve the reliability of data transfer. The fact that the transmitted signal must traverse a potentially difficult environment with scattering, reflection. In fact space time coding combines all the copies of the received signal in an optimal way to extract as much information from each of them as possible was shown S. Alamouti (1998). A transmission scheme, which uses two transmitting sensors and STBC. That used to provide transmission diversity in distributed wireless sensor networks with antenna array. Full diversity are achieved which improves the bandwidth efficiency and reliability. And introducing a multi transmission scheme where each data packet is transmitted by multiple sensors simultaneously, which effectively builds antenna array. For transmission scheme we derive an expression based on Rayleigh flat fading. To reduce Bit Error Rate (BER) we derive expression based on traditional STBC decoding algorithm X. Li (2003).

To focus on improve the network lifetime by minimizing the energy consumption of each node. For that it introduces cooperative multiple input multiple output (CMIMO) along with data aggregation to reduce the energy consumption through reducing the amount of data for transmission. For that we form a new expression with relates with data generated by the nodes and distance between them. Using that we can easily analyse , the effect of the cluster size on the average energy consumption per node QiangGao., et al (2010). Data aggregation involved in both centralized and distributed approach for cooperating nodes to exchange and compress their data and send. Data aggregation has naturally been considered an essential tool for integrating such data to reduce redundancy and minimize the number of transmissions; result follows in lowered energy consumption L. Krishnamachari et al (2002). To reducing energy consumption by constructing Virtual multiple input multiple output based communication architecture is proposed for distributed and cooperative wireless sensor networks. It initially concentrates an investigation of dependence of energy and delay efficiencies of Virtual MIMO scheme on system and propagation parameters such as transmission distance, constellation size and channel path loss. Then refined the expression used in S. Cui et al (2003) for training overhead required in MIMO system. Required number of training bits is a function of the operating SNR and could be much higher than this minimum required value. Both the delay and energy efficiency are important to carefully design a virtual MIMO based communication architecture can provide significant improvement in performance metrics Sudharman K. Jayaweera (2006).

The issue of cooperative node selection in MIMO communications for wireless ad hoc/sensor networks, where a source node is surrounded by multiple neighbors and all of them are equipped with a single antenna. Given energy, delay and data rate constraints, a source node dynamically chooses its cooperating nodes from its neighbors to form a virtual MIMO system with the destination node.Heuristic algorithms, such as maximal channel gain (MCG) and least channel correlation (LCC) algorithms are proposed in order to exploit available system information and to solve the optimization problem. Performance gain can be achieved by appropriate power allocation among nodes that join the cooperation M. O. Hasna et al (2004), J.Luo et al (2005).And it follows with the various steps for forming an optimal cluster and selecting cooperating nodes and implementing LCC algorithm Qi Qu et al (2010).

Topology control in a sensor network balances load on sensor nodes and increases network scalability and

ISSN: 2321-9653

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

lifetime. Here focus on propose a new distributed clustering approach for long lived ad hoc sensor networks. We present a protocol, HEED that periodically selects cluster heads according to a hybrid of the node residual energy and node proximity to its neighbors or node degree. These protocols can be classified into three classes. Protocols in the first class control the transmission power level at each node by increasing network capacity while keeping the network connected V. Kawadia et al (2003), S. Narayanaswamy et al (2002). Protocols in the second class make routing decisions based on power optimization goals C. Intanagonwiwat et al (2000). Protocols in the third class control the network topology by determining which nodes should participate in the network operation and which should not A. Cerpa et al (2002), Y.Xu et al (2001).

To show, how spatial correlation in data can be used to reduce energy consumption in a wireless sensor network. We analytically characterize the optimal cluster size, and then use a greedy clustering algorithm to find optimal solutions. Energy aware data gathering techniques are used to extend the lifetime of the WSN Ali Dabirmoghaddam et al (2010). An effective way to conserve energy is to avoid reporting redundant data that occurs due to the spatial correlation between nearby readings R. Cristescu et al (2004).

Traditionally, clustering algorithms aim at generating a number of disjoint clusters that satisfy some criteria. In this paper, we formulate a new clustering problem that aims at generating overlapping multi hop clusters. For that we propose algorithm called K-hop Overlapping Clustering Algorithm (KOCA). KOCA aims at generating connected overlapping clusters that cover the entire sensor network with a specific average overlapping degree. In overlapping clusters, a node may belong to more than one cluster. Clustering nodes into groups saves energy and reduces network contention as nodes communicate their data over shorter distances to their respective cluster heads [9]. Energy-efficient sensor state planning consists in finding an optimal assignment of states to sensors in order to maximize network lifetime. In this paper, we provide the optimal planning of sensors' states in cluster-based sensor networks. First, we formulate this problem as an Integer Linear Programming model that we prove NP-Complete. Then, we implement a Tabu search heuristic to tackle the exponentially increasing computation time of the exact resolution. We address the global problem of maximizing network lifetime under the joint clustering, routing and coverage constraint. Clustering can provide for substantial energy saving since only CH sensors are involved in routing and relaying data K. Akkaya et al (2005). CHs consume more energy in aggregating and routing data, it is important to have an energy-efficient mechanism for CHs' election and rotation [10].

A cluster based cooperative MIMO scheme is proposed to achieve the multi-hop transmissions among clusters using LEACH protocol. Through the suitable selection of cooperative nodes and the coordination between multihop routing and cooperative MIMO transmissions the scheme can gain effective performance improvement in terms of energy efficiency and reliability. We modify the LEACH protocol to allow cluster heads to form a multi hop backbone and include the cooperative MIMO scheme into each single hop transmission [11].

III. BACKGROUND WORK

To minimize the energy consumption and efficient routing in Wireless Sensor Networks by CMIMO, it achieves byfollowingfour phases. Those are,

a) Neighbourhood Discovery:

In this phase, each node contends for the channel using CSMA/CA. Once the channel free, each and every node will broadcast a "hello" message to all the nodes to know those who are neighbours. This "hello" message includes its ID, RBL (Remaining Battery Lifetime) and its list of neighbours. By using that "hello" message, each node updates its table (i.e. updating information are neighbours and RBL).Whenever there is change in the connectivity of network, a new "hello" message will be broadcasted [11].

b) Master Cluster Head Selection:

Once neighbourhood discovery is Over, MCHs are selected. Because MCHs do more work than non MCH nodes. And the selection criterion for MCHs is the node's RBL. Each node maintains a table of RBL values. All nodes start the clustering process in the normal state. Every node compares its RBL to those of its one-hop neighbours. If the node has the highest RBL in its neighbourhood, it declares itself as an MCH and announces to its one hop neighbours. Any node that receives "MCH selected" announcement means, it have to stop competing for the role of MCH [1]. And the remaining node moves to the next process.

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c) Slave Cluster Head Selection:

The next step is to find an SCH with each MCH. The purpose of having SCHs is to achieve VMIMO during the inter cluster communications phase by constructing cooperative multi-antenna nodes. Specifically, to select SCHs, each MCH sends an ''SCH Invitation Message'' to a neighbour whose neighbour list overlaps the most with the MCH's neighbour list. Once the SCH node receives message it will wait for some time, because some chances to get closer MCH request. After the particular time elapses, it will join with the MCH, by sending message "SCH Confirmation Message". Not only this criterion is for selecting SCHs, some other conditions followed that are RBL value and proximity [11]. And the remaining node moves to the next process.

d) Cluster Membership:

This is the final phase in the cluster formation. Here all the non-Cluster Head (CH) (i.e. the node which is neither MCH nor SCH) has to identify which cluster to join. This process is done with the help of "membership request message". The MCH, who is receiving such message, replied in the form of "membership list message". This message includes nodes of ID which are willing to admit by MCH. Any non CH node finds its ID not present in that list, it will again send "membership request message". Once the clustering process done, now it ready for intra cluster communication. To perform the inter cluster communication, it follows the steps:

Step 1: If the MCH of a given cluster wishes to establish VMIMO links with neighbour clusters, it accesses the channel using the CSMA/CA scheme. Once it contends the channel, the MCH broadcasts a channel probing request. The main advantage of this request is to identify MCH/SCH of the receiving clusters of the presence or absence of an SCH at the source cluster.

Step 2: If the source cluster has an SCH, then after the source MCH sends its CPREQ packet, the source SCH will follow with its own CPREQ. This CPREQ is sent, and is used to obtain the channel state information (CSI) between the source SCH and the destination SCH and MCH.

Step 3: Once receiving the two CPREQ packets, the receiving MCHs and SCHs calculate the CSI between the source MCH/SCH and the receiving MCH/SCH and communicate such information to each other. From that, the receiving CHs calculate the minimum power needed to communicate between the CHs of the transmitting and receiving clusters using one of four possible modes.

Step 4: The MCH and SCH in each neighbouring cluster determine the optimal transmission mode that minimizes the total energy among the four modes. Each receiving MCH then sends this information back to the source MCH/SCH.

Step 5: A minimum energy routing algorithm is then executed by the source MCH on the inter-cluster topology of virtual nodes. This algorithm executes in two steps. In the first step, MCH and SCH virtual nodes that can directly communicate using at least one of the four modes are determined. In the second step, we run Dijkstra's algorithm with the weight of a link taken as its total energy value determined from the first step. The returned path has the minimum total energy among all possible paths between the source CHs and the sink [11].

IV. PROBLEM STATEMENT

When all the phases are completed they are ready to perform the operations like data collecting, aggregating and forwarding. Here MCH performing the major role for collecting the data, performing data aggregation and forwarding data. By the help of SCHs we can achieve cooperative transmission. So each cluster surrounded by non-Cluster Head (CH) nodes. Those nodes involves for sensing the data and forwarding data to the corresponding MCH. These non CH nodes always will be in active mode. Due to this, active node consumes energy for idle state. So the lifetime of network will be very less.

V. PROPOSAL OBJECTIVE

To minimize the energy consumption and maximize network lifetime by activate sleep and awake optimal planning of sensor state mechanism. By including this mechanism we can achieve improved network lifetime.

VI. OPTIMAL SENSOR STATE PLANNING FOR CMIMO IN MULTI-HOP WIRELESS SENSOR NETWORKS

Initially, we will be having some active sensor nodes with high battery power near the border and the remaining sensor nodes will be in sleep state. If an object enters the border, the active sensor nodes will detect the object

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properties and it will find the nearest MCH sensor nodes. Once the nearest MCH sensor nodes are found and it will broadcast the message to the nearest MCH sensor nodes.

The MCH sensor node gets the object properties it will find the shortest path to next nearest MCH sensor nodes and it will transmit the data to the base station. Hence, a new path will be found for transferring the data to the base station and all the sensor nodes will be active. While transmitting the data to the base station, the remaining MCH and SCH sensor nodes will be in sleep state. Once the data transmission is over, an acknowledgment will be sent back to the same path of the active sensor nodes to ensure that the base station has received the data. Comparing to the existing system, the proposed mechanism will achieve better results in terms improved network life time and the energy consumption will be less.

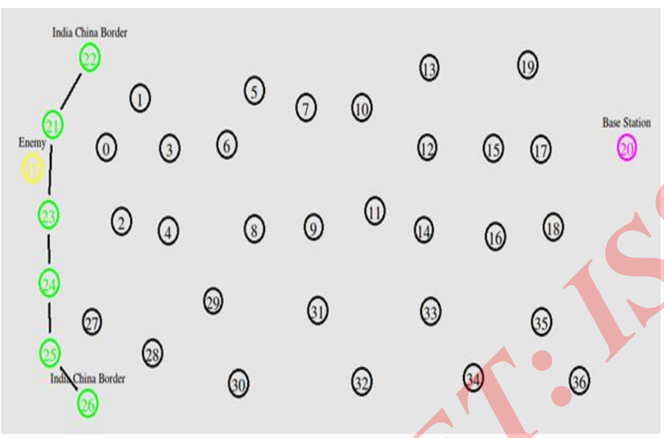

Fig 2 CMIMO Protocol applied in Defence System

In that below fig. 2 shows that, CMIMO protocol applied to defense application. Here India_China border is considered and node 1,0,2,27,28 all are always in an active mode. When enemy crosses the border, the active sensor nodes will detect the object properties and it will find the nearest MCH sensor nodes. Once the nearest MCH sensor nodes are found and it will broadcast the message to the nearest MCH sensor nodes.

The MCH sensor node gets the object properties it will find the shortest path to next nearest MCH sensor nodes and it will transmit the data to the base station. Hence, a new path will be found for transferring the data to the base station and all the sensor nodes will be active. By applying this method into the CMIMO Protocol, we can achieve better results compared to existing methods in terms of maximizing network lifetime and minimizing energy consumption by the sensor nodes. The main thing followed in this technique, it data reliability in terms of enabling acknowledgment in between the source node, which is collecting the data and forwarded to MCH and Base station.

In order to find the energy consumed by the normal node(i.e. always in an active mode) in a sensor network, need to know about the energy for sensing data , energy for idle state , energy for aggregation and energy for forwarding. So that the sum of all the above is equal to the energy consumed by the normal node.

Energy consumed for sensing data Es, Energy consumed for idle state Ei, Energy consumed for aggregation Ea, Energy consumed for forwarding Ef.

$$\text{(i.e.)}Etotal = Es+Ei+Ea+Ef \qquad (4.1)$$

Suppose, if a node holds energy Vvolt, then wastes its energy for always in active mode,then the remaining energy will be,

$$Vvolt = Vvolt - Etotal \qquad (4.2)$$

The remaining energy can support some time only. So if it includes the optimal sensor state planning of nodes meaning, it is not necessary all the nodes in an active mode and only some node can be active remaining move to sleep. And energy for sensing and idle can minimize.

$$Eminimizedenergy = \sum_{k=0}^{All\ nodes\ active} - \sum_{k=0}^{some\ nodes\ active}.$$

VII. ARCHITECTURE DIAGRAM

In order to improve the network lifetime an additional layer is in cooperated at the source side as shown in Fig 3the concept of optimal planning of sensor state is used, during forwarding data from the source node to destination.

ISSN: 2321-9653

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

The cluster of nodes are deployed in the network, consists of two states. For example node say N1 will have two states: (i) sleep (ii) awake.

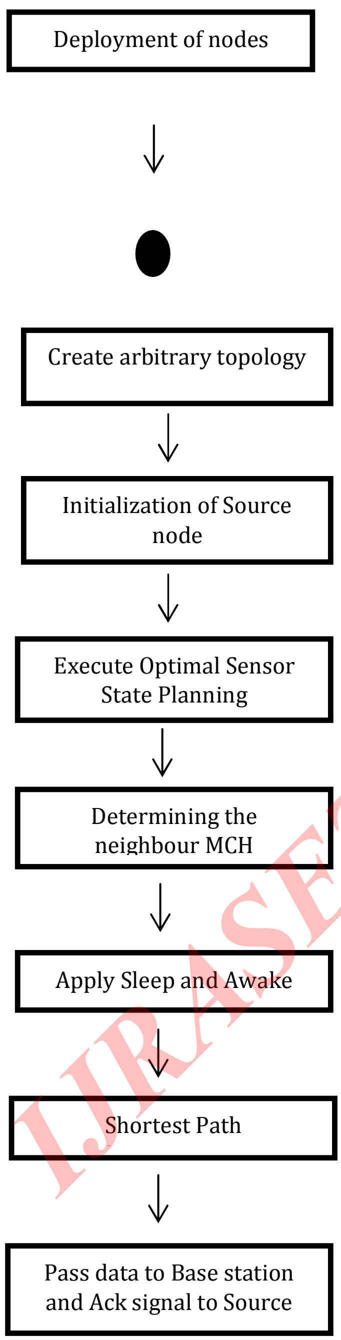

Fig 3 Optimal Sensor State Planning Architecture

VIII. METHODOLOGY

Step 1: Variable declaration: Flow ID, shortest path, Maximum cluster size

Step 2: Deployment of nodes and create arbitrary topology

Step 3: Compute path information

Step 4: Initialisation of cooperative transmission

Step 5: Optimal sensor state planning process

Step 6: Activate border nodes

Step 7: Determine the neighbour MCH

Step 8: Finding shortest path

Step 9: Route request and response for path availability

Step 10: Compute path information

Step 11: Route failure and maintenance

Step 12: VMIMO clustering process

Step 13: VMIMO communication

Step 14: Sending data to base station

Step 15: Stop

IX. RESULTS AND DISCUSSIONS

A) THROUGHPUT VS TIME

Here CMIMO protocol compared with optimal sensor state planning and without optimal sensor state planning. Figure 4 compares the number of packets received at a particular time by DCA and CMIMO. DCA tries to decrease the number of dropped packets, but at a later stage it can be seen that lot of packets dropped, since the route complexity. At the same time CMIMO with optimal sensor state planning tries to increase the throughput by decreasing number of dropped packets, after certain stage in CMIMO performance maintained in a same manner.

ISSN: 2321-9653

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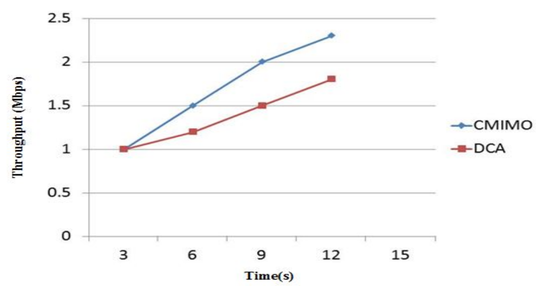

Fig 4 Throughput Vs Time

B) ENERGY CONSUMPTION VS TIME

Figure 5 clearly compares the amount of energy used at a particular time by DCA and CMIMO.

DCA tries to make use of less amount of energy, but at a later stage it can be seen that lot of energy is used, since the nodes active since its deployment CMIMO tries to optimise the energy and saves maximum amount of energy by making use of sleep and awake.

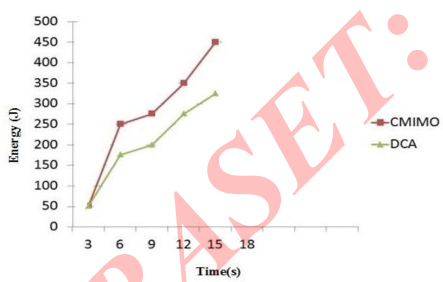

Fig 5 Energy Vs Time

C) NETWORK LIFETIME VS TIME

Figure 6 shows that at a certain time lifetime of network decreased in DCA. CMIMO optimizes the network lifetime with respect to time with the help activating sleep and awake mode.

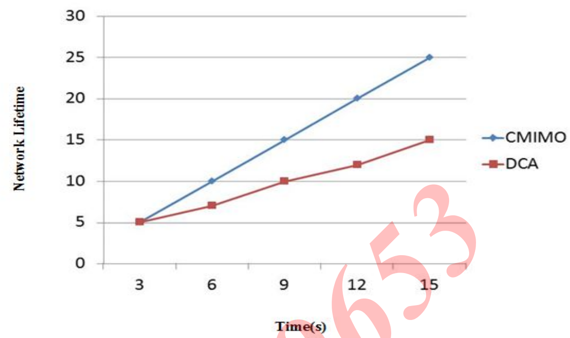

Fig 6 Network Lifetime Vs Time

Hence the results show that optimal sensor state planning produces much more optimized results compared to DCA. To minimize the energy of sensor node not only increases the network lifetime but also increases throughput and data rate comparatively. This project aims at optimising certain metrics that was found to be not much in the existing systems. By the help of including sleep and awake mechanism, it improves the performance metrics like network lifetime, energy consumption and throughput. Here VMIMO performs important role. Because with this help , it can achieve cooperative transmission and increases the link throughput.

X. CONCLUSION

Sensor Networks hold a lot of promise in applications such as gathering and sensing information in remote locations. Thus in wireless networks multiple active flows and cooperative transmission has been activated. In cooperative transmission VMIMO is comparatively a standardised method. The existing protocol optimizes link, throughput but does not optimize energy. To overcome the energy issues an optimised method is in cooperated which optimises energy. This has been activated by optimal sensor state planning which uses sleep and awake method to optimise energy. Hence the simulation results shows how energy is optimised and network lifetime increased. Wireless network is an interconnection of nodes for faster communication without use of expensible cables by using certain communication protocols. And for this communication purpose introduced a virtual link that is Virtual Multiple Input Multiple Output (VMIMO). Its performance is enhanced by using cooperative communication. By focusing on that source side, further try to

ISSN: 2321-9653

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

minimize energy by sleep and awake of nodes. In the end, VMIMO in physical layer benefits and improves network layer performance. After an investigation on the end result, it was shown that the improvements are non-trivial. A study is made on various routing protocols and finally optimal sensor state planning is introduced. This technique also strengthens VMIMO links to achieve performance improvements.

ACKNOWLEDGMENT

The authors would like to thank the Karunya University for full support.

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BIOGRAPHY

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