Efficient Connectivity Using Cooperative Transmission in Wireless Multi-Hop Sensor Networks

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Abstract- **Wireless sensor networks are spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location. Multi-hop wireless networks use two or more wireless hops to convey information from a source to a destination. There is a loss of connectivity of nodes , the path creates partitioning of the network. To overcome this, cooperative transmission helps nodes to combine nodes to form a group and gains higher emission power as whole. So the final resulting power consumption is very less.So to avoid connectivity problems and to make the operation more effective we present cooperative transmission to connect previously disconnected parts of a network thus overcoming the separation problem of multi-hop network. This approach improves connectivity over 50% compared to multi-hop approaches and reduces the number of nodes necessary to provide full coverage of an area up to 30%.**

Index Terms- **Wireless Sensor Networks, Cooperative transmission, Multi-hop wireless sensor networks**

I. INTRODUCTION

Wireless sensor networks (WSNs) are attracting increasing research attention, due to their wide spectrum of applications, including military purposes for monitoring, tracking and surveillance of borders, intelligent transportation systems for monitoring traffic density and road conditions, and environmental applications to monitor, for example, atmospheric pollution, water quality, agriculture, etc. A Wireless sensor networks is composed of a number of spatially distributed sensor nodes (SN) transmitting wirelessly the information they capture. A sensor node is generally composed of a power unit, processing unit, sensing unit, and communication unit. These nodes usually have restrained resources, such as limited battery power, processing power and memory storage. In the last years, research communities have developed several different wireless sensor network platforms, such as the Motes [1] or Smart-Its [2], [3]. Mentionable business is already being generated through this emerging technology [4].

Wireless sensor networks are subject to significant resource constraints. Particularly, routing protocols for low rate Wireless sensor networks suffer from maintaining routing metrics and stable links of paths, it consists of several hundreds of nodes that have to be placed in the area of interest. The mass processes have been proposed to simplify and accelerate the task of placing the nodes instead of manually placing each single node. There are many reasons for connections breaks and clustering in sensor networks. [13] They are:

1) Installation of nodes using random scatter process
2) Environmental changes
3) Energy efficiency
4) Mobility of the nodes

In this paper its mainly concerned about how to deal with inhomogeneous settings caused by random distribution of nodes process which we consider relevant for practical usage of cooperative transmission systems. The effects of e.g. the Energy efficiency of critical relay stations or heterogeneous and inhomogeneous environments with unpredictable connections are major threads for the success of wireless sensor nodes. With cooperative transmission, a group of nodes can combine its emission power and achieve a higher emission power as a whole. To do so, cooperatively transmitting nodes emit identical symbols synchronously to superimpose the emitted waves on the physical medium. The destination receives the sum of waves and thus a higher total power. The more nodes cooperatively transmit, the higher will the power on the physical medium be. With the higher power, the nodes can reach destinations that are very far away

II. RELATED WORK

The sensors nodes transmit identical symbols simultaneously over the radio channel to sum up the total transmit power. The most related work can be found in [8] and [9]. In those publications, the authors understand cooperative transmission in the sense that several sensor nodes transmit symbols simultaneously to achieve a power gain. In [9] the broadcast-coverage of a system using cooperative transmission is analyzed. It is based on a continuum approach modeling the nodes as a homogeneous density of possible transmits power. This simplifies the modeling and leads to closed-form solutions and formulations. In [8] there is also a small section on the coverage achievable with cooperative transmission.

In this paper is discussed about cooperative transmission under the constraint of very inexpensive sensor network nodes to achieve a power gain through summation. We want to look deeper into the topic of coverage and connectivity for sparse settings using cooperative transmission. For the discussion of energy efficiency, we refer to [10]. [11] Provides a good overview and comparison of broadcast-techniques for wireless sensor networks which is also relevant for this paper.

This paper includes cooperative transmission to connect previously disconnected parts of a network thus overcoming the separation problem of multi-hop networks. We show that this approach improves connectivity over 50% compared to multi-hop approaches and reduces the number of nodes necessary to provide full coverage of an area up to 30%. The paper presents theory, a comparison of 2 types of cooperative transmission approaches to multi-hop networks

III. SYSTEM ANALYSIS

Cooperative transmission

There are various relaying strategies for wireless network. Cooperative transmission is an ideal means to tackle the threads that are introduced by bad connectivity or sparse settings in general. With cooperative transmission, a group of nodes can combine its emission power and achieve a higher emission power as a whole.

Different transport scenarios will be discussed and simulated in the remainder of this paper. We distinguish mainly two types of transport scenarios which we consider the most relevant for sensor networks: the peer-to-peer scenario and the access point scenario. In the peer-to-peer scenario, we want to transport information between arbitrary pairs of nodes of the network realizing a mesh connectivity.

For fast changing and unpredictable connectivity and topologies, there is a straight-forward solution that provides the best possible connectivity between any nodes: broadcast communication. As connectivity is the main concern in this paper we choose this communication for all following simulations and communication processes. For the multi-hop communication in the next section, this broadcast implies the use of flooding.

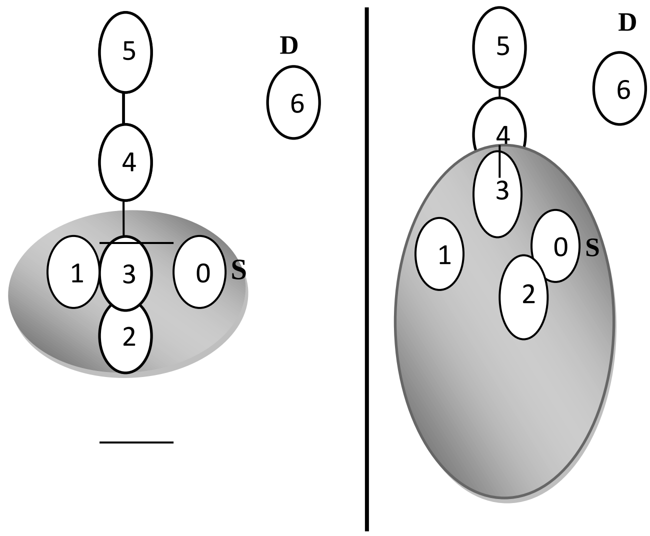
Types of communication principles

There is difference between traditional approaches to cooperative approach and we have different communication principles. The cooperative transmission can help to “heal” the broken links. How to take advantage out of the possibilities that cooperative transmission provides is difficult to decide. we distinguish between two different types of communication principles [13]

1. Accumulating cooperative transmission
2. Hybrid multihop cooperative transmission

1. Accumulating Cooperative Transmission:

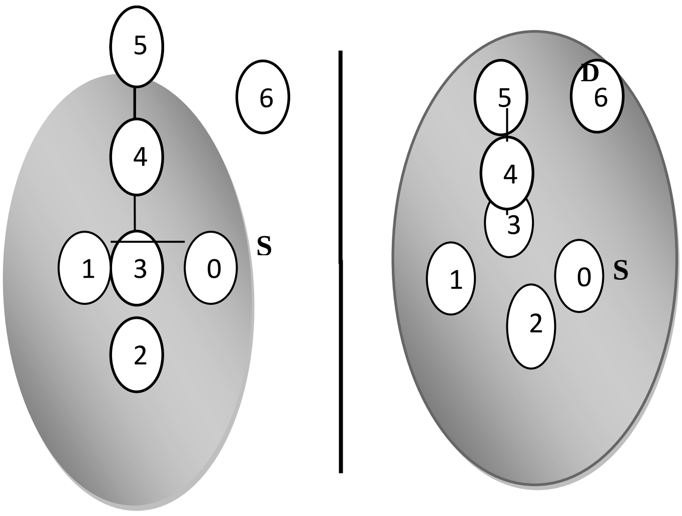
Accumulative Cooperative transmission, where parallel nodes forward information to the destination node, can greatly improve the energy efficiency and latency in Wireless Sensor Networks. However, current networks do not fully exploit its potential, as they only use traditional energy-accumulation, the nodes which are present in the network will be grouped according to the distance from the source node and that node which has shorter distance will be leveled like Level1, Level2, Level3 depending on number of nodes present in the transmission range. which is often used in conjunction with repetition coding or cooperative space-time codes. In this paper, we show that the concept of mutual-information-accumulation can be realized with the help co-operative transmission, and leads to a lower energy expenditure and a lower transmission time than energy accumulation. We then provide an analysis of the performance of mutual information accumulation in relay networks with N relay nodes. We also give closed-form equations for the energy savings that can be achieved by the use of mutual-information-accumulation at the destination. We then analyze and provide bounds for an alternate scenario where each relay node starts its transmission to the destination, independent of the state of the other relay nodes.



S:Source,D:Destination

Fig. 1. The communication scenario using *accumulating cooperative transmission*

This approach further reduces the transmission time, because the transmission by the relay nodes helps the other relay nodes that are still receiving. we see the first gains in tackling the problem to deliver a message from node 0 to node 6. Figure 2 shows the situation for the first two steps. After node 0 has delivered the message to node 1, they both repeat the message simultaneously and this cooperative transmission leads to summation of energy left side in Figure 1. The next two nodes (no. 2 and 3) can be reached. In the then following step, the group of cooperatively transmitting nodes includes the partners no. 0, 1, 2 and 3. Figure 2 shows the last two steps where node 4 and 5 are included (accumulated) in the cooperative transmission that finally all nodes except no. 6 transmit cooperatively. The sum of powers is then enough to finally reach to node 6. For this the simple implementation for the wave propagation cooperative transmission also holds: For the delivery and relaying of packets, it is not necessary to keep track of connections and paths. Nodes simply repeat a message several times after reception. In this case the Nodes that received a message will not only transmit this message once but several times. We set the number of repeats as a system parameter. This is the technique which is most useful when we are trying to send number of messages from one node to another node using accumulating process.

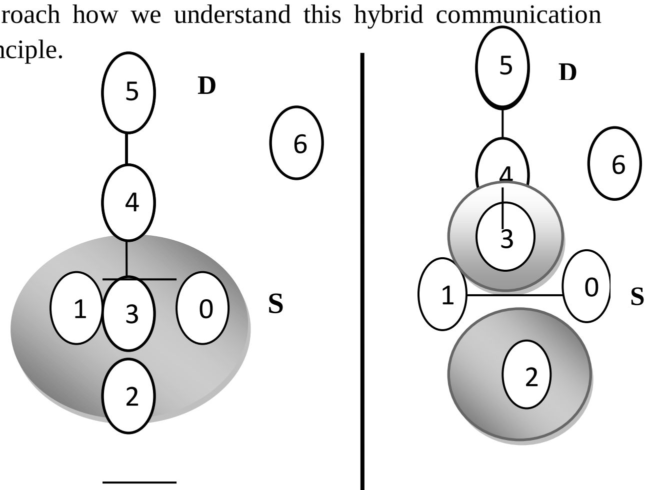


S: Source, D: Destination

Fig. 2. The communication scenario using *accumulating cooperative transmission*

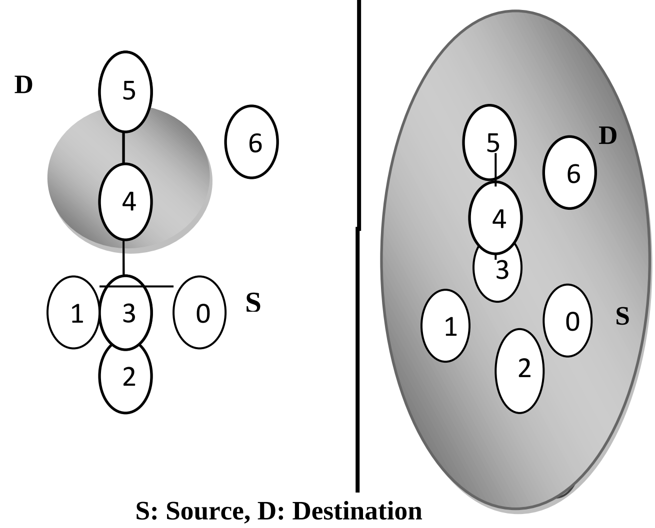
2. Hybrid Multi-hop Cooperative Transmission:

This is the modern multi-hop mechanism using which large amount of data is going to be submitted in peer to peer as well as access point scenario. The idea of this communication principle is to use multi-hop communication wherever possible and cooperative transmission wherever necessary. Depending on the topology of the communication links, this decision whether to choose multi-hop or cooperative transmission for the next communication step can be very hard to decide. If the next communication step should be cooperative transmission it is also hard to select the right nodes to exactly bridge the communication barrier. In mobile scenarios, this topology information can hardly or impossibly be generated. Therefore, we chose a pragmatic approach how we understand this hybrid communication principle.



S: Source,D:Destination

Fig. 3. The communication scenario using hybrid multi-hop *cooperative transmission*



S: Source, D: Destination

Fig. 4. The communication scenario using *hybrid multi-hop cooperative transmission*

It is an alternating communication between multi-hop and accumulative cooperative transmission. After the cooperative transmission, all "new" nodes will try to acquire further partners using multi-hop and after this, a new accumulated cooperative transmission will take place with the now larger group. Whether a node is new or not to the actual group can be identified through the message sequence number of the message that has to be delivered.

The time necessary for sufficient multi-hop communication between two steps of cooperative transmission will be unpredictable for the initiator node and must therefore be set to a certain value with a best-guess approach. It would then be understood as a deadline, such that the nodes would cooperatively transmit, then do multi-hop broadcast until a certain deadline and then starting over again with cooperative transmission.

The figure 3 and 4 explain the steps in detail. With the first multihop broadcast, node 0 has found node 1 as partner. With this partner, node 0 then cooperatively transmits the message. This is show in the left side in figure3.After this step, nodes3and 2 are "new" to the group and forward the message using multihop. These steps are on the right side in figure 3 and left side in figure 4. Then, as a consequence of the alternating process, all new partners and the old partners together cooperatively transmit the message again. This is shown on the right side in figure 4. This process continues then with alternating multihop and cooperative transmission until a predefined number of repeats is through.

Using cooperative transmission, nodes can increase their radio range by combining transmit power with their neighbors. With this mechanism it is obvious that the overall connectivity and coverage will be improved as lost nodes or clusters have a new way to establish a connection which is not possible without cooperative transmission.

IV. IMPLIMENTATION

ALGORITHM

1. **Start**
2. Select N // Initialize the nodes
3. Select the node S and node D
4. **for** i=1 to N **do**
5. Randomlydeploy the nodes in the network
6. **Endfor**
7. **While**
8. Calculate 1-Hop neighbors
9. **If 1**-Hop neighbor< 250**then**
10. Select them as first level neighbor
11. Else
12. Select them as second level neighbor
13. **Endif**
14. **Endwhile**
15. Perform the Cooperative transmission between the nodes
16. Broadcast through multihop cooperative transmission
17. Represent the Performance metrics using X-graph
18. **End**

DATA FLOW DIAGRAM

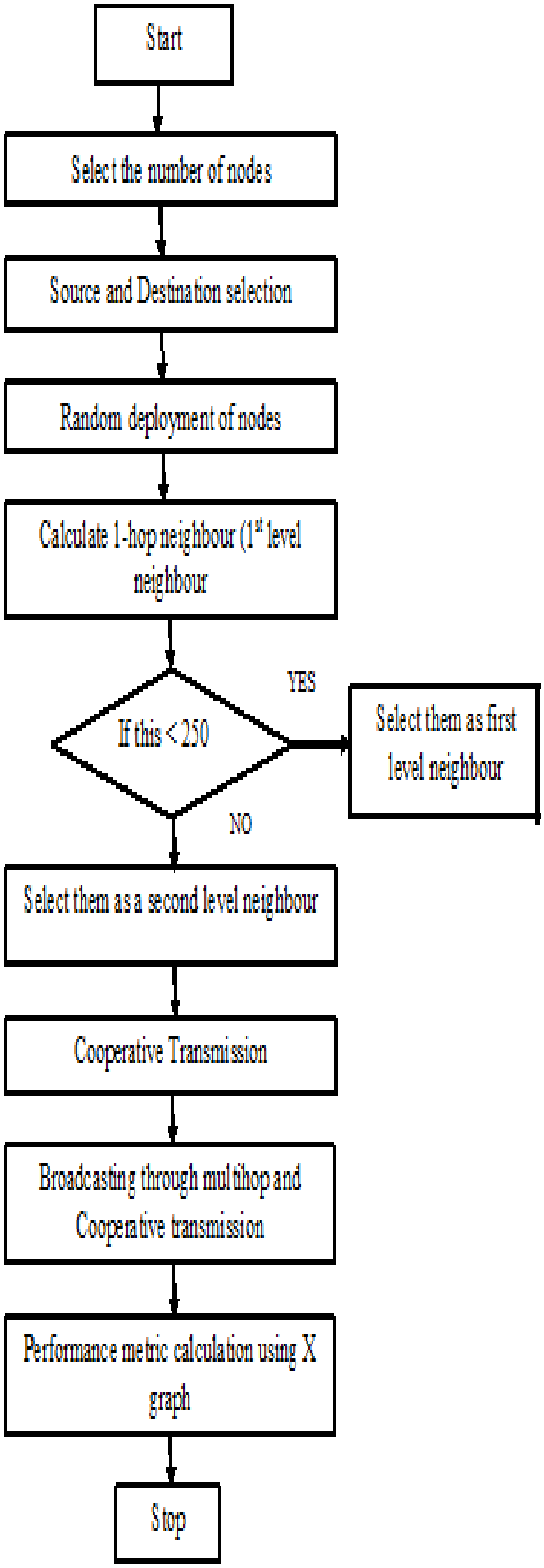
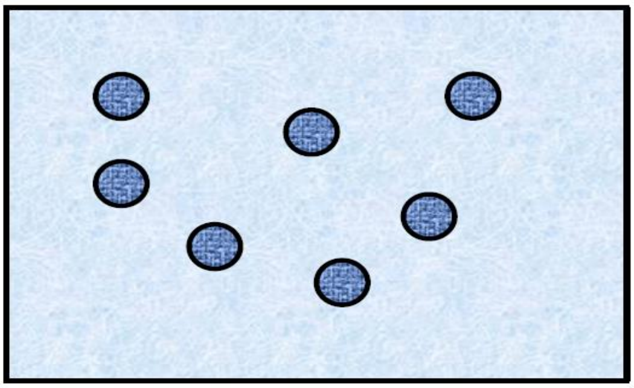


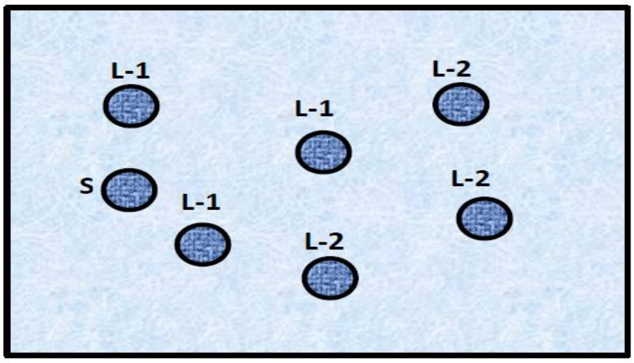
Fig: Dataflow Diagram

1. RANDOM DEPLOYMENT OF NODES:



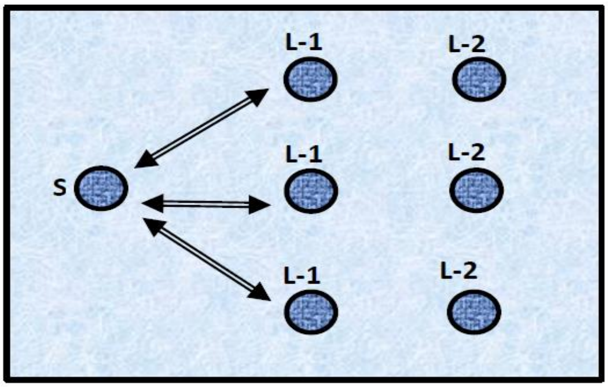
It is Deployment of WSN nodes in randomly fashion with the same density over the entire sensing area, where all nodes are homogeneous with the same available energy.

2. SELECTION OF LEVEL-1 AND LEVEL-2 NODES:



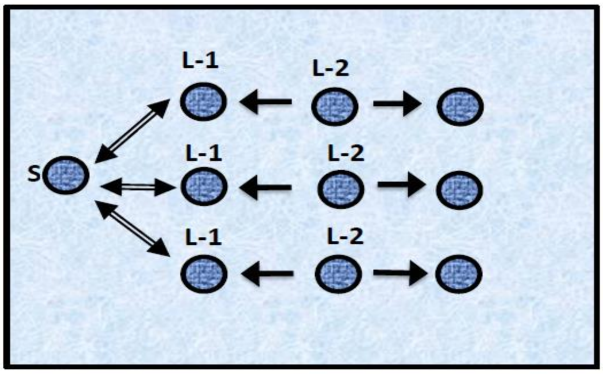
The randomly deployed nodes are grouped together depending on the no of nodes deployed in the network.

3. COOPERATIVE TRANSMISSION:



In the high density network many packets from source are transmitted simultaneously and thus cause a high contention rate. The next neighbor node will receive the packets and will transfer the packet to the high density node and cooperative transmissions starts and obtain the higher power gain and it improves the connectivity by 50% as the whole.

4. MULTI HOP COOPERATIVE TRANSMISSION



Wireless sensor networks can be deployed over a large area, the multi hop transmission will help to deliver the sensed data and it will provide end to end delay guarantees.

V. SIMULATION RESULTS

The simulation results of the different communication principles are shown in the below figures.

We can compare the performance between two different types of communication principles by using X graph.

1. Accumulating cooperative transmission.
2. Hybrid multihop cooperative transmission

The following performance metrics describes the advantages of the hybrid multihop cooperative transmission over the accumulating cooperative transmission.

1. Bit Error rate:

Bit Error rate is the number of bit errors divided by the total no of transferred bits during the transmission. The Bit error rate is an indication of how often a packet or other data unit has to be retransmitted because of an error.

2. Throughput:

Throughput is the measure of how many packets can be transmitted in a given amount of time. The data these messages belong to may be delivered over a physical or logical link or it can pass through a certain network node.

3. Increasing Connectivity

Increasing Connectivity defines the number of nodes in the network. Connectivity of an access point especially in sparse settings and support topologies of clustered and partitioned networks that contain separated groups of nodes.

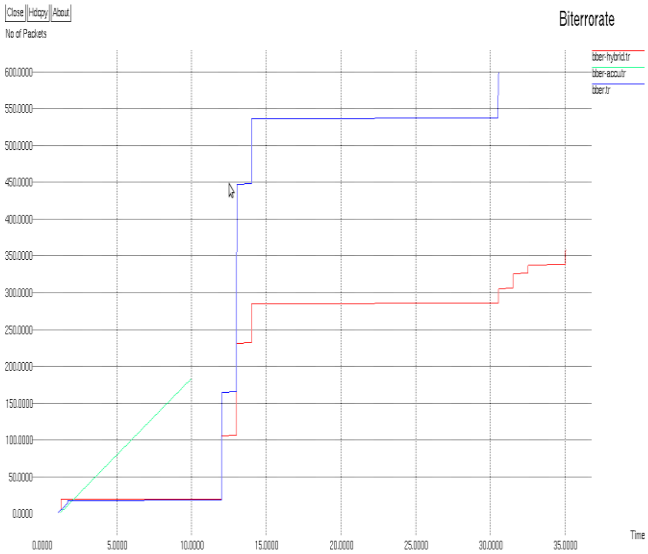
4. Control Overhead:

Control overhead is any combination of excess or indirect computation time, memory, bandwidth, or other resources that are required to transfer the packets from source to destination.

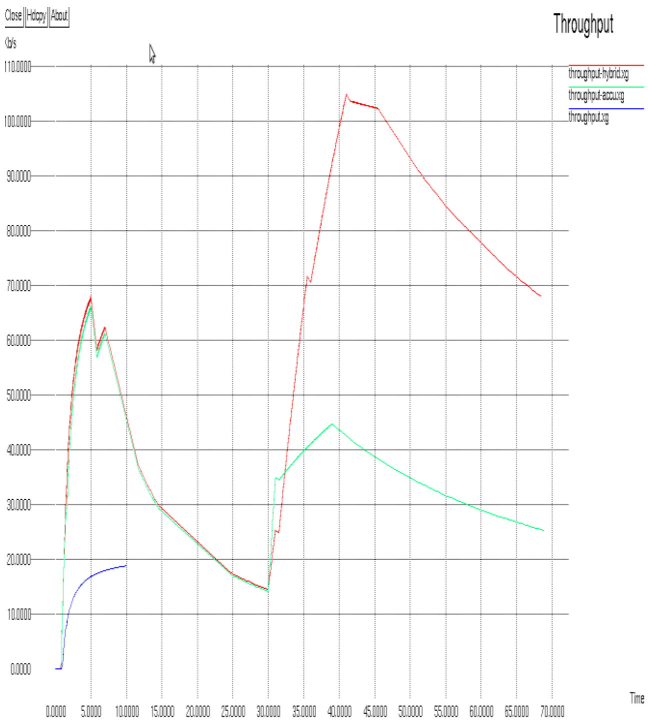
5. Distance:

Distance in network topology is defined as the average number of steps along the shortest paths for all possible pairs of network nodes. It is a measure of the efficiency of information or mass transport on a network.

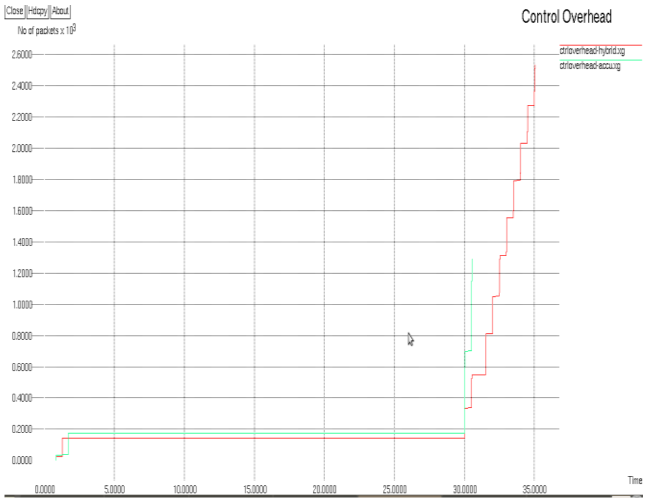
1. Bit Error rate:



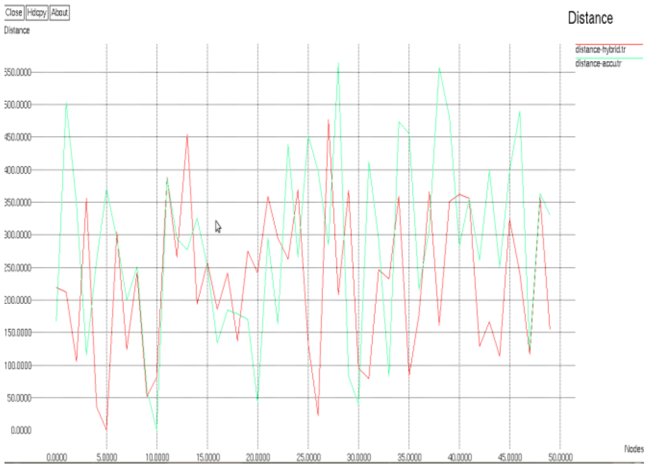
2. Throughput:



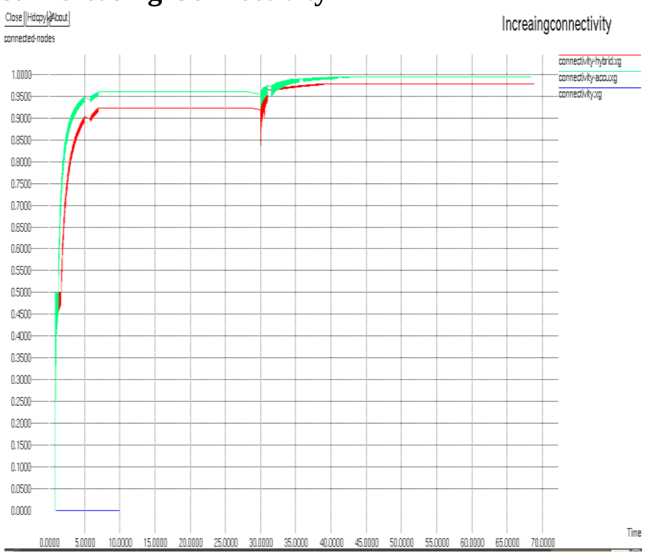
3. Control Overhead:



4. Distance



5. Increasing Connectivity



VI.CONCLUSON

Cooperative transmission can increase the connectivity of an access point especially in sparse settings and support topologies of clustered and partitioned networks that contain separated groups of nodes. Using cooperative transmission, a separated group can jointly transmit a message with higher transmission power reaching the otherwise unreachable partner nodes. This effects to increase connectivity by using cooperative transmission, that otherwise cannot be accomplished by normal multi-hop. New communication principle can overcome connectivity problems in sparse settings or heavily partitioned topologies. Multi-hop communication is instead limited to its one-hop mesh connectivity. The implementation of cooperative transmission is very easy and can be stateless and without routing tables or similar connectivity lists. For wireless sensor networks cooperative transmission can also be applied as a fall-back solution only. For that case, the network would perform normal routing, broadcast and multi-hop protocols with the necessary properties. Only in cases where nodes find themselves unconnected as a separated group, they would perform a cooperative transmission. For this system design, cooperative transmission would selectively be evoked as a solution when traditional processes cannot overcome the connectivity problem in a sparse setting or partitioned network. So the final resulting power consumption is very less. So to avoid connectivity problems and to make the operation more effective we present cooperative transmission to connect previously disconnected parts of a network thus overcoming the separation problem of multi-hop network. This approach improves connectivity over 50% compared to multi-hop approaches and reduces the number of nodes necessary to provide full coverage of an area up to 30%.

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