ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Optimal Placement of Relay Nodes in Multi-pair Co-Operative Network to Increase System Capacity in WSN

Baldeep Kaur Brar[1], Abhilasha[2]
Student[1], Associate Professor[2], GZS PTU Campus, Bathinda, Punjab, India
baldeepkaurbrar@gmail.com

Abstract

With the advancement of technology the usage of wireless sensor network are increasing day by day. There are two types of sensor networks: Single tiered and multi-tiered [5]. In single tired sensor network there is one sink and multiple sources and in multi-tiered sensor network there are multiple sources and multiple destination. For the proper transmission of data we need to place relay nodes in source and destination if distance of source and destination is large than range of wireless sensor node. In this paper an optimal placement of relay node in multi-pair co-operative network has been presented so as to increase the system capacity.

Keywords: Wireless Sensor Network, Relay Node Placement, Amplify and forward (AF), Decode and forward (DF), Network Deployment, System Capacity.

Introduction

In today's era, everything is to be done by using sensor. The sensors application can range from securing home to military applications, and then from mobile phones to toys [1]. Wireless sensor network consist of several nodes where each node is connected to one or more sensor. These nodes perform the sensing and tracking tasks. Despite of small size and limited energy of sensor nodes, these are used in very vast fields and everything is needed to be done attentively. Wireless sensor network is a part of ad-hoc network which is a network having mobile nodes [3]. But the difference between ad-hoc network and sensor network is

- The number of nodes in sensor network is more than in ad-hoc network.
- Sensor network are densely deployed.
- Sensor nodes are prone to failures.
- The topology of a sensor network can be changed frequently.
- Ad-hoc network send message point to point but sensor network broadcast message.
- Sensor node is limited in size, power computation capacities and memory.
- There is no global identification of sensor nodes.

Sensor

A sensor is an electromechanical device which can sense any physical, motion, contact, presence/absence, bio-chemical and identification properties of any real object [2]. It is actually a Transducer in the concept of electronics which converts any sensed properties of object into equivalent electrical signal**.**

Sensor Node

Sensor Node are use to create Sensor network. A Sensor node generates raw data by sensing the several properties of object transmit to the Sink via other sensor node or relay node, so It has capacity to receive data of other Sensor [9] .Typical Sensor node have following components

a) **Sensor.**
b) **Analog to digital Converter.**
c) **Processor**
d) **Storage**
e) **Transceiver**
f) **Power Unit**
g) **Antenna**

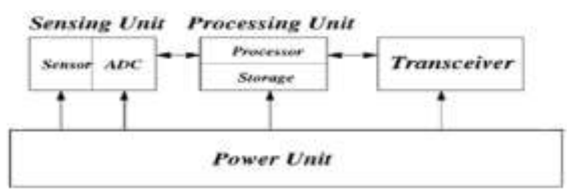


Figure 1: A schematic diagram of Sensor Node [8]

Relay Node

Relay based communication is supported by wireless networks, in which source node sends message to destination which is received by relay node. Relay node processes the message and forward it to its

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

intended destination node [13]. R*elaying* will be especially beneficial when there is no line-of-sight path between the source and the destination exists. Relay node act as an amplifier that amplifies the signal and transmit it to its destination node. Relay node is placed between source and destination so as to increase the capacity of the network.

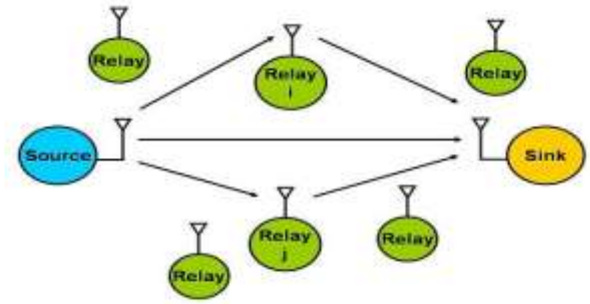


Figure 2: Relay Nodes location with source and Sink [6]

Multi-pair network architecture is considered in the study as shown in Figure 3, which consists of three network entities: the Base station (BS), the Relay station (RS), and the fixed Sensor station (SS) [12]. The BS serves as a central controller/coordinator and handles all the routing and signaling issued in the cell. The RSs are liable for relaying data between the BS and the associated SSs based on the given cooperative relaying strategy. The RSs have no direct connections to the core network and are eligible to be deployed at certain outdoor candidate positions (CPs) where uninterrupted power supply can be provided.

The SS may stand for a hotspot or a building at which a large amount of traffic load generated by user terminals (UTs) are aggregated at the corresponding SS. For a certain degree the network design and deployment depends on the geographical distribution of traffic load. Based on the statistical study of data for traffic measurement and monitoring as well as the anticipation of traffic load growth [10], the mean and peak traffic load demand of each SS can be estimated for the network planning. For the sake of long-term network deployment, upgrading and extensions, for this research work the geographical distribution of peak traffic load demands at SSs as a known input in this study.

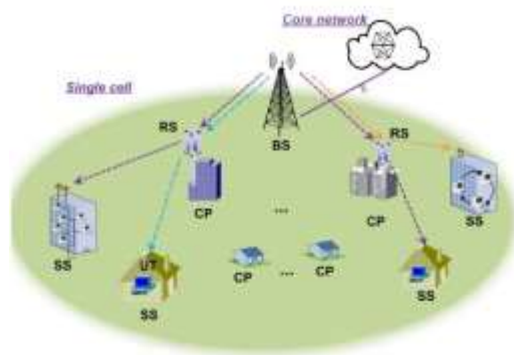


Figure 3: A relay-based broadband wireless access network architecture.

The BS can be multiple accessed simultaneously by different SSs at their assigned frequency band with the Orthogonal Frequency-Division Multiple Access (OFDMA) technique. In other words, each transmission between the BS and an SS is inherently an instance of the basic "BS-RS-SS" three-node relay model, where the three wireless links, BS-SS, BS-RS and RS-SS links, are assigned a common frequency spectrum [11]. In addition, due to the consideration regarding transmission delay, only two-hop cooperative relaying is assumed in this study. The COST231-Hata model is adopted as the radio propagation model which is applicable to the transmissions inside an urban environment. Small scale fading is not explicitly included in the system model since a long-term planning and design is targeted.

Network structure

In multi-pair cooperative network there are multiple sources and multiple destinations. Consider set of n sources and destinations such that source nodes are S= $\{s_1, s_2, s_3 ... s_n\}$. Similarly destination nodes are D= $\{d_1, d_2, d \ldots d_n\}$. There are m relay nodes such that R= $\{r_1, r_2, r_3 \ldots r_n\}$. It is assumed that at most one relay node can be placed between source and destination pair. Distance between source (s_i) and destination (d_j) is $\mathbb{D}_{i,j}$. Relay node placed between source s_i and destination d_j is represented as $\mathcal{R}(s_i)$.
When transmission of signal from node i to node j is done with power P_i then signal to noise ratio is represented by [4]

$$\gamma_{i,j} \triangleq \frac{P_i \mathbb{D}_{i,j}^{-\alpha}}{N_0} \qquad (1)$$

Here, α is pass loss exponent and N_0 is spectral density of additive Gaussian white noise. Band width of all channels is assumed to be W.

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

Transmission types

Relay node can be of two types: Amplify-and-Forward (AF) and Decode-and-Forward (DF). Hence there are three types of transmission:

1) **Direct transmission**: It is the transmission in which no relay node is present between source and destination. It is represented by T_{DT}. Equation to calculate transmission capacity between pair <s_i, d_j> in direct transmission is[4]

$$T_{DT}(s_i, d_j) = W \log_2(1 + \gamma_{s_i,d_j}) \quad (2)$$

2) **AF transmission:** It is the transmission in which there is a relay node of type Amplify-and-Forward. It is represented by T_{AF}. Equation to calculate transmission capacity between pair <s_i , d_j> with relay node $\mathcal{R}(s_i)$ in AF mode transmission is[4]

$$T_{AF}(\mathcal{R}(s_i)) = \frac{W}{2}\log_2\left(1 + \gamma_{s_i,d_j} + \frac{\gamma_{s_i,\mathcal{R}(s_i)}\gamma_{s_i,d_j}}{\gamma_{s_i,\mathcal{R}(s_i)} + \gamma_{\mathcal{R}(s_i),d_j} + 1}\right) \quad (3)$$

3) **DF transmission:** It is the transmission in which there is a relay node of type Decode-and Forward. It is represented by T_{DF}. Equation to calculate transmission capacity between pair <s_i, d_j> with relay node $\mathcal{R}(s_i)$ in DF mode transmission is[4]

$$\boldsymbol{T_{DF}}(\mathcal{R}(s_i)) = \frac{W}{2}\min\{ \log_2(1 + \gamma_{s_i,\mathcal{R}(s_i)}), \log_2(1 + \gamma_{s_i,d_j} + \gamma_{\mathcal{R}(s_i),d_j})\} \quad (4)$$

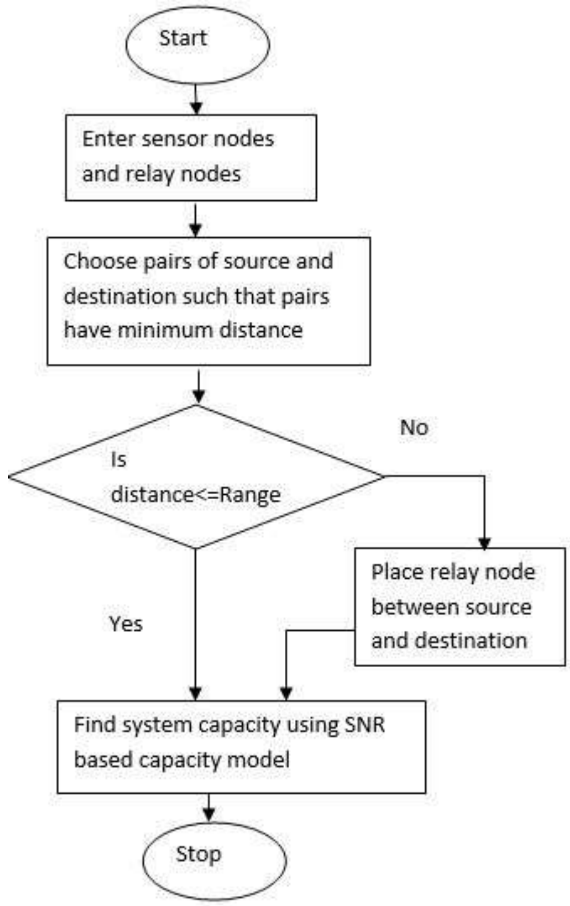
Consider δ which is 0 it relay node is not present and 1 if relay node is present. Then system capacity is:

$$\mathbb{S} = \sum_{i=1}^{i=n} \delta_i . T_{CC}(\mathcal{R}(s_i)) + (1 - \delta_i) T_{DT}(s_i, d_j)$$

Where, n is number of sources and destinations.

Modified work of Optimal Relay Node Placement Algorithm

In traditional optimal relay node placement in multi-pair co-operative network to source and its destination minimum source distance pair is found out for first source then second and so on. Instead of that we can choose minimum distance then can assign source and distance pair associated with it. It will increase the system capacity. Flow chart of algorithm is as shown in figure



Flowchart 1: Flowchart of algorithm.

To test the work done take an example in which there are 10 source and destination nodes which are shown in table 1 and table 2.

Table 1: Source nodes

1	50	50
2	80	50
3	110	60
4	130	55
5	150	65
6	170	60
7	190	55
8	215	65
9	235	50
10	255	70

Table 2: Destination nodes

1	50	150
2	89	160
3	60	155
4	136	150
5	145	155
6	177	150
7	190	165
8	230	180

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

9	270	200
10	250	165

The output of the program is shown in Figure 4.

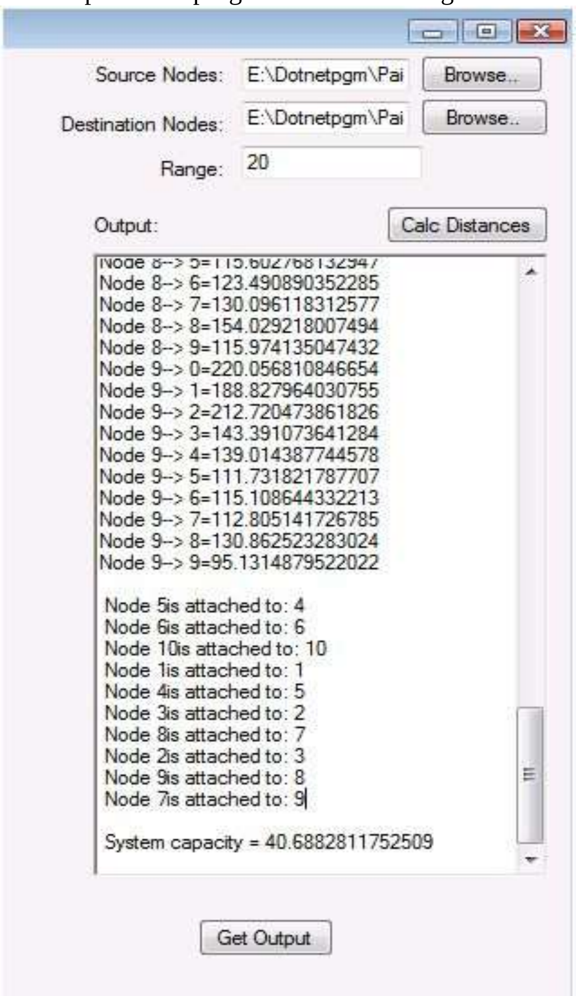


Figure 4: Output of program to calculate system capacity

The graph generated showing source, destination and relay nodes is shown in Figure 5.

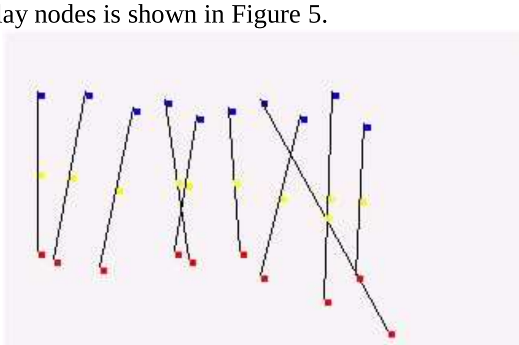


Figure 5: Graph of source, destination and relay nodes.

In this graph blue nodes represent sources, red node represents destinations and yellow nodes represent relay nodes.

The comparison of previous work and modified work in case place relay node optimally in multi-pair co-operative environment is shown in Table 3.

Table 3: System capacity by previous and modified work

	Previous Work	Modified Work
System capacity	38.87	40.6

The graphical representation of above mentioned table is shown in Figure 6.

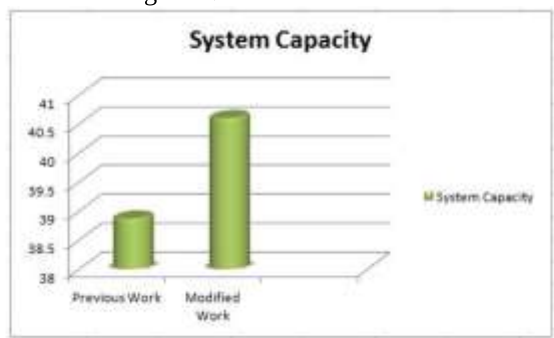


Figure 6: System capacity of traditional and modified technique.

Conclusion and future work

As it has been concluded that the presence of relay node is very important of better signal transmission. Also by placing relay nodes optimally system's capacity can be increased. As it can be seen from Table 4 that modified technique give more system capacity than previous technique. So it can be said that modified technique is better than previous technique. In future more work on multi-pair network can be done to further improve system's capacity.

References

1. Ying Zhu (2009), "The More Relay Nodes, The More Energy Efficient?", *International Conference on Computational Science and Engineering*, pp. 87-92.
2. E. L. Lloyd and G. Xue(2007), "Relay node placement in wireless sensor networks," *IEEE Trans. Comput.*, vol. 56, no. 1, pp. 134–138
3. B. H. J. Tang and A. Sen(2006), "Relay node placement in large scale wireless sensor networks," in *Computer communications*, vol. 29. Elsevier Science, Amsterdam, PAYS-BAS (Revue), pp. 490–501
4. H. Biao, L. Jie,S. Jinshu(2013) , "Optimal Relay Node Placement for Multi-pair Cooperative communication in Wireless Networks", *2013 IEEE Wireless*

Communications and Networking Conference (WCNC): Services & Applications, pp. 4724 – 4729.

5. B. Hao, J. Tang, and G. Xue, "Fault-Tolerant Relay Node Placement in Wireless Sensor Networks: Formulation and Approximation," Proc. IEEE Workshop High Performance Switching and Routing (HPSR '04), pp. 246-250, 2004
6. Y.T. Hou, Y. Shi, and H.D. Sherali, "Rate Allocation in Wireless Sensor Networks with Network Lifetime Requirement," Proc. ACM MobiHoc '04, pp. 67-77, 2004.
7. B. Karp and H. Kung, "GPSR: Greedy Perimeter Stateless Routing for Wireless Networks," Proc. ACM MobiCom '00, pp. 243-254, 2000.
8. C.K. Lo, R.W. Heath, Jr., and S.Vishwanath, "The Impact of Channel Feedback on "opportunistic Relay Selection for Hybrid-ARQ in Wireless Networks," submitted to the *IEEE Trans. Veh. Technol.*, June 2007.
9. C.K. Lo, S. Vishwanath, and R.W. Heath, Jr., "Relay Subset Selection in Wireless Networks Using Partial Decode-and-Forward Transmission," submitted to the *Proc. of the IEEE VTC-Spring*, May 2008.
10. Q. Han, A. P. Jayasumana, T. Illangasekare, and T. Sakaki, "A wireless sensor network based closed-loop system for subsurface contaminant monitoring," in *Proceedings of the NSF Workshop on Next Generation Software (NSFNGS)*, 2008.
11. G.-H. Lin and G. Xue, "Steiner tree problem with a minimum number of Steiner points and bounded edge-length," *Inf. Process. Lett.*, vol. 69, no. 2, pp. 53–57, 1999.
12. J. Augustine, Q. Han, P. Loden, S. Lodha, and S. Roy, "Energy efficient shortest path algorithms for converge cast in sensor networks," in *submitted for publication*, 2009
13. D. Chen, D.-Z. Du, X.-D. Hu, G.-H. Lin, L. Wang, and G. Xue, "Approximations for Steiner trees with a minimum number of Steiner points." *J. Glob. Optimal*, vol. 18, no. 1, pp. 17–33, 2000.