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Finding an Optimum Transmission Range in a multi-sink Wireless sensor network to make a tradeoff between delay and energy consumption

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Abstract: *Increasing the lifetime in wireless sensor networks is a major challenge because the nodes are equipped with low power batteries. The effective way to increase the energy efficiency is to reduce the transmission overheads and to choose accurate routing technique for data transmission. When two communicating nodes are not in range of each other in wireless Sensor networks, they need to rely on multi-hop transmissions. In such a case, packet forwarding or packet routing, becomes imperative. The selected value of radio transmission range considerably affects network topology and node energy consumption. On the one hand, a large transmission range increases the distance progress of data packets toward their final destinations. This is unfortunately achieved at the expense of high energy consumption per transmission. On the other hand, a short transmission range uses less energy to forward packets to the next hop, but a large number of hops are required for packets to reach their destinations. Thus, there exists an optimum value of the radio transmission range. In this paper we have studied the effect of certain factor such as source selection, node deployment, transmission range, number of intermediate hops and forwarding techniques to make a tradeoff between Delay and Energy Consumption*
Keywords: *Lifetime, Energy Efficiency, Transmission range, energy consumption, intermediate hops.*

I. Introduction

Wireless Sensor Networks (WSN's) have attracted a great deal of research attention due to the wide-range of potential applications. Applications of WSNs include battlefield surveillance, biological detection, medical monitoring, home security and inventory tracking [2]. This type of Network consists of a group of nodes and each node has limited battery power. There may be many possible routes available between two nodes over which data can flow. Any node in the network can easily transmit their data packet to a distance node if it has enough battery power. If any node is far from its neighbour node then large amount of transmission energy is required to transmit the data to Destination node. After every transmission, remaining energy of this node decreases and some amount of data transmission this node will be eliminated from the network because of empty battery power and in similar situation there will be a condition that no node is available for data transmission and overall lifetime of network will decreases [4]. One of the most important performance measures for wireless sensor networks is network lifetime. Whereas network lifetime is defined as the time until all nodes are able to send or receive data. For maximizing the network lifetime, data should be routed such that energy expenditure is fair among the nodes in proportion to their energy reserved, instead of routing the data to a path that Minimize consumed power [5].

The main component of energy consumption in a wireless sensor network is the energy consumed for transmitting. This transmitting energy consumption increases exponentially with the transmitting distance [7] so it might appear that more the transmitting radius of a node more is the energy consumption and thereby lesser the lifetime of a network. But the flip side of having more transmitting radius is having more number of neighbours we choose for packet forwarding. So it becomes important to choose an optimum transmitting radius for nodes to enhance the life time of multi-sink wireless sensor network.

In section 2 of this paper, we discuss some of the existing routing protocols. In section 3 the proposed scheme to show the energy consumption and number of intermediate hops variations according to different parameters have been described. Section 4 consists of the experimental results and in section 5 follows the conclusions thus drawn.

II. Related Works

In wireless sensor network, data transmission is very expensive in terms of energy consumption, while data processing consumes significantly lesser energy [1]. The energy cost of transmitting a single bit of the information is approximately the same as that needed for processing a thousand operations in typical sensor node [2]. The communication subsystem has much higher energy requirement than the computation subsystem. Most of the earlier works on energy efficient routing in wireless sensor network uses the Minimum total energy

(MTE) routing for data transmission approach to minimize the energy consumption to reach the destination. This was done by sending the traffic through same path for consecutive transmissions. But if all the traffic follows the same path then all the nodes of that path will deplete their energy quickly [3].

Effect of a transmission radius, number of nodes and the transmission area in the lifetime of a wireless sensor network has been discussed in[4].It was seen that lifetime increases with an increase in number of nodes and transmission area and decreases with an increase in transmission range of sensor nodes. In [5], the optimal transmission radii1 that maximizes the expected packet progress in the desired direction were determined for different transmission protocols in a multi-hop packet radio network with randomly distributed terminals. The optimal transmission radii were expressed in terms of the number of terminals in the range.

In [6], Multiple Sink Dynamic Destination Geographic Routing (MSDDGR) is proposed. It is based on greedy forwarding scheme. When a packet needs to be sent the sender selects the nearest sink as the current destination. Also, if the intermediate node sees that another sink is nearer to it, then the current destination node is changed and the new sink node is selected as the destination

The optimization of transmission range as a system design issue was studied in [7]. The wireless network was assumed to have high node density and to consist of nodes with relatively low mobility and short transmission range. As justified by the assumption of high node density, the authors further assumed that intermediate routing nodes are always available at the desired location whenever they are needed. Considering the nodes without power control capability, the authors argued that the optimal transmission range can be set at the system design stage. Specifically, they showed that the optimal one-hop transmission progressive distance is independent of the physical network topology, the number of transmission sources, and the total transmission distance; and that it only depends on the propagation environment and radio transceiver device parameters.

A similar assumption was made in [8], even though the node density was only considered for the energy consumption of overhearing nodes. They investigated the problem of selecting an energy-efficient transmission power to minimize global energy consumption for ad hoc networks. They concluded that the average neighbourhood size is a useful parameter in finding the optimal balance point. Effect of network lifetime on forwarding technique selection has been discussed by Ghosh and Das [13]. In [15], a protocol called MRMS (Multipath Routing in large scale Sensor networks with Multiple Sink nodes) is proposed which incorporates multiple sink nodes. In MRMS, a primary path is created with minimum path cost. It also saves the other paths from different Sinks. Thus, when the primary path is not reachable or if the residual energy of the sensors along the path falls below a certain threshold, another path is selected.

III. Present work

Transmission range, number of intermediate hops, size of the coverage area and data forwarding techniques are the crucial factors in calculating the energy consumption of WSNs. A comparable study of different forwarding techniques is present in [4]. The source nodes or intermediate nodes select a next node to forward the data to the destination based on different criteria, the process repeats until data reaches the destination. In the greedy forwarding technique, neighbour node nearer to the sink is chosen considering its distance from sink node as a criterion. In the residual energy based forwarding technique, remaining energy of the neighbouring nodes is used as a criterion to select the next node. We have used these two forwarding techniques here for finding an optimum transmission range to enhance network lifetime.
The nodes were deployed in a grid fashion as shown in Figure 1.

Table 1. Parameter Settings

Parameter	Value
*Simulation area	250 x 250 m^2
Initial energy of nodes	1 J
Permittivity of free space	8.8548.854x10^{-12} Pj/bit/m^2
*No. of nodes	387
*Transmission energy	25 J
Fraction of energy Consumed for transmission And reception	50x10^{-9} J
*Cell Size	10x15 m^2
Path loss exponent	3

NOTE: The (*) marked fields shows the default values. These values have been changed as per the experimental needs.

The radio model proposed in [17] has been used here.

ETX (m, d) =m*E+m* ε * d2

ERX (m) =m*E

Where

E=50nJ/bit and ε = 10 pJ/bit/ m2.

ETX= Energy Consumed for transmission

ERX=Energy Consumed for reception

d= Distance between transmitting and receiving node

ε= Permittivity of free space

m=number of bits

IV. Performance Evaluation and discussion

Before measuring the energy consumption in a WSN, one must decide a particular forwarding technique for transmission and receiving data packet. In our case, we are using greedy forwarding and residual energy based forwarding. Figure 1 show the deployment pattern formed when the location of nodes is taken in a grid fashion and the source node is selected randomly.

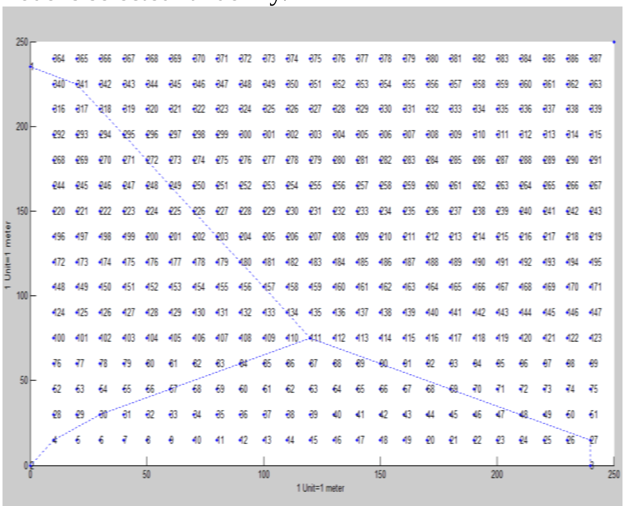
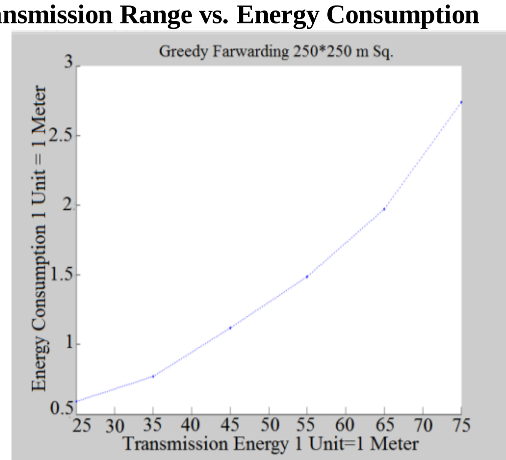


Fig.1 Pseudo-random deployment with 387 nodes in an area of 250 x 250. Node 111selected as Source node and Node 1, 2, 3 are Sink nodes.

4.1 Transmission Range vs. Energy Consumption



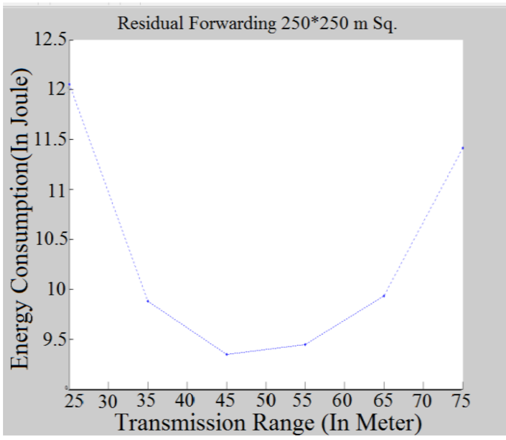


Fig.2 Energy consumption variation with increase Transmission Range by using greedy forwarding technique.

Fig.3 Energy Consumption variation with increase Transmission Range by using residual energy based forwarding.

In Fig.3 and fig, 4 shows an increment in the total energy consumption of the network with increase the transmission range of nodes within a fixed coverage area by using greedy forwarding and residual energy based forwarding respectively. The total energy Consumption in the WSN is directly proportional to the transmission range while using greedy forwarding technique. Whereas, for residual energy based forwarding, we see a parabolic nature of the graph, when total energy consumption is plotted against increased transmission range.

4.2 transmission ranges vs. No. of intermediate nodes

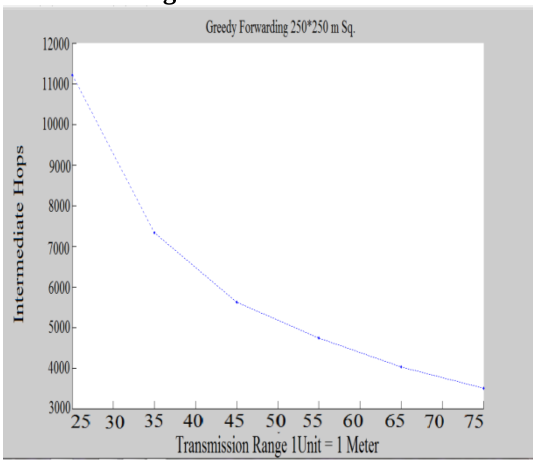


Fig.4 No. of intermediate hops variation with increase Transmission Range by using greedy forwarding technique.

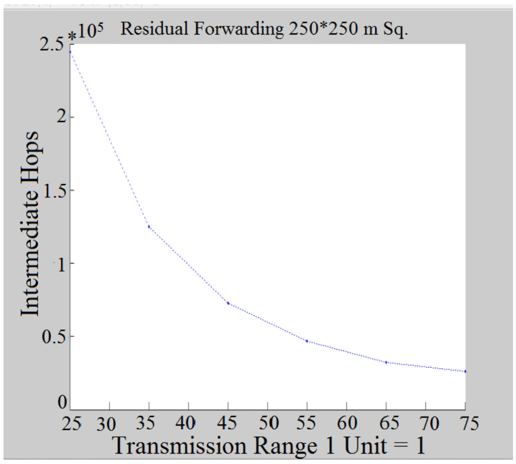


Fig.5 No. of intermediate hops variation with increase Transmission Range by using residual energy based forwarding

The figure 5 and 6 shows the effect of transmission range on the total number of intermediate hops of a WSN by using greedy forwarding and residual energy based forwarding respectively within a fixed coverage area. As we increase the transmission range the Number of intermediate hops of the sensor node decreases. By total number of intermediate hops we mean, the cumulative number of hops every packet encounters throughout the lifetime of the network.

4.3 optimum transmission ranges

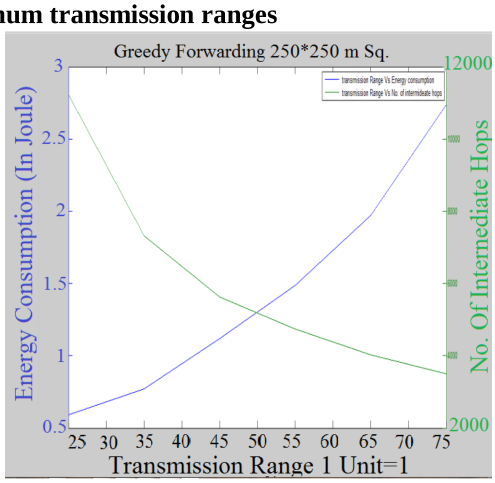


Fig.6 optimum transmission Range by using greedy Forwarding Technique

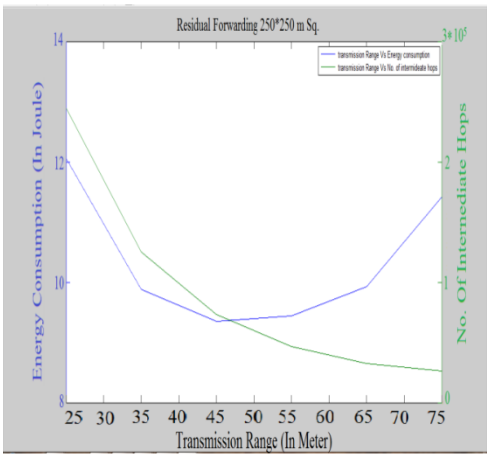


Fig.7optimum Transmission range by using residual energy based forwarding

Now, to find out the optimum transmission range, we plot both graphs in together to get a crossover point . We propose this crossover point to be the optimum transmission range.
In figure 6 we can see the optimum transmission range is 50 using greedy forwarding.
Same comparison for residual energy based forwarding. In figure 7 shows that range 50 is also an optimum range for residual energy based forwarding.
Hence, we can say range 50 is an optimum range of both forwarding techniques.

V. Conclusion and future work

The experimental result shows that the transmission range, number of intermediate nodes and the transmission area have a direct effect on the lifetime of a WSN. Our experimental result shows a direct relation to the energy consumption and transmission range while an inverse relation to the transmission range and number of intermediates hops of the sensor nodes. Energy consumption increase with increases transmission range and number of intermediate nodes decreases with increase transmission ranges. The future work may involve the effect of various parameters on lifetime of WSN and will propose a protocol that enhance the lifetime of a WSN.

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