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Routing through Forward Intersection-area (RFIA) of Mobile Wireless Sensor Networks

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ABSTRACT

Mobile Wireless Sensor Networks (MWSNs) have found their applications in various streams, especially in the field of agriculture. The routing through the mobile sinks is a difficult procedure. We design a new architecture with mobile and static WSNs in an agricultural area for monitoring crop cultivation and giving the information to base stations. Efficient routing through forward intersection area is a new concept that uses forward intersecting sectors of nodes to enable the selection of the next best node. Consequently, we are able to form an efficient route to the base station, thereby improving the network performance. Network simulator is used to verify the network performance.

Keywords: Mobility, Wireless Sensor Networks, Routing, Packet delivery, throughput..

I. INTRODUCTION

Mobile Wireless Sensor Networks (MWSNs) allow the sensor nodes to move anywhere in the network and are able to communicate with other nodes without the need of any fixed infrastructure. A sensor node includes three basic components: a sensing device, a processing device and a wireless communication device like antenna. Introducing mobility in wireless sensor network is considered to be advantage. MWSNs outperform static WSNs in various factors including energy consumption, channel capacity, relocation, dynamic topology, lifetime, better targeting, data fidelity etc.

The most important application of a mobile sink is in the field of agriculture where a person can remotely monitor the crop cultivation methods. Introducing mobility in wireless sensor network is considered to be advantage. MWSNs outperform static WSNs in various factors including energy consumption, channel capacity, relocation, dynamic topology, lifetime, better targeting, data fidelity etc. The most important application of a mobile sink is in the field of agriculture where a person can remotely monitor the crop cultivation methods.

In MWSN, the sensor nodes are deployed randomly in the network. Path failure occurs frequently in MWSNs due to channel fading, interference, node failure, node mobility and shadowing. The mobile node changes its locations periodically which can lead to excessive drain of the sensor node's battery supply and also increase collisions. The main factors to be considered in MWSNs include bandwidth restrictions, limited resources and mobility of nodes.

The act of moving a data packet from source to destination is termed as routing. The lifetime of the network and power supply are considered to be a crucial in WSN. Various paths are available from source to destination of which the longer routes can increase the network delay in the communication network and the shorter routes will cause the intermediate nodes in the network to drain the energy supply leading to network partition.

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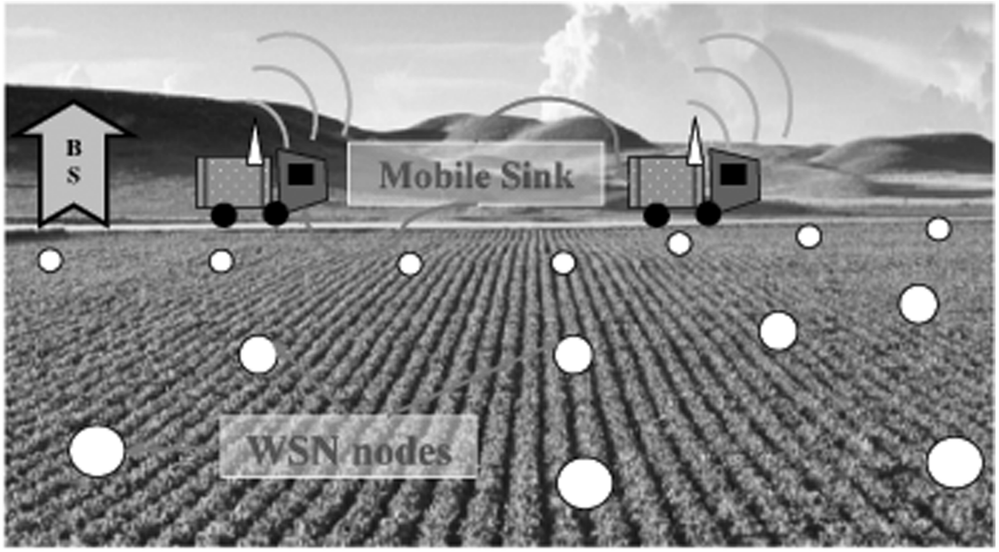

Figure 1: Mobile Wireless Sensor Network with an Attacker

The significant challenges for routing in MWSNs include the following:

- It is mandatory to know the position of MWSNs since data gathering is based on location.
- The routing protocols should adapt to the self-organizing nature of the mobile nodes.

Multiple sensors can sense the occurrence of an event simultaneously and generate data. This data traffic has to be aggregated to minimize the energy consumption and improve the bandwidth utilization.

2. RELATED WORKS

Development of small sized and low cost appliances has facilitated the nodes to be capable of sensing, communicating and computation in the network. Networks of such nodes can coordinate to perform distributed sensing of environmental phenomena. The directed diffusion paradigm for such coordination is explored in this paper [1]. Directed diffusion is data centric such that all nodes in a directed diffusion-based network are application-aware.

SPIN effectively propagates data to nodes in an energy-limited sensor network [2]. Nodes running a SPIN communication protocol, call their high-level data with the name metadata. These nodes can rely on their communication decisions both upon application specific information of the data and upon knowledge of the resources that are available to them. This allows the sensors to efficiently distribute data given a limited energy supply.

In OR-RSSI protocol, a sink's beacon packets are taken to measure opportunistic probability (OP) and mobility vector (MV). These are used to find the next best node so that it has higher OP value and thereby consequently packets are relayed until the destination is reached [3].

A location-based protocol called PAGER-M, for mobile sensor networks consist of frequently moving sensors [4]. This protocol uses the location data of nodes including the BS to assign a cost function to each sensor node in the communication network which is close to the Euclidean length of a sensor node's shortest path to the base station. The packets are forwarded to the base station using greedy forwarding. When a packet reaches sensor nodes near local minimums, the packet is forwarded following the high-cost-to-low-cost rule.

Due to Wireless Broadcast Advantage (WBA), devices in the range of one particular node transmitting may receive the packet and therefore they can serve as cooperative caching and backup nodes if the anticipated destination fails to receive the packet in the network [5]. A distributed robust routing protocol was presented in which nodes work cooperatively to develop the strength of routing in opposition to link breakages.

TTDD, a Two-Tier Data Dissemination approach provides scalable and efficient data delivery to multiple and mobile sinks. The data source in TTDD constructs a grid structure proactively which enables mobile sinks to continuously receive data by flooding queries within a local cell. TTDD's design exploits the fact that sensors are stationary and location-aware to build and sustain the grid infrastructure with low overhead.

Grid Based Energy Efficient Routing (GBEER) [7] addresses the problem of packet transmission from multiple sources to multiple mobile sinks in large scale sensor network. The sensing field is divided into grid structure and sensor nodes decide their cells based on the location information. The header is selected randomly in the communication network. To advertise the data detected by a sensor node, the header sends data announcement packet to other headers.

MinRoute is a routing protocol designed for data transmission style of WSNs [8]. The dynamic nature of wireless communication poses major challenges to reliable, self-organizing multi-hop networks. Such features are difficult with the primitive, low-power radio transceivers found in sensor networks and raise new issues. Link connectivity statistics should be captured dynamically through a capable link status estimator and routing judgments should develop such connectivity statistics to achieve reliability. The status of the link and information about routing must be maintained in a neighborhood table with constant space regardless of cell density. The most effective solution uses a time averaged EWMA estimator, frequency based table management and cost based routing.

The CEER algorithm uses the clustering method to aggregate the data and uses a dynamic path finding to find a neighbour node with highest energy to route the data to an anchor close by [9]. Energy Saving Dynamic Source Routing (ESDSR) utilizes local broadcast to obtain a route and selects the most efficient one with maximum expected life but the source node does not accumulate neighbour node data to send it to the destination. So CEER algorithm saves more energy as compared to ESDSR as the network density increases.

Sensor nodes assume deploying a stationary sensor network over a hazardous locality such as a battlefield. Even if an advanced method to make the deployment safer is used, diverse element will cause coverage holes [10]. Even though perfect coverage can be achieved initially, various factors such as malicious attacks would definitely destroy the coverage of network eventually. Every sensor node has mobility by placing on vehicles. Mobility reinforces fault-tolerance and scalability. Generally traditional routing methods find it difficult to manage routing in the mobile sensor networks.

3. DESIGN OF THE PROPOSED RFIA METHOD:

The architecture proposed for efficient data collection using mobile sinks contains both static and mobile sinks as given in the figure 2. Consider the architecture in the figure 2, there is a single base station and a number of nodes deployed in the area of monitoring. To avoid the entire load to be pressurized on the nodes around the base station, we propose the mobile sinks to aid in the collection of the information from the sensor nodes and deliver them later to the base station. These special nodes are called Mobile Sinks (MS) as they help in the transfer of data without any congestion.

We propose a routing method to obtain the data in a very efficient manner towards the destination and also handing over the overloaded data from time to time. We first establish a forward intersection area using all the neighbouring nodes in the network. The forward intersection area is formed using the farthest neighbour in the direction of the destination as illustrated in the figure 3.

The steps involved in the RFIA method are

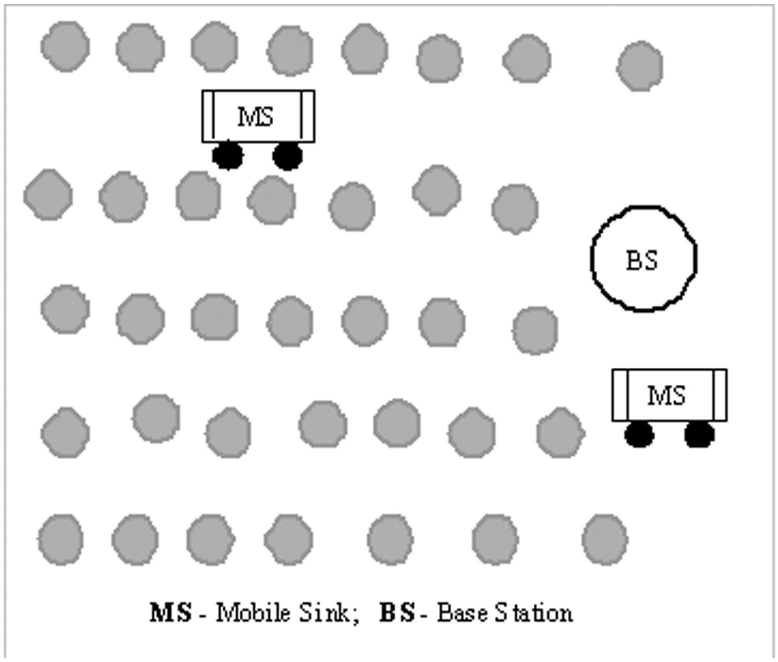

Figure 2: Scenario to illustrate the proposed ESMT

The algorithm steps are:

Step 1: Collect vertices of neighbour nodes of current hop *CurHop*

Step 2: Get the Forward Intersection Area (FIA) of all the vertices of neighbour list.

Step 3: Collect all the nodes in the FIA as *FIA(n)*

Step 4: Pick the shortest distance node (i^{th} Node) of the *FIA(n)* as *NxHop = FIA(n)*

Step 5: Send the data to the *NxHop*.

Step 6: Set *NxHop = CurHop* and repeat from step 1 until data reaches destination.

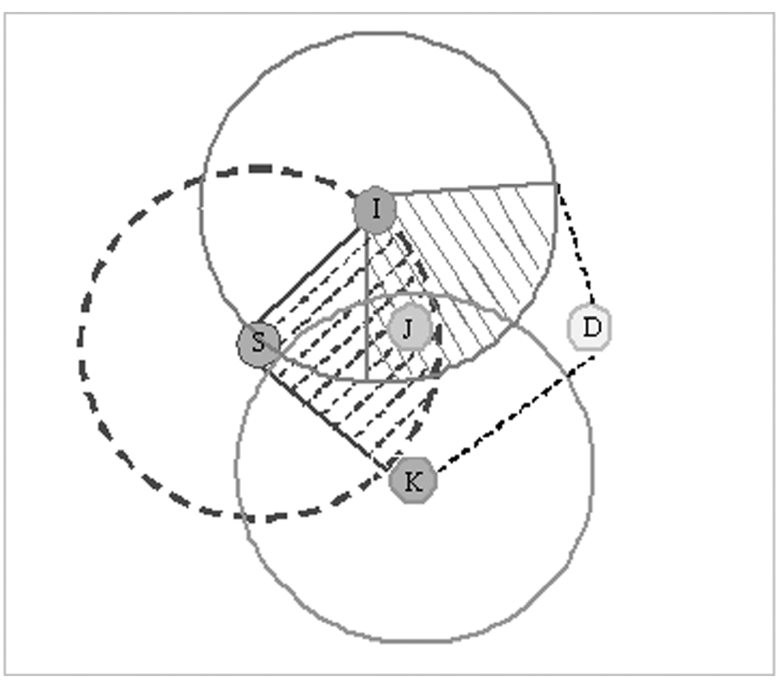

Figure 3: Forward Intersection Area formation of RFIA

Clearly, figure 3 shows the working strategy of the RFIA mechanism. The forward sector of the source node is shaded and the forward are of the nodes I and K are shaded. The intersection area contains the nodes J, therefore the node D is selected to send data to the destination. Any experienced delays will cause the data transfer to the mobile sinks, which will deliver the data to the destination. The simulation of the RFIA is method performed through NS-2.

4. SIMULATION ANALYSIS

The simulation of the proposed architecture is achieved through the simulation analysis network simulator tool. The simulation metrics used for the simulation of the RFIA mechanism and the existing mechanisms are given in the table 1.

The packet delivery, loss and delay are measured using the simulation tools. The total number of packets delivered is given in the figure 1 below. It can be observed from the figure that the proposed RFIA mechanism has increased packet delivery rate when compared to that of the existing baseline protocol. Therefore, this is used to evaluate the performance of the RFIA mechanism to be efficient.

The total number of packets delivered per second is plotted for the existing and proposed methods, which shows the efficiency of the proposed method. The figure 4 therefore shows the efficiency of the RFIA mechanism over the existing sink trail protocol. It can be therefore concluded that the optimized

Table 1
Simulation parameters of RFIA

Parameter	*Value*
Channel Type	Wireless Channel
Simulation Time	50 s
Number of nodes	50
MAC type	802.15.4
Traffic model	CBR
Simulation Area	100×100

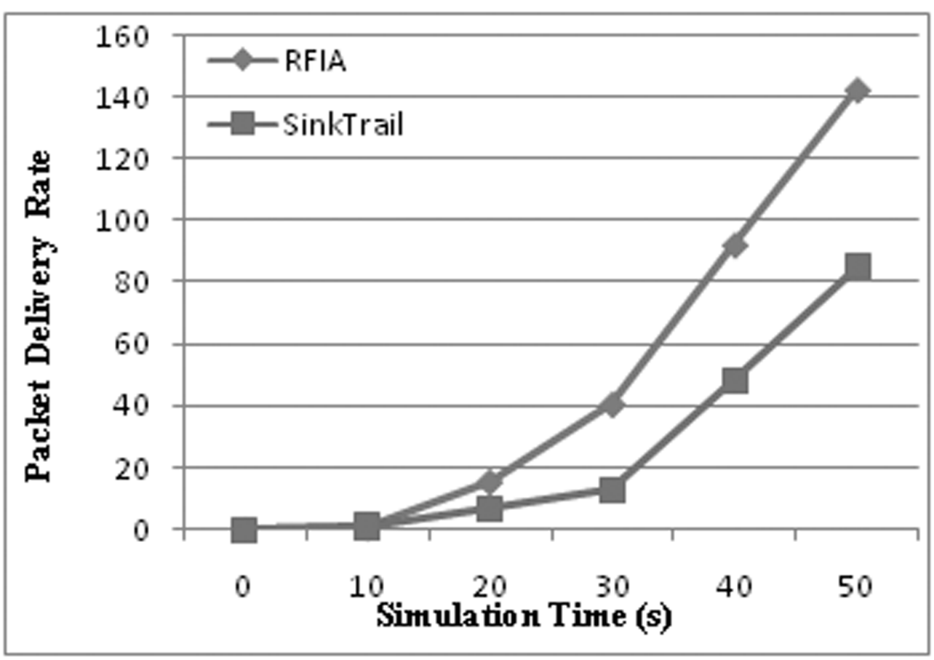

Figure 4: Packet Delivery Rate of RFIA and Sink Trail

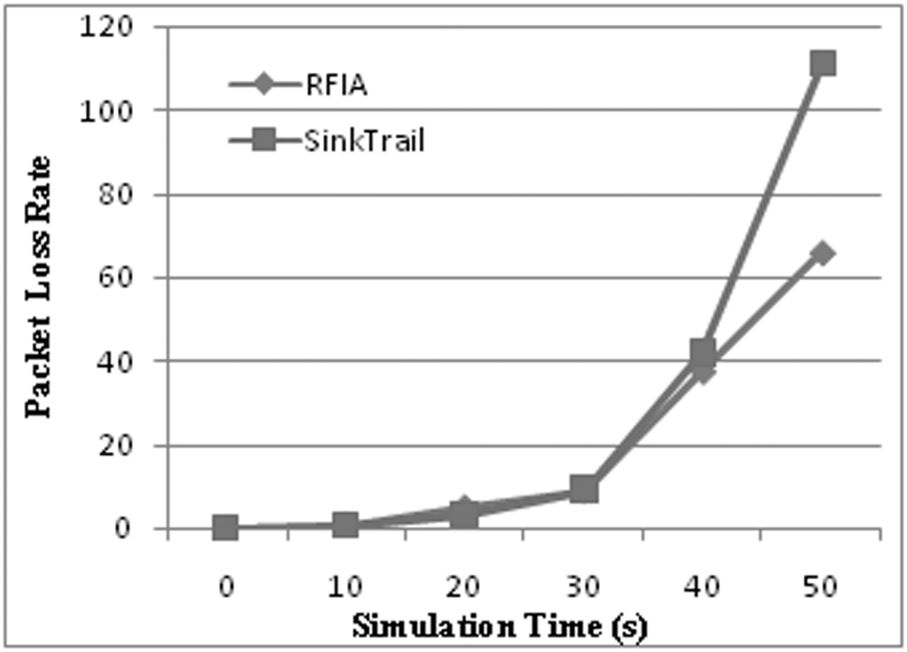

Figure 5: Packet Loss Rate of RFIA and Sink Trail

control of the mobile sinks in an agricultural WSN can effectively improve the packet delivery of the network.

In a similar manner, the packets lost are measured in both the RFIA system and the existing system to observe the difference in performance. It can be observed from the graphical plots of figure 5 that the packet loss rate of RFIA is lesser when compared to that of the existing protocol.

Further to this delay is estimated for the same existing and proposed methods. The plots in the figure 6 show the delay of the RFIA method is lesser when compared to the existing method. The delay is reduced in the figure 6 shown due to the set of routing operations performed in the proposed RFIA method.

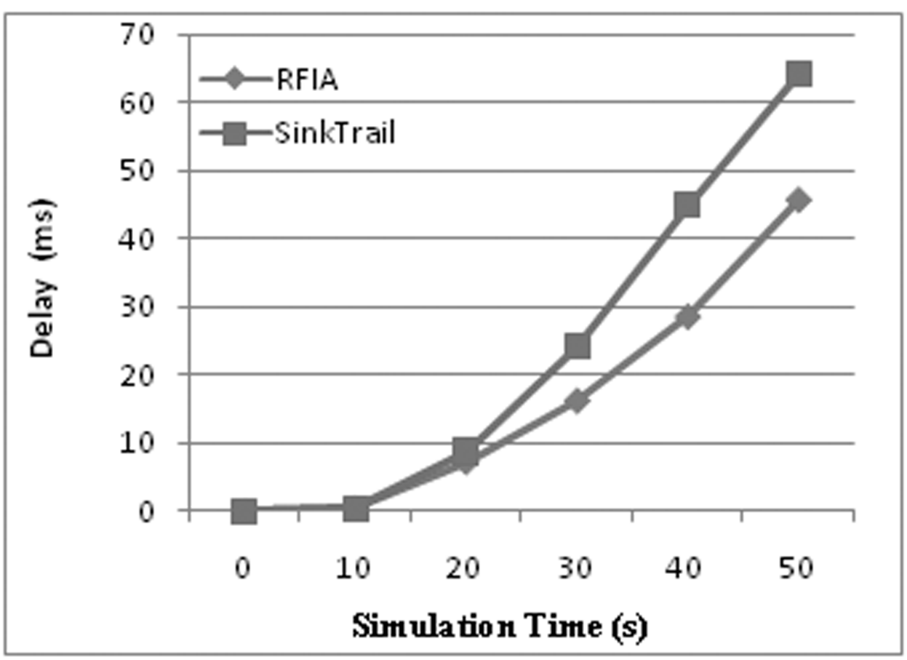

Figure 6: Delays of RFIA and Sink Trail methods

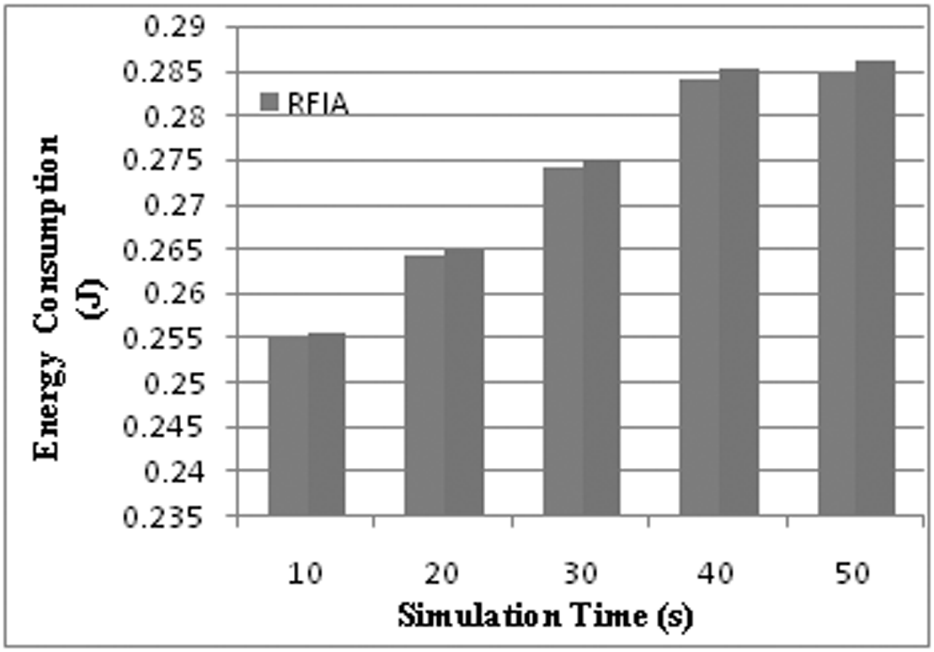

Figure 7: Residual Energy of RFIA and Sink Trail methods

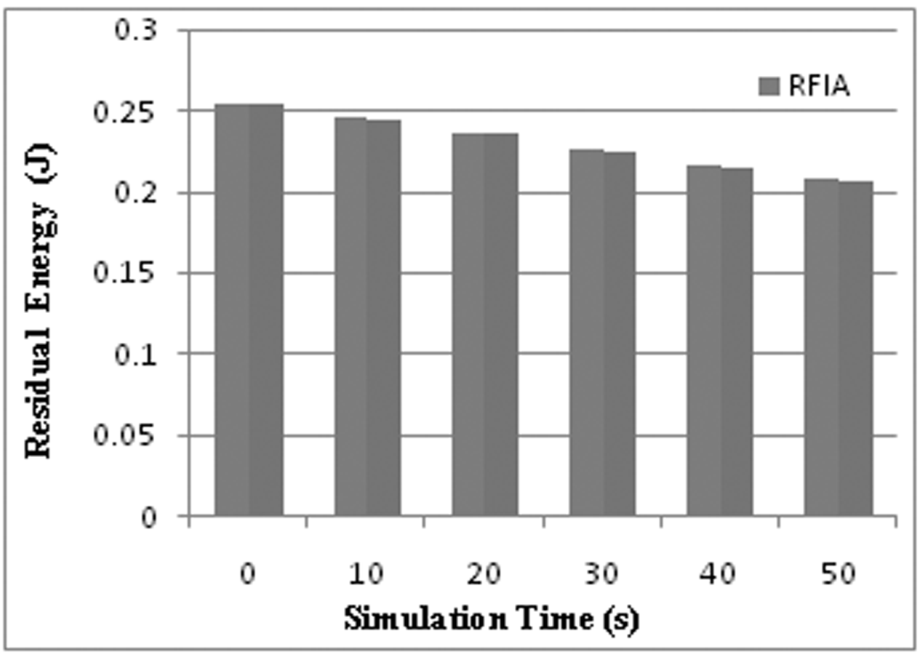

Figure 8: Energy Consumption of RFIA and Sink Trail methods

It can be observed from the figures 7 and 8 that the energy consumed by the RFIA methods is lesser when compared to the sink trial protocol. These results are obtained by modeling the energy design in the network simulator. The performances are thereby obtained and plotted using the X-graph plots proving the efficiency of RFIA.

5. CONCLUSION

The RFIA mechanism proposes an intelligent route from the source to the destination in the wireless sensor network that is equipped with mobile wireless sinks as well. The cooperative operation of nodes that thereby progresses the data packets towards the destination gives improved performance in the network. Therefore from this analysis it can be observed that the RFIA shows greater delivery along with reduces loss, delay and energy consumption. Future works include the mobility control of the mobile sinks with low overhead generation procedure.

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