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Performance Analysis of Wireless Sensor Networks Using Compass and Nearest with Forward Progress Algorithms

Shivanka
Information Technology Department
Maharaja Surajmal Institute of Technology, GGSIPU
New Delhi, India
Shivankachugh84@gmail.com

Karan Naveen
Information Technology Department
Maharaja Surajmal Institute of Technology, GGSIPU
New Delhi, India
shivankachugh84@gmail.com

Gourav Chadha
Information Technology Department
Maharaja Surajmal Institute of Technology, GGSIPU
New Delhi, India
Shivankachugh84@gmail.com

Ashwani Kumar
Mass Spectrometric Service Department
ABSIEX India Pvt. Ltd.
Gurgaon, Haryana, India
Ashwani_smash@yahoo.com.in

Esha Kumar
Project Engineer
Wipro Technologies
Pune, India
eshakumar86@gmail.com

Abstract: We propose a model to define the lifetime of a wireless sensor network (WSN) based on threshold energy and transmission time. Today main objective of WSN is to minimize the energy dissipation for the whole network. The proposed model takes into consideration several parameters such as threshold energy, total no. of sensors, map size, transmission time and location of sensors. Using this model, we compared two types of algorithms COMPASS and Nearest with Forward Progress (NFP) and observed that Compass performs better than NFP.

Keywords: Compass and Nearest with Forward Progress (NFP) algorithms, Network Lifetime, Simulation, Wireless Sensor Network

I. INTRODUCTION

The use of wireless sensor network (WSN) will play a major role in future technology. Characteristics of sensor nodes make them suitable for use in many different fields like intrusion detection, environmental monitoring and military applications. A WSN typically consists of a large number of low-cost, low power, and multifunctional wireless sensor nodes, with sensing, wireless communications and computation capabilities. These small sensing devices are called nodes and consist of a Central Processing Unit (for data processing), memory (for data storage), battery (for energy) and transceiver (for receiving and sending signals or data from one node to another). These nodes form a network by communicating with each other either directly or through other nodes. One or more nodes among them will serve as sink(s) that are capable of communicating with the user either directly or through the existing wired networks. Although they are very cost effective and easily deployed in harsh environment, they are limited by the power available through their life cycle. Once their power is depleted, the sensors become dead and they are no more useful. An evaluation of the life cycle of a wireless sensor network is very essential to estimate how long a network can live and when the network and its sensors might be replaced or recharged if possible.

II. ALGORITHMS USED

A. Compass:

Suppose that we want to travel from an initial vertex s to a destination vertex t and that all the information available to us at any point in time is the coordinates of our destination, our current and the directions of the edges incident with the vertex we are located at. Starting at s, we will in a recursive way choose and traverse the edge of our geometric graph incident to our current position and with the closest slope to that of the line segment connecting the vertex we are standing at to t. Ties are broken randomly [1].

B. Nearest with Forward Progress:

Nearest with Forward Progress (NFP) [2] is an energy-aware protocol which tries to minimize the energy consumption by sending the message to the closest node in the direction of the sink. The main advantage of NFP is that it makes collisions less likely as a node will adjust its transmission power to be just strong enough to reach the nearest neighbor which will result in forward progress. This leads to a succession of a large number of small hops (thus high data delivery latency) and less energy consumption than long hops [3].

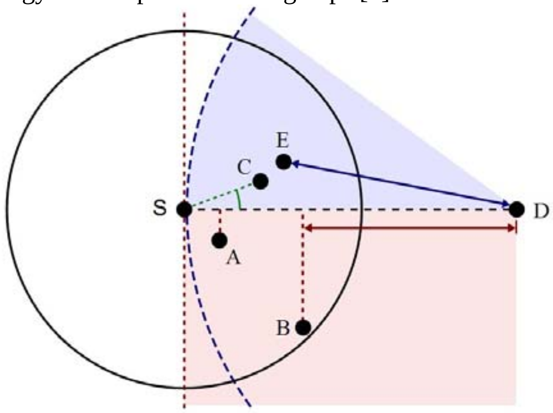

Figure 1. Illustration of two greedy routing protocols, A = Nearest with Forwarding Progress (NFP), C = Compass Routing

III. PARAMETERS USED

a. Location of sink node in X and Y coordinates
b. Maximum Range of Transmission of each node
c. Overhead Energy
d. Total energy of the system
e. Time duration for which Transmission takes place
f. Rate of Arrival of Packets
g. Path loss exponent
h. Lifetime Threshold
i. Total Number of Sensors

IV. NETWORK LIFETIME

A Network lifetime has become the key characteristic for evaluating sensor networks in an application specific way. Especially the availability of nodes, the sensor coverage, and the connectivity have been included in discussions on network lifetime. Even quality of service measures can be reduced to lifetime considerations. A great number of algorithms and methods were proposed to increase the lifetime of a sensor network while their evaluations were always based on a particular definition of network lifetime [4]. The definition of the life time of the network is based on the following criteria:

The time for the first node to die as in [5, 6, 7, 8], percentage of live sensors to total sensors percentage of available power to total power, and percentage of alive sink sensors to total sink sensors [9].

The first is too pessimistic since when one node fails the rest nodes still can provide appropriate functionality. While the latter does not consider the different importance of sensors in the sensor network [10].

V. RELIABILITY

Reliability is the percentage of original data packets that arrive at the final destination [11]. It is the ability of the network to ensure reliable data transmission in a state of continuous change of network structure. Any node wishing to communicate with other nodes should generate more packets than its data packets. These extra packets are generally called "control packets" or "network overhead." More overhead is unavoidable in a larger scale wireless sensor network to keep the communication paths intact. More dynamics in the environment will increase the number of control packets and, at some point the network cannot sustain the amount of overhead caused by the dynamics, which will result in less reliability of data transmission [12,13,14].

VI. CODE SIMULATION

The simulation of lifetime of WSN is performed using a simulator developed using JAVA technology. This simulator takes the parameters defined in section 3. The values of all the parameters as shown in Table I are provided by default and can also be changed to provide custom values for simulation.

Table: 1 Default values of parameters

Parameters	Initial Values
Sink X location	0
Sink Y location	0
Knowledge Range	30.0
Initial Battery Capacity	10000
Overhead Energy	0.02
Transmission Time	250
Packet Arrival Rate	60
Path Loss Exponent	3.0
Lifetime Threshold	0.60
Sensor Number	200
Map Dimension	200

A. Threshold Energy:

Energy Threshold defined, distance of node from base station & energy required by the node to transmit data to BS, the energy threshold is used to decide whether or not the node has enough energy to communicate with the base station, distance contains distance of node from base station, and transmission energy contains amount of energy required to transmit data to BS.

B. Knowledge Range:

Knowledge or Transmission range is a coverage area within which nodes can communicate with base station.

C. Overhead Energy:

It is the energy used for sending control packets.

D. Sensor Number:

It is the number of sensors in the simulation model.

The following cases are taken into consideration; each case varies a particular parameter while other parameters are kept constant.

A graph showing the relationship between corresponding parameters and network lifetime as well as reliability is also drawn for each case.

E. Case 1:

We fixed the Transmission time to 0.250s and varied the value of E0 and observed the values of reliabilities of NFP and COMPASS as shown in Table II. A corresponding graph between E0 and Reliability is shown in Fig. 2.

F. *Case 2:*

In this case, we fixed the Transmission time to 0.500 s and varied the value of E0 and observed the values of reliabilities of NFP and COMPASS as shown in TableIII. A corresponding graph between E0 and Reliability is shown in Fig. 3.

G. *Case 3:*

We fixed the Threshold energy to 0.50 J and varied the value of overhead energy and observed the values of reliabilities of NFP and COMPASS as shown in Table IV and the values of lifetime of NFP and COMPASS as shown in Table V. Corresponding graphs are shown in Fig. 4, and Fig. 5.

Table: 2 E0 vs. Reliability when Transmission time is 250ms

Initial Energy (J)	RELIABILITY	
	NFP	*COMPASS*
0.10	0.060	0.094
0.25	0.185	0.229
0.50	0.475	0.454
0.75	0.665	0.715
0.95	0.96	0.985

Table: 3 E0 vs. Reliability when Transmission time is 500ms

Initial Energy (J)	RELIABILITY	
	NFP	*COMPASS*
0.10	0.030	0.094
0.25	0.24	0.209
0.50	0.47	0.485
0.75	0.71	0.68
0.95	0.99	0.985

Table: 4 Overhead energy vs. Reliability when Threshold energy is 0.50J

OVERHEAD ENERGY (J)	RELIABILITY	
	NFP	*COMPASS*
0.02	0.229	0.449
0.10	0.37	0.464
0.15	0.235	0.435
0.20	0.204	0.495
0.25	0.37	0.31

Table: 5 Overhead energy vs. Lifetime when Threshold energy is 0.50J

OVERHEAD ENERGY (J)	LIFETIME	
	NFP	*COMPASS*
0.02	708	630
0.10	660	378
0.15	438	636
0.20	396	396
0.25	107	390

In the criteria as used in [15], we observe the following:

a. In TABLE II, the reliability is approximately 12.06% better in COMPASS than NFP
b. In TABLE III, the reliability is approximately 10.28% better in COMPASS than NFP
c. In TABLE IV, the reliability is approximately 30.93% better in COMPASS than NFP
d. In TABLE V, the lifetime is approximately 3.34% better in COMPASS than NFP

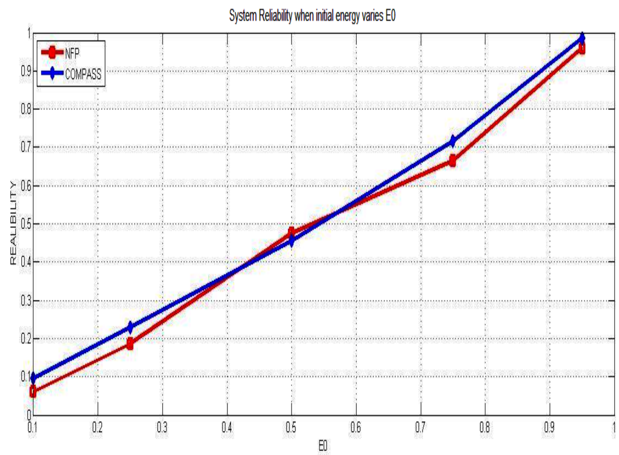

Figure: 2 E0 vs. Reliability when Transmission time is 250ms

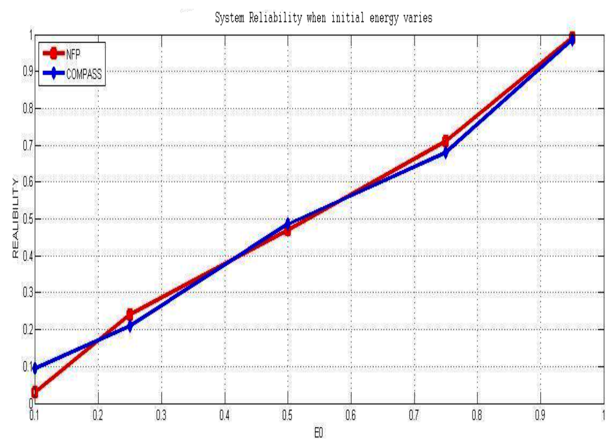

Figure: 3 E0 vs. Reliability when Transmission time is 500ms

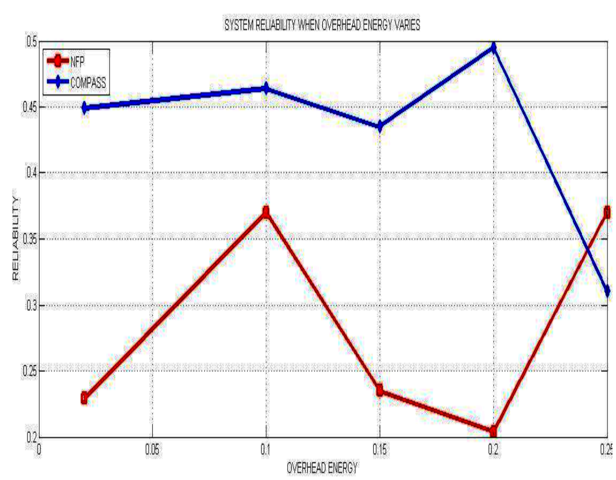

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Figure: 4 Overhead energy vs. Reliability when Threshold energy is 0.50J

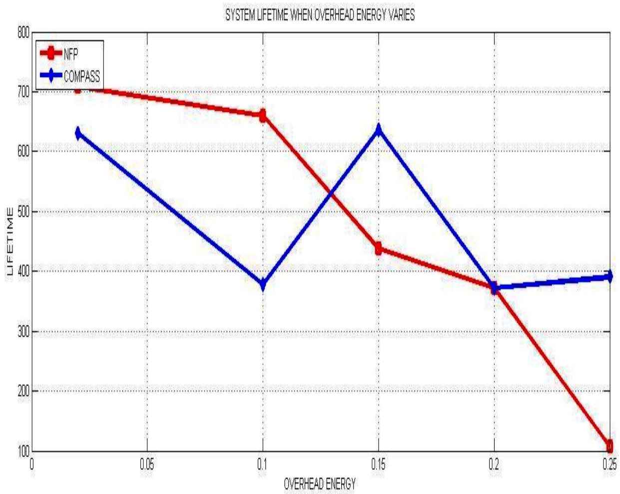

Figure: 5 Overhead energy vs. Lifetime when Threshold energy is 0.50J

VII. CONCLUSION

Wireless Sensor networks have emerged as a promising tool for monitoring (and possibly actuating) the physical world, utilizing self-organizing networks of battery powered wireless sensors that can sense, process and communicate. Routing in sensor networks has attracted a lot of attention in the recent years and introduced unique challenges compared to traditional data routing in wired networks.

Because of energy limitation the sensors will die and networks cannot work well, as a result increasing lifetime is very important. We simulate on the lifetime and reliability of the network based on NFP and COMPASS algorithm.

We conclude from the research that COMPASS is much more efficient as compared to the NFP algorithm with respect to lifetime and reliability of sensor nodes in the criteria as used in [15].

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