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Efficient Path Reconstruction for Wireless Sensor Network

Payel Ray[1*], Ranjan Kumar Mondal[2], Debabrata Sarddar[3]

[1]Department of Computer Science & Engineering,
University of Kalyani, WB, India

[2]Department of Computer Science & Engineering,
University of Kalyani, Kalyani, India

[3]Assistant Professor, Department of Computer Science & Engineering,
University of Kalyani, Kalyani, India

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Abstract— Recent wireless sensor networks (WSNs) are becoming increasingly complex with the growing network scale and the dynamic nature of wireless communications. Many measurement and diagnostic approaches depend on per-packet routing paths for accurate and fine-grained analysis of the complex network behaviors. In this paper, we propose a Path, a novel path inference approach to reconstructing the per-packet routing paths in dynamic and large-scale networks. The basic idea of the Path is to exploit high path similarity to iteratively infer long paths from short ones. The Path starts with an initial known set of paths and performs path inference iteratively.

In order to further improve the inference capability as well as the execution efficiency, it includes a fast bootstrapping algorithm to reconstruct the initial set of paths. We also implement the Path and evaluate its performance using traces from large-scale WSN deployments as well as extensive simulations. Results show that it achieves much higher reconstruction ratios under different network settings compared to other state-of- the-art approaches.

***Keywords*—**Measurement, path reconstruction, wireless sensor Network.

I. Introduction

A Wireless Sensor Network [1] is a dense wireless network of small low cost sensors, which collect and disseminate environmental data. WSNs facilitate monitoring and controlling of physical environments from remote locations with better accuracy [2]. Wireless Sensor Network has applications in a variety of fields such as environmental monitoring, military purpose and gathering sensing information in hospital locations. Sensor nodes have various energy and computational constrains due to their inexpensive nature and ad hoc method of deployment [3]. A wireless sensor network basically does- **Sensing:** Senses the dada from environment. **Computation:** each Sensor node made some computation based on sensed data. **Communication:** the sensed data communicates with other sensor nodes and/or base stations to make a result based computed data. WSN contains large number of tiny nodes that can assemble and configure themselves and are deployed to create a mesh network. The node uses advanced mesh networking protocols. The protocol searches every possible communication path by hopping dada from node to node in search of the destination. Unlike traditional wireless devices, wireless sensor nodes communicate only with its local peers, not with the high Power control tower or base station. These WSNs are able to support very different kind of applications. But working with WSNs leads to many challenges due to their many inherent constraints (for instance coverage and connectivity, power efficiency, localization) [4]. These challenges have emerged many research issues. There is not any common solution which can solve all problems associated with WSN. So many research initiatives have been taken on this field to optimize the performance and overcome the constraints of WSN.

II. Applications of Wireless Sensor Network:

Sensor network may consist of many different kind of sensors, such as- Seismic sensor, Thermal Sensor, Visual Sensors, Infrared Sensor, Acoustic Sensor, Rader [5]. These sensors are able to monitor a wide variety of environment, such as- Temperature, Humidity, Noise level, Lightening condition. The presence or absence of certain objects Pressure, Speed, direction and size of an object With the help of these very different kinds of sensors, many new WSN applications are developed. The most proficient application areas-

1) Military applications: WSNs are used in various fields of military applications. Application areas include- Military command and control, Communication, Intelligence, Surveillance, Reconnaissance, Targeting system, Enemy troop detection. This type of sensor network possesses different kind of requirements than others for example small, relatively powerful, large numbers of sensor nodes, and lifetime requirement is not particularly high.

2) Disaster relief applications

One of the most often mentioned application types for WSN are disaster relief operations. A typical scenario is forest fire detection: Sensor nodes are equipped with temperature sensors and can determine their own location (relative to each other or in absolute coordinates). These sensors are deployed over a forest fire, for example, a forest, from an airplane. They collectively produce a "temperature map "of the area or determine the perimeter of areas with high temperature that can be accessed from the outside, for example, by a base station or sink node (PDAs or Laptops).This type of application also includes Flood detection, Earthquake detection, Tsunami monitoring etc.

3) Intelligent building

Buildings waste vast amounts of energy by inefficient Humidity, Ventilation and Air Conditioning usage. A better, real-time, high-resolution monitoring of temperature, airflow, humidity, and other physical parameters in a building by means of a WSN can considerably increase the comfort level of inhabitants and reduce the energy consumption. In addition, such sensor nodes can be used to monitor mechanical stress levels of buildings in seismically active zones.

4) Medicine and Health care

Possibilities range from postoperative and intensive care, where sensors are directly attached to patients – the advantage of doing away with cables is considerable here – to the long-term surveillance of (typically elderly) patients and to automatic drug administration (embedding sensors into drug packaging, raising alarms when applied to the wrong patient, is conceivable). Also, patient and doctor tracking systems within hospitals can be literally life saving.

5) Environmental applications

Environmental applications include noise and air Pollution detection and reporting, Bio-complexity mapping. Another important application area is Precision agriculture. Here WSN monitors the pesticide level in drinking water, level of soil erosion, level of air pollution in real time.

6) Traffic Control: Sensors embedded in the streets or roadsides can gather information about traffic conditions at a much finer grained resolution than what is possible today. Such a so called "intelligent roadside" could also interact with the cars to exchange danger warnings about road conditions or traffic jams ahead.

7) Logistics: In several different logistics applications, it is conceivable to equip goods (individual parcels, for example) with simple sensors that allow a simple tracking of these objects during transportation or facilitate inventory tracking in stores or warehouses.

8) **Robot Control:** Robotic operation can be solved by WSN.

III. Challenges in WSN

The basic challenges of Wireless Sensor Networks are [6]:

A. Resource constraints

Kilo Bytes of memory must implement Complex, distributed and ad hoc networking protocols.

Sensor nodes can store only a small amount of data. Processors run at <10 MIPS speed. Nodes don't have the capability to do real signal processing.

B. Production cost

Since WSN consist of large number of sensor nodes, the cost of single node must be small so that cost of overall network is not much expensive

C. Fault tolerance

Failure of K sensor node should not affect the overall operation of WSN. Where K>0 and depends on application.

D. Power Consumption

As size of the sensor node decreases, the energy capacity also decreases. Low duty cycle operation can be use to minimize the power consumption.

E. Poor communication bandwidth

Current radios achieve about 10kbps per mote, though raw channel capacity is much higher.

Overhead occurs due to CSMA back off, noise floor detection start symbol etc.

F. Scalability: WSN must perform well when number of sensor nodes are added to a WSN which is currently operational i.e. other sensor nodes must adapt themselves with newly added nodes

G. WSN Topology:

If nodes in WSN are mobile then topology will be dynamic. Example, Sensor node fitted in human body.

H. Environmental constraints

Sensor nodes are densely deployed either very close or directly inside the object to be observed. This may operate in busy intersection, bottom of an ocean, biologically or chemically contaminated field etc.

IV. Power Efficiency in WSN:

Sensor nodes are built and deployed in such a way that, replacement of power source is not possible [7].

For example-

Temperature monitoring sensor deployed in blast furnace.

WSN deployed to monitor forest fire.

WSN deployed in battlefield or for intelligence purpose.

WSN deployed in sea bed to monitor temperature, earthquake, Tsunami.

So power is a very important resource in WSN and it should be used efficiently.

Possible approaches to use power efficiently:

The following approaches need to be adopted for a WSN to be energy efficient.

Low power consuming hardware:

Power consumption directly depends on hardware design. Power consumption can be reduced by sending one or more parts of the hardware into sleep mode, when they are not operational. Power consumption can also be reduced by using dynamic voltage scaling and slowing down processor speed.

Using less computationally complex algorithms:

Algorithms for routing, computation should be efficient and less computationally complex to consume less amount of energy.

Power efficient MAC protocols:

Sensor MAC (S-MAC), Power Aware Multi Access with Signaling (PAMAS), Self-originating Medium Access Control for Sensor Network (SMACS), IEEE802.15.4 is used for power efficiency at the MAC layer.

Using secondary energy source:

In some situation secondary energy source, for example solar power, wind power can be used. But it has several disadvantages-Sensor nodes become bulky and costlier. Moreover it cannot be deployed anywhere.

Using Power efficient routing protocols:

Many routing protocols have been proposed which takes power consumption as one of its metrics during route calculation. For example Sensor Protocol For Information via Negotiation (SPIN), Directed Diffusion, Rumor Routing. I will discuss it in details in next section.

Using Power efficient topology:

Routing is directly dependent on network topology. So efficient topology leads to efficient routing. So during construction of topology, we need to keep in account energy level of a node, distance, connectivity etc. Some protocols have been devised for that purpose. Example Topology control protocol, R&M protocol. Local Minimum Spanning Tree(LMST) protocol. I will discuss it in details in next sections.

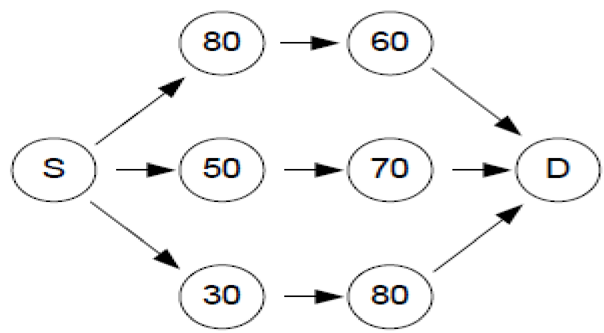
Previous Algorithms on Path Reconstruction in WSN

EEDD- Energy Efficient Directed Diffusion

EADD- Energy Aware Directed Diffusion

EAADD- Energy Aware Adaptive Directed Diffusion.

Energy Aware Directed Diffusion



Select the path in which available energy is more

When available energy of the paths are same-

select the path in which the energy of lowest available energy node is more than that of other paths.

Energy Aware Adaptive Directed Diffusion for WSN

Energy Aware Directed Diffusion does not consider the amount of energy consumed. So energy loss might be greater and the available energy decreases quickly. To solve the above problem Energy Aware Adaptive Directed diffusion was proposed. EAADD chooses the path in which energy consumption is lowest or minimum.

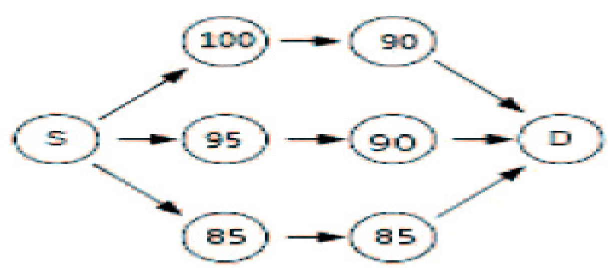


Fig. 1. Initial Status of network

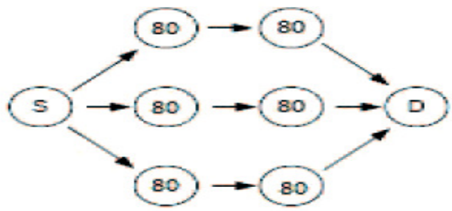


Fig. 2. Current Status of network

In EADD and EAADD both are energy aware routing protocols and both try to make the lifetime of the network longer. EAADD tries to choose the path in which energy consumption is minimum. But if it continuously chooses the same path, the available energy of that path may reduce drastically. This leads to network failure.

Modified _Algorithm for Efficient path reconstruction for WSN:

1. When a node is first switched on, it scans its environment and maintains its neighbor information.

2. Setup a link to the neighbor which is closest to the node. By this step the whole network is setup.

3. Now when a node dies, it can be detected in a reactive fashion by trying to forward a packet when through that node as and when required. If the packet cannot be forwarded even after three retries, then that node is considered as dead.

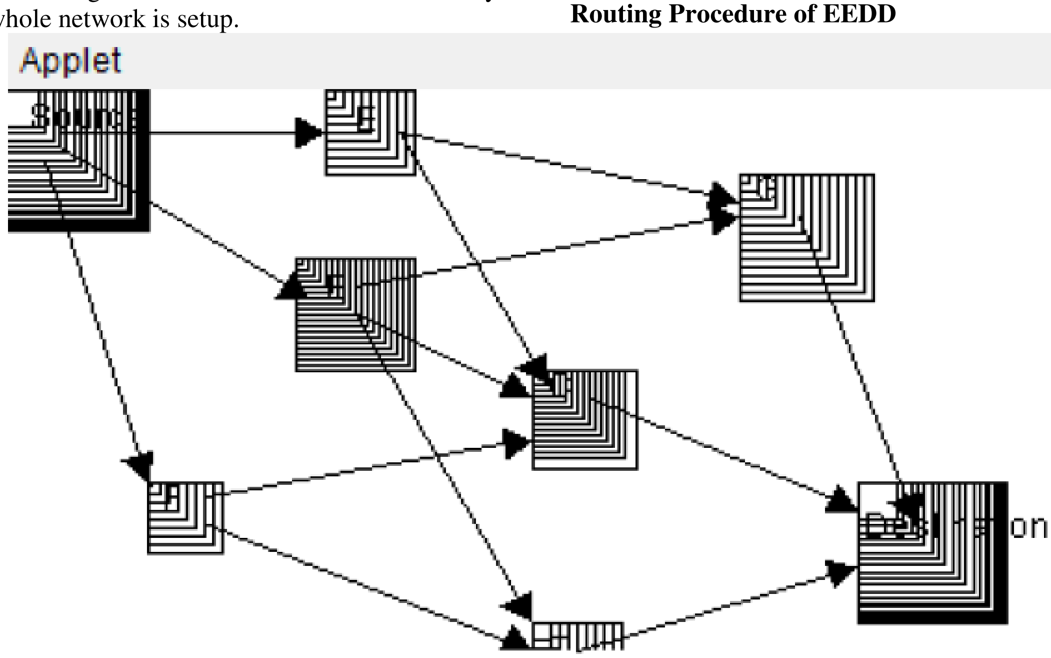
4. If a dead node is detected, the detecting node updates its neighbor information. And forwards a query packet to know if the destination can be reached via other nodes.

5. On receipt of such a query message, a node checks if the dead node exists in its neighbor information and updates it accordingly if it cannot reach the dead node. Now it checks its neighbor information to see if the intended destination node exists in its neighborhood. If yes, then it sends back a reply message, else forwards the query.

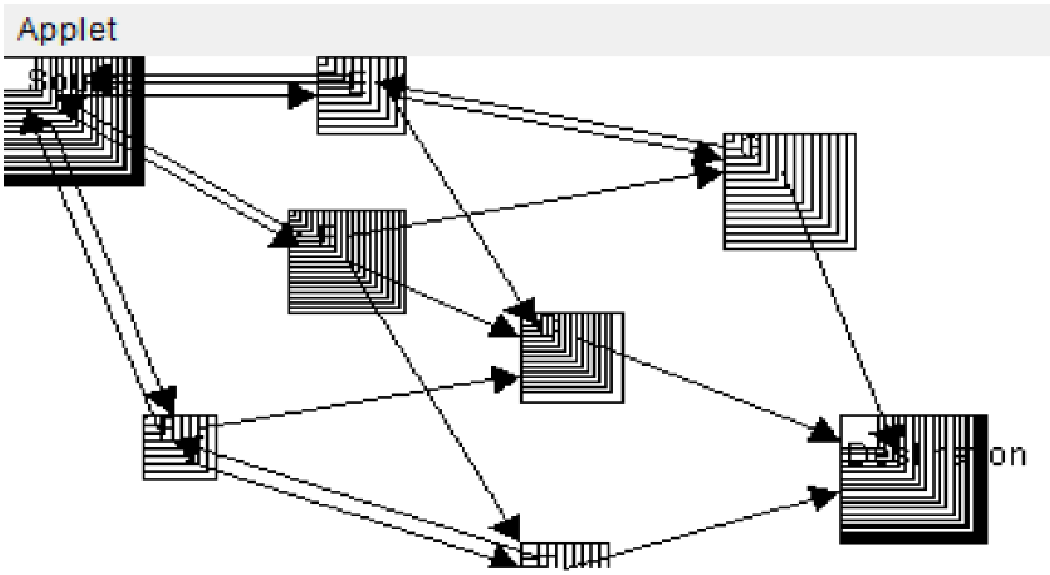
6.

7. The above step is followed until the destination is found or else if the TTL of the query message expires. If TTL expires, it means that the destination can no more be reached.

Routing Procedure of EEDD



Routing Procedure of Efficient path Reconstruction

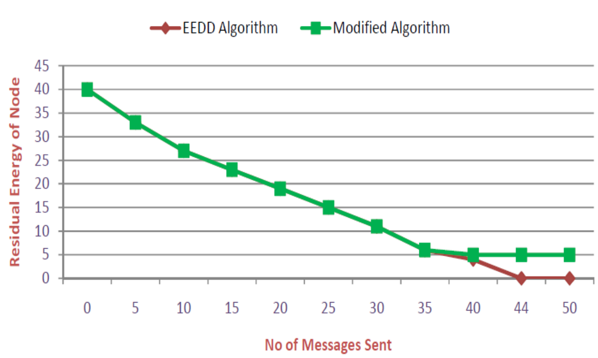


Performance Analysis

In our algorithm Efficient Path Reconstruction is a procedure which increases the life span of the nodes. It prevents from breaking down the intermediate node which is in critical power state**.**

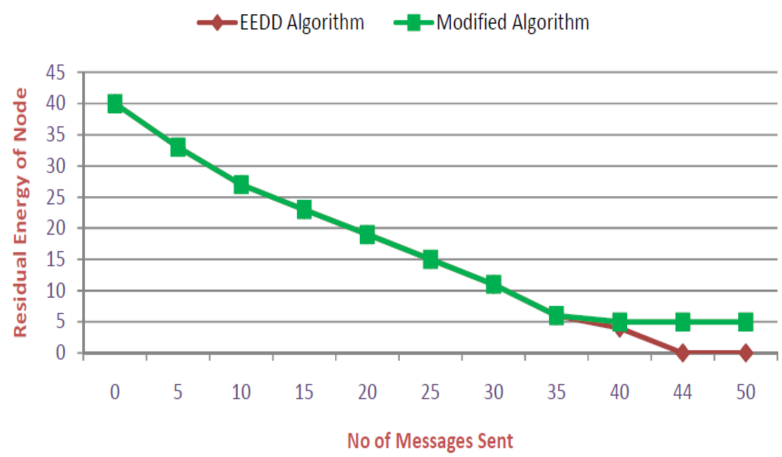
Data table and Residual Energy graph for Node B in EEDD Algorithm and Modified Algorithm

No. of messages sent	Available energy in EEDD Algorithm	Available energy in Modified Algorithm
0	40	40
5	33	33
10	27	27
15	23	23
20	19	19
25	15	15
30	11	11
35	6	6
40	4	5
44	0	5
50	0	5



Data table and Residual Energy graph for Node E in EEDD Algorithm and Modified Algorithm

No. of messages sent	Available energy in EEDD algorithm	Available energy in Modified algorithm
0	37	37
5	34	34
10	28	28
15	24	24
20	21	21
25	15	15
30	12	12
35	8	8
40	3	5
43	0	5
45	0	5
50	0	5



Conclusions and Future Scopes

Path Reconstruction algorithm in wireless sensor network can be more efficient if some parameters are considered like-

Number of hop count in path finding strategy Energy Aware Adaptive Directed Diffusion algorithm can be modified

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AUTHORS PROFILE

Payel Ray received her M.Tech in Computer Science and Engineering from Jadavpur University, Jadavpur, India; and B.Tech in Computer Science & Engineering from Murshidabad College of Engineering and Technology, Berhampore, Murshidabad, West Bengal under West Bengal University of Technology, West Bengal, India. At present, she is a Ph.D research scholar in Computer Science and Engineering from

University of Kalyani. Her research interests include Cloud Computing, Wireless Adhoc and Sensor Network and Mobile Communication Systems.

Ranjan Kumar Mondal received his M.Tech in Computer Science and Engineering from University of Kalyani, Kalyani, Nadia; and B.Tech in Computer Science and Engineering from Government College of Engineering and Textile Technology, Berhampore, Murshidabad, West Bengal under West Bengal University of Technology, West Bengal, India. At present, he is a Ph.D research scholar in Computer Science and Engineering from University of Kalyani. His research interests include Cloud Computing, Wireless and Mobile Communication Systems.

Debabrata Sarddar is an Assistant Professor at the Department of Computer Science and Engineering from University of Kalyani, Kalyani, Nadia, West Bengal, India. He completed his PhD from Jadavpur University. He did his M. Tech in Computer Science & Engineering from DAVV, Indore in 2006, and his B.E in Computer Science & Engineering from NIT, Durgapur in 2001. He has published more than 75 research papers in different journals and conferences. His research interests include Cloud Computing, Wireless and Mobile Communication System.