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Optimized Ring Routing Protocol for Wireless Sensor Networks

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Abstract: In a typical wireless sensor network, the batteries of the nodes near the sink deplete quicker than other nodes due to the data traffic concentrating towards the sink, leaving it stranded and disrupting the sensor data reporting. To mitigate this problem, mobile sinks are proposed. They implicitly provide load-balanced data delivery and achieve uniform-energy consumption across the network. On the other hand, advertising the position of the mobile sink to the network introduces an overhead in terms of energy consumption and packet delays. In this paper, we propose Ring Routing, a novel, distributed, energy-efficient mobile sink routing protocol, suitable for time-sensitive applications, which aims to minimize this overhead while preserving the advantages of mobile sinks. Furthermore, we evaluate the performance of Ring Routing via extensive simulations.

Keywords: Mobile sinks, distributed routing, data dissemination, energy efficiency, mobility, wireless sensor networks

I. INTRODUCTION

Today telecommunication industry is the multibillion dollar industry connecting millions of people all over the world through public switched telephone network. Technological. Advancements in the field of computers have made the area of telecommunication to experience rapid development resulting in improvement in the life style. Telecommunication network supporting wireless connections used for multimedia services leads to the refinement of wireless communication networks. In the last two decades, wireless communication industry has grown by orders of magnitude, fueled by improvement in digital and RF circuit fabrication, very large scale integration techniques and other electronics technologies. Since then, the new wireless communication methods and services have been enthusiastically adopted by people [1]. Wireless communication network consists of mobile communicating devices and wireless network infrastructure. Recent technological advancements in micro electronics and wireless communication technologies have enabled manufacturing of small, low cost, battery operated and multi-functional sensor nodes [1, 2, 3, 4, 5]. These sensor nodes measure ambient condition in the surrounding environment that can be processed to reveal the characteristics of the phenomena occurring at the location where the sensor nodes are deployed. A large number of these sensor nodes are either placed carefully or randomly deployed over a geographical area and networked through wireless links to form a WSN. Each sensor node in WSN is capable of communicating with each other and the base station (BS) for the purpose of data integration and dissemination. WSN are used mainly in military, civilian and for industrial applications. WSNs applications in the military field include battlefield surveillance, intrusion detection, target field and imaging. However, WSN are now being used in many civilian application areas too, including environment and habitat monitoring, health applications, home automation and traffic control. Traditional wireless communication networks like Mobile Ad hoc Networks (MANET) differs from WSN. WSN have unique characteristics such as denser level of node deployment, higher unreliability of sensor nodes and severe energy, computation and storage constraints which present many challenges in the development and application of WSN.

Research has been made to explore and find solutions for various design architecture and application issues and significant advancement has been made in the development and deployment of WSNs. WSN typically contains hundreds or thousands of sensor nodes which allows for sensing over larger geographical regions with greater accuracy. In this paper, we propose a novel hierarchical routing protocol for WSNs with a mobile sink, named Ring Routing. We highlight some key features and the contributions of Ring Routing as follows:

- Ring Routing is a routing protocol targeted for large scale WSNs deployed outdoors with stationary sensor nodes and a mobile sink.
- Ring Routing establishes a virtual ring structure that allows the fresh sink position to be easily delivered to the ring and regular nodes to acquire the sink position from the ring with minimal overhead whenever needed.
- The ring structure can be easily changed. The ring nodes are able to switch roles with regular nodes by a straightforward and efficient mechanism, thus mitigating the hotspot problem.
- The mobile sink selects anchor nodes along its path and the anchor nodes relay sensor data to the sink. In case the sink position information obtained by a sensor node loses its freshness, the sensor data is relayed through the old anchor nodes to the current anchor node, preventing

- packet losses. This mechanism is based on progressive footprint chaining
- Ring Routing relies on minimal amount of broadcasts; therefore, it is applicable to be used for sensors utilizing asynchronous low-power MAC protocols designed for WSNs [11].
- Ring Routing does not have any MAC layer requirements except the support for broadcasts. It can operate with any energy-aware, duty cycling MAC protocol (synchronized or a synchronized).
- Ring Routing is suitable for both event-driven and periodic data reporting applications. It is not query based so that data are disseminated reliably as they are generated.
- Ring Routing provides fast data delivery due to the quick accessibility of the proposed ring structure, which allows the protocol to be used for time sensitive applications.
- No information about the motion of the sink is required for Ring Routing to operate. It does not rely on predicting the sink's trajectory, and is suitable for the random sink mobility scenarios.

II. LITRETURE REVIEW

A. Wireless Sensor Network

Sensor network consists of hundreds to thousands of small, low cost multifunctional sensors powered by low-energy batteries [6]. Each sensor node comprises of sensing, processing, transceiver, mobilize, position finding system and power units. Sensor nodes deployed in strategic areas sense the changes in their surroundings and send these changes to a data sink. The data sink may be a fixed or mobile node capable of connecting the sensor network to wireless network infrastructure or internet to access the reported data. The potential of collaboration among sensors in data gathering, processing and monitoring applications require novel routing techniques. Hence, routing of data from sensor node to data sink is a very challenging task in sensor networks that distinguish them from contemporary communication and wireless adhoc networks. It is not possible to build a global addressing scheme for the dense deployment of sensor nodes as the overhead of identity maintenance is high. Also in contrast to typical communication networks, almost all applications of sensor networks require the flow of sensed data from multiple regions (sources) to a particular sink. Further, generated data traffic has significant redundancy, since multiple sensors may generate same data within the vicinity of a phenomenon. Such redundancy needs to be exploited by the routing protocols to improve energy and bandwidth utilization. Furthermore, sensor nodes are tightly constrained in terms of transmission power, on-board energy, processing capacity and storage. In view of the aforesaid constraints, many routing techniques have been proposed for wireless sensor network by considering the inherent features along with the applications and architecture requirements of sensor networks [7]. The routing hybrid protocols depending on how the source finds a route to the destination. In proactive protocols, all routes are computed before they are really needed. However, routes are computed on demand in reactive protocols. Hybrid protocols use a combination of these two protocols. Destination Sequenced Distance Vector (DSDV) is the representative example of the proactive protocol. Dynamic Source Routing (DSR) and Adhoc on Demand distance Vector (AODV) routing are the reactive routing protocols. It is preferable to have reactive routing protocols rather than table-driven routing protocols for dynamic sensor nodes.

B. Backward References

Jamal.N. Al-karaki and Ahmed E.Kamal [7] highlighted the design challenges of routing protocols of WSN. A comprehensive review has been presented on application and architecture based routing techniques. Subsequently, Karlof and Wager [8] brought out the various security issues in WSNs. Various security threats have been highlighted and counter measures have been proposed against various attacks existing in the different layers of networks. It has been emphasized that routing protocols should be designed with security in mind. Perrig et al. [9] outlined the variety of attacks including node capture, physical tampering and DoS attacks. Also, the state of security mechanisms such as secrecy, authentication, key establishment and robustness to DoS attacks in sensor networks has been highlighted. These aspects have been fulfilled by incorporating high level security services. Also, scope of future research in the area of WSNs has been highlighted. Wang et al. [10] discussed about the security requirements, constraints and attacks with their corresponding countermeasures in WSNs. Various security protocols of WSNs have been highlighted with the merits and demerits. It has been concluded with the possible research directions on security in WSNs. Al-Sakib Khan Pathan et al. [11] examined the security related issues and challenges in WSNs. The different types of security threats and various security mechanisms against these threats are also analysed. It has been highlighted that holistic approach of security schemes should be developed for ensuring layered and robust security in WSNs. Jones et al. [12] addressed a holistic security model involving a frequency hopping scheme to defend against the jamming attacks in the physical layer. This scheme provides secure paths rather than securing each link between sender and receiver. Although, the proposed method reduces the effect of jamming, DoS attacks are still exist. DoS attacks affect the entire network, as there is no mechanism to detect and or isolate the compromised segments of the network.

III. PROPOSED SYSTEM

In this section, we propose Ring Routing, a novel hierarchical routing protocol for wireless sensor networks with a mobile sink. The protocol imposes three roles on sensor nodes: ring node, regular node, and anchor node. Ring nodes form a ring structure which is a closed loop of single-node width (Fig. 1.1). The basis of Ring Routing is

1. Advertisement of sink position to the ring,

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2. Regular nodes obtaining the sink position information from the ring whenever necessary
3. Nodes disseminating their data via the anchor nodes, which serve as intermediary agents connecting the sink to the network. The three sensor roles are not static, meaning that sensor nodes can change roles during the operation of the WSN. Three simple assumptions are made before going into the details of the protocol.

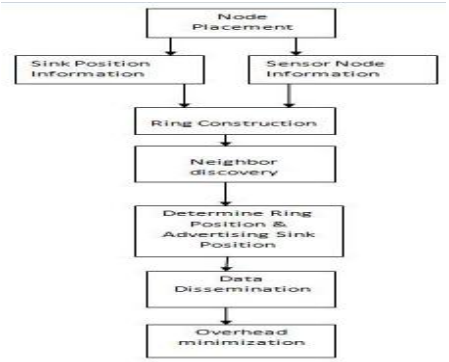

Fig 1.1 Proposed System Architecture

A. Ring construction

The ring consists of a one-node-width, closed strip of nodes that are called the ring nodes. As long as the ring encapsulates the pre-determined network center, it can change. The shape of the ring might be imperfect as long as it forms a closed loop. Various examples of the ring structure are shown in Fig. 2. After the deployment of the WSN, the ring is initially constructed by the following mechanism: An initial ring radius is determined. The nodes closer to the ring, which is defined by this radius and the network center, by a certain threshold are determined to be ring node candidates. Starting from a certain node (e.g. the node closest to the leftmost point on the ring) by geographic forwarding in a certain direction (clockwise/counterclockwise), the ring nodes are selected in a greedy manner until the starting node is reached and the closed loop is complete. If the starting node cannot be reached, the procedure is repeated with selection of different neighbors at each hop. If after a certain number of trials the ring cannot be formed, the radius is set to a different value and the procedure above is repeated. An example ring construction scenario is depicted in Fig. 1.2. The initial ring construction procedure is straightforward and energy-efficient. It does not require a centralized decision entity, hence it is applicable to a pure WSN architecture with a single type of nodes.

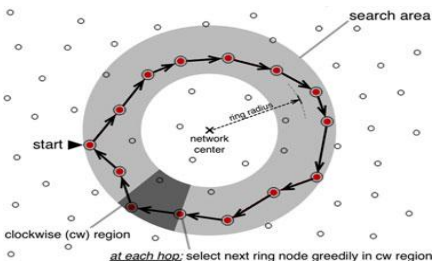

Fig 1.2 Ring construction

B. Advertisement of Sink Position

As the sink moves, it selects anchor nodes (ANs) among its neighbors. The AN serves as a delegate managing the communications between the sink and the sensor nodes. Initially, the sink selects the closest node (e.g., the node with the greatest SNR value) as its AN, and broadcasts an AN Selection (ANS) packet. Before the sink leaves the communication range of the AN, it selects a new AN and informs the old AN of the position and the MAC address of the new AN by another ANS packet. Since now the old AN knows about the new AN, it can relay any data which is destined for it to the new AN. If the data reaches an old AN, the follow-up mechanism is used to relay the data to the sink. The essence of sink position advertisement is delivering the newly selected ANs position and MAC address information to the ring. Upon selection of a new AN, it sends an AN position Information (ANPI) packet towards the ring. If the AN is outside the ring, it sends the ANPI packet towards the network center, and if it is inside the ring, it sends it towards a point which resides on the opposite direction of the network center using greedy geographic forwarding. If the ANPI packet on its way arrives at a node which has a ring node neighbor, it is directly related to that ring node.

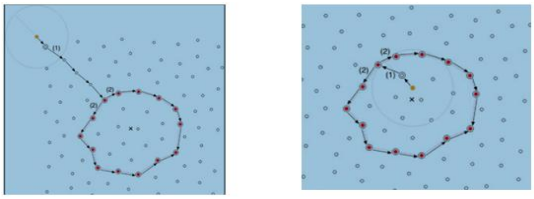

Fig 1.3 Advertisement of Sink Position

C. Obtaining Sink position from Ring

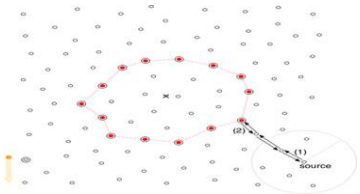

Fig 1.4 Obtaining Sink position from Ring

D. Data Dissemination

Once a source node receives a response (ANPIRESP) to its request (ANPIREQ), it learns the position of the AN and can now send its data directly to it by geographic forwarding (Fig.9). If data reaches an old AN, meaning that the AN has already changed by the time data has arrived at the destined AN, the follow-up mechanism is used to disseminate data to the current AN.

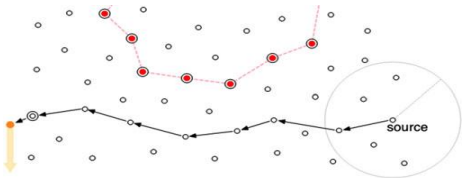

Fig 1.5 Data Dissemination

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IV. PERFORMANCE ANALYSIS

A. Mathematical Model

Following are the major steps of Route Discovery and maintenance phases of any reactive routing protocol:

- Flooding RREQ Packet (Route Request Packet)
- Receiving RREP Packet (Route Reply Packet)
- Link is established and now link monitoring initiates using periodic messages
- When link is found broken, different methods apply to rectify this problem
- New route discovery/ local repair/ wait for time out occurs.

Form the above mentioned steps of Route Discovery and Route maintenance; we modeled first three steps of Reactive Routing. In this work, we have analyzed two types of scenarios i.e. the one where there is only one link active in the network and a source node S wants to create a link to its destination node D during network life time T . And in other case we have tested the limits of a network of n nodes where every node is eager to send its data during network life time T . Modeling route request over head, route reply overhead and hello message overhead, we follow the following scheme.

1. Network of N nodes Initiates.
2. Route discovery Route Maintenance = =Routing overhead.
3. Given = = average number of neighbors of any node in network.
4. RREQ RREP = = Route Discovery overhead .
5. Ring radius constructed.
6. Ring formation.
7. ANPI reaches a source node .
8. Data dissemination to sink node.
9. Data packet reached sink node.
10. Link Established.
11. Route Discovery Phase Ends

Table 1.1 Comparison of Traditional System Vs Proposed System

Comparison Graph		
	Energy Saving ratio	
Dataset	Traditional System (%)	Proposed System (%)
100 Nodes	76	81
200 Nodes	91	96
200 Nodes	90	93

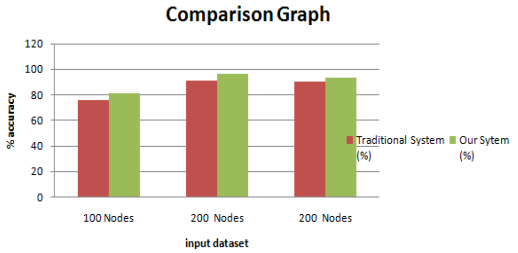

Fig 1.6 Comparison Graph

Table 1.2 Comparison of Time Distribution

File Size (in KB)	Auditing Time with distribution (millisecond)	Auditing Time with 0ut distribution (millisecond)
3072	1014	921
3891	1154	1014
4096	1154	999
4505	1532	1045
3734	1632	1357

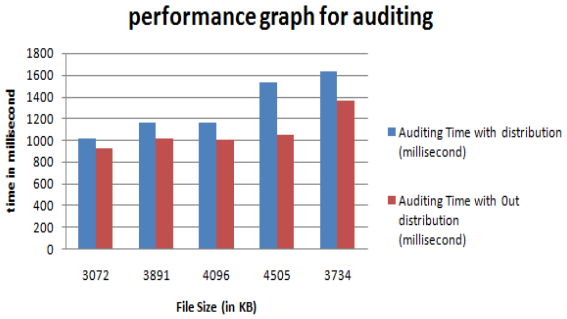

Fig 1.7 Performance graph for Auditing

a.

CONCLUSION

In this paper, we proposed a novel mobile ring routing protocol for multiple mobile sinks, they form ring and then source transfer data to appropriate sink which reduces energy consumption and balances load using dynamic sink. Ring Routing is a hierarchical routing protocol based on a virtual ring structure which is designed to be easily accessible and easily reconfigurable. The design requirement of our protocol is to mitigate the anticipated hotspot problem observed in the hierarchical routing approaches and minimize the data reporting delays considering the various mobility parameters of the mobile sink. In future, we modify ring routing for multiple mobile sink. Here we proposes ring of multiple mobile sinks and because of ring of sink, communication between nodes and sink will done effectively and efficiently.

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