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ARTICLE

A STATE OF ART APPROACHES ON ENERGY EFFICIENT ROUTING PROTOCOLS IN MOBILE WIRELESS SENSOR NETWORKS

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ABSTRACT

Background: *WSN is composed of large number of sensor nodes which sense the environmental parameter and forwards the data to sink node. The nodes near the sink in static WSN die earlier than other nodes (hot spot problem).* ***Methods:*** *Energy efficient routing protocols play a vital role in WSN. To eliminate hot spot problem, sink mobility is introduced. The mobile sink moves and receives data from sensor node using 1-hop communication and minimizes the energy dissipation of the sensor nodes and eliminates the hot spot problem.* ***Results:*** *In this paper, various type of routing techniques in mobile wireless sensor network is presented.* ***Conclusions:*** *A detail comparison of various protocols is also given at the end of the paper. Finally some future directions for energy efficient routing in WSN are also presented.*

KEY WORDS
Energy efficiency
Mobility
Routing protocol
Wireless Sensor Network

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INTRODUCTION

Recent advancement in the field of IT and IC technology leads to the deployment of cheap and small size sensor nodes. WSN is commonly used in various fields from military to civilian applications. Energy efficiency is a main problem in WSN [1]. Routing techniques plays a crucial role in reducing the energy consumption. Clustering is the most popular energy efficient technique where a set of sensor nodes are joined to form a cluster. From each cluster, a cluster head (CH) is selected and the rest of the nodes are defined as cluster members. In those situations, the CHs near the BS burdened with heavy load and exhaust their energy quicker than the nodes located far from the sink. This is termed as hot spot problem and various techniques are proposed to eliminate it [2]. An efficient technique to eliminate hot spot problem is the introduction of mobility in WSN. By introducing mobility in WSN [3], sensor node or sink node can move to any part of the network to transmit or receive data. So, the energy consumption in the network is distributed and connectivity is also attained. Mobility in WSN can be helpful to collect data from spare and disconnected WSN [4]. The usage of mobility in WSN reduces the transmission distance which results to lesser energy consumption. The main benefit of these techniques is flexibility and scalability [5].The architecture of mobile WSN with and without clustering is shown in [Fig. 1] and [Fig. 2].

A major drawback of mobility is the enormous amount of packet loss because of changes in network topology and increased delay [6]. Though mobility provides good performance, mobile sink and mobile nodes are expensive compared to static node and static sink. Using multiple mobile sinks, the performance is increased significantly compared to static WSN [7]. A mobile sink node is the effective solution when the cost of the network is not an important issue. The movement of mobile sink leads to topology charges and affects routing performance [8]. Various routing protocol are developed for mobile WSN with mobile sink. In this paper, a review of various routing protocols in mobile WSN is given.

ENERGY EFFICIENT ROUTING PROTOCOLS

Termite Hill

Termite hill is developed to distribute the load in WSN to eliminate hot spot problem [9]. It is based on the idea of using one mobile sink which capable of moving without any limits. The hot spot problem is avoided which is caused by the static nodes located need the sinks. Termite hill is a bio-inspired algorithm derived by the behavior of termites. The method is employed in both static and mobile WSN and implemented in WSN hardware. From the result, it produces high throughput, reduce energy consumption compared to AODV [10], in term of various speed. The network lifetime is improved than static sinks.

Mobicluster

Mobicluster is an effective clustering protocol for mobile sinks which moves in a predictable path [11]. It is used to cover isolated nodes which cannot move in the network. The CHs need to communicate with rendezvous nodes and takes turn in communicating data. There are 5 steps in mobicluster: clustering, rendezvous node selection, CH attachment to rendezvous node, data aggregation and forwarding to rendezvous nodes and communication between to rendezvous nodes and mobile sinks. An algorithm is also used to produce the cluster of various sizes. As a result, energy consumption in the network is well balanced. To select rendezvous nodes, a new algorithm is given which leads to reduce collision and increased throughput. For minimizing network lifetime, CHs can be rotated when their energy level in reduced.

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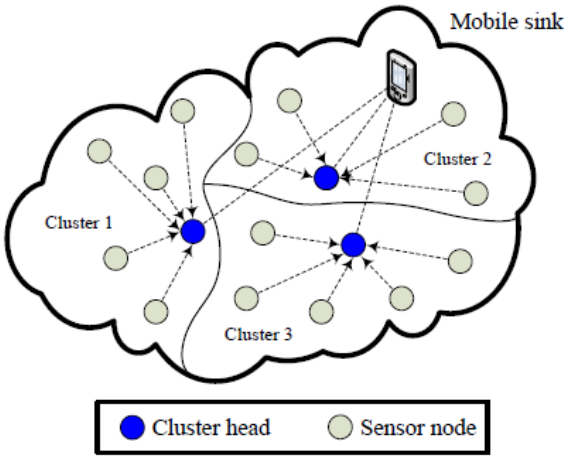

Fig. 1: Architecture of mobile WSN with clustering.

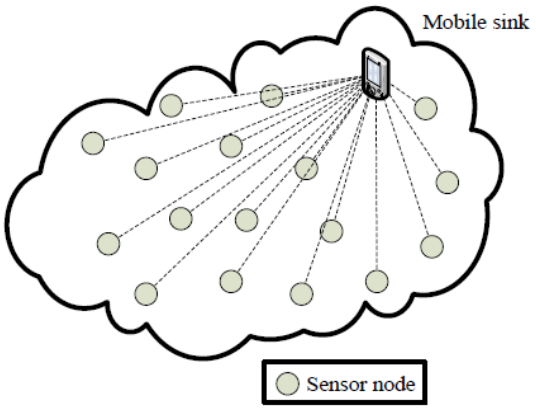

Fig. 2: Architecture of mobile WSN without cluster head.

Trace Announcing Routing Scheme (TARS)

Trace announcing routing scheme is developed to focus on various situations where the sink and targets need to be in mobility[12] .as both targets and sinks are mobile, a virtual grid based routing called TARS is developed. It is an improved version of target assisted routing scheme for WSN .it is based on the process capturing the mobile objects movement path by flooding and trace-announcing packet instead of path reconstruction. TARS maintain two tables: routing and tracking information. Additionally, a simple shortcutting method is also developed to reduce energy consumption.

W-L

W-L is an effective distance aware routing protocol with various mobile sinks [13]. To minimize the energy consumption, first order radio model is used to very transmission power with respect to the distance. The reduction in transmission energy reduces the interference. The energy dissipation at the transmitter (E_{TX}) and receiver (E_{RX}) with distance d for transmitting an l-bit data packet is computed in Eq. (1) and (2):

$$E_{TX}(l,d) = \begin{cases} l \times E_{elec} + l \times \varepsilon_{fs} \times d^2 if d \leq d_0 \\ l \times E_{elec} + l \times \varepsilon_{mp} \times d^4 if d > d_0 \end{cases} \quad (1)$$

$$E_{RX}(l) = l \times E_{elec} \quad (2)$$

where E_{elec} is the dissipated energy in transmitter or receiver and it is based on various factors like digital coding, modulation, filtering, and spreading of the signal. The distance threshold is defined as $d_0 = \sqrt{\varepsilon_{fs}/\varepsilon_{mp}}$. Based on the transmission distance d, the free space (ε_{fs}) or multipath fading channel (ε_{mp}) is used for the transmitter amplifier. A relay node is chosen with higher energy and lesser distance to mobile sink. A parking position is used where the mobile sink can gather data. Here, the collection of data is not possible when the sink is in mobility .the performance is improved with multiple mobile sink .the drawback is the cost of mobile sink.

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HARP (Hierarchical and Adaptive Reliable Routing Protocol)

HARP is a heterogeneous network based protocol which divides the nodes in two ways: regular nods and cluster nodes based on the residual energy [14]. CH section is done based on the remaining energy of the node. It constructs a hierarchical tree with two divisions: intra cluster and inter cluster. A mechanism to recover nodes and mobility management is introduced to reconstruct tree when link failure occurs .HARP is more energy efficient, reliable and scalable when compared to LEACH.

RAHMoN: (Routing Algorithm for Heterogeneous Mobile Network)

It splits the sensor nodes into static nodes and mobile proposed [15]. The energy of the static node is less and mobile node is of higher energy. It operates in 3 phases: network configuration, detection and selection of CH and data delivery to sink. It is assumed that every node can be selected as CH. the CH is selected based on residual energy, mobility level and distance to sink. It leads to effective routing in terms of less overhead and large number of data transmissions.

HSN (Heterogeneous Sensor Network)

HSN is clustering protocol with a mobile sink for heterogeneous WSN [16]. It partition the network in three ways based on the energy level. 1. H-nodes (higher energy level), 2.L-nodes (lower energy level), 3.sink (infinite energy level). H-nodes has longer data transmission range and high data rate compared to L-nodes, It produces better results than HARP and RAHMON, CH is stationary and 1-hop communication is provided. It uses PSO to adjust the movement of sink among CHs. It is useful for large scale WSN. It provides better results compared to static sink.

Clue Based Data Collection Routing Protocol

CBDCR [17] uses a mobile sink which moves in random paths instead of fixed path and it broadcasts it location information to a limited distance and does not broadcast to the entire network. The sensor nodes which receive the location information are known as watchers which can send or receive data and assume the hop(s) from the sensor node to the mobile sink. Then the watcher node saves the information as clue to the location of mobile sink for data transmission. When the mobile sink moves, the number of watchers is increasing and the data sensed by the nodes can be easily transmitted to the mobile sink based on these clues. Various simulations are done with mobile sinks in network to assess the performance of CBDCR and the results shows that CBDCR decreases the transmission of duplicate and balances the energy consumption of the network. The overview of CBDCR is shown in [Fig. 3].

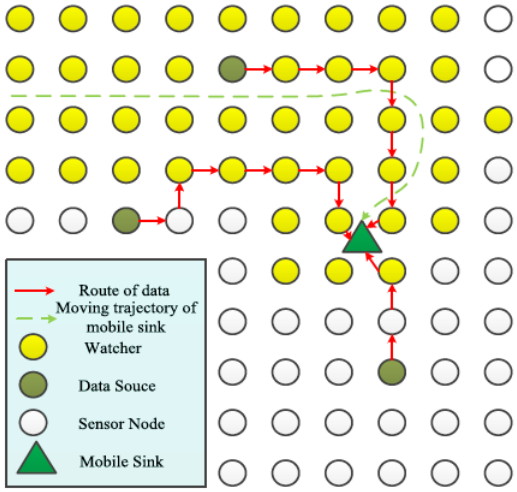

Fig. 3: Overview of clue based data collection routing protocol.

Zone based Energy Efficient routing Protocol

ZEEP is developed for both static and mobile nodes and needs no additional process for discovering path, maintaining routes or routing tables [18]. It employs the idea of dynamic forwarding and reduces the computation of the nodes. The simulations are done to verify that ZEEP achieves higher packet delivery ratio, reduced energy consumption by the network and results to maximum lifetime than well known protocol On Demand Distance Vector routing (AODV). ZEEP provides better performance than AODV protocol in terms of energy consumption and packet delivery ratio of the network. ZEEP, the customized version of ZBR also decreases the number of control packets created in the network compared to AODV and there is no need of path discovery or route maintenance. ZEEP is scalable as ZBR ZEEP can be easily extended to integrate optimizations which are default in AODV. A major advantage of ZEEP is simplicity.

Location aware sensor routing (LASeR)

Location aware sensor routing (LASeR) [19] protocol provides better solution to the issues of MWSNs. It concentrates on maximum reliability and minimum latency necessities of the emerging applications. It utilizes location information to retain a gradient field even in highly mobile environments, at the same time

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as minimizing the routing overhead. This results to the usage of blind forwarding technique to circulate packets towards the sink. The protocol intrinsically uses multiple paths concurrently to generate route diversity and enhances its robustness. LASeR is proposed to employ in wide range of MWSN applications with independent land, sea or air vehicle. Logical expressions are derived and evaluated against the simulations. Extensive modeling and simulation of LASeR proves it is more flexible and robust. The results of LASeR is compared with advanced MWSN routing protocol includes the high performance mobility adaptive cross-layer routing protocol, as well as adhoc on-demand distance vector (AODV) and optimized link state routing. Protocols are analyzed based on the performance metrics such as packet delivery ratio, end-to-end delay, overhead, throughput and energy consumption. The performance of LASeR in several harsh environments shows that the proposed method is significantly better than the existing protocols. The packet structure of Laser is shown in [Fig. 4].

Field name	Node ID	Location	Data	Priority bit	Packet ID
Size (bits)	$\lceil \log_2 n \rceil$	$\left\lceil \log_2 \left(\frac{\sqrt{2} \cdot L}{Q_L} \right) \right\rceil$	L_{data}	1	$\lceil \log_2 n \rceil$
Total size (bits)	$L_P = 2 \cdot \lceil \log_2 n \rceil + \left\lceil \log_2 \left(\frac{\sqrt{2} \cdot L}{Q_L} \right) \right\rceil + L_{data} + 1$				

Fig. 4: Packet structure of LASeR

Table 1: Comparison of various energy efficient routing protocols

Protocol	Mobile element	Moving path	Node type	No. of sink	Application
Termite-hill	Sink	Random	Static node	Single	WSN with one mobile sink
TARS	Sink and targets	Random	Static node	Single	Location aware WSN
mobicluster	Sink	Fixed	Static node	Single	fixed paths of mobile sinks in WSN
W-L	Sink	Rectangle boundary	Static node	Single	Distance aware WSN
HARP	Sink	Random	CH and normal nodes	Single	Reliable WSN
RAHMON	Cluster based sink	Random	Mobile and static node	single	Hydropower plant
HSN	Sink	Random	l-node h-node sink	sink	Large scale WSN

COMPARISON AND DISCUSSION

In addition to eliminating hot spot problem, routing protocols are used in sparse and disconnected WSNs. The movement of sink or the sensor node reduces the distance of data transmission to preserve energy. This results to the uniform distribution of load among the nodes. The main benefit of these techniques is flexibility and scalability. Though these techniques have some advantages, severe drawbacks are also present. First, packet loss and latency is high due to topology changes in the network. Next, the mobile sinks are very expensive when compared to stationary nodes and the usage of mobile sink is doubtful. Using a number of mobile sinks in the network achieves greater performance than a single mobile sink, when the cost is not a consideration. When the cost is an important issue, selecting adequate number of mobile sink become an issue needs to be solved. The movement path of mobile nodes plays a major role on network topology and performance. MobiCluster and W-L follows a predefined path which is easier and adaptable to various situations. The nodes near the sink consume more energy than the nodes located away from the sink. This method does not equally distribute the load in the network. In Termite-hill and TARS, the sink changes the path based on the present network conditions without any limits. It is more convenient, but the implementation is very difficult and results to uncertainty. When the mobility speed on the nodes is low in large network, data latency will be increased significantly. Many researches need to done in the area of designing delay guaranteed routing protocols which is highly suitable for practical conditions. All the reviewed protocols used the same first order energy model, except W-L. As the routing protocols in homogeneous WSN eliminates hot spot problem, using mobile nodes in heterogeneous WSN also eliminates hot spot problem results to improved energy efficiency and uniform distribution of energy among nodes. [Table 1] compares the various reviewed protocols based on their characteristics.

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CONCLUSION

Wireless sensor network (WSN) is composed of large number of sensor nodes which sense the environmental parameter and forwards the sensed data to sink node. The nodes near the sink in static WSN die earlier than other nodes (hot spot problem). Energy efficient routing protocols plays a vital role in WSN. To eliminate hot spot problem, sink mobility is introduced. The mobile sink moves and receives data from sensor node using 1-hop communication and minimizes the energy dissipation of the network and eliminates the hot spot problem. In this paper, various type of routing protocols in mobile WSN is presented. A detail comparison of various protocols is also given at the end of the paper. Finally some future directions for energy efficient routing in WSN are also presented. In future, different routing metrics like spatial reusability can be considered to improve the network throughput. Future work of the mobile routing protocols is network routing metrics: New routing metrics such as spatial reusability should be taken into consider in order improve the network throughput. Secure routing: Node and sink node act as perceived role and a router and makes it a vulnerable attack. Data rate consumes: To reduce high data rate in mobile sink and reduce energy consumption and transformation in multiple mobile sink.

CONFLICT OF INTEREST

There is no conflict of interest.

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FINANCIAL DISCLOSURE

None

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