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SHORT COMMUNICATION

Energy Aware Location Based Routing Protocols in Wireless Sensor Networks

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ABSTRACT

Wireless Sensor Networks have played a great role in various application domains like environmental tracking for precision agriculture, structural health monitoring, patient health monitoring, intrusion detection, earthquake or volcano prediction and industrial monitoring etc. The major design issues to be dealt in Wireless sensor networks (WSNs) are its resource constraint nature, limited network lifetime and scalability. The most stringent of all is energy consumption and battery life which actually limits the network lifetime. This paper presents various energy aware location based routing protocols and in depth comparison based on various characteristics such as routing selection method, data aggregation, routing metrics, periodic message type, scalability, energy efficiency, robustness, event/query based and strengths.

***Keywords*:** Wireless Sensor Networks, Location based Routing, ing, Energy Efficiency, Routing metrics

1. INTRODUCTION

Wireless sensor networks (WSNs) [1-2] are composed of low-cost, multi-functional and low-energy sensor nodes (SNs) which are deployed in the required region or an area to be

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inspected. These small sized SNs are equipped with radio receivers, microprocessors, actuators, computing, communication and power modules. WSNs transfer information over a small distance via wireless channels and combined procedures to accomplish a common task. These can be positioned on a large scale for observing the environmental changes, military surveillance, industrial monitoring, intelligent highway monitoring in smart cities [3-4] and health monitoring of patients. These WSN applications utilize an enormous amount of energy for sensing, processing and data communication. Therefore, routing protocols play an important role for energy efficient route selection [5-6]. Figure 1 depicts the classification of WSN routing techniques.

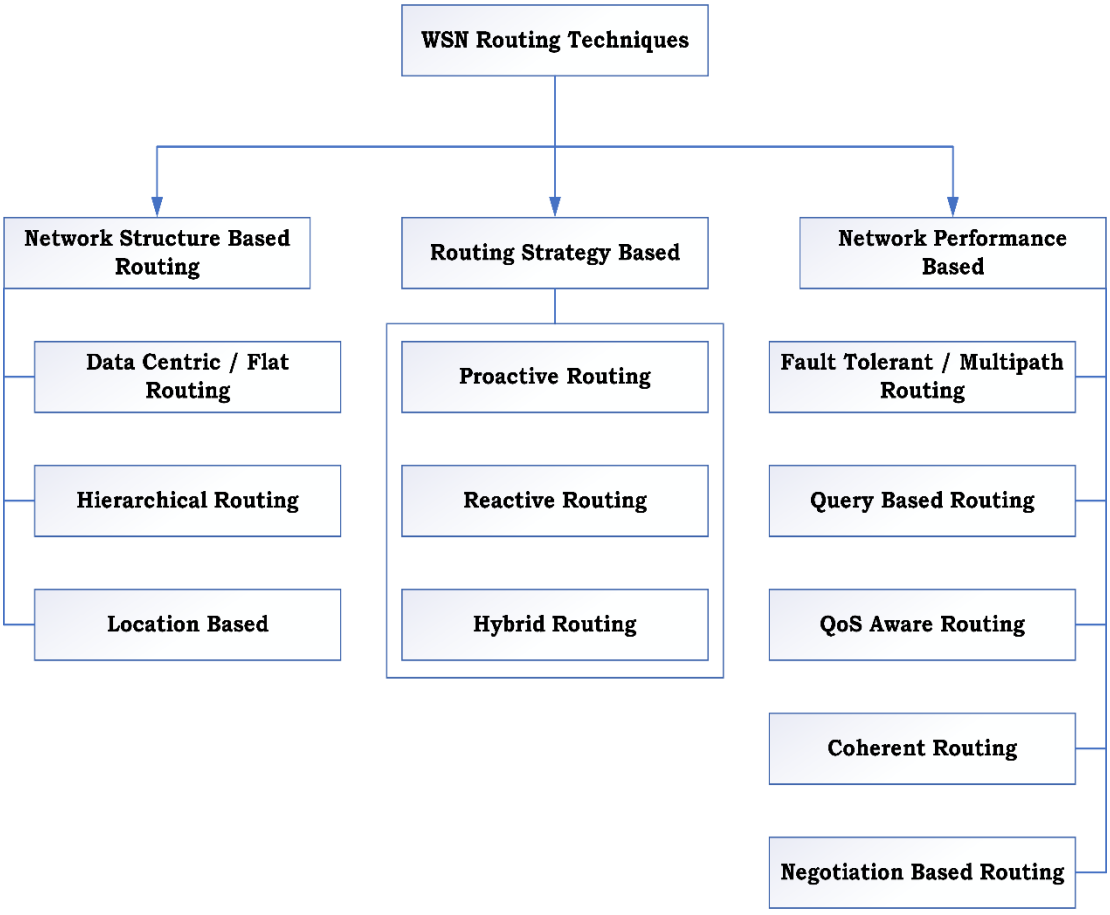

Figure 1. WSN Routing Techniques

2. LOCATION BASED ROUTING PROTOCOLS

In location based routing SNs stores location information of itself and all its neighboring nodes in the network. To calculate the distance between two nodes the information of respective locations of the nodes is required. The information about the relative distance among various nodes in the network is utilized to send region specific queries. This results in limiting the amount of messages [7] for transmission. Therefore, location based routing techniques consume less energy. Figure 2. depicts location based routing.

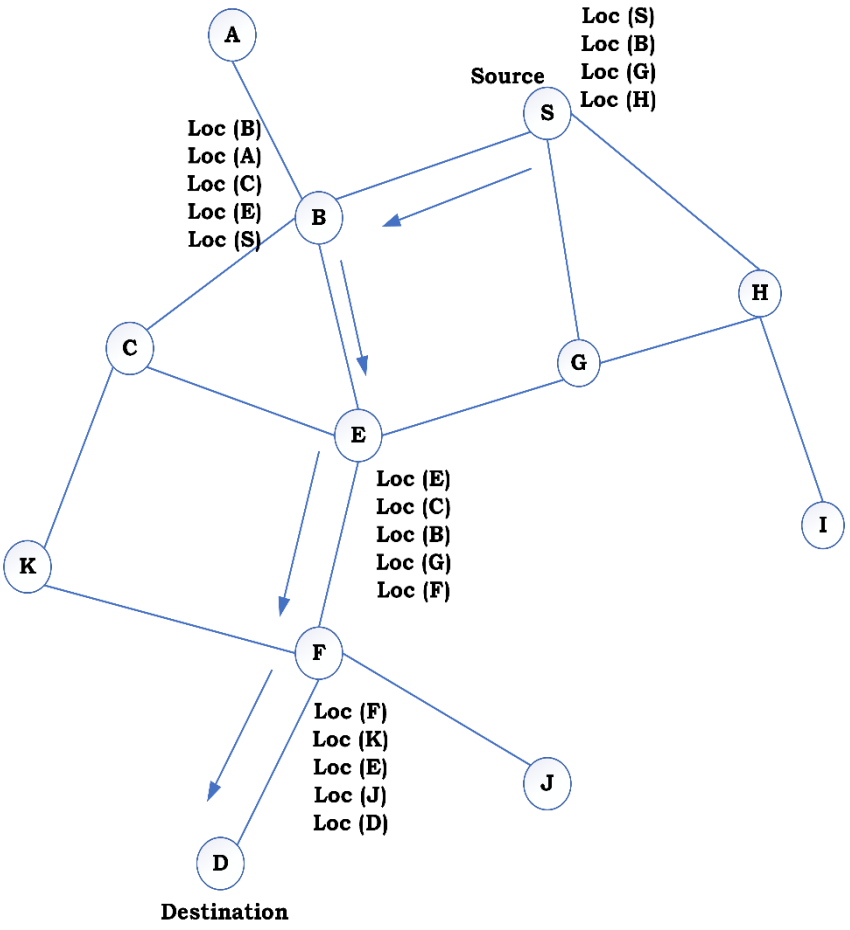

Figure 2. Location Based Routing

The following section explains various energy aware location-based routing protocols for WSN's.

2. 1. GEAR (Geographic and Energy Aware Routing)

In GEAR [8] every SN is aware of its location and its neighbor's location. SNs location identification is enabled through GPS. This protocol is an improvement over Directed Diffusion and it conserves more energy. The energy conserving policy of GEAR is to limit the number of interest by firing region based queries in the network. Every node keeps a record of cost which is calculated through remaining energy and distance metric of the destination. GEAR reduces the energy usage, as well as it also outperforms GPSR [9]. It exhibits better PDR than GPSR.

2. 2. GAF (Geographic Adaptive Fidelity)

GAF [10] protocol is primarily developed for MANET's whereas it can be utilized for WSNs as well. GAF assures less energy consumption of network by putting the SNs in sleep mode which are not participating in routing process. Nodes change their states from sleep to active by turning on their radio. The three types of the states exist in GAF are; discovery, active,

sleep. During discovery the location of the neighboring nodes is searched. Active indicates that SNs are participating for the route construction. Sleep state indicates that the node has turned off its radios in order to conserve energy. GAF is a hierarchical approach in which clusters are formed based on geographical database. The only difference of GAF from hierarchical context is that it does not perform data aggregation.

2. 3. Minimum Energy Communication Network (MECN) & Small Minimum Energy Communication Network (SMECN)

MECN [11] is basically designed for MANET's whereas it is also best suited for WSNs with static architecture. MECN utilizes low power GPS and exhibits minimum energy set up for WSNs. MECN uses the concept of localized search to form global minimum energy paths. Basic concept of MECN is to construct a path from source to destination with minimum possible SNs. SMECN is an enhancement of MECN. It nullifies the assumption made by MECN that each SN can transfer data to every other SN located in the WSN and therefore the actual practical situation in sensor network is considered. It has been proved through simulations [11] that SMECN exhibits reduced energy consumption and low maintenance cost in comparison to MECN.

2. 4. Trajectory – Based Forwarding (TBF)

TBF [12] transfers the packets along the predetermined curve (trajectory) which avoid the undesired areas. TBF utilizes multiple pathways hence exhibits fault tolerance as well. Mobility aspect of SNs gives rise to route maintenance. TBF utilizes various route construction methodologies which are unicast communication/ multicast communication/ broadcast communication/ multipath construction. Trajectory construction is a tedious task in TBF which needs global information of network.

2. 5. An Efficient Routing Protocol based on Position Information in Mobile Wireless Body Area Sensor Networks

The WSNs application domain has been expanded a lot in the recent years, specifically in Wireless Body Area Networks (WBAN's). WBAN's consists of SNs fixed to human body to measure heart rate, temperature, blood pressure etc. The network coverage is affected by the body movements and it may degrade as the time goes on. The energy consumption in WBAN's is an important issue to be dealt with utmost care since it may be impossible to recharge the battery. Therefore, an energy efficient routing protocol based upon two heuristic measures like information obtained from GPS and energy of SNs is proposed for WBANs [13]. The protocol functions in three phases. During 1^{st} phase, the routing range limit is set. In 2^{nd} phase, the neighboring SNs send reply based upon certain heuristic values. The reply messages contain information regarding the energy level and P_n value which is shortest value of distance from source to destination node. During third phase the route construction is done by source node by giving priority to the nodes with the high energy level and short P_n. Therefore, the best possible route is selected. The protocol queries the information from neighboring nodes as and when it is required for neighbor discovery thereby reducing the network processing overhead and consequently saving the energy resource. The simulation results prove that protocol has better

performance for energy consumption and delivery ratio metrics. The future enhancement of the protocol is needed to reduce the end to end delay.

2. 6. Efficient Zone based Routing of sensor network in Agriculture monitoring system (EEZRP)

Agriculture monitoring is one of the major application areas of WSNs which requires energy efficient routing protocols. Therefore, EEZRP [14] is proposed which deploys an optimum number of SNs for agricultural monitoring. In EEZRP the sink node is positioned in the outmost area and some SNs are placed in the zones which are close to BS. The sensed information obtained from SNs which are in the farther area passes through the SNs which are nearer to sink node. Therefore, SNs nearer to sink spend more energy and have shortest network lifetime. To achieve the long network lifetime a more number of SNs are required to be placed in the area near to sink. Every zone is defined with certain number of active and backup (alternate) SNs for a particular time period. The backup SNs remain in sleep state and conserves energy. The active node selection is done in such a way so that it can cover the sensing of whole zone. The active SNs utilize the minimum distance path to reach the sink node.

2. 7. Geographical location based hierarchical routing strategy for WSN

Geographical location based hierarchical routing algorithm [15] emphasizes region-based index measure which is calculated depending upon the binary encoding of spatial frames. This approach provides good scalability because it uses hierarchical network architecture. An effective mechanism is formulated for selection of cluster heads and it also avoids the formation of hot spot in clustering.

The proposed approach divides the network into four zones. The zones are further divided into regions which are again divided into sub-regions. The sub-regions are divided into grids. Initially the sink is assumed to be stationery. The grids are further divided into cells. Each query is sent to local aggregator (LA). With the passage of time the consistent usage of pattern of these LA's and SNs may get into a situation where local aggregator's and SNs may reaches to a predefined lowest possible energy level called "HOT SPOT". Therefore, in order to increase the network lifetime, the selection of LA's is done through the binary encoded spatial encoding scheme. It eliminates HOT SPOT effect and maximizes expected lifetime of the network.

Protocol	**Route selection**	**Data Aggregation**	**Routing Metric**	**Periodic Message Type**	**Scalability**	**Energy efficiency**	**Robustness**	**Location Awareness**	**Event Driven /Query Driven**	**Strength**
GEAR [6]	Reactive	No	The best path	Hello Messages	Limited	Good	Good	Yes	Event Driven	Balanced energy consumption and Improved performance than Directed Diffusion.

GAF [8]	Hybrid	No	The best path and distance metric	Virtual Grid	Good	Moderate	Moderate	Yes	Event Driven	Low network energy consumption.
MECN [9]	Reactive	No	Distributed Bellman ford shortest path	Optimal link for enclosure graph	Limited	Moderate	Moderate	Yes	Event Driven	SMECN achieves minimum energy consumption and low maintenance cost cared to SMECN.
SMECN [9]	Reactive	No	Distributed Bellman ford shortest path	Optimal link for enclosure graph	Limited	Good	Good	Yes	Event Driven	The sub network provided by SMECN for minimum energy relaying is smaller in terms of edges. Therefore, it uses less energy, lower link maintenance cost as compared to MECN.
TBF [10]	reactive	Yes	Closest trajectory node with max. battery	Minimum deviation from the curve	Limited	Good	Good	Yes	Query Driven	Route maintenance is unaffected by the sensor mobility and it has moderate level of energy efficient operation.
Efficient Routing based on Position info in MWBSN [11]	Reactive	No	Heuristics of nodes with high energy levels & short P_n.	Query message for neighbor discovery	limited	Very Good	Good	Yes	Event Driven	Better performance for energy consumption and good delivery ratio.
EEZRP [14]	proactive	Yes	Shortest Path	Periodic Message to check active/sleep node	Good	Very Good	Very Good	Yes	Event Driven	Better network lifetime than LEACH and DSR.
Geographical Loc. Based Hierarchical Routing [15]	Proactive	Yes	Residual Energy & Binary Loc. Index(BLI)	Query Mess. to LA's to find HOT SPOT	Good	Very Good	Good	Yes	Event Driven	The protocol is energy efficient, well scalable and avoids the HOT SPOT" effect.

3. COMPARISON & ANALYSIS

GEAR utilizes reactive route construction strategy and selects the best path for data transmission from source to sink. GEAR exhibits a good level of energy efficiency. However, it does not perform data aggregation and exhibits limited scalability. GAF uses hybrid routing mechanism and utilizes the best path and distance metric for route selection. GAF exhibits good scalability and shows a moderate level of energy efficient behavior. MECN utilizes reactive route construction strategy and constructs the routing path based on Distributed Bellman Ford shortest path for data transmission from source to sink. However, it does not perform data aggregation and exhibits limited scalability. MECN exhibits a moderate level of energy efficiency. SMECN uses reactive routing mechanism and utilizes Distributed Bellman ford shortest path for communication. SMECN exhibits good robustness against failures and good energy efficiency.

TBF utilizes reactive route construction strategy and construct the routing path based on closest trajectory node with maximum battery for data transmission from source to sink. However, it has limited scalability and exhibits a good level of energy efficient behavior. Efficient Routing based on Position information uses reactive routing mechanism and utilizes heuristics of nodes with high energy levels & short P_n for route construction. It exhibits a very good level of energy efficiency and good robustness against path failures. EEZRP utilizes proactive route construction strategy and constructs the routing path based on shortest path for data transmission from source to sink. EEZRP performs data aggregation and shows very good energy efficiency. It also exhibits very good robustness against failures. Geographical Location Based Hierarchical Routing uses proactive method for route formation and utilizes residual energy & binary location index for path selection during data communication. It exhibits a good level of scalability, robustness and very good energy efficiency as well.

4. CONCLUSION

Location based routing protocols utilize region specific information to calculate the distance among nodes to find the routes rather than using parameters like information from routers and control information from packet header. Location based routing avoids flooding mechanism for route construction thereby providing the energy efficient network operation and increases the network lifetime as well. Future research in location-based routing emphasizes on intelligent utilization of location information and spatial query for an enhanced network lifetime.

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