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Research paper



Comparative Study of Routing Techniques in Wireless Sensor Network

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Abstract

A Wireless Sensor Network is made up of small sensor nodes. These nodes are deployed in monitoring area. All nodes collect necessary data and route this data to centre server. A WSN should have self-organizing capability, as nodes positions are not determined in advance. Important factor in WSN is co-operation between nodes. Depending on WSN architecture and application, routing between nodes can vary. This paper presents a comparative study of different routing protocols/algorithm in WSN. Depending on network organization, WSN routing algorithms gets divided into 3 types, i.e. location based, hierarchical and flat. These routing algorithms can be divided further into sub types, depending on how an algorithm/protocol operates. This paper presents advantages and limitations of each routing algorithm.

Keywords: *WSN, routing algorithm, WSN energy limitation.*

1. Introduction

In today's era, Wireless Sensor Network is used in many applications. Both industry and academia is giving tremendous attention to this technology. Lots of research is happening in this field. A WSN is made up of lots of small sensor nodes. These nodes have different capabilities like sensing, communication with other node and computing the data. The communication capability of these nodes have limitation of communication distance, they communicate through wireless medium [2]. By using wireless communication, nodes sends data to other node, performs computing to accomplish its operation or task. For example, WSN used for military surveillance, industrial process control and environment monitoring. Figure 1 shows all components of sensor node. Power unit in sensor node component is nothing but battery which has limited energy. It has processing unit which is required to process sense data. Sensing unit is tiny sensor which is used to sense data depending on application of WSN. Transceiver is used to receive and transfer data to different neighbour nodes using wireless communication. ADC is used to convert sense data from analog to digital form. BS is nothing but the base station which connects the WSN to external world through internet.

Due to size, sensor node has some limitations, but to achieve required operation, entire networks power is sufficient. Depending on application, sensor nodes deployment can be done in an ad hoc way without proper planning. After deployment, it is expected that node will organize itself into a WSN and perform its operation [1]. All sensor nodes have battery which limited in power. In some scenarios, it is very difficult to recharge sensor nodes.

A WSN have dense level of nodes deployment, with power, memory and computation constrains. These constraints present challenges for WSN application. Due to these constraints, it's necessary to have some sort of protocols in WSN such as network security, node localization and synchronization. So, different routing protocols came up to handle these constraints. Because of energy limitation problem, some routing protocols have shortcoming when used in WSN. For example, routing protocol flooding. In this protocol, sensor node receives packet from other nodes and broadcasts it. This packet broadcasting process is repeated till packet is reached to its destination. As every node is broadcasting every packet, energy problem is not taken into consideration [3]. Also, nodes can receive duplicate packets and thus is possibility of implosion. Due to this, this protocol cannot be used in WSN. To overcome problems in flooding algorithm, new technique gossiping was developed. In gossiping technique, instead of broadcasting a packet, node sends packets randomly to one of other node in neighbours. This technique solves the problem of implosion but there is delay in reaching packet to its destination node.

A lot of research is happening in this area to handle or overcome these WSN constraints effectively. This paper discusses different routing protocols and compares those protocols. This papers section 2 discusses different WSN routing algorithm/protocols. In Section 3, different routing protocols are compared. At last, Section-4 concludes the paper.

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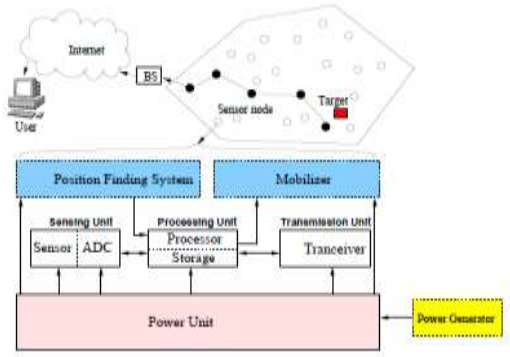


Fig 1: Components of Sensor node components

2. Routing Protocols in Wsns:

This Section 2, studies different WSN routing algorithm. As shown in figure 2, routing algorithms gets divided into 3 types in WSN, routing based on location, routing based on hierarchical and routing based on flat [7]. In routing algorithms based on location, all sensors positions are broken for routing data. In hierarchical routing algorithms, all sensors will have different roles in WSN. In flat routing, all sensors will have equal functionality

2.1. Flat

In Flat routing protocol, every node has same responsibility. All sensors work collectively to carry out the required operation. As there are large numbers of nodes in network, it's not possible to allocate a unique identity to each node. This limitation leads to routing which is data centric. Based on data centric routing, two protocols have been developed, directed diffusion and SPIN. Using data negotiation, these protocols saves energy.

2.1.1 Sensor Protocols for Information via Negotiation (SPIN)

The SPIN protocols are designed to handle the problems of flooding protocol by using resource adaption and negotiation.

These protocols are developed using following 2 ideas:

1. Energy can be saved and nodes operations can be optimised by sending only data which describes node data as an alternative of transmitting entire data.
2. Instead of broadcasting a packet, choose random node and then send data. This approach saves energy and avoids the problem of implosion in gossiping or flooding based routing protocols.

Meta data negotiation facility of SPINs solves problems in flooding and thus improves energy efficiency of WSN.

2.1.2 Directed Diffusion

This protocol increases the network lifetime by saving network energy. Directed diffusion combines data which comes from different sources. Thus it eliminates redundancy and minimizes the number of transmission in network.

2.2.3Rumour Routing

Rumour routing is nothing but variation in direction diffusion. This routing was designed keeping in mind the application where geographic based routing is not possible. As discussed, to inject the query, flooding technique is used by directed diffusion. But if there is very small data requested then flooding is not necessary. To overcome this, flooding is used only when requested data is large. Rumour routing uses long-lasting packets for flooding purpose. These long lasting packets are called as agents.

2.2.4 Minimum Cost Forwarding Algorithm (MCFA):

In routing techniques, direction of routing is known. Due to this, there is no need to of routing table. Messages are transferred to base station using cost path estimate (CPE) at each sensor. MCFA uses same approach where every sensor nodes knows the CPE from base station to itself. To obtain CPE, base station sends message to all nodes with zero cost. All nodes set its CPE to infinity. After receiving packet from base station, node checks if CPE with received CPE, and based on this updates its own CPE.

2.2.5 Gradient-based Routing (GBR):

GBR is another variation in directed diffusion. In GBR algorithm, numbers of hops are memorized when there is interest diffusion. Every node in WSN finds what are minimum numbers of hops required to reach to base station. This is called as height of node. Difference of nodes height with its neighbour's height is considered as the gradient. Link which has largest gradient is used for sending packet.

2.2.6 Energy Aware Routing:

Energy aware routing algorithm was designed to maximise the networks lifetime. This protocol is somewhat comparable to directed diffusion protocol. This protocol does not maintain one best path in WSN, instead of this, it maintains set of different paths. All maintained path are chosen on the basis of some probability. This probability value depends on factor which will minimise energy consumption in WSN.

2.2.7 Routing Protocols with Random Walks:

This algorithm was designed for large scale WSN, where mobility of nodes is limited. This protocol considered that nodes can go on or off at any time. For find the route, location of node is calculated by finding distances between different nodes in WSN.

2.2 Hierarchical:

Hierarchical routing provides advantages in efficient communication and scalability. In the hierarchical routing algorithms, nodes which have elevated energy are used to route the data and send the processed data to other nodes, while the nodes which have low energy are used for sensing purpose only. This algorithm efficiently lowers the energy requirement of WSN.

2.2.1 LEACH Protocol

Low Energy Adaptive Clustering Hierarchy (LEACH) is protocol based on hierarchical structure. LEACH protocol randomly declares some nodes as cluster heads. Cluster head role is shifted to other nodes to share our energy load in WSN. Role cluster head is to pack together incoming data and then send that packet (with data) to respective base station. This way, it reduces the data that gets transmitted in WSN.

2.2.2 Hierarchical Power-Aware Routing (HPAR):

Idea behind this protocol is to divide WSN into different groups of nodes. Each group is entity in this protocol. During routing, each group has authority to decide how to route packet hierarchically across other group which can help in optimising energy in WSN.

2.2.3 Power Efficient Gathering in Sensor Information Systems (PEGASIS):

This chain based protocol is enhances to LEACH protocol. To increase WSN lifetime, nodes in this protocol sends packets to

their closest node only, this may packet reaches to base station. This way is used to reduce the operating power required in WSN to send required packet to base station. This protocol increases the network lifetime and also, allows only local management between neighbour nodes.

2.2.4 Self Organizing Protocol (SOP):

This protocol was developed to support WSN which is heterogeneous in nature, where sensor nodes can be fixed or movable. Some of sensor nodes work as routers, which are fixed in WSN. Other nodes sense the data and send that data to routers. Routers send collected data to base station.

2.2.5 Sensor Aggregates Routing:

This routing algorithm was specially designed where tracking is required. This algorithm forms an aggregate of sensors. To be a part of that aggregate group, a node needs to satisfy some requirement which is required for a task.

2.3 Location based:

In routing which is based on location, nodes are accessed on the basis of their location. Distance between two nodes is decided based on signal strength of incoming message.

2.3.1 Geographic Adaptive Fidelity (GAF):

GAF is routing algorithm based on energy aware structure. In this protocol, WSN area is divided into some predetermined number of zones [6]. These zones form a virtual grid. Within a zone, sensor team up together and get diverse roles. In zone, a node will be elected to stay awake during certain operation and all other remaining nodes in zone can go into sleep mode. This awake node is responsible for data transmission in that zone now. Due to this, GAF algorithm saves energy in WSN by turning some nodes into sleep mode.

3. Comparison of Routing Protocols

Table I shows the comparison between SPIN, directed diffusion and LEACH routing protocol. From this table, it can be seen that each algorithms has its own advantages and disadvantages.

Table I: Comparison: SPIN vs. Directed Diffusion vs. LEACH routing

	SPIN	Directed Diffusion	LEACH
WSN Life	Fine	Fine	Excellent
Best Possible Route	No	Certainly	No
Meta Data Usage	Certainly	Certainly	No
Resource Knowledge	Certainly	Certainly	Certainly

Table II shows the comparison between hierarchical and flat routing topologies. From comparison table, it can be seen that hierarchical protocol avoids the collision with low latency but the same is not possible with flat topology routing protocols.

Table II: Comparison: Hierarchical vs. Flat topologies routing

Hierarchical	Flat
Scheduling type: Reservation	Scheduling type: Contention
Avoids crash	Cannot avoid crash
Cluster head aggregates data	Node aggregates data from neighbour node
Routing is not optimal	With added complexity, routing can be made optimal
Needs synchronization	No synchronization
Cluster formation overhead	No cluster formation overhead
Low latency	Latency in waking up nodes
Energy usage is even in WSN	Energy usage data pattern
Energy usage can't be controlled	Energy usage depends on data pattern
Channel allotment is fair	Fairness is not sure

Table III shows the different routing algorithm/protocols comparison, which are discussed in section 2. From this table, it can be seen that each protocol has advantages and disadvantages compared to other protocols.

Table III: Comparison of different routing protocols

	Classification	Mobility	Position Awareness	Power Usage	Negotiation Based	Data Aggregation
SPIN	Flat	Possible	No	Limited	Yes	Yes
Directed Diffusion	Flat	Limited	No	Limited	Yes	Yes
Rumor	Flat	Very limited	No	N/A	No	Yes
MCFA	Flat	No	No	N/A	No	No
GBR	Flat	Limited	No	N/A	No	Yes
Energy Aware	Flat	Limited	No	N/A	No	No
LEACH	Hierarchical	Fixed BS	No	Maximum	No	Yes
HPAR	Hierarchical	No	No	N/A	No	No
PEGASIS	Hierarchical	Fixed BS	No	Maximum	No	No
SOP	Hierarchical	No	No	N/A	No	No
Aggregate	Hierarchical	Limited	No	N/A	No	Yes

	Localization	QoS	State Complexity	Scalability	Multipath	Query based
SPIN	Not Possible	Not Possible	Low	Limited	Possible	Possible
Directed Diffusion	Possible	Not Possible	Low	Limited	Possible	Possible
Rumor	Not Possible	Not Possible	Low	Good	Not Possible	Possible
MCFA	Not Possible	Not Possible	Low	Good	Not Possible	Not Possible
GBR	Not Possible	Not Possible	Low	Limited	Not Possible	Possible
Energy Aware	Not Possible	Not Possible	Low	Limited	Not Possible	Possible
LEACH	Possible	Not Possible	CHs	Fine	Not Possible	Not Possible

HPAR	Not Possible	Not Possible	Low	Fine	Not Possible	Not Possible
PEGASIS	Possible	Not Possible	Low	Fine	Not Possible	Not Possible
SOP	Not Possible	Not Possible	Low	Low	Not Possible	Not Possible
Aggregate	Not Possible	Not Possible	Low	Fine	Not Possible	Possible

4. Conclusion

WSN routing algorithms is latest research happening now a days. Routing algorithm research results are rapidly growing. This paper presents a complete comparative study of WSN routing algorithms/protocols. Purpose of all routing algorithms is to increase the lifetime of WSN without adding any extra delay in data transmission.

Generally, depending on network organization, the routing algorithms are divided into 3 types: location, hierarchical and flat routing protocols. This paper highlights comparison between routing protocols. Some routing protocols look promising but still there are some challenges in WSN that need to be targeted.

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