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Review on Energy Efficient Chain based Hierarchical Routing Protocols in WSN

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Abstract

In WSN sensor nodes are deployed to gather data and communicate with each other for specific application .For this each sensor needs ,some energy which is limited and provided by batteries. Thus efficient use of energy and network life time is vital issues in WSN. Many researches were done based on routing protocols, coverage problems and overall performance to improve lifetime. This article studies different routing protocols and issues in WSN. This paper mainly reviews on energy efficient chain based hierarchical routing protocols. PEGASIS is one of the chain based hierarchical routing protocol with reduced energy consumption and improved lifetime. In this article PEGASIS and improvement on it were studied and compared.

Keywords

WSN, Hierarchical routing protocol, PEGASIS, Energy Efficiency

Introduction

A WSN typically consists of a hundreds or thousands of low-cost, low-power, and multifunctional sensor nodes that are deployed in a region of interest. These sensor nodes are small in size, but are equipped with embedded microprocessors, radio receivers, and power components to enable sensing, computing, communication, and actuation [6]. The nodes of wireless sensor networks are defined with limited energy. Wireless sensor node deployed into the network to monitor the physical or environmental condition such as temperature, sound, vibration at different location. The data is transferred over the network each sensor consume some energy in receiving data, sending data. The lifetime of the network depends on how much energy spent in each transmission [1].

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Routing is one of the most important issues that directly affected the performance of WSN. The main goal of the routing protocols in WSN is to develop efficient algorithms to reduce the power consumption and extend the life time of the network's nodes. PEGASIS avoids the formation of clusters and allows a single node in the chain, to forward data to the BS [3]. This article studies and analyzes chain based hierarchical routing protocols and some hybrid or mix hierarchical routing protocols. It also concludes features and properties of them. This paper is organised in following way. General PEGASIS and its working was explained briefly. Then, PEGASIS improvement techniques and modifications were explained. After that, common characteristics of chain based hierarchical routing protocols were identified.

Chain based Routing Protocols in WSN

There are many algorithms were developed and proposed in chain based routing protocols in which PEGASIS is one of the most popular algorithms.

General PEGASIS

The PEGASIS (Power-Efficient Gathering in Sensor Information Systems) protocol forms a chain of the sensor nodes and the chain is formed using a greedy method, starting from the node farthest most to the sink node. The nearest node sends the data to the neighbour node. This process is continued until all the nodes are integrated in the chain. This approach distributes the energy load evenly among the sensor nodes in the network. Before passing the information to the adjacent neighbour data aggregation takes place in two steps-

a) Chain Construction-PEGASIS build a chain using a greedy algorithm to route the data to the leader of all nodes.

b) Gathering data-In this step after leader node is selected and chain is constructed next step is data aggregation and leader node is responsible for forwarding the aggregated data to the sink node.[1]

Modified PEGASIS

In this approach parameter was increased for making decision in which route data will transfer and called as CIdel which defines as the quick response of the node. Here CIdel was defined as: CIdel= Throughput $C_{effective}$

$C_{effective}$ is defined as distance*Transmission-distance*Transission*overhead, where overhead is supposed t be .02. It was assumed that nodes are suffered from congestion. Therefore, Throughput is defined as

Throughput = (distance+Congestion*distance)*Transmission-distance*Transmission*overhead*m
When its value less than congestion<5 then value of m is 2 otherwise m will be 3.
It will check all the three parameter for making decision and then data is forwarded and in each step data aggregation go on.

Based on above parameters and assumptions PEGASIS was modified in this approach to increase network life time of sensor networks. It also achieves balance of energy

dissipation among the nodes and to increase the existence of more nodes in the network.[1]

PEGASIS Improvement Techniques

A) H-PEGASIS Hierarchical-PEGASIS is an extension to PEGASIS, which aims at decreasing the delay incurred for packets during transmission to the base station and proposes a solution to the data gathering problem by considering energy * delay metric. In order to reduce the delay in PEGASIS, simultaneous transmissions of data messages are pursued. To avoid collisions and possible signal interference among the sensors, two approaches have been investigated. First approach incorporates signal coding, e.g. CDMA. In the second approach only spatially separated nodes are allowed to transmit at the same time.[8]

B) IEEPB Improved energy-efficient PEGASIS-based protocol (IEEPB) was proposed to improve the deficiencies of PEGASIS. This novel algorithm adopts a more reasonable method to build the chain which simplifies the chain construction process and avoids the formation of LL (long link). In leader selection phase, IEEPB uses weighting method which considers the node energy and distance between node and BS parameters to select more suitable leader and keep energy consumption balanced .IEEPB outperforms EEPB by achieving higher energy-efficiency and extending lifetime of network.[5]

C) PEGASIS_M PEGASIS_M (Multi-round Power Efficient Gathering in Sensor Information Systems). PEGASIS_M protocol is to make a chain among the sensor nodes so that each node could receive and transmit signal. The leader node cannot change at every round but after a definite number of rounds. The Multi-hop technology is used to reduce the energy consumption of the architecture. PEGASIS_M is used in a real-time detection system of trains based on the wireless sensor network. The Giant magneto resistive (GMR) sensor is used to detect the train wheels. According to the difference of wheels types, locomotives and wagons can be distinguished. Wheel sensors are connected to the sensor node which could send detected signal to sink nodes by the radio. The sink node is connected to PC where the information of trains are gathered and processed .This system has those advantages such as low power dissipation, low cost and easy maintenance[5].

D) MH-PEGASIS A multi hops Power-Efficient Gathering in Sensor Information Systems). Hierarchical PEGASIS protocol is focus to certain constraints and assumptions that generate disadvantages. For example, the routing in a single hop within cluster-heads has an important drawback because CHs located far from the BS must use strong signals to communicate with BS which increases their energy consumption. To cure this problem, MH-PEGASIS was proposed that allows the use of multi-hop routing between the cluster-heads (inter clusters) in order to reach efficiently the BS. This protocol can be divided into four phase : (a) Announcement phase (b) cluster formation phase (c) Inter & inter clusters trees formation phase (d) data communication phase. Average amount of energy consumed by MH-PEGASIS is lower than the average amount of energy consumed by the other protocols. The protocol MH-PEGASIS improves the network life time duration compared to the original hierarchical PEGASIS protocol and this is due to the multi-hop

communications between CHs and BS as well as data aggregation at the CHs which allows reducing the amount of packets routed in the network.

E) PEGASIS-TC uses the concept of Topology control to manage the constrained energy resource. Node redundancy in Wireless Sensor Network leads to wastage of energy by providing the already available information. This protocol turns off the node which lies in CTR (Critical transmission range) till there is a node to provide information. The energy thus saved is used in later stage to prolong network lifetime. PEGASIS-TC outperforms PEGASIS by achieving higher energy efficiency extending network lifetime.[5]

Chain and Chain-Cluster based Routing Protocols

A. Balanced chain-based routing protocol BCBRP decrease the energy consumption in the network by partitions the network area into small equal sub area, since the number of the sub-area equal j_2 (j= 1,2,3,….) . After that BCBRP allocate header and leaf nodes in every sub-area. Nodes location in bounder of this sub-network, furthermore leaf node make connection between its sub-network and previous sub-network while, header nodes make connection between its network with next sub-network (with Notice that first sub-network don't have leader node and last sub-network don't have leaf node). After that in every sub-area chain will constructed by using minimum Spanning tree algorithm instead of greedy in PEGASIS to ensure there is minimum chain distance will construction in each network.[1]

B. Chain-cluster based mixed routing CCM take the low power advantage from PEGASIS protocol, and short transmission delay from LEACH protocol, CCM protocol has two phases, Phase 1is known as chain-based routing. In this step, the sensor nodes construct a chain for the intra-connection and all chain member nodes send data to the chain head using chain-based routing concept. This process involves two steps namely Selection of chain head node and Data transmission in a chain. In Phase2, the CCM have two steps namely Voting cluster head and Data transmission in the cluster. All chain heads construct a cluster-based routing as inter-connection. Finally the voted cluster head send fused data to the Base Station. If the cluster head is a far away from the base station more energy will be used to send data. CCM in can mitigate the power consumption by the uniformity deployment for the sensors and combined the advantage from LEACH and PEGASIS. However, it ignores the energy consumption coming by long distance between chains, also the delay that is coming with long link.[1]

C. Chain-Chain based routing protocol CCBRP was proposed to achieve both minimum energy consummation and minimum delay. CCBRP divides the WSN into a number of chains; Greedy algorithm is used to construct each of the chains as in PEGASIS. Each chain contains a number of sensor nodes, the number of chains and the number of sensor nodes in each chain depend on the number of sensor nodes in the WSN under consideration. The proposed CCBRP forms each of the partitioned chains using Greedy algorithm and runs in two phases. The first phase starts by randomly selecting a leader for each chain, and then each chain leader(CL) sends a token message to the two ends of its chain to notify them. After that each of the two end nodes of each chain simultaneously starts sending its data to its closet neighbour node, the neighbouring nodes receive the data and fuse its data along with the received data and send to the next

node in the chain and so on. This process is repeated till the data has reached all the chain leader nodes. The second phase of CCBRP starts after all the CL nodes have received all the data from their chain nodes. These CL nodes form a chain (using Greedy algorithm) and randomly choose a chain leader for the newly formed chain. Then the randomly chosen leader sends a token message to the two ends of the newly formed chain. Thereafter, each of the two nodes at the two ends of the formed chain of leaders simultaneously starts sending its data to its closest neighbouring node. The neighbouring nodes receive the sent data and fuse their data with the received data and send to the next neighbouring nodes and so on. This process of sending data is repeated till all the data of the WSN under consideration has reached the leader node of the chain of leader nodes. After the node leader of leaders has received this data it is fused with its own data and sent to the BS.[7]. In [4] a fault tolerant mechanism was introduced to CCBRP by replacing failed nodes with another node and deliver data to the base station. According to this, when a CL cannot find the next CL (because of such reasons as long distance, node failure, energy depletion etc.), nearest node will be considered as the CL of the next chain. The process of choosing replacement has two possibilities; 1) The CL is located in the middle of the chain and 2) it is located in the left or right fringes of the network.

D. Chain routing based on coordinates-oriented cluster CRBCC improves the data delivery time from nodes to BS. This is achieved by dividing the chain in PEGASIS to multi parallel chains depending on horizontal positions (avoid Long Link problem). Although depending on chain-based approach it minimizes the power consumption in data aggregation. Greedy algorithm used in PEGASIS is locale search and it is not provide global optimum link between nodes so, CRBCC used another heuristic algorithm for this issue. CRBCC has some of important drawbacks in term of chain leader election in the top of chains; furthermore these nodes will deplete its energy quickly than others without any active procedure to select another chain leader during the network lifetime. Although, randomly selection for the main head caused unlucky nodes selected twice or more than twice compared with others that never selected, randomize selection can replaced by choosing effective parameters like rest energy or node distance with base station these parameters can make leader selection more efficient and improve the network lifetime.[1]

E. A reliable and energy-efficient chain-cluster based routing protocol REC+ protocol aims to perform the maximum reliability in a multi hop network by calculating the best position for the CH and the proper shape and size of the cluster. REC+ is the first protocol that considers transmission reliability, energy efficiency, and intra cluster delay together to build the cluster and select the cluster head. First Cluster Formation phase, in this phase REC+ assume that the BS have all information about nodes in term of position and energy, then BS will divided the sensor nodes in the network into clusters according to Y-coordinator. Second, Cluster Head Selection and Chain- Cluster forming phase, opposite on other algorithms, REC+ choose the chain heads first then assign its members nodes. BS selected CHs base on residual energy divided by initial energy. Hop-by-hop reliability (HHR) reported to the BS by nodes to ensure quality link created, and this node will be the first node into this cluster if EER (end-to end reliabilities) is more than the threshold 0EER. Nodes play multi hop (chain) method to reach its CH, and another threshold apply to avoid long ling (LL) In every cluster chain which is 0delay This is second threshold prevent delay in the LL. Third phase in REC+ is steady state phase, in

this phase every node will sensing data and send to its neighbour, this node fuse the neighbour data with its data (if any) then deliver to CH, CHs used RNs to ensure this data reach BS in reliable way. If there is any significant changes accrued in nodes parameters can affected link quality or some nods below the threshold 0EER , the BS recalculate CHs and clusters shape as well as. The advantage of REC+ is by using tow threshold to create cluster and select the CH, one for energy and another for delay. However, REC+ make many more overhead on the network during it three phases, furthermore REC+ assuming all nodes can connected directly to the BS to setup the first and second steps and this is not always can applicable in practical networks.[1]

F. Rotation PEGASIS-based RPB is combined the advantage of PEGASIS with GAF (Geographical Adaptive Fidelity) in one protocol. RBP consist of three stages which are link establishment, leader selection and data transmission. In link establishment phase distance threshold factor will be control link construction. Link start from the farthest node in the sensing area, every node will check the distance with its neighbour with distance threshold if more than threshold, the node connected directly by sending request connection message and waiting to receive conformation message. If the distance less than or equal distance threshold this node going to sleep mode in this round and be sure wake up before next round coming and rotate this role with the neighbour node. Second phase is for chain leader selection, RPB selected leader node depend on residual energy and distance with base station with two specific weights and distance factor. In Data Transmission phase, every node will decrease its energy radio transmission to hear only closest neighbour node. RPB use Token mechanism to start data collection from all nodes. Token packets are very small and take very few energy to process and transmitted along chain member. RPB has advantage when make distance threshold and using sleep mode for this nodes to save their energy in this round. Another advantage in RPB is when selected the chain head by considering both residual energy and distance with base station and putted some priority for distance. RPB has disadvantage when it loss the sleeper coverage range along round time and overhead caused by selection sleeper nodes.[1]

G. Position-based chain cluster routing protocol PCCR protocol was proposed for narrow strip area application This area is divided into belt-shape region cluster where every region selects a cluster head depending on position and residual energy. These CHs then create the chain as a backbone of the strip. PCCR have four phases: (1) Divided Phase, (2) Cluster Head Elect Phase, (3)Cluster Head Chain Establishment Phase, and (4) Steady-State Phase. This protocol can improve the lifetime for the network by saving the CHs energy especially for the farthest cluster by creating the backbone (as a chain). In this way the CH does not suffer from energy exhaustion when transmitting its data. Data will be forwarded to the next hop only.[07]

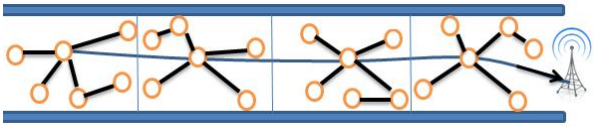

Figure 1: PCCR routing protocol

H. Grid-PEGASIS routing protocol Grid-PEGASIS protocol is an improvement on PEGASIS protocol in term of energy efficient and energy balancing. It is created to prevent the long hop causes by greedy algorithm by divided sensing area into small grid area and this protocol has many assumptions like (1) all nodes in the network and BS are stationary. (2) The sensing area is divided into small grids and every grid has unique ID, (3) each node has unique ID also and it is knows its Grid ID, (4) all nodes send data periodically and they are homogeneous.[1]

Chain-Based Routing Protocols Characteristics

1. -Every node in the network is connected with the closest neighbour node only in a chain form.
2. -Some protocols assume that all nodes can send Hello massage to the BS in first round to collect all nodes information.
3. -Connection type in intra-connection is multi-hop, on the other hand inter-connection use single or multi hop until reach a BS.
4. -Base Station should be stationary and there exists only one base station in all protocols
5. -Extendable of network lifetime with low power consumption.
6. -Reduce the overhead coming from dynamic cluster formation.
7. -Compared with cluster based protocols, in chain based may reduce the energy consumption when nodes send data only to its closest neighbour.
8. -Chain-based network structure suffers from delay caused by Long Link (LL) and data redundant (repetition of data transmissions).
9. -Residual energy is not considered when select CH in some protocols, while others consider this as CH selection condition.
10. -Division of Long Link (long chain) into sub-level of small chain is good idea to avoid data redundancy.
11. -Energy distributions in chain-based routing protocols are even due to little energy per bit used for communication.

Conclusion

In this paper it was found that Routing protocol can effectively increase WSN performance using efficiently utilizing energy of sensor node. Therefore, routing protocols designed for WSNs should be as energy efficient as possible to prolong the lifetime of individual sensors. Depending on the network structure, chain-Based is one of the important types that can reduce the power consumption and improve the lifetime for the network. The characteristics and some of the important performance metrics of chain-based routing protocols are explained. This article may be useful to study and develop various approaches of chain based routing protocol in WSN.

Still there are many areas for research to develop new protocols in WSN by considering chain construction, node deployment, chain head node selection, scalability, coverage area, energy consumption, location awareness, nature of environment, WSN Applications, control message and QoS etc.

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