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Study on Typical Hierarchical Routing For WSNS

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Abstract-

Hierarchical routing in wireless sensor net-works (WSNs) is a vital point that has been pulling in the examination network in the most recent decade. Typical hierarchical routing is called grouping routing, in which the system is isolated into different bunches. As of late, a few sorts of atypical hierarchical routing emerge, including chain-based, tree-based, grid-based routing, and area-based routing. There are a few study papers that present and think about the hierarchical routing conventions from different points of view, however a review on atypical hierarchical routing is as yet absent. This paper makes a first endeavor to give a far reaching audit on atypical hierarchical routing. We offer a classification of atypical hierarchical routing of WSNs, and give nitty gritty examination of various legitimate topologies. The most illustrative atypical hierarchical routing conventions are portrayed, examined, and subjectively thought about. Specifically, the favorable circumstances and inconveniences of various atypical hierarchical routing conventions are examined as for their noteworthy performances and application situations. At last, we set forward some open issues concerning the plan of hierarchical WSNs. This overview plans to give helpful direction to framework creators on the best way to assess and select fitting consistent topologies and hierarchical routing conventions for particular applications**.**

Index Terms— Wireless sensor networks, atypical hierarchical routing, chain-based, tree-based, grid-based, area-based.

I. INTRODUCTION

WIRELESS sensor networks (WSNs) consist of countless cost, low-control and clever sensor hubs and at least one sinks or base stations (BSs) [1], [2].

Those hubs are little in measure and can perform numerous essential functions, including occasion detecting, information preparing, and information communication [3], [4]. WSNs can be utilized in wide military applications and regular citizen situations [5], [6]. Because of different favorable circumstances, for example, simplicity of sending, expanded transmission range, and self-organization, WSNs have been supplanting the traditional networks.

Sensors are for the most part outfitted with non-rechargeable batteries, so vitality proficiency is a noteworthy outline issue keeping in mind the end goal to build the system life expectancy [7]. Information transmission is the real wellspring of vitality consumption [8], and it is a genuine test to outline a vitality productive routing plan for prolonging the system lifetime [9], [10]. Besides, as the system scale builds, the versatility of the system turns into an essential issue. Hierarchical engineering is ended up being a compelling solution to the issue of versatility and vitality proficiency. In a hierarchical engineering, the system is separated into various layers, and hubs in various layers perform distinctive undertakings. The typical hierarchical routing method is bunching, in which the system is partitioned into numerous groups and hubs attempt two distinct errands, group heads (CHs) and customary hubs (ONs). An ON only conveys its detected information to its related CH, while a CH is respon-sible for gathering the information from its ONs and exchanging information to the sink by means of hierarchical routing. Drain [11] is a pioneering group routing convention for WSNs, and different sequent conventions have been proposed to form the alleged LEACH family, for example, [12]– [20].

As of late there emerge some atypical hierarchical routings, which are variations of group base routing and present exceptional hierarchical design, including chain-based, tree-based, grid-based, and area-based routing. These kinds of atypical hierarchical routing are like the traditional grouping routing, however are pretty much extraordinary in chain of importance division and communication plot. There exist a few study papers that present and think about the hierarchical routing conventions of WSNs from different points of view, however so far no work centers around atypical hierarchical routing. Propelled by this, we make a first endeavor to give an exhaustive study on atypical hierarchical routing for WSNs.

The principle contributions of our work can be abridged as takes after.

1) We offer a classification strategy regarding atypical hierarchical routing for WSNs. This gives another point of view to perusers to comprehend this sort of routing. To the extent we know, it is the first run through for atypical hierarchical routing to be arranged into four classifications based on consistent topologies.

2) We give a point by point investigation of various legitimate topologies for atypical hierarchical routing with their focal points and inconveniences. To the best of our insight, this is the most far reaching audit of sensible topologies for typical hierarchical routing of WSNs.

3) It is a first endeavor to introduce an extensive audit of atypical hierarchical routing conventions of WSNs. This audit consists of a few traditional and breakthrough atypical hierarchical routing conventions with their qualities, qualities, and in addition shortcomings.

4) We give an extensive comparison of various atypical hierarchical routing conventions concerning their general performances and application situations. This may help arrange originators to choose appropriate hierar-chical routing conventions for particular applications.

5) A couple of open issues for this exploration area are condensed. New research directions for specialists are brought up, which contribute to facilitate improvement of this exploration area.

The rest of this paper is sorted out as takes after: Section II gives an outline of studying typical hierarchical routing conventions for WSNs. Section III makes a nitty gritty investigation of various topologies for atypical hierarchical routing of WSNs. Section IV gives a com-prehensive survey on some illustrative atypical hierarchi-cal routing conventions regarding their qualities, fortifies and disadvantages.

II. RELATED WORK

ATYPICAL HIERARCHICAL

ROUTING PROTOCOLS IN WSNS

In this section, we select and analyze a few atypical hierarchical routing protocols of WSNs based on different logical topologies.

A. Chain-Based Hierarchical Routing Protocols

1) **PEGASIS**: PEGASIS (power-efficient gathering in sensor information systems) [37] is a pioneering chain-based hierarchical protocol. In PEGASIS, all nodes are organized into a linear chain for data transmission and data aggregation. The chain can be formed by the sink with a centralized approach or by a greedy algorithm with a distributed manner. It is assumed in both cases that all nodes have global knowl-edge of the network topology. If the calculation task of the chain is assigned to nodes, they can first achieve the location information of all nodes and compute the chain using such a greedy manner. The chain construction is begun with the furthest node from the sink. The closest neighbor node is selected as the next node of the chain. If a node dies, the chain will be rebuilt using the same method to remove the dead node. Data is delivered from each node to its neighbor node, and nodes act as leaders which communicate to the sink in alteration. Every node fuses its neighbor’s data with its own to generate a new packet and then delivers it to its next neighbor. This is a repeated course until

all data are gathered at the leader, which then directly transmits the final data packet to the sink.

2) **CCS**: CCS (concentric clustering scheme) [40] is centralized chain-based routing algorithm in which there exist multiple chains. The goal of CCS is to improve the energy efficiency of PEGASIS. The location of the BS is considered to achieve such a goal. The whole network is divided into several concentric circular tracks which represent different clusters with different levels. Level-1 is assigned to the track that is nearest to the BS. The larger the distance to the BS is, the larger the level number is. Multiple chains are created within the track. At each hierarchy, one node of the chain is elected as a CH. All nodes in each level transmit the data to the nearest node from themselves along the chain. After CH selection, data is delivered from one CH to its two one-hop neighbor CHs with different levels.

3) **EBCRP**: EBCRP (energy-balanced chain-cluster routing protocol) [43] is a distributed hierarchical algorithm with chain-cluster topology for WSNs. The routing scheme is based on the idea that each node delivers equal data and only short-distance communication is performed among different nodes. Only neighbor nodes communicate with each other except CHs. The implementation of EBCRP can be partitioned into three phases: 1) chain-cluster formation; 2) cluster-head selection; and 3) steady-state. In the chain-cluster formation stage, the network is divided into multiple rectangular sections which are equivalent to different clusters, and a routing chain is created in each rectangular section by the ladder algorithm instead of the greedy algorithm. Thus, the long-distance communication is removed. In the cluster-head selection stage, several nodes act as CHs and communicate with the BS in rotation. The CH selection is performed according to the residual energy of different nodes. In the steady-state stage, the CHs, similar to the leaders of PEGASIS, collect and process data from other nodes along the cluster-chain and directly send data to the BS. This process is repeated until one node depletes its whole energy. At this point, the steady-state phase is ended. After that, a new round of tree construction, CH selection, and data transmission will begin.

4) **CHIRON**: CHIRON (chain-based hierarchical routing protocol) [44] is a chain-based routing protocol with the goal of alleviating several flaws such as data propagation delay. This protocol consists of four operation phases: group construction, chain formation, leader election, and data transmission. In group construction phase, the network is divided into several fan-shaped areas. The BS sends control information to all nodes, and all nodes determine which group they respectively belong to. In chain formation phase, the node that is farthest away from the BS is initiated to create the group chain in each group. By using a greedy algorithm, the nearest neighbor node will be chosen to link the node, and become as the newly initiate node in next linking step. Leader node election is performed based on the maximum

residual energy of group nodes. Initially, the node farthest away from the BS is assigned to be the group chain leader. Then, the node with the maximum residual energy will be elected the group chain leader. In data transmission phase, initially, data transmission is performed in each group along the chain to the chain leader. Then, the chain leaders collaboratively relay their aggregated data to the BS by leader-by-leader transmission manner.

B. Tree-Based Hierarchical Routing Protocols

1) **EADAT**: EADAT (energy-aware data aggregation tree) [45] is an energy-aware distributed heuristic. The main goal of this algorithm is to tackle the problem of energy shortage by considering energy-aware data-centric routing. The algorithm is initiated from the sink by broadcasting a control message. The sink is assumed the root node in the aggregation tree. If a sensor node receives a control message for the first time, it sets up its timer which counts down when the channel is idle. The timer is associated with each sensor. The initial value of the timer is a decreasing function of residual power. In other words, the bigger the residual power, the smaller the value of the timer, the shorter the waiting time. During this process, the sensor chooses the node with the higher residual power and shorter path to the sink as its parent. When the timer times out, the node increases its value of hop count by one and broadcasts the control message. The result is an aggregation tree or a reversed multicast tree rooted at the sink. The tree can be re-constructed periodically. When the residual power of a node is below some threshold, an active sensor periodically broadcasts help messages and then shuts down its radio. After receiving the first help message from its parent, an active node switches to a new parent in the original tree, if it exists. Otherwise, it turns into a danger state.

2) **BATR**: BATR (balanced aggregation tree routing) [46] is a typical tree-based routing algorithm. Its goal is to find an optimal path based on a balanced tree, in which each node consumes the equal amount of energy. It is assumed that the BS is aware of the location information of all nodes in advance by special equipments such as GPS, and performs the task of routing computing. The routing algorithm begins with the BS as the root node, and then creates the relationship of parent and child with other nodes. This algorithm chooses the minimum weighted edge as much as the number of child nodes, and adds the new node to the tree. This means that data will be delivered from the node of the tree to the new node. When a neighbor node is found, the node is labeled as a leaf node. This process lasts until all nodes join in the routing tree. After several rounds of energy dissipation, the BS updates the routing information by eliminating the dead nodes and recalculating the child nodes. In a summary, this routing algorithm constructs a minimum spanning tree with energy dissipation cost to achieve a minimum energy consuming system and extend the network lifetime.

3) **PEDAP**: Power-efficient data gathering and aggregation protocol (PEDAP) [47] is a tree-based routing protocol. The objective of PEDAP is to maximize the network lifetime, which is defined by the number transmission rounds. The minimum energy cost tree is uses to data transmission. This tree is constructed by a centralized manner using Prim's minimum spanning tree algorithm. Initially, the sink is defined as the root of the tree. After that, the authors select the minimum weighted edge, one vertex of which is in the tree and another vertex is not in the tree. Such an edge is added to the tree. This process lasts until all nodes are merged into the tree. The total energy consumption in each communication round is achieved by computing a minimum spanning tree with link cost, which is related to data volume and transmission distance. In order to achieve load balancing among all nodes, the residual energy of the nodes is taken into account during the course of data aggregation. When data transmission is performed, the root of the tree structure acts as the CH. Each node receives data from its child nodes, aggregates the data with its own and delivers it to its parent node. This process continues until the aggregated data reaches the CH. Ultimately, the data is delivered from the CH to the sink.

4) **ETR:** ETR (enhanced tree routing) [48] is a typical tree-based routing scheme. ETR is an improvement of the tree routing (TR) [48], which is a simple routing protocol for a moderate tree-like network and follows only parent-child links starting from root node to leaf node. ETR was proposed to implement balance between performance and cost. In ETR, it is assumed that each node has an updated neighbor table which has the address of its immediate one-hop neighbors. This neighbor table is important to identify the alternate path to the sink with the number of hops less than the actual path. ETR introduces an important parameter named network depth of a node, which represents the minimum number of hops from the node to the root node using only parent–child links. The network depth of the root node is 0, and the network depth of other nodes increases gradually. For data delivery among different nodes, each node has a unique identification number, which is initially assigned to the node. Each node on the tree route seeks to identify a proper neighbor node for the selection of the next hop. If such a neighbor node is found, the ETR route has a smaller hop-count. If no neighbor is identified at a node, the parent–child link is used.

C. Grid-Based Hierarchical Routing Protocols

1) **PANEL**: As a grid-based hierarchical algorithm in WSNs, PANEL (position-based aggregator node election protocol) [49], [50] uses the geographical position information of the nodes to determine the aggregators of the nodes. The most distinctive feature of PANEL is that it can satisfy both synchronous and asynchronous applications. In PANEL, the network is divided into several geographical clusters. A reference point is computed

in each cluster by the nodes with respect to the position of the lower-left corner of cluster. The node that is the closest to the reference point is elected the CH. In the next epoch, the reference points and the CHs will be re-selected. There are two types of transmission manners, intra-cluster transmission and inter-cluster transmission. The intra-cluster transmission is to deliver a message to the aggregator of a specific cluster. It takes advantage of the communications within the cluster during the process of aggregator selection. The inter-cluster transmission is to deliver messages between the BS and distant clusters.

2) **TTDD**: TTDD (two-tier data dissemination) approach [51] is a grid-based protocol in which there exist multiple mobile sinks. Initially a grid structure is established when the network is divided into multiple cells with several dissemination nodes. Such dissemination nodes are responsible for relaying query message to proper sources. Whenever sinksrequire specific data, they query the whole network by a flooding manner until such queries are relayed to the source nodes. A source, at one crossing point of the grid, propagates data announcements to reach the other dissemination points by greedy geographical forwarding. When the message arrives at a node that is closest to the crossing point, it stops. This propagation process continues until the message reaches the boundary of the network. All sinks can move from one cell to another and each sink locally floods query messages within the cell to find the nearest agent node of the source. When a sink plants to move out of reach from communication with a primary agent node, it selects an immediate agent node which acts as a bridge between the primary agent node and the sink.

HGMR: HGMR (hierarchical geographic multicast routing) [53] is a typical grid-based hierarchical protocol which combines the advantages of two previous location-based hierarchical protocols, GMR [54] and HRPM [55]. GMR is used to improve the forwarding efficiency while HRPM is used to reduce the encoding overhead. In HRPM, the whole network is hierarchically partitioned into multiple cells using the mobile geographic hashing idea. Each cell has an Access Point (AP) which manages the location information of the destinations in the corresponding cell. All APs are managed by an only Rendezvous Point (RP) of the network. There are two overlay trees, the Source–to–AP tree and the

4) **GMCAR**: Grid-based Multipath with Congestion Avoidance Routing (GMCAR) [56] is a grid-based multipath routing scheme. In GMCAR, the network is divided into several grids, where each grid consists of a master node and multiple ordinary nodes. The master node has two tasks. One is to deliver data from ordinary nodes of the same grid, and the other is to forward data from other neighbor master nodes. Each master node has a routing table which stores multiple diagonal paths from the master node to the sink. Two important

factors, grids densities and hop count, are taken into account for routing selection. According to traffic density of the grids, the network in GMCAR is also classified into two types of grids: boundary grids with low traffic and non-boundary grids with high traffic. GMCAR has two different routing schemes, multiple diagonal paths to the sink for the non-boundary grids, and a single path to the sink for the boundary grids. Furthermore, congestion mitigation is achieved by traffic sharing mechanism in which a secondary master node is selected.

D. Area-Based Hierarchical Routing Protocols

1) **LBDD**: LBDD (Line-based Data Dissemination) [57] is a typical area-based routing protocol, in which the network is divided into two equal parts by a vertical strip or line of nodes. The nodes on this strip or line are referred to as inline nodes. This line acts as a rendezvous region for data storage and lookup. It assumes that each node knows its geographic location and network geographic boundaries. The operation of LBDD includes two main steps: dissemination and collection. In the former step, when an ordinary sensor node generates new data, it forwards the data to the nearest inline node. In the latter step, a sink sends a query to the line in a perpendicular direction. The first inline-node which receives this query propagates it in both directions along the strip or line until it reaches the inline-node storing the data. After that, the data is delivered directly to the sink.

2) **Ring Routing**: Ring Routing [59] proposes a ring topology in which the ring consists of a one-node-width, closed strip of nodes that are called the ring nodes. After the formation of the ring, neighbor discovery is performed to determine the neighboring ring nodes. The ring acts as a rendezvous for the events and queries. The sink communicates with the ring by forwarding packets of its location information towards the network center by a follow-up manner, and the ring nodes conserve the current information of the sink at all times. The source nodes query the ring by a similar commu-nication way. Moreover, the ring structure can be changed to prevent the ring nodes from dying quickly. So, the ring nodes must switch roles with regular nodes from time to time.

3) **Railroad**: A data dissemination architecture named Railroad was presented for large-scale WSNs [60]. This routing protocol proactively designs a virtual infrastructure called Rail which is a specific area where all the metadata of event data are stored. There is only one Rail which acts as a rendezvous area of the events and the queries. Rail is located in the middle area of the network so that each node can easily access it. Once a query is issued, it is delivered around Rail for relevant data stored in Rail. Once a relevant metadata appear, the source node of the data delivers such data to the sink which has issued the query.

Queries issued by the sink travel on the rail by unicasts rather than broadcasts. This is the difference between Railroad and LBDD.

4) **VLDD**: Virtual Line-based Data Dissemina-tion (VLDD) [61] is proposed to achieve energy-efficient and reliable data transmission. VLDD designs a Virtual Line Structure (VLS) for data storage. The VSL is a specific area for data collection and information delivery. When a source node receives the location information of a mobile sink group, it calculates the entry point of the VLS. If an entry node receives data packets from a source, it delivers the data to its neighbor node of the VLS. Then, the neighbor node transmits the data to its neighbor node of the VLS. Ultimately, the data reach the exist node of the VLS. When a sink in a group wants to obtain data packets from VLS, it sends a query packet toward VLS and follows one of two cases by the flag value, True or False. When a sink has False value in its flag, it means that the LS finished the group region calculation. Then, the sink obtains data packets from the VLS. When a sink has True value in its flag, it means that the LS collected the location information of sinks to calculate new actual group region. To process this case, two steps are performed. In the first step, the sink obtains the current location information of the actual sink group region from the LS agent. In the second step, the sink achieves the location of the new VLS and sends a query to the new VLS.

CONCLUSION

WSNs have pulled in expanding attention as of late for their broad applications. Because of the restricted assets, routing is loaded with challenges in WSNs and coherent topology assumes a pivotal part in routing plan of asset constraint networks. Previously, much effort has been made in planning viable hierarchical routing conventions for WSNs based on various coherent topologies. In this paper, a review of coherent topologies and hierarchical routing is given. All the more particularly, hierarchical routing for WSNs is separated into five classifications, including bunch based, chain-based, tree-based, grid-based, and area-based topologies. Additionally, unique coherent topologies for hierarchical WSNs have been examined by various sensible topologies, including their attributes, points of interest and disservices. Additionally, different hierarchical routing conventions for WSNs have been examined in detail. From that point forward, hierarchical routing conventions for WSNs have been contrasted agreeing with a few performances. At last, some open issues have been pointed out.We trust that this review not just gives a more sweeping comprehension of consistent topologies and hierarchical routing for perusers, yet in addition assists analysts and framework architects with selecting proper intelligent topologies and hierarchical routing conventions for their particular applications.

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