Journal of Contemporary Issues in Business and Government Vol. 26, No. 02, 2020
https://cibg.org.au/

P-ISSN: 2204-1990; E-ISSN: 1323-6903
DOI: 10.47750/cibg.2021.26.02.275

A Survey On Importance Of Routing Protocol In WSN

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Abstract
Many novel protocols specifically intended for sensor networks where energy awareness is an important concern have emerged as a result of recent improvements in wireless sensor networks. The routing protocols, on the other hand, have gotten the most attention because they might alter based on the application and network architecture. This research examines modern sensor network routing protocols and assigns a classification to the various methodologies taken. Data-centric, hierarchical, and location-based are the three key types examined in this paper.
These networks are made up of a huge number of tiny devices known as sensor nodes. The sensor nodes connect with one another using a variety of wireless communication methods. Routing protocols are in charge of these communication mechanisms.
This research examines modern sensor network routing protocols and assigns a classification to the various methodologies taken. Data-centric, hierarchical, and location-based are the three key types examined in this paper.
WSNs are defined by denser node deployment, increased sensor node unreliability, and severe power, compute, and memory constraints. Various design issues for routing protocols in WSNs are highlighted, including energy efficiency, data delivery models, quality of service, overheads, and so on.
Keywords: Energy Efficiency,Routing protocols,Sensors, WSN

Introduction

The WSN(Wireless Sensor Network) generally used in the research literature comes in the form of large number of small chips, resource constrained sensor and a few base stations or sinks.Mostly in WSN settings sensors collect data from the environment and send it hop by hop to the sink.A sink serves as a gateway to another network, a data processing or storage center, or an access point for human interface.WSN deployment can be ad-hoc.Many sensors connect to controllers and processing stations directly,an increasing number of sensors communicate the collected data wirelessly to a centralized processing station.It is important as many network application need hundreds or thousands of sensor nodes that often deployed in remote and inaccessible areas[1].

With the popularity of laptops,cell phones ,global positioning system(GPS) devices and intelligent electronics,computing devices have become cheaper.WSN consists of large number of small low cost,low power and multifunctional sensor nodes where each node has a processing capability,multiple types of memory,radio frequency(RF) transceiver and a power

P-ISSN: 2204-1990; E-ISSN: 1323-6903
DOI: 10.47750/cibg.2021.26.02.275

source.The nodes accommodate sensors and actuators[2].In many applications,the deployment of sensor nodes is performed in an adhoc fashion.After the sensor nodes communicate wirelessly and self organize into an appropriate network infrastructure often with multihop connections among sensor nodes.Sensor nodes are typically battery-powered and should operate without attendance for arelatively longer period of time.Mostly,it is very difficult and even impossible to change or recharge batteries for the sensor nodes.The design of routing protocols in WSNs is challenging because of several network constraints with an emphasis on energy efficiency.

A wireless sensor comprises not only a sensing component but also on-boardingprocessing,communication,and storage capabilities.A sensor node is often not only for data collection but also for in-network analysis.When many sensors cooperatively monitor large physical environments,they form a wireless sensor network.Sensor nodes communicate not only with each other but also with a base station.Wireless networks is an emerging new technology that will allow users to access information and services electronically,irrespective of their geographic position.[3]

The sensor nodes have significantly lower communication and computation capabilities than do the full-featured computers participating in ad hoc networks.The problem of energy resources is especially difficult[4].Due to their deployment model,the energy source of the sensor node is considered nonrenewable.Routing protocols deployed in sensor networks need to consider the problem of efficient use of power resources.Sensor networks are composed of resource constrained sensor nodes and more resource base stations.The communication cost of all nodes in a network communicate with each other is much higher than its computational cost.Moreover,the energy needed to transmit a message is about twice as great as the energy needed to receive the same message.The route of each message destined to the base station really crucial in terms network lifetime.On the other hand,using a long route composed of many sensor nodes can significantly increase the network delay.

The Components of WSN:

The main components of a WSN are the sensor nodes,the sink(Base Station) and the events being monitored.The communication among the nodes is low-power wireless link while the communication between the base stations low latency and higher bandwidthlink.[5,6].

Base Station(Sink)

The sink is an interface between the external and computational world.There can be single or multiple base stations in a network.Practically,the use of multiple base stations decreases network delay and performs better using robust data gathering.[6]

The Sensor Nodes

A sensor node comprises of four basic components: Sensing unit,Processing unit,Transceiver unit and a power unit.[1]

Routing Challenges in Sensor Networks

Energy Consumption:Due to the limited battery power,it becomes challenging to perform computation and transmission while optimizing energy consumption.[2].The transmission of one bit of data consumes more energy than processing the same bit of data.Sensor node life time strongly depends on its battery life.

Node Deployment:Sensor nodes are usually densely deployed in the field of interest depending on application thus influencing the performance of a routing protocol.The

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DOI: 10.47750/cibg.2021.26.02.275

deployment can be either deterministic or self-organizing.In deterministic case,the sensor nodes are manually placed and sensed data is routed through determined paths.In selforganizing systems,sensor errors are scattered randomly creating a topology in an adhocmanner.[7]

Data delivery Models:Data delivery models can be time driven,data driven and hybrid depending on the application of sensor nodes and timing of data reporting.These data delivery models highly influence the design of routing protocols.[8,9].

Network Dynamics:Mostly, the sensor nodes are static but the mobility of base stations and sensor nodes is necessary in some applications.[10].In addition to minimizing energy consumption and bandwith utilization,the routing packets becomes challenging.

Data Aggregation:As sensor nodes generate duplicate data,cluster heads or base stations may receive similar packets from multiple nodes.These packets need to be aggregated before being forwarded to the base station.Signal processing methods can also be used for data aggregation.[11].

WSN Routing Protocols

Routing is a process of determining a path between the source node and the sink(destination)node upon request of data transmission.In WSNs ,the network layer is mostly used to implement the routing of the incoming data.Generally ,in multi-hop networks the source node cannot reach the sink directly. So, intermediate sensor nodes have to relay their packets. The implementation of routing tables gives the solution. These contain the lists of node option for any given packet destination. Routing table is the task of the routing algorithm along with the help of the routing protocol for their construction and maintenance [1] WSN Routing Protocols can be classified into five ways, according to the way of establishing the routing paths, according to the network structure, according to the protocol operation, according to the initiator ofcommunications, and according to how a protocol selects a next-hop on the route of the forwardedmessage.

Path establishment Based Routing Protocols:

Routing paths can be done in one of three ways, namely proactive, reactive or hybrid.

Proactive protocols calculate all the routes before they are really required and then store these routes in a routing table in each node. Reactive protocols compute routes only when they are needed. Hybrid protocols use a combination of these two ideas [5].

Proactive Protocols:

Proactive routing protocols are maintaining consistent and accurate routing tables of all network nodes using periodic dissemination of routing information. In this type of routing, all routes are computed before their needs. Most of these routing protocols can be used both in flat and hierarchal structured networks. The advantages of flat proactive routing is its ability to compute optimal path which requires overhead for this computation which is not acceptable in many environments. While to meet the routing demands for larger ad hoc networks, hierarchal proactive
routing is the better solution [12].

Reactive Protocols

Reactive routing strategies do not maintain the global information of all the nodes in a network rather the route establishment between source and destination is based on its dynamic search according to demand. In order to discover route from source to destination, a

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route discovery query and the reverse path is used for the query replies. Hence, in reactive routing strategies, route selection is on demand using route querying before route establishment. These strategies are different by two ways: by reestablishing and re-computing the path in case of failure occurrence and by reducing communication overhead caused by flooding on networks[12].

Hybrid Protocols

This strategy is applied to large networks. Hybrid routing strategies contain both proactive and reactive routing strategies. It uses clustering technique which makes the network stable and scalable. The network cloud is divided into many clusters and these clusters are maintained dynamically if a node is added or leave a particular cluster. This strategy uses proactive technique when routing is needed within clusters and reactive technique when routing is needed across the clusters. Hybrid routing exhibit network overhead required maintaining clusters[12].

Network Based Routing Protocols

Protocols are divided on the basis of structure of network which is very important for the required operation.The protocols are further divided into three subcategories on the basis of functionalities:

- **Flat-Based Routing**

When huge amount of sensor nodes are required, flat based routing is needed where every node plays same role. Since the number of sensor nodes is very large so it is not possible to assign a particular identification (Id) to each and every node. This leads to data-centric routing approach in which Base station sends query to a group of particular nodes in a region and waits for response.

Examples of Flat-based routing protocols are [12,13,14].

o Energy Aware Routing (EAR).
o DirectedDiffusion (DD).
o Sequential Assignment Routing (SAR).
o Minimum Cost Forwarding Algorithm(MCFA).
o Sensor Protocols for Information via Negotiation (SPIN).
o Active Query forwarding Insensor network (ACQUIRE).

- **Hierarchical-Based Routing**

When network scalability and efficient communication is needed, hierarchical-based routing is thebest match. It is also called cluster based routing. Hierarchical-based routing is energy efficientmethod in which high energy nodes are randomly selected for processing and sending data whilelow energy nodes are used for sensing and send information to the cluster heads. This property ofhierarchical-based routing contributes greatly to the network scalability, lifetime and minimumenergy. Examples of hierarchical-based routing protocols are; [12,13,14]In hierarchical architecture, sensor nodes are organized into clusters, where a node with lowerenergy can be used to perform the sensing task and send the sensed data to its cluster head at shortdistance, while a node with higher energy can be selected as a cluster head to aggregate the datarom its members and forward it to the sink [15]. This process can

P-ISSN: 2204-1990; E-ISSN: 1323-6903
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not only reduce the energyconsumption, but also balance traffic load and improve the scalability [16].

- Hierarchical Power-Active Routing (HPAR).
- Threshold sensitive energy efficient sensor network protocol (TEEN).
- Power efficient gathering in sensor information systems.
- Minimum energy communication network (MECN).

- **Location-Based Routing**

In this type, sensor nodes are scattered randomly in an area of interest andmostly known by the geographic position where they are deployed. They are located mostly bymeans of GPS. The distance between nodes is estimated by the signal strength received from those nodes and coordinates are calculated by exchanging information between neighboring nodes.Location-based routing networks are; [12,13,14]

In most cases, location information is needed to calculate the distance between two particular

nodes so that energy consumption can be estimated.

Geographic Adaptive Fidelity (GAF) protocol[17] is a location based protocol although proposed for Mobile Adhoc Networks (MANETs), itfavors energy conservation and thus can be used for WSNs.

Geographic Adaptive Fidelity (GAF) : If the region to be sensed is known, using the location of

sensors, query can be diffused only to that region thus reducing the number of transmissions

significantly. It is possible to locate nodes through satellites or GPS (Global Positioning System) on the basis of the signal strength passed between neighbor nodes. The common approach for energy saving is to use sleep modes in nodes expecting no activity in a period of time.

- Sequential assignment routing (SAR)

It is a set of algorithms which performs organization and mobility management in sensor networks. The sequential assignment routing (SAR) algorithm creates multiple trees, where the root of each tree is a one-hop neighbour of the sink. Each tree grows outward from the sink and avoids nodes with low throughput or high delay. Each sensor node records two parameters about each path through it: the available energy resources on the path and an additive QoS metric such as delay.

- Ad-hoc positioning system (APS).

A distributed, hop by hop positioning algorithm, that works as an extension of both distance vector routing and GPS positioning in order to provide approximate location for all nodes in a network where only a limited fraction of nodes have self location capability.

- Geographic adaptive fidelity (GAP).

  Geographic Adaptive Fidelity or GAF [17] is an energy aware location-based routing algorithm designed primarily for mobile ad hoc networks, but is used in sensor networks as well. This protocol aims at optimizing the performance of wireless sensor networks by identifying equivalent nodes with respect to forwarding packets.

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- Greedy other adaptive face routing (GOAFR).
  In mobile ad hoc networks, GOAFR+ (greedy other adaptive face routing plus) has a strong point that guarantees the packet delivery to the destination with low cost by combining greedy forwarding and face routing. In face routing mode, GOAFR+ uses the boundary circle to restrict a searching area. However, since the boundary circle is used without any location information of neighbours, it caused unnecessary expansion of boundary circle frequently. In this paper, we propose an efficient GOAFR+ based on adaptive boundary circle called GOAFR Plus-ABC (greedy other adaptive face routing plus adaptive boundary circle) to minimize expansion of boundary circle by using location information of neighbours in face routing mode.
- Geographic and energy aware routing (GEAR).
  The Geographic and Energy Aware Routing (GEAR) algorithm uses energy aware neighbour selection to route a packet towards the target region and Recursive Geographic Forwarding or Restricted Flooding algorithm to disseminate the packet inside the destination region.
- **Geographic routing**

Geographic routing is a routing principle that relies on geographic information. It is mainly proposed for wireless networks and based on the idea that the source sends a message to the geographic location of the destination instead of using the network address. In the area of packet radio networks, the idea of using position information for routing was first proposed in the 1980s[1] for interconnection networks. Geographic routing requires that each node can determine its own location and that the source is aware of the location of the destination. With this information, a message can be routed to the destination without knowledge of the network topology or a prior route discovery.

Operation Based Routing Protocols

Routing protocols are classified according to their functionalities. It is done in order to achieve optimal performance and to save the scarce resources of the network.

• Multipath Routing Protocols

As its name implies, protocols included in this class provides multiple path selection for a message to reach destination thus decreasing delay and increasing networkperformance. Network reliability is achieved due to increased overhead. Since network paths are kept alive by sending periodic messages and hence consume greater energy. Multipath routingprotocols are [12] :

o Multi path and Multi SPEED (MMSPEED).
It is a packet delivery mechanism called Multi-Path and Multi-SPEED Routing Protocol (MMSPEED) for probabilistic QoS guarantee in wireless sensor networks. The QoS provisioning is performed in two quality domains, namely,

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timeliness and reliability. Multiple QoS levels are provided in the timeliness domain by guaranteeing multiple packet delivery speed options. In the reliability domain, various reliability requirements are supported by probabilistic multipath forwarding. These mechanisms for QoS provisioning are realized in a localized way without global network information by employing localized geographic packet forwarding augmented with dynamic compensation, which compensates for local decision inaccuracies as a packet travel towards its destination. This way, MMSPEED can guarantee end-to-end requirements in a localized way, which is desirable for scalability and adaptability to large scale dynamic sensor networks.

- Sensor Protocols for Information via Negotiation (SPIN)

SPIN is a negotiation-based protocol and is among the early work to pursue a data-centric routing mechanism. The idea behind SPIN is to name the data using high level descriptors or meta-data. Before transmission, meta-data are exchanged among sensors via data advertisement mechanism, which is the key feature of SPIN. Each node upon receiving new data, advertises it to its neighbours and interested neighbours, i.e., those who do not have the data, retrieve the data by sending a request message.

Query Based Routing Protocols

In this protocol, it works on sending and receiving queries for data.The destination node sendsquery of interest from a node through network and node with this interest matches the query andsend back to the node which initiated the query. The query normally uses high level languages.

Query based routing protocols are [12] :

Sensor Protocols for Information via Negotiation (SPIN).

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Directed Diffusion (DD)

Directed diffusion is a data-centric, energy saving dissemination technique for wireless sensor networks. In directed diffusion, the human operator's query would be transformed into an interest. The interest is then diffused throughout the network nodes (called source).

COUGAR.

Another data-centric protocol called COUGAR[18] views the network as a huge distributed database system. The key idea is to use declarative queries in order to abstract query processing from the network layer functions such as selection of relevant sensors and so on. COUGAR utilizes in-network data aggregation to obtain more energy savings. The abstraction is supported through an additional query layer that lies between the network and application layers. COUGAR incorporates an architecture for the sensor database system where sensor nodes select a leader node to perform aggregation and transmit the data to the BS.

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Negotiation Based Routing Protocols

This class of protocols uses high level data descriptors to eliminate redundant data transmission through negotiation. These protocols make intelligent decisions either for communication or other actions based on facts such that how much resources are available. Sensor Protocols for Information via Negotiation (SPAN):

Span builds on the observation that when a region of a shared-channel wireless network has a sufficient density of nodes, only a small number of them need be on at any time to forward traffic for active connections. Span is a distributed, randomized algorithm.

Sequential assignment routing (SAR).

The sequential assignment routing (SAR) algorithm creates multipletrees, where the root of each tree is a one-hop neighbour of the sink. Each tree grows outward from the sink and avoids nodes with low throughput or high delay. At the end of the procedure, most nodes belong to multiple trees.

Direct Diffusion

Direct Diffusion is a routing protocol, which enables communication between sink and source nodes in random and mesh topology networks. This routing protocol is based on a data-centric approach, where intermediate nodes can aggregate data and send it to a sink node.

QoS Based Routing Protocols

In this type of routing, network needs to have a balance approach for the QoS of applications. In thiscase the application can delay sensitive so to achieve this QoS metric network have to look also forits energy consumption which is another metric when communicating to the base station. So toachieve QoS, the cost function forthe desired QoS also needs to be considered. Examples of suchrouting are: [12]

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SPEED.

SPEED is a highly efficient and scalable protocol for sensor networks where theresources of each node are scarce.

P-ISSN: 2204-1990; E-ISSN: 1323-6903
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Multi path and Multi SPEED (MMSPEED).

multipath multi-SPEED protocol for QoS guarantee of reliability and. ... Multiple QoS levels are provided in the timeliness domain by guaranteeing multiple packet delivery speed options. In the reliability domain, various reliability requirements are supported by probabilistic multipath forwarding.

Coherent and non-coherent processing:

Data processing is a major component in the operation of wireless sensor networks. Hence, routing techniques employ different data processing techniques. There are two ways of data processing-based routing [5]. Non-coherent data processing: In this, nodes will locally process the raw data before being sent to other nodes for further processing. The nodes that perform further processing are called the aggregators. Coherent data processing: In coherent routing, the data is forwarded to aggregators after minimum processing. The minimum processing typically includes tasks like time stamping, duplicate suppression, etc. When all nodes are sources and send their data to the central aggregator node, a large amount of energy will be consumed and hence this process has a high cost. One way to lower the energy cost is to limit the number of sources that can send data to the central aggregator node.

Initiator of Communication Based Routing Protocol

In this type of routing protocol, it depends on the communication between a network component, where they usually in sleep mode temporary. When any part of a network, the sink (destination, base station) node or the source node, needs service from other part, it will initiate the routing with other part to send or/and receive the control or data packets[5].

Source Initiator Routing Protocol.

The Dynamic Source Routing protocol (DSR) is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes. DSR allows the network to be completely self-organizing and self-configuring, without the need for any existing network infrastructure or administration.

- Destination Initiator Routing Protocol.
- Next-Hop Selection Based Routing Protocols
- Content-based routing protocols

The Content-Based Router examines the message content and routes the message onto a different channel based on data contained in the message. The routing can

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DOI: 10.47750/cibg.2021.26.02.275

be based on a number of criteria such as existence of fields, specific field values etc.These protocols determine the next-hop on the route purely based on the query content. This type of routing protocols fits the most to the architecture of sensor networks, since the base station do not query specific nodes rather it requests only for data regardless of its origin[13, 14].

Directed Diffusion.

Directed Diffusion is a data transmission approach that is particularly well suited to distributed sensing settings.

GBR

The Gradient Based Routing (GBR) broadcast of interest messages in Wireless Sensor Networks (WSNs) causes significant packets duplications and unnecessary packets transmissions. This results in energy wastage, traffic load imbalance, high network traffic, and low throughput.

Energy Aware Routing.

Energy-Aware Routing Protocol (ERP) ERP is a query-based routing protocol designed to consider both energy and distance while routing packets across a network.

Probabilistic routing protocols

These protocols assume that all sensor nodes are homogeneous and randomly deployed. Using this routing protocol, sensor nodes randomly select the next-hop neighbor for each message to be forwarded. The probability of selecting a certain neighbor is inversely proportional to its cost[13].

- Energy Aware Routing Protocol.
- Location-based routing protocols

These protocols select the next-hop towards the destination based on the known position of the neighbours and the destination. The position of the destination may denote the centroid of a region or the exact position of a specific node. Location-based routing protocols can avoid the communication overhead caused by flooding, but the calculation of the positions of neighbours may result extra overhead. The local minimum problem is common for all decentralized location-based routing protocols: it might happen that all neighbours of an intermediate node are farther from the destination than the node itself. In order to circumvent this problem, every protocol uses different routing techniques [13].

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GEAR (Geographical and Energy Aware Routing).

GEAR(**Geographic and Energy Aware Routing**) [12,13,14,19], is a location-based routing protocol which takes energy conservation as a major area of concern in routing the data from source to sink. It uses an energy aware neighbour selection and forwards the packet in recursive manner.

Hierarchical-based routing protocols

In case of hierarchical protocols, all nodes forward a message for a node (also called aggregator) that is in a higher hierarchy level than the sender. Each node aggregates the incoming data by which they reduce the communication overload and conserve more energy. Therefore, these protocols increase the network lifetime and they are also well-scalable. The set of nodes which forward to the same aggregator is called cluster, while the aggregator is also referred as cluster head. Cluster heads are more resourced nodes, where resource is generally means that their residual energy level is higher than the average. The reason is that they are traversed by high track and they perform more computation (aggregation) than other nodes in the cluster. Hierarchical routing is mainly two-layer routing where one layer is used to select cluster heads and the other layer is used for routing. [13,14].

Hierarchical or cluster-based routing, originally proposed in wireline networks, are well-known techniques with special advantages related to scalability and efficient communication. As such, the concept of hierarchical routing is also utilized to perform energy-efficient routing in WSNs. In a hierarchical architecture, higher energy nodes can be used to process and send the information while low energy nodes can be used to perform the sensing in the proximity of the target. This means that creation of clusters and assigning special tasks to cluster heads can greatly contribute to overall system scalability, lifetime, and energy efficiency. Hierarchical routing is an efficient way to lower energy consumption within a cluster and by performing data aggregation and fusion in order to decrease the number of transmitted messages to the BS. Hierarchical routing is mainly two-layerrouting where one layer is used to select clusterheads and the other layer is used for routing.However, most techniques in this category are not about routing, rather on “who and when to sendor process/aggregate” the information, channel allocation etc., which can be orthogonal to themultihop routing function.

LEACH (Low Energy Adaptive Clustering Hierarchy) protocol.

Low-energy adaptive clustering hierarchy ("LEACH") is a TDMA-based MAC protocol which is integrated with clustering and a simple routing protocol in wireless sensor networks (WSNs).

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Broadcast-based routing protocols

The operation of these protocols is very straightforward. Each node in the network decidesindividually whether to forward a message or not. If a node decides to forward, it simply re-broadcasts the message. If it declines to forward, the message will be dropped [13].

- MCFA (Minimal Cost Forwarding Algorithm).

Minimum Cost Forwarding Algorithm (MCFA) [12,13,14]computes the least cost from each node to the Base Station (BS). If the node is in the shortest path, the node retransmits the data; the same procedure repeats until the packet reaches the BS. Nevertheless, computing and updating the Minimum Cost generates overhead. A Gossiping protocol requires that a node receiving a packet retransmit it with a probability less than 1.0, which improves upon flooding performance because if the packet is not retransmitted, there is one less duplicate in the network. However, sensor nodes using Gossip waste energy receiving a packet if that packet is not retransmitted. The Gossip-based Sleep Protocol (GSP) improves on Gossiping because it drops a packet by not receiving it. If a packet is received it will be retransmitted, so energy spent for receiving is not wasted. GSP divides time in Gossip Periods with fixed duration. At the beginning of each gossip period, every node decides with probability p, the Gossip Probability, to turn off its radio, and with probability (1-p) to turn it on, ready to receive. A node receiving one packet must retransmit it in the following gossip period. All sleeping nodes must wake up in the next gossip period. A node can be in one of three possible states: On Receiving, On Transmitting and Off.

Conclusion

When compared to routing in typical wired networks, routing in WSN has gotten a lot of attention, which has led to several unique challenges and design issues. addresses data routing in sensor networks and divides the methods into three groups: data-centric, hierarchical, and location-based. In this paper, we reviewed recent research on routing in WSNs and divided routing algorithms in sensor networks into three categories: data-centric, hierarchical, and location-based.

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