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A Survey on the Energy Efficient Protocols in Wireless Sensor Networks

[1]Preethi Dsouza, [2]Dr. H S Guruprasad

[1]PG Scholar, Dept. of ISE, BMSCE, Bangalore, India

[2]Professor and Head, BMSCE, Bangalore, India

drhsguru@gmail.com

ABSTRACT

Wireless sensor networks are formed by deployment of numerous sensor nodes on a wide area. These sensor nodes are limited in energy supply and bandwidth which pose many challenges in maintenance of sensor networks. Thus, intelligent usage of available energy through optimal route setup and reliable data transmission across sensor networks is vital in order to maximize lifetime of the network. This paper gives an overview of various routing protocols based on energy efficiency and QoS through which optimal data exchange is carried out in wireless sensor networks.

INTRODUCTION:

Wireless sensor nodes are tiny and low power devices which are capable of data processing and transmission. These sensor nodes perform sensing of their surrounding environment and collectively forward this data to the sink node either directly or through intermediate nodes. Sink nodes carry the application specific analysis and computations of gathered information. With the advancement of Micro-sensors with reduced cost and size, monitoring of sensing activity and coordination among sensor nodes plays a key role in increasing the lifetime of the network.

Constrained power supply is one of the key distinguishing characteristic of wireless sensor networks in comparison to traditional ad-hoc networks. Most of the power utilization is done in routing of data. Classical IP based protocols cannot be employed to wireless sensor networks as the number of nodes deployed in particular vicinity are huge. Data aggregation from multiple nodes, forwarding as well as elimination of redundant data are other factors which add on to power consumption and must be carefully monitored.

Numerous algorithms have been proposed to route the data in a more efficient way so as to minimize energy consumption in addition to the fulfilment of application specific requirements. Various protocols have been proposed in literature that belong to one of the above specified protocol categories. However, recent protocols have shifted their focus on multipath routing and QoS factors to address speed and efficiency need of modern world. In this paper, we have done a detailed survey on existing protocols in the field of wireless sensor networks.

LITERATURE SURVEY:

Siva D. Muruganathanet. al. [1] proposes a new protocol called Base Station Controlled Dynamic Clustering Protocol (BCDCP) where each node is identified using their geographic location of deployment. In BCDCP protocol, base station gets current energy status of all nodes and selects Cluster Heads which are above threshold energy level. Low energy routing path is formed using minimum cost spanning tree which is then used to transmit data to base station. Ruay-Shiung Chang et. al. [2] proposed Maximum Energy Cluster Head (MECH) protocol where cluster head broadcasts hello message to one-hop neighbour within certain radio range. Based on the number of responses received from neighbours (cluster number-CN), a node advertises itself as Cluster Head. This count is passed to Base Station which then calculates TDMA time slot under each cluster to transmit data. Nodes will keep their radio on and transmit data only in their respective time slots, while Cluster Head keeps it on all the time. Sung-Min Jung et. al. [5] discusses Concentric Clustering Scheme protocol which divides all nodes into levels of concentric form. Assignment to levels is carried out on the basis of number of nodes or location from base station. Every level forms a chain among its nodes and a node is elected as head node in turns. This cluster head gathers and aggregates data from nodes within same level and passes it to cluster head of next level neighbour to reach base station. Wan Norsyafizanet. al. [8] states a new protocol which is event driven and source initiated. Cluster head, does data aggregation in order to reduce number of transmissions and receivables and thus reducing network overhead.

Cluster heads are selected in such a way that they are at identical distance from base station thus reducing overall energy consumption of the network.

Stefanos et. al. [11] introduces ECHERP as a new energy efficient protocol. In ECHERP, base station collects data from all nodes (residual energy and distance) and selects cluster heads. Nodes that are directly connected to base station are taken as high level clusters. Nodes that are far use high level clusters for data transmission. BS then calculates cluster heads using algorithm and also tells number of rounds when each node can become cluster heads. It runs only once also turns off the radio to save energy when nodes do not transmit. Li Han et. al. [12] propose LEACH-HPR protocol where a new agent will be selected based on RSSI (Received Signal Strength Identifier) by the current agent. Agent CH will select a node with maximum residual energy and each node is assigned a timer based on its residual energy. Less time is set to a node with more energy and vice versa. All nodes start their counter down and broadcast advertisement message to become a cluster head to other nodes within a specified radius. If any node receives such advertisement from other nodes before timer expires it becomes non-cluster head. Else a node announces itself as a cluster head by sending message containing its ID and residual energy. Based on received signal strength and residual energy nodes join as members under CH's. CH choses a node with maximum residual energy in the cluster as it's assistant. Assistant CH will help in gather, aggregate data as well as assign tasks to member nodes whereas CH forwards data to BS. If CH is far away from BS a multi-hop routing algorithm is used to select an optimal shortest path to the destination with interim nodes. Residual energy of the interim node is also taken as factor for selection criteria. Xiaoyan Cui et. al. [13] uses K-means algorithm to calculate centroid of each cluster. Distance between nodes is measured based on RSSI (Received Signal Strength Identifier). The nodes nearer to centroid as well as maximum energy left are elected as CH. After certain threshold time T, each node randomly selects CH agents to reform cluster head. This protocol uses ant colony optimization routing algorithm to find optimal shortest multi-hop path to destination from CH to sink node. Ant control packets are sent which collect quality of path like delay, hop count etc. all the way till destination and way back to source to update routing table of all intermediate nodes. This routing table is later used for data transmission. Wenjun Liu et. al. [14] proposes a protocol which selects few CH's based on residual energy of the nodes and distance from the BS and broadcasts all this information to all the nodes in the network. Candidate CH's on receiver of this message calculate the distance to BS based on received signal strength. Clusters closer to BS have fewer nodes in it so that energy in intra-cluster communication is minimized and rest of the energy can be used for inter-cluster relay traffic. BS records the information and uses for multi hop routing to transmit form CH to BS. The normal nodes wake up and based on received signal strength it selects its CH and uses that to pass data. TDMA time slot is allocated to new joined neighbour.

Bao Xi-ronget. al. [15] discusses the protocol which does uneven clustering and uses Particle Swarm Optimization (PSO) algorithm to optimize the clusters. It contains four stages namely uneven clustering, selecting of cluster heads, formation of multi-hop routing among clusters and stable data transmission. In uneven clustering, clusters near base station have few cluster members so that intra-cluster communication is minimized and some energy will be used for inter cluster communication between cluster heads. In the second stage, selecting of cluster head PSO algorithm is used which selects CH's based on its residual energy as well as how well other nodes from the cluster can communicate with it in an efficient way consuming optimal energy. In third and final stages, i.e., Multi-hop communication and Data Transmission CH aggregates data generated from different cluster members and forwards it to the BS using Multi-hop communication. Lutful Karim et. al. [19] discuss Mobility-Centric Energy Efficient and Fault Tolerant Clustering Protocol [MEFC] which selects minimum number of active nodes in each cluster to increase energy efficiency. Alternative Cluster Head (ACH) and alternative nodes to each of the active node is used for fault tolerance. Data from both mobile nodes and mobile objects attached to sensor nodes are supported. It uses shortest Euclidean distance to select a data transmission path from a source node to BS. HendAlqamziet. al. [21] discuss a protocol where each node exchanges its ID and residual energy with its local neighbours that are within its communication range R. Each node compares its current energy level with the message from neighbour and accordingly Cluster Heads are finalized. Based on RSS other nodes join CH to form cluster. If there is single node in cluster, then it tries to join any other Cluster Head within range 2R else it remains as isolated cluster. This cycle is repeated periodically to optimize network lifetime. Zhao Han et. al. [22] discuss a General Self-organization Tree-based Energy-Balance Routing Protocol for WSN which works in three phases. In the initial phase, BS will broadcast a message to all the nodes and accordingly all nodes will calculate their energy level (EL).

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Each node can collect neighbour information by sending a query packet. In the Tree Construction Phase, BS selects new node as root node which can directly communicate to BS and broadcast's its ID to the network. Each node then selects a parent node based on the conditions that EL of root must be greater than itself and Distance from root to parent is less than root to itself. In the final phase, data is generated by leaf nodes and forwarded to parents where it fuses it with its own data until it reaches root. Root node finally forwards the data to base station.

Maher N. Elshakankiriet. al. [6] proposes Pairs energy efficient routing protocol (PEER) is the location based routing protocol. Nodes are grouped into regions based on their locality. Each node works with dual power modes where high power level is used for longer transmissions and low power level is used for shorter transmissions. HELLO-JOIN-ACK is exchanged to find a nearest partner to a given node. Node receiving HELLO messages from neighbour's replies to one of the nearest node based on highest RSS (Received Signal Strength) using JOIN message. The sender node on receiving of JOIN messages confirms it to the nearest node using ACK message. Once pair is formed one of the node is used for high power level transmission and other in low level transmission. Low level node turns on its receiver periodically to gather data from its neighbours and passes it on to high level node after which it turns off its receiver again. High level node keeps it's receiver on and gets data from its partner. When its energy level reduces to 0.6 from original it sets a flag to low level node to change the roles. Different partner will be found if one of the partner node exhausts of its energy.JisulChoeet. al. [16] proposes a protocol which selects the most efficient gradient path from source to sink by considering the available energy (AE) of the nodes along the path. Average available energy of the path is calculated using individual node's AE. The path with highest Average available energy is selected as the path for data transmission between source and sink. If two paths have same average available energy then path having minimum AE node will be discarded so as to avoid breaking the connection. Javed et. al. [18] proposes Spatial Vector Routing (SVR) protocol used to route data from point to point, point to region or even to global network. Instead of flooding the network for packet transmission it finds the optimal path. It does proximate node set-up by which each node identifies their proximate nodes. Node that is nearest to destination than the current node is chosen as next node and this continues until it reaches target. Thus path establishment move s in only direction rather than just flooding.

DanyanLuoet. al. [3] discusses Radius Self Adjust Energy Saving Routing Protocol (RSES) where the sensor node reduces its max transmission radius only to reach the farthest neighbour, before it sends the first packet. Data communication can be carried out in two different paths i.e. Asymmetric links. When the remaining energy of the node reaches a threshold value the transmission radius is readjusted. Mohammad et. al. [20] discuss EESPEED protocol where the neighbour set of each node is determined. Necessary information about nodes is gained by using beacon exchange message. Weight function is calculated by taking delay, residual facts into consideration. Node with highest value for weight function will be chosen as next hop forward node. Anfeng Liu et. al. [23] proposes a technique to enhance security in WSN as well as increase its lifetime. In this protocol, packets are sliced and each slice is sent in separate disjoint path to preserve the security as well as to maximize the lifetime of the network. This protocol employs Secure and Energy efficient disjoint route (SEDR) Algorithm which slices packets and forwards it in random paths from source node based on least-hop routing and finally aggregates the slices together. It preserves security as the attacker will not be able to get entire packet as a whole as it is sliced and sent over disjoint paths. Overall lifetime of network also increases as different nodes participate in data forwarding each time thus balancing the power consumption of nodes.

Kee-Young Shin et. al. [7] proposes REAR protocol, source node broadcasts Multipath-route request (MREQ) to get path to destination. Intermediate nodes on getting this request check their residual energy and accordingly forward the request until it reaches destination. Nodes having more energy forward request faster than compared to nodes having less energy. Accordingly two disjoint paths are selected which makes the network robust making data transfer in alternate path in case if there is link breakage in any one path. Alternate path is chosen even if energy level of first path falls below threshold. Destination node on receiver of data sends back the acknowledgement back to source. If there is a timeout, source retransmits the data. If any nodes fail to forward data to next node then it sends error message to source which then choses the alternate path for transmission. Nidal Nasser et. al. [9] discuss the working of SEEM protocol is carried out in three phases i.e., Topology Construction, Data Transmission and Route Maintenance. In Topology Construction, base station sends neighbour discovery (ND) message to whole network. It waits for some time and then sends Neighbours Collection (NC) to collect neighbour's

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information of all the nodes. In data transmission phase, base station sends data enquiry (DE) message. If node satisfy the enquiry it replies with data enquiry reply (DER) else redirect the packet. The base station uses Breadth First Search (BFS) algorithm to select shortest path from source to destination and uses the same for data transmission. Shortest path must also satisfy that it has residual energy is more than required level. If there are multiple paths available for data transmission then it uses path with maximum residual energy to break the tie. In route maintenance phase, base station decreases the energy along the shortest path being selected by one. After certain rounds path calculation and selection of other energy efficient route will be done. Tuan Anh Le et. al. [10] proposes a routing technique which is driven by their energy costs and traffic loads. It improves throughput, load-balancing and energy efficiency by diverting more traffic from a congested and higher energy cost path to a better path thereby avoiding a single path being overloaded.

Guang Yang et. al. [4] states a routing protocol which combines both energy based strategy and direction-based geographical strategy. A common node selects Cluster Heads having forwarding angles satisfying restrictive conditions and whose energy is above threshold level. Data fusion is performed before moving data to next node. Slaheddine et. al. [17] discusses the protocol which avoids nodes with low remaining energy from becoming cluster heads. In multi hop transmission cluster heads near to BS exhaust first due to relay transmission. This protocol classifies nodes into either super nodes (more energy) or normal nodes(less energy). Base station selects and broadcasts IDs of cluster heads and super nodes to the network. Each node joins the cluster head which is more near to it. Cluster head accordingly assigns TDMA time slot to all nodes under it for data transmission. It turns off the radio otherwise to preserve energy. This completes first level clustering. In second level clustering cluster heads try to connect to one of nearby super nodes. Super nodes do not participate in clustering instead simply forward data sent by cluster head to base station. In Data transmission normal nodes transmit their data to cluster head only if the sensed value is greater than or equal to certain threshold. Cluster head aggregates data from multiple nodes under its cluster and forwards it to super node which in turn forwards it to base station. Ahmed et. al. [24] discuss a novel hybrid multi-hop routing algorithm, HTMN. It works on basis of Sink Connectivity Area (SCA) which is the area consisting of nodes in direct transmission range of the sink. Nodes in SCA perform more forwarding than sensing and hence die sooner compared to other nodes. When all nodes in SCA die, the sink node gets isolated from rest of the network leading to sink node isolation problem. The paper proposes an algorithm to maximize lifetime of SCA nodes by carefully minimizing the inflow of data to nodes and also lowering the energy consumption in relaying the data by each node in SCA. This technique uses hierarchical multi hop routing to manage inflow of data as well as flat routing technique to relay data within SCA. Shiva Murthy G et. al. [25] propose a secure Energy Efficient Node Disjoint Multipath Routing Protocol (EENDMRP) which is a sink initiated protocol. In route construction phase, sink node starts generating multipath to create routing tables at each node. Routing table contains details like node id, residual energy, number of hops away from sink, neighbour nodes public key etc. In data transmission phase, one of the primary path is chosen based on energy consumption rate, queue length etc. This algorithm employs RSA for public key cryptography and MD5 is used for obtaining digital signatures. Both public key and digital signatures secure data transmissions and make the network robust.

CONCLUSION:

Routing in wireless sensor networks is more challenging when compared to traditional data routing in wired networks. In this paper, an overview of several routing techniques in wireless sensor networks has been summarized.

Data centric approach focuses mainly on gathering and collectively forwarding data to nodes of interest either by broadcast or selective forwarding. Cluster-based routing protocols form group of sensor nodes to efficiently forward sensed data to the sink. Areas like cluster formation, selection of cluster head, data aggregation can still be explored. Location-based protocols use topological information of sensor nodes to efficiently utilize the energy of sensor nodes. Spatial queries and databases are some of the areas to be investigated and analysed further.

Emerging protocols majorly concentrate on energy efficiency to increase the lifetime of the network. Greater efforts are needed to guarantee Quality of Service (QoS) for real time applications with improved performance. Also, only few protocols focus on node mobility. Design of new and efficient algorithms to tackle these issues still remains challenging.

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