Comprehensive Survey of Network Architecture Based Routing Protocols for WSN

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Abstract— **Sensor networks are designed to monitor events and are application oriented by nature. Data propagation in these networks needs routing algorithms those are specifically designed for sensor networks. In past few years several novel routing techniques have been proposed and studied widely. This paper presents a brief survey of network architecture based routing algorithms and classifies them into different categories based on the routing approach pursued. Working methodology of protocols is explored along with merits and demerits. Paper concludes with property based comparison of protocols.**

Keywords- Routing, wireless sensor networks, clustering, sensor node, sink.

INTRODUCTION

Infrastructure of a wireless sensor network comprises of small nodes with sensing, computation, and wireless communication capabilities. Several characteristics of sensor network distinguish them from contemporary communication and wireless ad-hoc networks. Sensor nodes are tightly constrained in terms of transmission power, on-board energy, processing capacity and storage and thus require careful resource management. In a typical wireless sensor network, sensor nodes are battery powered and it makes energy efficiency a crucial issue because sensor nodes have limited energy capacity and death of a node can disrupt the operation and topology of network. Considering the usually random characteristics of the network deployment an intrinsic property of WSNs is that the network should be able to operate without human intervention for an adequately long time, since replacing the batteries of the sensor nodes requires significant effort. Hence energy conservation in sensor networks is an important issue. Many techniques for energy saving are developed, including MAC protocols[1], cross-layer design[2], routing protocols[3], compressive sensing[4], clustering[5][6] etc.

Routing techniques are required for communication among sensor nodes and base station. Effective and robust data propagation strategy results in significant energy conservation and load balancing throughout the network and hence increase network lifetime efficiently. Further sections in this paper provide comprehensive study of network architecture based routing techniques.

NETWORK ARCHITECTURE BASED APPROACHES

Network architecture based routing algorithms are designed based on the characteristics of sensor nodes along with mechanisms and architecture requirements. These algorithms are categorized as data centric, hierarchical and location based. In order to select the most suitable routing mechanism for a sensor application, we have to classify the routing protocols according to the network and operational characteristics and an objective model that describes the routing goal.

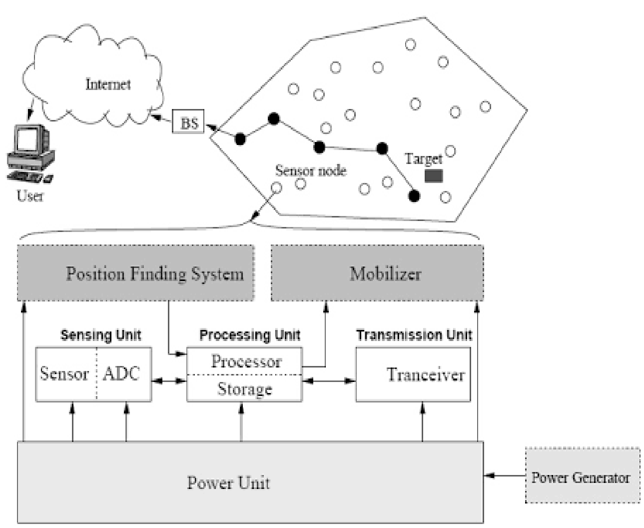
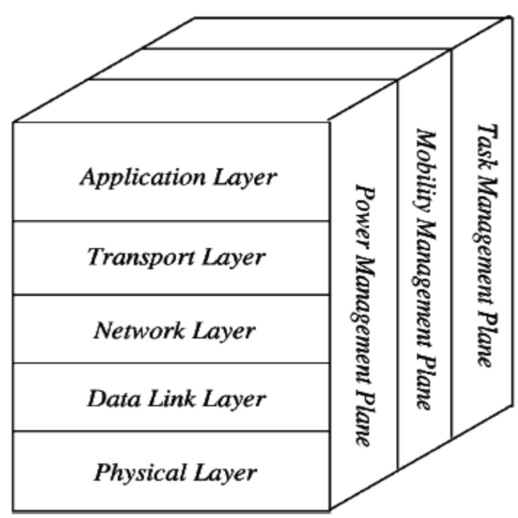


Figure1. a) WSN network architecture



b) Protocol stack for WSN

Data Centric Approach

Since transmitting data from every sensor node within the deployment region might result in redundant data and incur in unnecessary energy and traffic expenditure, routing protocols those are able to select a set of sensor nodes and utilize data aggregation in process of relaying data have been considered. In data-centric approach, data routing strategy is concerned with the information about event occurred. Since data are requested through queries, attribute-based naming is necessary to specify the properties of data. Sensor Protocol for Information via Negotiation (SPIN) [7] is first data-centric protocol, which considers data negotiation between nodes in order to eliminate redundant data and save energy. Later, Directed Diffusion [8] has been developed and has become a breakthrough in data-centric routing. Many other protocols have also been proposed based on Directed Diffusion, such as Energy aware routing [11], Rumor routing [14], Minimum Cost Forwarding Algorithm [15] and Gradient-Based Routing [16].

1) *Spin:* The design of SPIN [7] grew out of analysis of the different strengths and limitations, such as implosion, overlapping and resource blindness, of conventional flooding protocols for disseminating data in a sensor network. The main aim of SPIN is to reduce communication overhead and duplicate packets. Nodes running a SPIN communication protocol name their data using high-level data descriptors, called meta-data. Fig.2 shows the working mechanism of SPIN. There are three messages defined in SPIN to exchange data between nodes.

- ADV message to allow a sensor to advertise a particular meta-data,
- REQ message to request the specific data,
- DATA message that carry the actual data.

SPIN nodes can base their communication decisions both upon application- specific knowledge of the data and upon knowledge of the resources that are available to them. This allows the sensors to efficiently distribute data given a limited energy supply.

Sensors use meta-data to succinctly and completely describe the data that they collect. If x is the meta-data descriptor for sensor data X, then the size of x in bytes must be shorter than the size of X, for SPIN to be beneficial. If two pieces of actual data are distinguishable, then their corresponding meta-data should be distinguishable. Likewise, two pieces of indistinguishable data should share the same meta-data representation.

Merits and Demerit: In SPIN protocol, nodes need to know only the single hop neighbors in order to send the data and this property makes it possible to make changes in local topology. Main drawback of this protocol is that the data advertisement mechanism of SPIN does not guarantee the delivery of data. For instance, if the node interested in data is far away from source and the intermediate nodes are not interested in data then the data will not be delivered to the destination.

2) *Directed diffusion:* In [8] an on demand query based application aware protocol has been proposed named Directed diffusion. Attribute based naming is used in order to establish efficient n-way communication paths for fault tolerance and reconfiguration. Each sensor node generates an attribute-value pair (for example: motion-location, where motion is the attribute and location of motion is the value related to this attribute) for sensed event. Based on the attribute, the sink node may demand the information of event occurred in any particular area of sensor network. The sink initiates data gathering task by disseminating an interest, where interest is a range of values for attributes. Each intermediate node disseminates interests towards source sensor nodes based on the contents of the interest. An associated gradient is used to maintain the robustness of data propagation. The concept of gradient is useful when each intermediate node propagates the interest towards multiple neighbor, the path with higher gradient is chosen for data dissemination and thus a reverse source-to-sink path with different gradients is established.

Merits and Demerits: The diffusion model allows data caching and aggregation on intermediate nodes. This property of

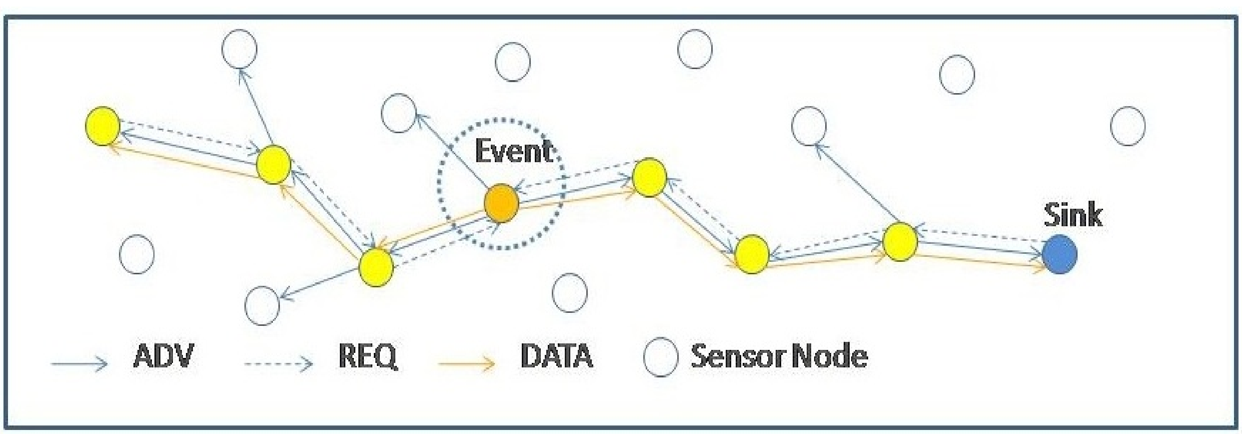


Figure 2. SPIN Protocol

energy and delay. It also increases the scalability of coordination by using the cached information for carful propagation of interest. Neighbor to neighbor communication does not need any node addressing mechanism. Because of being based on on-demand query-driven data delivery model, directed diffusion can't be applied to all the sensor network applications, especially which need continues data delivery, for example: environment monitoring. This routing protocol is application oriented.

3) Energy Aware: Always using lowest energy paths may not be optimal solution for increasing network lifetime and for long-term connectivity because it leads to energy depletion of the nodes along that path and in worst case may lead to network partition. Energy aware routing [11] increases the survivability of networks, by using sub-optimal paths occasionally and this ensures that the network degrades gracefully without getting partitioned. Multiple paths are found between source and destinations, and each path is assigned a probability of being chosen according energy metric. Every time data dissemination takes place, one of the paths is randomly chosen for sending the data depending on the probabilities. This protocol works in three phases:

a) *Setup phase:* Connection is initiated by destination node using localized flooding in the direction of source node. Request forwarding task is accomplished using routing tables. Energy metric is computed for each hop as follows:

$$C_{N_{ji}} = Cost(N_i) + \text{Metric}(N_j, N_i),$$

Where N_i represents sending node and N_j is represents receiving node. Only the paths with an optimal low cost are added to routing table and used for data forwarding. Each node assigns probability to each of its neighbors in forwarding table FT_j:

$$P_{N_{ji}} = \frac{1/C_{N_{ji}}}{\sum_{k \in FT_j} 1/C_{N_{jk}}}$$

The average cost, Cost (N_j) is set in "Cost" field of request packet:

$$\text{Cost}(N_j) = \sum_{k \in FT_j} P_{N_{ji}} C_{N_{ji}}$$

b) *Data propagation phase:* Source node sends data packet to any of the neighbors in forwarding table, with the probability of the neighbor being chosen equal to the probability in the forwarding table.

c) *Route maintenance phase:* Localized flooding is performed infrequently from destination to source to keep all the paths alive. It is similar to diffusion in certain ways. Multiple paths are maintained from source to destination. However, diffusion sends data along all the paths at regular intervals, while energy aware routing uses only one path at all times. But due to the probabilistic choice of routes, it can continuously evaluate different routes and choose the probabilities accordingly.

Merits and Demerits: Using probabilistic forwarding to send traffic on different routes provides an easy way to use multiple paths without adding much complexity or state at a node. Nodes also burn energy in a more equitable way across the network ensuring a more graceful degradation of service with time. Shah et al. select a single path randomly from the multiple alternatives in order to save energy. However, such single path usage hinders the ability of recovering from a node or path failure. In addition, the approach requires gathering the location information and setting up addressing mechanism for the nodes, which complicate route setup.

Hierarchical Routing

Hierarchical or cluster-based routing method, is two-layer routing, in which one layer containing higher- energy nodes named cluster heads, can be used to process and send the information, while at another layer low-energy nodes can be used to perform the sensing in the proximity of the target. Aim of hierarchical routing is to efficiently maintain the energy consumption of sensor nodes by involving them in multi-hop communication. Cluster formation is typically based on the several network metrics like energy reserve of sensors and sensor's proximity to the cluster head etc. Some of the clustering protocols are discussed.

LEACH: Reference [9] has proposed Low-Energy Adaptive Clustering Hierarchy, a self-organizing, adaptive clustering-based protocol that provides even energy load balancing throughout the network using randomization. LEACH uses localized coordination to enable scalability and robustness for dynamic networks, and incorporates data aggregation into the routing protocol. LEACH is completely distributed, requiring no control information from the base station, and the nodes do not require knowledge of the global network in order for LEACH to operate. In LEACH, the nodes organize themselves into local clusters, with one node acting as the local base station or cluster-head. Sensors elect themselves to be local cluster-heads at any given time with a certain probability. The operation of LEACH is broken up into rounds, where each round begins with a set-up phase, when the clusters are organized, followed by a steady-state phase, when data transfers to the base station occur. In order to minimize overhead, the steady-state phase is long compared to the set-up phase.

Set-up phase: This phase includes two sub phases:

Advertisement Phase: Initially for each round, each node decides whether it should be a cluster head or not. This decision is based on the predefined percentage of cluster heads for the network (P) and the number of times the node has been a cluster-head so far. This decision is made by the node n choosing a random number between 0 and 1. If the number is less than a threshold T (n), the node becomes a cluster-head for the current round. The threshold is set as:

$$T(n) = \begin{cases} \frac{P}{1 - P * (r \bmod \frac{1}{P})} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases}$$

Where r is current round and G is set of nodes that have not been cluster- head for last (1/P) rounds. Each elected cluster-head for current round broadcasts an advertisement message to the rest of the nodes using CSMA MAC protocol and same transmit energy. After completion of this phase, based on the received signal strength of the advertisement each non cluster head node decides the cluster to which it belongs.

Cluster Set-Up Phase: After each node has chosen its cluster, it informs the cluster head node that it will be a member of the cluster. Again CSMA MAC protocol is used for information forwarding.

Steady state phase: This phase also has two sub phases:

a) *Schedule Creation:* Based on the number of member nodes of cluster, cluster head node creates and broadcasts TDMA schedule to each member. Each member can transmit its data in this schedule.

b) *Data Transmission:* After creation of TDMA schedule data transmission can begin. It is assumed that nodes always have data to send. They send it during their allocated transmission time to the cluster head.

Merits and Demerits: LEACH minimizes global energy usage by distributing the load to all the nodes at different points in time. LEACH outperforms static clustering algorithms by requiring nodes to volunteer to be high-energy cluster-heads and adapting the corresponding clusters based on the nodes that choose to be cluster-heads at a given time. Distributing the energy among the nodes in the network is effective in reducing energy dissipation from a global perspective and enhancing system lifetime. LEACH is completely distributed and requires no global knowledge of network. LEACH uses single-hop routing hence it is not applicable to networks deployed in large regions. Furthermore, the idea of dynamic clustering brings extra overhead, e.g. head changes, advertisements etc., which may diminish the gain in energy consumption.

EWC: Energy-efficient, weighted clustering algorithm [10] improves the cluster formation process of LEACH by taking residual energy, mutual position, workload balance and MAC functioning in to consideration. To decide how well a node is suited to become a cluster head, several features like residual power, distance between cluster heads and node degree are taken into consideration. Each sensor node keeps a neighbor table which records necessary information about its neighbors such as neighbor ID, energy level, distance to neighbor and base station, state and weight.Each sensor node has three states: Initially, each sensor node keeps PRELIMINARY state. After cluster selection procedure, cluster head will mark its state in to CLUSTER_HEAD while cluster member changes its state from PRELIMINAFRY into CLUSTER_MEMBER. The algorithm uses the following steps to select a cluster header:

- At initial stage, base station will broadcast information message to the whole network. By estimating distance D_{bs} between sensor node and base station based on the strength of the signal received.
- In order to discover the neighbor, each sensor node broadcasts Neighbour Discovery message which contains its' ID, energy level and distance to base station, at random time. Node v receives message from neighbor at time $T_{neighbourdiscovery}$ and store them into its neighbour table. Number of entries in neighbour table refers to node degree.

  $D_v = |N(v)| = \sum_{w \in V, w \neq v} \{dist(v, w) < tx_{range}\}$
- Degree of diversity Δ_v for node v is

  $\Delta_v = |D_v - \delta|$

  Where δ is ideal number of members a cluster can handle.
- Single hop communication is used between cluster head and cluster members within a cluster. Average distance between cluster head and cluster numbers is calculated as,

  $D_{cm} = \frac{\sum_{w \in V, w \neq v} d^2_{toCH}}{D_v}$
- Calculate energy portion $E_P = \frac{E_{init}}{E_v}$, where E_v represents the residual energy for node v for round n while E_{init} represents the initial energy for node v.
- Calculate combined weight for each node.

  $W_v = w_1 E_p + w_2 \Delta_v + w_3 (D_{toCH} + D_{toBS})$

  Where $D_{toBS} = d^4_{toBS}$ and $w_1 + w_2 + w_3 = 1$ are the weight factors.
- After weight calculation each node exchanges weight information with its neighbour and is stored in neighbour tables. Minimum weight node is selected as cluster heads and other nodes decide to join appropriate clusters according to the strength of announcement message they receive from cluster heads.

After the cluster topology formed, the cluster head creates schedule for cluster members and starts steady state as LEACH does.

Merits and Demerits: The algorithm perfects the cluster setup stage of LEACH, especially the cluster head selection process as we can adjust weight coefficients according to system requirement. The simulation experiments prove EWC achieve energy efficiency by selecting more suitable cluster heads and keep workload and energy balance. The EWC outperforms LEACH as it transmits more data with restricted energy and prolongs network lifetime. However, as EWC algorithm is fully distributed, the possibility of system overhead will increase because nodes need to exchange information with their neighbors.

PEGASIS: Power-Efficient Gathering in Sensor Information Systems (PEGASIS) [12], is an optimal chain-based protocol that achieves increased network lifetime by using collaborative techniques and by allowing only local coordination between nodes in order to reduce bandwidth consumption. The chain in PEGASIS is constructed in greedy fashion and will consist of those nodes that are closest to each other and form a path to the base station. The nodes need to communicate only with their closest neighbor. Each node uses the signal strength to locate the closest neighbor and then adjusts the signal strength so that only one node can be heard. Nodes take turn once per round to communicate with sink. Once each node has taken its turn, then new round starts, this way uniform load balancing throughout the network is achieved in this protocol. Aggregated data will be sent to sink by one of the members of chain.

Merits and Demerits: This protocol achieves significant performance gain by eliminating the overhead of cluster formation. Data aggregation provides improved communication. PEGASIS introduces excessive delay for distant node on the chain. In addition the single leader can become a bottleneck. This approaches avoid the clustering overhead of LEACH, they still require dynamic topology adjustment since sensor's energy is not tracked. For example, every sensor needs to be aware of the status of its neighbor so that it knows where to route that data. Such topology adjustment can introduce significant overhead especially for highly utilized networks.

TEEN: This protocol was developed for reactive networks. Threshold sensitive Energy Efficient sensor Network protocol [24] uses two new attributes Hard Threshold (HT) and Soft Threshold (ST) along with other common network attributes. Use of these two attributes can reduce the data transmission overhead in network significantly.

- Hard Threshold (HT) is the absolute value of the sensed attribute at which the sensing must turn on its transmitter and report cluster head. Value of HT is stored in an internal variable in the node called sensed value (SV).
- Soft Threshold (ST) is small change in value of sensed attribute that triggers the node to turn on the transmitter and transmit.

First time a parameter from the attribute set reaches its HT value, node turns on the transmitter and sends the sensed data. The nodes will next transmit data in the current cluster period, only when both the following conditions are true:

1. The current value of the sensed attribute is greater than the hard threshold.
2. The current value of the sensed attribute differs from SV by an amount equal to or greater than the soft threshold.

Whenever a node transmits data, SV is set equal to the current value of the sensed attribute. Thus, HT and ST try to reduce the number of transmissions by allowing the node to transmit only when the sensed attribute is in the range of interest.

Merits and Demerits: Better response time makes it suitable for time critical applications. Adjustable HT and ST provide the user control over energy consumption and accuracy. Data communication depends on threshold, if threshold is not reached the data communication will not take place and user will not come to know even if all the nodes die in the network. Thus this scheme is not good for the networks those need continues environment monitoring. Another issue is to ensure collision less communication, TDMA and CDMA scheduling can be used to solve this problem but it will introduce delay in data reporting in time sensitive applications.

FSC: H. Lin et al. [23] proposed a clustering protocol that aims at prolonging lifetime of Wireless Sensor Networks called Fan-Shaped Clustering (FSC) by partitioning a large-scale network into fan-shaped clusters in order to efficiently utilize the network energy by incorporating synchronized data routing among clusters. It is assumed that sensor node deployment is uniform and each node is aware of its location with respect to sink. A sensor node can act as a cluster head, relay node or cluster member node during its lifetime. The node transmission range covers the adjacent clusters. This protocol includes the following phases:

Cluster head selection: For each cluster, a round central area is defined. Only nodes in this area with remaining energy above a predefined threshold can be Cluster heads. Each cluster head candidate sets a back off for interval $\{0, \frac{E_{init}}{E_r}\}$, where E_{init} is initial energy of node and is the residual energy for current round. Node whose timer elapses first declares itself as cluster head by broadcasting a head message. As soon as the energy of current cluster head goes below threshold, it broadcasts a head-selection message. Other nodes in the central area start competing for cluster head following the same old procedure. Re-clustering is applied if all the nodes in central area are dead.

Re-clustering: Instead of the whole network, re-clustering process is localized only on each layer. Re-clustering is done by simply shifting each cluster at a predefined angle θ in counter clockwise direction. This procedure must ensure that the new central area does not overlap with new central area.

Relay node selection: Nodes those do not belong to central area can participate for relay node selection. Relay node selection procedure is similar to that of cluster head selection procedure.

Routing: Cluster head collects data from sensor nodes and aggregates it. Data is sent from cluster head to sink via relay nodes. Routing process is simple. Data is forwarded only to the relay nodes on next lower layer until it reaches sink node. If relay node on next lower layer is not found then data is forwarded to relay node in adjacent cluster on same layer in either clockwise or counter clockwise direction until alive relay node is found on next lower cluster.

Merits and Demerits: Partitioning brings benefits for clustering. It makes Clustering strategy simple, robust, efficient and concept of central area minimizes intra-communication cost. Re-clustering is triggered only when there is no node available in the central area. It reduces frequency of re-clustering. All these enable the network to achieve good performance. Control message add extra overhead in network data traffic. This protocol does not provide efficient performance in void zone area.

Location-based Approach

Most of the routing protocols for sensor networks require location information for sensor nodes in order to calculate the distance between two particular nodes so that energy consumption can be estimated. Location information of a node can be obtained by either exchanging the information of relative coordinates or by some other technique like GPS. In this section, we review some of the location based routing protocols.

GEAR: Unlike directed diffusion, Geographic and Energy Aware Routing (GEAR) [19] restricts the number of interests to a particular region rather than considering the whole network. In this protocol the nodes use energy level and geographic location information of the neighbours to propagate the data packets towards target region. Each node keep two attributes, estimated cost and learning cost of reaching the destination node via neighbours. Estimated cost is calculated based on the residual energy of node and its distance from destination. The learning cost is estimated cost for routing around the regions where node does not has any neighbour closer to the target region. Such regions are called as holes. Route setup for next packet is done by propagating the learning cost one hop back every time a packet reaches the destination. Algorithm works in two phases:

Forwarding packets towards the target region: As a node receives a packet, it checks for its one hop neighbours those are closer to target region than itself. If a hole occurs i.e. if all the neighbours are farther from the target region than the node then learning cost is used for packet forwarding. Further nodes are selected on the basis of convergence in the value of learning cost.

Forwarding the packets within the region: Recursive geographic forwarding or restricted flooding is used for packet diffusion on arrival of packets in target region. Restricted flooding is an efficient technique for sparsely deployed regions while recursive geographic forwarding is more energy efficient for densely deployed regions. In recursive geographic forwarding, target region is partitioned into sub regions and one copy of packet is generated for each region. This process is repeated until region with only one node is left.

Merits and Demerits: Geographic and Energy Aware Routing (GEAR) protocol uses energy aware and geographically informed neighbor selection to route a packet towards the target region. Within a region, it uses a recursive geographic forwarding technique to disseminate the packet. This strategy attempts to balance energy consumption and thereby increase network lifetime. GEAR performs better than other location aware protocols in terms of connectivity after initial partition. The protocol is sensitive to location errors caused due to either imprecise measurement from GPS or localization system, or failure of timely node location update in case of moving nodes.

GAF: Geographic Adaptive Fidelity (GAF) [17] is a location aware protocol that aims to conserves energy by using application- and system-level information for identifying nodes that are equivalent from a routing perspective and turning off unnecessary nodes, keeping a constant level of routing fidelity. Only source and sink nodes remain on and intermediate nodes monitor and balance energy utilization. A virtual grid is formed for target region. Using their location information, each node associates itself with a point in grid. Routing cost is considered to be equal for all the nodes associated with a point. This routing cost equivalence is used to keep some nodes in sleeping state in a particular grid.

Node provides load balancing across the network by changing their state. Node can be in one of the three states.

- Discovery for determining the neighbours in the grid
- active reflecting participation in routing
- sleep when the radio is turned off

The length of sleep state and changes in related parameters are application and routing process dependent. Mobility of node is managed by updating the neighbour of mobile node about its leaving time from grid. In order to keep routing fidelity one of the sleeping neighbours must awake before the leaving time of currently active node expires.

Merits and Demerits: GAF provides good network connectivity and efficient energy conservation mechanism. GAF is robust to correlated location errors because it considers only relative node position when assigning a node to a grid. The performance of GAF protocol is badly affected by shadowing impacts on data propagation. It encounters significant downfall in packet delivery rate.

MECN and SMECN: Minimum Energy Communication Network (MECN) [18] utilizes low power GPS in order to deploy and maintain a minimum energy network. MECN

PROPERTY BASED COMPARISION

Category	Protocol	Routing Strategy	Node Mobility	Data Aggregation	Route Maintenance	Goal
Data centric	SPIN	Event driven	Possible	Yes	No	Lifetime enhancement, Redundancy Reduction.
	Directed Diffusion	On demand	Limited	Yes	Yes	Find efficient n-way communication path for fault tolerance
	Energy Aware	On demand	Limited	Yes	Yes	Lifetime enhancement
Hierarch-ical	LEACH	Cluster head based	Fixed BS	Yes	No	Cluster formation for enhancing network life time.
	EWC	Cluster head based	Fixed BS	Yes	No	Improve cluster head selection and network lifetime.
	PEGASIS	Chain based	Fixed BS	No	Yes	Lifetime and bandwidth Optimization.
	TEEN	Threshold based	Fixed BS	Yes	No	Efficient energy consumption using controlled data transmission.
	FSC	Cluster head based	Fixed BS	Yes	Yes	Formation of uniform clusters lifetime enhancement.
Location aware	GEAR	On demand	Fixed	No	No	Sending packets to destination based on energy and location information.
	GAF	Virtual grid	Possible	No	No	Using application and system level information for balanced use of node energy.
	MECN/ SMECN	Sub network	Fixed	No	No	Maintain low energy network.

includes a master node that is assumed as a information sink in case of sensor network. Main approach of MECN is to find a smaller network within a network with less number of nodes and less transmission power requirements between any two particular nodes. In this way, global minimum power paths are found by performing localized search for each node. Global minimum power paths are globally optimal links in terms of energy consumption. A relay region is identified for every node in which only those neighbour nodes are include to which transmission from this node is comparatively more energy efficient than direct transmission. Figure shows relay region for node (i, r). Union of all relay regions node i can reach is considered for finding boundaries of node i. This protocol works in two phases:

- An enclosure graph is constructed on two dimensional planes, which consists of enclosure for each transmit node. It also contains global minimum power paths.
- Distributed Bellman-Ford shortest path algorithm is used to find optimal links on the enclosure graph. It uses power consumption as the cost metric.

The small minimum energy communication network (SMECN) [20] is an extension to MECN. SMECN considers all the possible hurdles in communication between two nodes i in a fully connected network. Unlike MECN, sub networks constructed in SMECN are smaller in terms of number of edges.

Merits and Demerits: MECN is self-reconfiguring and thus can dynamically adapt to node's failure or scalability. Simulation results show that SMECN uses less energy than MECN and maintenance cost of the links is less. MECN considers a fully connected network that is not always possible. For SMECN, finding a sub-network with smaller number of edges introduces more overhead in the algorithm.

CONCLUSION

In this survey we have categorized network architecture based protocols for WSN in three classes named data centric, hierarchical and location aware protocols. Data routing strategy of each protocol is discussed under appropriate category. Benefits and limitations of these protocols are analyzed. Protocols in each category are compared based on the properties of working methodology.

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