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Energy Efficient Scheme for Wireless Sensor Networks

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Abstract- Recent advances in wireless sensor networks have commanded many new protocols specifically designed for sensor networks where energy awareness is an important concern. This routing protocols might differ from depending on the application and the network architecture. To extend the lifetime of Wireless sensor network (WSN), an energy efficient scheme can be designed and developed via an algorithm to provide reasonable energy consumption and network for WSN. To maintain high scalability and better data aggregation, sensor nodes are often grouped into disjoint, non-overlapping subsets called clusters. Clusters create hierarchical WSNs which incorporate efficient utilization of limited resources of sensor nodes to reduce energy consumption, thus extend the lifetime of WSN. The objective of this paper is to present a state of the art survey and classification of energy efficient schemes for WSNs. *Keywords:* Wireless Sensor Network, clustering, energy efficient clustering, network lifetime, energy efficient algorithms, energy efficient routing, and sensor networks.

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I. Introduction

Recently, there has been a rapid growth in wireless communication technique. Inexpensive and low power wireless micro sensors are designed, deployed and widely used in wireless and mobile environment [1], [3],[4],[5],[7]. Wireless Sensor Networks (WSNs) are a collection of devices referred to as nodes which sense the environment around them and transmit this data via wireless communication to a sink. It is a network of large number of sensor nodes deployed over a geographical area for monitoring physical phenomena like temperature, humidity, vibrations, seismic events, and so on, where each node is equipped with limited on-board processing, storage and radio capabilities. All sensor nodes are used for detecting an event and routing the data in wireless networking. These sensor nodes are small in size that includes three basic components: a sensing subsystem for data acquisition from the physical surrounding environment, a processing subsystem for local data processing and storage, and a wireless communication subsystem for data transmission and are deployed in sensing area to monitor specific targets and collect the data. Then the sensor nodes send the data to base station (BS) by using wireless transmission techniques. WSN is used in various applications like health care system, battlefield surveillance system, environment monitoring system, human behavior monitoring, agriculture monitoring and so on. Energy saving is one of the most important features for sensing the nodes to increased their lifetime in WSN.A sensor node consumes mostly its energy in transmitting and receiving data from source to destination. And the main power supply of the sensor node is battery. In most application scenarios, users are usually difficult to reach a location of sensor nodes. Due to large number of replacement of batteries might be impossible. Sensor node used its battery may make sensing area uncovered because of finite battery energy. Therefore, energy conservation becomes critical concern in WSN. To provide nodes with a long period of autonomy, new and efficient energy scheme and corresponding algorithm must be designed and developed that aims to optimize energy usage are needed, so as to extend the lifetime of nodes and the lifespan of the network as a whole [8][13].

To maintain high scalability and better data aggregation, sensor nodes are often grouped into disjoint, non-overlapping subsets called clusters. The cluster-based technique is one of the approaches which incorporate efficient utilization of limited resources of sensor nodes to reduce energy usage in wireless sensor networks also it provides network scalability, resource sharing and efficient use of constrained resources that gives network topology stability and energy saving attributes. Clustering schemes offer reduced communication overheads, and efficient resource allocations thus decreasing the overall energy consumption reducing the interferences among sensor nodes. The main focus of this article is to study and survey of energy efficient protocols to reduce the data transmission distance of sensor nodes in wireless sensor networks. Some of the advantages and limitations of WSNs are:

Advantage:
- Reduce cabling costs.
- Radio transmission technology optimized for harsh industrial environment.
- Real time measurement monitoring.

Limitations:
- Limited degree of hardware flexibility, processing power, and communication bandwidth and storage space.
- Sensors typically powered through batteries.
- For batteries that cannot be recharged, sensor node should be able to operate during its entire mission time or until battery can be replaced.
- Energy efficiency is affected by various aspects of sensor node/network design.

WSNS are widely used in variety of applications like Area monitoring, Health care monitoring, Air pollution monitoring, Forest fire detection, Landslide detection, Water quality monitoring, Natural disaster prevention, Industrial monitoring, Machine health monitoring, Data logging, Water/Waste water monitoring. Given the importance of clustering for WSNs and advantages, limitations and applications of the WSNs, rest of the paper is organized in following structure. Section II presents an overview of routing protocols in WSNs. Section

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III presents a survey on state of art of clustering algorithms and section IV presents the conclusion of the paper.

II.WSN routing protocols

Wireless Sensor Networks (WSNs) consist of small nodes with sensing, computation, and wireless communications capabilities. A routing protocol specifies how routers communicate with each other, disseminating information that enables them to select routes between any two nodes on a computer network. Routing algorithms determine the specific choice of route. Many routing, power management, and data dissemination protocols have been specifically designed for WSNs where energy awareness is an essential design issue. The focus, however, has been given to the routing protocols which might differ depending on the application and network architecture. The design challenges for routing protocols in WSNs followed by a wide-ranging survey of different routing

techniques. Routing is a process of determining a path between the sensor nodes and the destination node upon request of data transmission, In WSNs the network layer is mostly used to implement the routing of the incoming data. It is known that 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 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 [16].

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 of communications, and according to how a protocol selects a next hop on the route of the forwarded message, as shown below:

Table 2.1 Protocol

Initiator of communication				
Source	**Destination**			
SPIN,DD[26]	DD,LEACH[26]			
Path Establishment				
Proactive	**Reactive**		**Hybrid**	
DD[23],SPIN[23]	PEGASIS[23],TEEN[23]		RR[23],APTEEN[23]	
Network Structure				
Flat	**Hierarchical**		**Location Based**	
EAR[18],DD[18],SAR[18],MCFA [18],SPIN[18],ACQUIRE[18], Flooding[20],Gossiping[20], RR[20],GBR[20],CADR[20], COUGAR[20],IDSQ,CADR[21], SEER[25]	HPAR[18],TEEN[18],PEGASIS[18] ,MECN[18],LEACH[19],DWEHC [19],EECS[19],EEUC[19],APTEEN [19],TIDD,CCS[19],SOP[20],VGA [21],HEED[10],SMECN[20],OP, Sensor aggregate		SAR[18],APS[18],GAP[18],GOAFR [18],GEAR[18],GEDIR[18],PANEL [19],HGMR[19],MECN[20],SMECN [20],GAF[20],MFR,DIR,GEDIR[21],SP AN[21],GeRaF[22],TBF[22],BVGF[22]	
Protocol Operation				
Multipath Based	**Query Based**	**Negotiation Based**	**QoS Based**	**Coherent and Non-coherent**
MMSPEED[18], SPIN[18],DD[21]	SPIN[18],DD[18], COUGAR[18]	SPAN[18],SAR [18],DD[18],SPIN[21]	SAR[18],SPEED[18], MMSPEED[18],EAR [20]	SWE[21],MWE[21]
Next Hop Selection				
Broad cast Based	**Hierarchical**	**Location Based**	**Probabilistic**	**Content Based**
MCFA[18]	LEACH[18]	GEAR[18]	EAR[18]	DD,GBR,EAR[18]

2.1 Initiator of communication based routing protocols: This type of routing protocol depends on the communication between network components, where they are usually in a temporary sleep mode. When any part of the network, the sink (destination, base station) node or the source node needs the service from other part to send or/and receive control or data packets [18].

- Source initiated routing protocol [27]: It sets up the routing paths upon the demand of the source node, and starting from

the source node. Here source presents the data when available and initiates the data delivery.

- Destination initiated routing protocol [27]: It initiates path setup from a destination node.

2.2 Path establishment based routing protocols: Routing paths can be established one of the three ways, namely proactive, reactive or hybrid. On the basis of methodology used for the path establishment following protocols are defined [18]:

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- Proactive protocols compute all the routes before they are really needed 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.

2.3 Network structure based routing protocols: Protocols are divided on the basis of the structure of network required by proposed operations. The underlying network structure can play significant role in the operation execution. On basis of the functionalities of the routing protocol in WSNs are classified as: Flat, Hierarchical and Location Based Routing Protocols.

2.3.1 Flat Based Routing: The first category of routing protocols is the multi-hop flat routing protocols. When huge amount of sensor nodes are required, flat base routing is needed where every node typically plays the same role. In flat networks, sensor nodes collaborate together to perform the sensing task. Due to the large number of such nodes, it is not feasible to assign a global identifier to each node. This consideration has led to data centric routing, where the BS sends queries to definite regions and waits for data from the sensors located in the selected regions. Since data is being requested through queries, attribute-based naming is necessary to specify the properties of data. Some examples of flat based routing protocols are SPIN, DD, RR, CADR, COUGAR, ACQUIRE, EAR, Flooding, Gossiping, SAR, SEER, MCFA and so on. Some of them are discussed below:

SPIN (Sensor protocols for information via negotiation) [25] is a family of adaptive protocols that use data negotiation and resource-adaptive algorithms. SPIN is a data centric routing protocol. These families of protocols disseminate information to each and every node in the network with the assumptions that all nodes in the network could be potential base sinks. This enables a user to request for information from any node in the network and get the requested information since all the nodes in the network have the same information. In these protocols all neighbors nodes have the same data and it is only data that the others nodes do not have that distributed to the neighbors nodes. **DD** (Direct diffusion) [25] is a data-centric (DC) and application-aware protocol in which data generated by sensor nodes is named by attribute-value pairs. Data that is on its way to the sink is combined as it is forwarded in order to remove redundancy; minimizing the no. of transmissions thus saving battery energy which in turn prolongs the network lifetime. The performance of the data aggregation methods in directed diffusion method is affected by factors such as position of the source nodes, number of sources and the network topology. **RR** (Rumor routing) [25] is a kind of directed diffusion and is used for applications where geographic routing is not feasible. It combines query flooding and event flooding protocols in a random way. It has the following assumptions:

- The network is composed of densely distributed nodes.
- Only bi-directional links exits.
- Only short distance transmissions are allowed.
- It has fixed infrastructure.
- It varies from directed diffusion in a sense that when the no. of events is small and the requests are large; the idea is to flood the events. Rather than flooding the entire network with queries are routed to only the nodes that have observed events. In order to flood events through the network, the RR algorithm employs long-lived packets, called agents. When a node detects an event, it adds such event to its local table (events table), and generates an agent. These agents eventually disseminate information to distant nodes about the state of local events. In RR, if a node generates a request for an event, the other nodes which know the route may generate a response to the request by inspecting their event table. This eliminates the need for flooding the whole network in turn reduces communication costs.

CADR (Constrained anisotropic diffusion routing) [20] is a protocol, which attempts to be a general form of Directed Diffusion. The idea is to query sensors and route data in a network in order to maximize the information gain, while minimizing the latency and bandwidth. This is accomplished by activating only the sensors that are close to a particular event and dynamically adjusting data routes. The major difference from Directed Diffusion is the consideration of information gain in addition to the communication cost. In CADR, each node evaluates an information/cost objective and routes data based on the local information/cost gradient and end-user requirements. The information utility measure is modeled using standard estimation theory. In **COUGAR [20]** approach, the network is predicted as a distributed database where some nodes containing the data are temporary unreachable. Since node stores historic values, the network behaves as a data warehouse. Additionally, it is value noting that poor propagation conditions may lead to the storage of incorrect data in the nodes. Taking into account this circumstance, COUGAR provides a SQL-like interface extended to incorporate some clauses to model the probability distribution. The sink is responsible for generating a query plan which provides the hints to select a special node called the leader. The network leaders perform aggregation and transmit the results to the sink. **ACQUIRE** (Active query forwarding in sensor network) [18] also considers the wireless sensor network as a distributed database. In this scheme, a node injects an active query packet into the network. Neighboring nodes that detects that the packet contains obsolete information, emits an update message to the node. Then, the node randomly selects a neighbor to propagate the query which needs to resolve it. As the active query progress through network, it is progressively resolved into smaller and smaller components until it is completely solved. Then, the query is returned back to the querying node as a completed response. In **EAR** (Energy aware routing) [18], once multiple paths are discovered, it associates a probability of use to each

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route. And this probability is related to the residual energy of the nodes that form the route but it is also considers the cost of transmitting through that route.

FLOODING [20] can be used for routing WSNs in which a node sends a packet received, to all its neighbors other than the neighbor which sent the packet to it, if the packet is not destined to itself or the maximum number of hops a packet can pass is not crossed. It is very simple to implement, and it is reactive protocol, as it does not maintain any routing table (topology maintenance) and does not require discovering any routes. A disadvantage of this technique is it is responsible for large bandwidth consumption and it wastes valuable energy. This is no aware energy protocol. **GOSSIPING[20]** is like to Flooding except that, a node receiving a packet, instead of broadcasting, the node sends it to only one of its randomly selected neighbor, and the neighbor in turn sends the packet to one of its randomly selected neighbor, this continues until the packet reaches its destination. Gossiping decreases the no. of packets in the network but the delay to reach destination in some cases may be very large. **SAR** (Sequential assignment routing) [18] is one of the first protocols for WSNs that provide the conception of QoS routing criteria. It is built on the association of a priority level to each packet. Additionally, the links and the routes are related to a metric that characterizes their potential provision of quality of service. This metric is based on the delay and the energy cost. Then, the algorithm creates trees rooted at the one-hop neighbors of the sink. For this, several parameters such as the packet priority, the energy resources and the QoS metrics are taken into account. The protocol must periodically recalculate the routes to be prepared in case of failure of one of the active nodes.

SEER(Simple energy efficient routing protocol for sensor network)[25] is an energy efficient routing protocol that achieves energy efficiency by use of hop count, remaining energy in the nodes and routing decisions are based on the distance to the base station. These metrics are used to determine the routes for forwarding data to the sink. It is a source initiated routing protocol and it uses a uniform network to achieve this efficiency. In this protocol, if the sink node at the center of the network with the source nodes uniformly distributed from the sink and from each other, it is possible that significant energy efficiency can be achieved. **MCFA** (Minimum cost forwarding algorithm) [18] is used to setting up paths to a sink in a WSN. Each node maintains the least cost estimate from itself to the BS, and broadcasts each message to its neighbors. This process is repeated till the BS is reached. Although MCFA is an efficient protocol, it invokes an expensive back off algorithm in the setup phase in order to avoid multiple and frequent updates received at the nodes which are far away from the BS.

2.3.2 Hierarchical Based Routing: Hierarchical or cluster-based routing, originally proposed in wire line 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-layer routing where one layer is used to select cluster heads and the other layer is used for routing. Examples of hierarchical based routing protocols are: LEACH, PEGASIS, HEED, SECA, TEEN, APTEEN, VGA, MECN and SMECN (Minimum energy communication network), OP, HPAR (Hierarchical power active routing), Sensor aggregate, TIDD .Some of them are discuss below:

LEACH (Low Energy Adaptive Clustering Hierarchy) [13] is most popular hierarchical routing protocol for sensor networks in which most nodes transmit to cluster heads, and the cluster heads compress and aggregate the data and forward it to the base station. LEACH assumes that each node has a radio powerful enough to directly reach the base station or the nearest cluster head, but that using this radio at full power all the time would waste energy. Nodes that have been cluster heads cannot become cluster heads again for P rounds. At the end of each round, each node that is not a cluster head selects the closest cluster head and joins that cluster to transmit its data. **HEED**(Hybrid energy efficient distributed clustering)[10] is a clustering protocol for WSNs, which extends the basic scheme of LEACH by using residual energy as a primary parameter and network topology features (e.g. node degree ,distances to neighbors) as secondary parameter to break tie between candidate cluster heads, as a metric for cluster selection to achieve power balancing. That means the cluster heads are probabilistically selected based on their residual energy and sensor nodes join the clusters according to their power level. The clustering process is divided into lot of iterations and in each iteration; nodes which are not covered by any cluster head double their probability of becoming cluster head. Since this energy efficient clustering protocol enable every node to independently and probabilistically decide on its role in the clustered network, They can't guarantee optimal elected set of cluster heads. The primary goals of HEED are prolonging network life-time by distributing energy consumption, terminating the clustering process within a constant number of iterations/steps, minimizing control overhead, and producing well-distributed cluster heads and compact clusters. HEED distribution of energy extends the lifetime of nodes within the network thus stabilizing the neighboring node. **SECA** (Saving energy clustering algorithm) [4] is used to provide efficient energy consumption in WSNs. In order to make an ideal distribution for sensor node clusters, authors calculates the average distance between the sensor nodes and take into residual

energy for selecting the appropriate cluster head nodes. The lifetime of WSNs is extended by using the uniform cluster location and balancing the network loading among the clusters. The main benefit of SECA is that the energy consumption is reduced and better network lifetime can be carried out.

TEEN (Threshold sensitive energy efficient sensor network protocol)[18]The sensor network architecture is based on a hierarchical grouping where closer nodes from clusters and this process goes on the second level until base station is reached. TEEN is not good for applications where periodic reports are needed since the user may not get any data at all thresholds are not reached. The architecture of **APTEEN** (Adaptive threshold sensitive energy efficient sensor network protocol)[19] is same as TEEN. APTEEN supports three different query types: historical, to analyze past data values, one time, to take a snapshot view of the network and persistent to monitor an event for a period of time.

PEGASIS (Power efficient gathering in sensor information systems) [24] is a data gathering and near optimal chain-based algorithm that establishes the concept that energy conservation can result from nodes not directly forming clusters. This algorithm reduces the energy consumption by creation of a chain structure comprised of all nodes and continually data aggregation across the chain. The algorithm presents the idea that if nodes form a chain from source to sink, only one node in any given transmission time frame will be transmitting to the base station. PEGASIS avoids cluster formation and uses only one node in a chain to transmit to the BS instead of per round as the power draining is multiple nods. In order to increase network lifetime, nodes need only to communicate with their closest neighbors and they take turns in communicating with the BS. When the round of all nodes communicating with the base station ends, a new round will start and so on. This reduces the power required to transmit data per round as the power draining is spread uniformly over all nodes. Hence PEGASIS achieves energy conservation. **VGA** (Virtual grid array protocol) [21]is a GPS-free technique to split the network topology into logically symmetrical, side by side, equal and overlapping frames (grids). And the transmission is occurred grid by grid. VGA provides the capability to aggregate the data and in-network processing to increase the life span of the network. Data aggregation is done in two steps i.e. first at local level (in grid) and then globally. The nodes that are responsible to aggregate data locally are 'local heads' (grid heads) and the nodes 'global heads' have to aggregate data received from local heads. After the formation of logical grids, election is started in each grid to decide for the local head of the grid based on node the energy and how many times it has been selected as local head. And then the global heads are also selected randomly from the selected local heads. Several local heads may connect to the global head. The local heads are allowed to communicate vertically and horizontally only. Each node within the grid that has the required data will send its data to the local head. Then the local head will aggregate the data and send it to its associated global head that will also aggregate the data again and send it to the BS via other global heads. If a local head or global head dies, a new local/global head is selected after the election. **HPAR** (Hierarchical power active routing) [29] discusses about an online power aware routing algorithm in large sensor networks. Path selection takes into consideration both the transmission power and the minimum battery power of the node in the path. It tries to compromise makes use of zones to take care of the large number of sensor nodes.

2.3.3 Location Based Routing: In this kind of network architecture, sensor nodes are scattered randomly in an area of interest and mostly known by the geographic position where they are deployed. They are located mostly by means 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. Simply in this kind of routing, sensor nodes are addressed by means of their locations. The distance between neighboring nodes can be estimated on the basis of incoming signal strengths. Examples of location based routing protocols are: GAF, GEAR, SPAN, TBF, BVGF, GOAFR (Greedy other adaptive face routing), GEDIR (Geographic distance routing), GeRaF, MFR, GEDIR, GOAFR, SAR (Sequential assignment routing), APS (Ad-hoc positioning system) and so on. Some of them are described below:

GAF (Geographic adaptive fidelity)[18] is used for WSN because it favors energy conservation. In this scheme, state transition diagram has three stages: Discovery, Active, Sleeping. When a sensor enters the sleeping state, it turns off radio for energy saving. In discovery state, a sensor exchange discovery message to learn about other sensors in the grid. In active state, a sensor periodically broadcast its discovery messages to inform equivalent sensors about its state. In **GEAR** (Geographic and energy aware routing)[18] algorithm, each node keeps an estimated cost and a learning cost of reaching the destination through neighbors. The estimated cost is a combination of residual energy and distance to destination. Hole occurs when a node does not have any closer neighbors to the target. If there are no holes, the estimated cost is equal to the learned cost. The learned cost is propagated one hop back every back every time a packet reaches the destination so that route set up for next packet will be adjusted.

SPAN [30] is a topology control protocol that allows nodes that are not involved in a routing backbone to sleep for extended periods of time. In Span, certain nodes assign themselves the position of "coordinator." These coordinator nodes are chosen to form a backbone of the network, so that the capacity of the backbone approaches the potential capacity of the complete network. Periodically, nodes that have not assigned themselves the coordinator role initiate a procedure to decide if they should become a coordinator. The criteria for this transition are if the minimum distance between any two of the node's neighbors exceeds three hops. To avoid the situation where many nodes simultaneously decide to become

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coordinator, back off delays are added to nodes' coordinator announcement messages. The back off delays are chosen such that nodes with higher remaining energy and those potentially providing more connectivity in their neighborhood are more likely to become a coordinator. To ensure a balance in energy consumption among the nodes in the network, coordinator nodes may fall back from their coordinator role if neighboring nodes can make up for the lost connectivity in the region**.**

2.4 **Operation based routing protocols:** WSNs applications are classified according to their functionalities. Therefore routing protocols are categorized according to their operations to gather these functionalities. The underlying principle behind their classification is to achieve optimal performance and to save the limited resources of the network. The protocols included in this category are [27]:

• Multipath based routing protocol: This type of routing protocols uses multiple paths instead of a single path in order to enhance network performance.

• Query based routing protocol: In this type of routing protocol destination nodes propagate a query for data (sensing task) from a node through the network, and a node with this data sends the data that matches the query back to the node that initiated the query.

• Negotiation based routing protocol: These protocols use high-level data descriptors in order to eliminate redundant data transmissions through negotiation. Communication decisions are also made based on the resources available to them.

• QoS base routing protocol: In QoS-based routing protocols, the network has to balance between energy consumption and data quality. In particular, the network has to satisfy certain QoS metrics (delay, energy, bandwidth, etc.) when delivering data to the base station.

• Coherent and Non-coherent data processing based routing: In non-coherent data processing routing, nodes will locally process the raw data before it is sent to other nodes for further processing.

2.5 **Next hop selection routing protocols:** The protocols which are included in this category are:

• Broadcast based routing protocol [27]: Many nodes must collect or distribute the information to every node in the network (broadcast).

• Hierarchical routing protocols [27] aim at clustering the nodes so that cluster heads can do some aggregation and reduction of data in order to save energy. Hierarchical routing is mainly two-layer routing where one layer is used to select cluster heads and other for routing.

• Location based routing protocol [27] utilizes the position information to relay the data to the desired regions rather than the whole network.

• Probabilistic routing protocol[31] The **Probabilistic Routing Protocol using History of Encounters and Transitivity (PRoPHET)** protocol uses an algorithm that attempts to exploit the non-randomness of real-world encounters by maintaining a set of probabilities for successful delivery to known destinations in the DTN (*delivery predictabilities*) and replicating messages during opportunistic encounters only if the Mule that does not have the message appears to have a better chance of delivering it.

• Content based routing protocol [32] designed for the communication network that features a new advanced communication model where messages are not given explicit destination addresses, and where the destinations of a message are determined by matching the content of the message against selection predicates declared by nodes. Routing in a content-based network amounts to propagating predicates and the necessary topological information in order to maintain loop-free and possibly minimal forwarding paths for messages.

Comparative analysis of routing protocols

Table 2.2: Hierarchical routing Vs Flat routing

Hierarchical routing	**Flat routing**
Reservation-based scheduling	Contention-based scheduling
Collisions avoided	Collision overhead present
Reduced duty cycle due to periodic sleeping	Variable duty cycle by controlling sleep time of nodes
Data aggregation by cluster head	Node on multihop path aggregates incoming data from neighbours
Simple but non-optimal routing.	Routing can be made optimal, with added complexity.
Requires global and local synchronization	Links formed on the fly without synchronization
Overhead of cluster formation throughout the network	Routes formed only in regions that have data for transmission
Lower latency as multiple hops network formed by Cluster heads always available	Latency in waking up intermediate nodes and setting up the multipath
Energy dissipation is uniform	Energy dissipation depends on traffic patterns
Energy dissipation cannot be controlled	Energy dissipation adapts to traffic pattern
Fair channel allocation	Fairness not guaranteed

III. Other clustering algorithms in WSNs

EEMC (Energy-efficient multi-level clustering algorithm) [11] also called as Multi-Level Clustering Algorithm, which aims at minimum energy consumption in sensor networks. EEMC also covers the cluster head election scheme. In EEMC, the data collection operation is broken up into rounds, where each round begins with a cluster set-up phase, which means that the nodes execute EEMC algorithm to form a multi-level clustering topology independently, and continues with a data transmission phase, which means the nodes transmit the sensed data packets to the sink node under such a clustering topology. Assuming that base station is remotely located and sensor nodes are stationary, simulation results show that their proposed algorithm is highly effective in the network lifetime of a large-scale network. They also show that the algorithm has low latency and moderate overhead across the network. The EEMC algorithm has the limitation that the regular nodes can join the last level of CHs only, thus incurring high latency in the network. Another notable limitation is that each node be GPS equipped to know its location precisely. If the precise location is not known, the algorithm will fail. In order to overcome these shortcomings, author proposes two new algorithms, LAMC (Location Aware Multi-level Clustering) and PAMC (Power Aware Multi-level Clustering). Simulations are used to analyze the performance of proposed algorithms. LAMC(Location aware multilevel clustering) and PAMC(Power aware multilevel clustering) the author presents two multilevel clustering algorithms are built upon EEMC algorithm and aim to further prolong the lifetime of WSNs by minimizing the energy consumption of the network. Clustering provides an effective method for prolonging lifetime of WSNs. Wireless sensor nodes are extremely energy constrained with limited transmission range. Due to the large area of deployment, the network needs to have a multilevel clustering protocol that will enable far off nodes to communicate with the base station. LAMC reduces the latency of the network and more efficient than EEMC and PAMC removes the constraint of location awareness altogether and gives comparable performance without the need of GPS fitting at each node.

NCACM (the New Clustering Algorithm with Cluster Members bounds for energy dissipation avoidance in wireless sensor network) [9] Energy consuming limitation often is main problem in wireless sensor networks. In this paper author introduce a new algorithm for reduce energy consumption and increase the useful lifetime of wireless sensor networks with cluster member bounds. This paper introduces the new energy adaptive protocol to reduce overall power consumption, maximize the network lifetime in a heterogeneous wireless sensor network. The protocol NCACM (the New Clustering Algorithm with Cluster Members bounds for energy dissipation avoidance in wireless sensor network), determine a confidence value for any node that want be a cluster head with parameters such as nodes remaining energy and distance between nodes and distance between cluster heads in each round then clustering provide. Simulation results show new algorithm has better performance as LEACH and

LEACH-E and cause to reduce energy consumption and progress wireless sensor network performance and lifetime.

IV. Conclusion

One of the most challenging issues in the WSNs is saving the energy. To make the sensor node energy efficient with extended lifetime, different energy efficient power saving schemes must be developed. We have surveyed the state of art of different clustering algorithms in WSNs reported in the literature. We have found that the some energy efficient algorithms increase the network lifetime. A sincere effort has been made to provide complete and accurate state of art energy efficient algorithms survey applicable to WSNs.

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