IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

IJARSCT
Impact Factor: 6.252

Volume 2, Issue 7, May 2022

Energy Efficient Management Approach For Wireless Sensor Networks

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Abstract: *This paper includes the survey of energy conservation in wireless sensor networks. Wireless sensornetworks(WSN) provides information from its surround-ing physical world to the base station. WSN consist of large number of static and mobile sensor nodes deployed in a sensor field, forward the sensed data towards static or mobile sink or base station. Sensor nodes are battery powered small devices, hence there is chance of quick depletion of battery due to the operational overhead and continuous sensing. Similarly increased data traffic concentration of the single-hop neighbors of sink lead to the creation of hotspot at these single-hop neighbors. Energy efficient routing protocols are the solution for reducing energy consumption in the networkby providing uniform energy distribution throughout thenetwork. This work deal with different routing protocols used in different scenario in order to enhance energyefficiency of the network.*

Keywords: Wireless sensor networks

I. Introduction

Sensor is a device that can measure physi- cal input from its surrounding environment and convert it into data that can be interpreted by either a human or a machine.Wireless sensor networks (WSN) are used to obtain and collect information, providing the essential data to be processed. And wireless sensor networks (WSN) have been widely applied and become an im- portant portion of the sensing layer nowadays. There are some advantages in wireless sensors, including a small volume, a low price and a high sensitivity. Therefore, wireless sensors have become a kind of crucial component and been applied to a variety of scenarios, for Example, health monitoring in human's body, fire warning in the forest, failure detection in the industrial production, target tracking in the military field and so on. Once information has been gathered by a sensor network, it will be sent to the data collector through communication devices. A network with large number of small sensor nodes deployed in a specific region for the purpose of monitoring is called wireless sensor network(WSN). In WSN distributed nodes monitor the sensing field and forward the sensed data towards a base station(BS) or sink either through single-hop or through multi- hop. Now WSNs are very much established for verity of applications ranging from simple mon- itoring to surveillance. The typical applications includes environmental monitoring, health care, animal tracking, smart buildings, habitat moni- toring and surveillance(Othman et al., 2012 and Kandris et al.,2020). The main objective of sensor nodes is to sense a particular area, process the generated data, and forward to sink or BS through single-hop or multi-hop. Multi-hop communications involves intermediate nodes to forward data to sink or BS from source node, although in singlehop communication source node directly transmit data to BS(pevsovic et al.,2010).

Since sensor nodes are battery powered small devices, their battery get easily depleted. Therefore achieving energy efficiency is an important consideration in WSN. WSN must be operate for a long time without human intervention in most of the applications. Replacement of batteries in an unattended environment need significant effort. Hence routing protocols for WSN must be designed in such a way that they increase the life time of sensor nodes as well as maximizing network performance.

In spite of advantages mentioned above, there are still some shortcomings in WSNs, such as the susceptibility by the electromagnetic interference, the limitation of the sensing scope, the limitation of the communication distance, and the limitation of the energy. Especially, a wireless sensor is usually powered by a battery. Once the battery is run out of, this wireless sensor will stop working and be ineffective. Routing protocols are the most suitable solution for reducing energy consumption in WSN. So, the topic of energy efficiency in a WSN has been an important topic and attracted researchers around the world. The existing energy management techniques in WSNs are:

1. Duty cycling: Duty cycling is a technique for reducing energy consumption in a WSN by periodically switching on and off transceivers of sensor nodes. Duty cycle refers to "the ratio between the duration when the sensor node is on and the sum of the times when the node is on and asleep". The transceivers operate in active, listen and sleep modes. Idle listening consumes a significant amount of energy. The main concept behind duty cycling is to minimize energy wastage due to idle listening. Inactive nodes are put into sleep mode by switching off their radios.
2. Data aggregation: Data aggregation is a data reduction scheme for minimizing communication overhead. It is an approach that eliminates redundant data to reduce energy consumption and prolong the lifetime of WSNs. Data aggregation is defined as the process of "fusing data from multiple sensors to avoid redundant transmission to the sink node and, thereby, reduce the total energy cost". Neighbouring nodes may measure correlated data especially in dense sensor networks. Therefore, data aggregation saves energy by avoiding transmission of the same data by several nodes via multiple routes.
3. Data compression: The quantity of energy consumed by a transceiver in a WSN strongly depends on the size of the transmitted data packets and the transmission distance. Data compression focusses on reducing the size of the sensed data. In this technique, information is encoded at the source nodes and decoded at the BS. Communication energy is usually minimized at the expense of increased computational energy. "Compressed sensing" and "distributed compressed sensing" are potential strategies for enhancing energy efficient sensing in WSNs.
4. Data prediction: It is a strategy that conserves energy in WSNs by reducing the number of data transmissions. In this strategy, algorithms are utilized to approximate future data values based on historical data and parameters. Energy saving is achieved in the sense that only those sensor nodes whose sensed data values considerably deviate from the predicted values are allowed to transmit. Prediction mechanisms allow certain assumptions made during data observation to be considered in the prediction models. This improves the prediction accuracy of the models. "Adaptive filters" are employed to estimate data at both the cluster member and the CH.
5. Dynamic Scaling: "Dynamic voltage scaling (DVS)" and "dynamic frequency scaling (DFS)" techniques focus on adjusting the supply voltage and clock frequency of subsystems of a wireless sensor node based on the instantaneous and predicted workload. The processor of a sensor node is not always required to execute scheduled tasks at its peak capacity. Running the processor at peak supply voltage and frequency causes unnecessary consumption of energy. Therefore, the operating voltage and frequency of the processor should be adjusted according to the current "computational load requirements". Dynamic voltage-frequency scaling (DVFS) is a technique that utilizes software to minimize the average power consumption in a WSN by appropriately adjusting both the voltage and frequency of operation. Reducing the operating voltage causes an increase in latency of executing scheduled tasks. Energy should be managed to avoid degrading overall performance of the WSN.

The routing protocols used in WSN should follow some performance criterion's:

- Reliability: Reliability can be defined as the delivery ratio of data to the sink. In WSN, if source node send data to sink, then data should reach the destination. Hence routing protocol should be designed in such a way that it eliminate packet loss.
- Latency: Latency is defined as the time taken between generation of sensor data and reception of data by sink. There is already some delays exist, like queuing delay, congestion, re-transmission delay etc. There exist an additional delay because source node have to find the location of sink. While dealing with time sensitive applications, efficient protocols which reduce latency have to be used.

In this paper, we discuss about the different categories of routing protocols to manage energy in the overall network.

II. DIRECT HOP TO SINK TRANSMISSION PROTOCOLS

A. SPIN

Sensor protocols for information via negotiation (SPIN) is a data-centric negotiation-based family of information dissemination protocols for WSNs. The main objective of these protocols is to efficiently disseminate observations gathered by individual sensor nodes to all the sensor nodes in the network. The main objective of SPIN and its related family members is to address the shortcomings of conventional information dissemination protocols and overcome their performance deficiencies. The basic tenets of this family of protocols are data negotiation and resource adaptation. Semantic-based data negotiation requires that nodes running SPIN "learn" about the content of the data before any data are transmitted between network nodes. SPIN exploits data naming, whereby nodes associate metadata with data they produce and use these descriptive data to perform negotiations before transmitting the actual data. A receiver that expresses interest in the data content can send a request to obtain the data advertised. This form of negotiation assures that data are sent only to interested nodes, thereby eliminating traffic implosion and reducing significantly the transmission of redundant data throughout the network. Furthermore, the use of meta data descriptors eliminates the possibility of overlap, as nodes can limit their requests to name only the data that they are interested in obtaining. Resource adaptation allows sensor nodes running SPIN to tailor their activities to the current state of their energy resources. Each node in the network can probe its associated resource manager to keep track of its resource consumption before transmitting or processing data. When the current level of energy becomes low, the node may reduce or completely eliminate certain activities, such as forwarding third party metadata and data packets. The resource adaptation feature of SPIN allows nodes to extend their longevity and consequently, the lifetime of the network. To carry out negotiation and data transmission, nodes running SPIN use three types of messages. The first message type, ADV, is used to advertise new data among nodes. A network node that has data to share with the remaining nodes of the network can advertise its data by first transmitting an ADV message containing the metadata describing the data. The second message type, REQ, is used to request an advertised data of interest. Upon receiving an ADV containing metadata, a network node interested in receiving specific data sends a REQ message the metadata advertising node, which then delivers the data requested. The third message type, DATA, contains the actual data collected by a sensor, along with a metadata header. The data message is typically larger than the ADV and REQ messages. The latter messages only contain metadata that are often significantly smaller than the corresponding data message. Limiting the redundant transmission of data messages using semantic-based negotiation can result in significant reduction of energy consumption.

B. DIRECTED DIFFUSION

Directed diffusion is a data-centric routing protocol for information gathering and dissemination in WSNs. The main objective of the protocol is to achieve substantial energy savings in order to extend the lifetime of the network. To achieve this objective, directed diffusion keeps interactions between nodes, in terms of message exchanges, localized within a limited network vicinity. Using localized interaction, direct diffusion can still realize robust multipath delivery and adapt to a minimal subset of network paths. This unique feature of the protocol, combined with the ability of the nodes to aggregate response to queries, results into significant energy savings. The main elements of direct diffusion include interests, data messages, gradients, and reinforcements. Directed diffusion uses a publish-and-subscribe information model in which an inquirer expresses an interest using attribute–value pairs. An interest can be viewed as a query or an interrogation that specifies what the inquirer wants. Sensor nodes, which can service the interest, reply with the corresponding data. For each active sensing task, the data sink periodically broadcasts an interest message to each neighbor. The message propagates throughout the sensor network as an interest for named data. The main purpose of this exploratory interest message is to determine if there exist sensor nodes that can service the sought-after interest. All sensor nodes maintain an interest cache. Each entry of the interest cache corresponds to a different interest. The cache entry contains several fields, including a timestamp field, multiple gradient fields for each neighbor, and a duration field. The timestamp field contains the timestamp of the last matching interest received. Each gradient field specifies both the data rate and the direction in which data are to be sent. The value of the data rate is derived from the interval attribute of the interest. The duration field indicates the approximate lifetime of the interest. The value of the duration is derived from the timestamp of the attribute.A gradient can be thought of as a reply link pointing toward the neighboring node from which the interest is received. The diffusion of interests across the entire network, coupled with the establishment of gradients at the network nodes, allows the discovery and establishment of paths between the data sinks that are interested in the named data and the nodes that can serve the data. A sensor node that detects an event searches its interest cache for an entry matching the interest. If a match is identified, the node first computes the highest event rate requested among all its outgoing gradients. It then sets its sensing subsystem to sample the events at this highest rate. The node then sends out an event description to each neighbor for which it has a gradient. A neighboring node that receives a data searches for a matching interest entry in its cache. If no match is found, the node drops the data message with no further action. If such a match exists, and the data message received does not have a matching data cache entry, the node adds the message to the data cache and sends the data message to the neighboring nodes. Upon receiving an interest, a node checks its interest cache to determine if an entry exists in its cache for this interest.

If such an entry does not exist, the receiving node creates a new cache entry. The node then uses the information contained in the interest to instantiate the parameters of the newly created interest field. Furthermore, the entry is set to contain a single gradient field, with the event rate specified, pointing toward the neighboring node from which the interest is received. If a match exists between the interest received and a cache entry, the node updates the timestamp and duration fields of the matching entry. If the entry contains no gradient for the sender of the interest, the node adds a gradient with the value in the interest message. If the matching interest entry contains a gradient for the interest sender, the node simply updates the timestamp and duration fields. A gradient is removed from its interest entry when it expires.During the gradient setup phase, a sink establishes multiple paths. The sink can use these paths to higher-quality events by increasing its data rate. This is achieved through a path reinforcement process. The sink may choose to reinforce one or several particular neighbors. To achieve this, the sink resends the original interest message, at a higher data rate, across the paths selected, thereby reinforcing the source nodes on the paths to send data more frequently. The path performing most often can then be retained while negatively reinforcing the remaining paths. Negative reinforcement can be achieved by timing out all high-data-rate gradients in the network, except for those that are explicitly reinforced.

III. MULTI-HOP TRANSMISSION PROTOCOLS

A. CATEGORY 1 WSN

It is almost invariably mesh-based systems with multihop radio connectivity among or between WNs, utilizing dynamic routing in both the wireless and wireline portions of the network. Military theater systems typically belong to this category. C1WSNs support highly distributed high-nodecount applications. C1WSNs tend to deal with large-scale multipoint-to-point systems with massive data flows. C1WSNs are networks in which end devices (sensors) are permitted to be more than one radio hop away from a routing or forwarding node. The forwarding node is a wireless router that supports dynamic routing (i.e., it has a mechanism that is used to find the best route to the destination out of a possible set of more than one route); wireless routers are often connected over wireless links.The important characterizations that are sensor nodes can support communications on behalf of other sensor nodes by acting as repeaters. The forwarding node supports dynamic routing and more than one physical link to the rest of the network is physically and logically present. The radio links are measured in thousands of meters and the forwarding node can support data processing or reduction on behalf of the sensor nodes.These are relatively complex and "meshy" wireless systems. Some refer to the two types of behavior as cooperative (when a node forwards information on behalf of another node) or noncooperative (when a node handles only its own communication). The two categories of WSNs are intended to be mutually exclusive by definition.1 WSNs (particularly C1WSNs) typically consist of hundreds (even thousands) of inexpensive WNs. Category 1 applications are most-often supported by and delivered over C1WSNs.Some of the applications of C1WSNs are:

1. Military: Military sensor networks to detect and gain as much information as possible about enemy movements, explosions, and other phenomena of interest.
2. Security: Law enforcement and national security applications for inimical agent tracking or nefarious substance monitoring.
3. Detection: Sensor networks to detect and characterize chemical, biological, radiological, nuclear, and explosive (CBRNE) attacks and material.
4. Monitoring: Sensor networks to detect and monitor environmental changes in plains, forests, oceans, and so on.
5. Traffic: Wireless traffic sensor networks to monitor vehicle traffic on highways or in congested parts of a city.
6. Surveillance: Wireless surveillance sensor networks for providing security in shopping malls, parking garages, and other facilities.
7. IOT: Wireless parking lot sensor networks to determine which spots are occupied and which are free.
8. Satellite: Borders monitoring with sensors and satellite uplinks.

B. FLOODING

Flooding is a common technique frequently used for path discovery and information dissemination in wired and wireless ad hoc networks. The routing strategy is simple and does not rely on costly network topology maintenance and complex route discovery algorithms. Flooding uses a reactive approach whereby each node receiving a data or control packet sends the packet to all its neighbors. After transmission, a packet follows all possible paths. Unless the network is disconnected, the packet will eventually reach its destination. Furthermore, as the network topology changes, the packet transmitted follows the new routes.To prevent a packet from circulating indefinitely in the network, a hop count field is usually included in the packet. Initially, the hop count is set to approximately the diameter of the network. As the packet travels across the network, the hop count is decremented by one for each hop that it traverses. When the hop count reaches zero, the packet is simply discarded. A similar effect can be achieved using a time-to-live field, which records the number of time units that a packet is allowed to live within the network. At the expiration of this time, the packet is no longer forwarded. Flooding can be further enhanced by identifying data packets uniquely, forcing each network node to drop all the packets that it has already forwarded. Such a strategy requires maintaining at least a recent history of the traffic, to keep track of which data packets have already been forwarded.

C. GOSSIPING

To address the shortcomings of flooding, a derivative approach, referred to as gossiping, has been proposed. Similar to flooding, gossiping uses a simple forwarding rule and does not require costly topology maintenance or complex route discovery algorithms. Contrary to flooding, where a data packet is broadcast to all neighbors, gossiping requires that each node sends the incoming packet to a randomly selected neighbor. Upon receiving the packet, the neighbor selected randomly chooses one of its own neighbors and forwards the packet to the neighbor chosen. This process continues iteratively until the packet reaches its intended destination or the maximum hop count is exceeded. Gossiping avoids the implosion problem by limiting the number of packets that each node sends to its neighbor to one copy. The latency that a packet suffers on its way to the destination may be excessive, particularly in a large network. This is caused primarily by the random nature of the protocol, which, in essence, explores one path at a time.

D. MLRC

The energy efficient multi-level route-aware clustering algorithm for WSNs called MLRC. To establish tree among sensor nodes, MLRC applies a route conscious manner in which nodes could gain desired information about possible routes to the destination. The proposed protocol eliminates extra generation of routing control packets by implementing cluster formation and routing tree construction, concurrently. Cluster heads are elected based on effective parameters. The algorithm could moderate energy consumption of relays close to the base station with assigning probability to adjacent cluster head and avoiding the insistence on the nearest cluster head selection. an energy efficient multi-level route-aware clustering algorithm for wireless sensor networks in a fully distributed manner. It includes two major phases: setup phase and data transmission phase. In setup phase CHs are selected based on effective parameters. With introducing a new route aware method an optimal path from each relay to the BS is specified and routing tree is constructed among sensor nodes. The algorithm balances inter-cluster and intra-cluster energy consumption among CHs by considering the remaining energy and density of nodes when choosing the next hop. In cluster formation stage cluster members give a probability to each adjacent CH and prevent greedy selection of nodes closer to the BS. Residual energy, proximity degree, number of hops through the path to the BS and actual distance each data traverses to reach the BS are such parameters involved in selection of relay nodes. Besides, route specification and cluster formation stage are performed concurrently which leads to decreasing the number of control packets. In data transmission phase all sensed data transfer to the BS through the constructed routing tree. The network infrastructure is composed of a BS and some autonomous sensor nodes. Nodes are classified into cluster members and CHs. The CMs generally sense surrounding area to monitor physical or environmental conditions and transmit data to the CH. In addition, each CH gathers data, aggregates it and forwards to the BS. This protocol contains two principle ingredients which are multicriterion clustering algorithm, and the route establishment algorithm. In multi-criterion clustering algorithm we tend to delineate the characteristics of eligible CHs for undertaking data aggregation and forwarding tasks. CHs are determined with utilizing the local information of nodes such as residual energy and distance to the BS. Residual energy is consequential factor since it helps to balance energy consumption among CHs.

E. MOTCO

The method of selecting the optimal cluster head is performed using Multi-Objective Taylor Crow Optimization (MOTCO) algorithm that is the combination of the Taylor series and the Crow Search Algorithm (CSA). The objective function is based on the distance between the nodes in the cluster, energy of the nodes, traffic density of the cluster, and the delay in transmitting the data packets. The designed objective function is tuned for a minimum value and the cluster head corresponding to the minimum value of the objective function becomes the optimal cluster head.

F. MULTI HOP CLUSTER BASED ROUTING APPROACH

The adoption of multi-hop communication instead of direct communication in cluster filed has optimized the communication in the network. Considering the communication distance and the network density requirements, the network structures assuring direct communication between any member node and CHs may not be practical for large scale sensor networks18. Consequently, for a large scale wireless sensor network there is a need for multi-hop communication structure which does not limit the cluster size and its area coverage. MTE algorithm is an effective multi-hop protocol widely adopted in wireless sensor network19. It consists of transmitting data by using other nodes that act as routers along with environment sensing. The intermediate nodes among the clusters route other sensor's data that are destined for cluster heads. The routers nodes are chosen such that the transmit amplifier energy is minimized. In each cluster, source nodes calculate the distance to the cluster heads by adopting MTE algorithm. If the distance of direct path (from source nodes to the attached CH) is the minimum distance, the source nodes convey its data directly through one hop to the attached cluster head. All selected CHs in the clusters transmit the aggregated data directly to the base station. In the other hand, if the distance from source nodes to the attached CHs is not the minimum distance, the source nodes forward their data through intermediate nodes in the clusters within the minimum distance. The source node transmits its data through multiple minimum hops to the cluster head. In this case, source nodes require m transmissions over a distance d and m
-1 receptions.

IV. DUTY CYCLE BASED ROUTING PROTOCOLS

A. STATIC ROUTING PROTOCOLS

1. PAMAS: The power aware multiaccess protocol with signaling (PAMAS) avoids overhearing among neighboring nodes by using a separate signaling channel. The protocol combines the use of a busy tone with RTS and CTS packets to allow nodes currently not actively transmitting or receiving packets to turn off their radio transceivers. The protocol does not, however, provide mechanisms to reduce energy waste caused by idle listening. This is a new multiaccess protocol for ad hoc radio networks. The protocol is based on the original MACA protocol with the adition of a separate signalling channel. The protocol is based on the original MACA protocol with the adition of a separate signalling channel. The unique feature of this protocol is that it conserves battery power at nodes by intelligently powering off nodes that are not actively transmitting or receiving packets. The unique feature of our protocol is that it conserves battery power at nodes by intelligently powering off nodes that are not actively transmitting or receiving packets. The manner in which nodes power themselves off does not influence the delay or throughput characteristics of our protocol.
2. STEM: The sparse topology and energy management (STEM) protocol trades latency for energy efficiency. This is achieved using two radio channels: a data radio channel and a wake-up radio channel. A variant of STEM uses a busy tone instead of encoded data for the wake-up signal. STEM is known as a pseudo asynchronous scheduled scheme. Based on this scheme, a node turns off its data radio channel until communication with another node is desired. When a node has data to transmit, it begins transmitting on the wakeup radio channel. The wake-up signal channel acts like a paging signal. The transmission of this signal lasts long enough to ensure that all neighboring nodes are paged. When a node is awakened from its sleeping mode, it may remain awake long enough to receive a "session" of packets. A node can also be awakened to receive all of its pending packets before going into the sleep mode again. The STEM protocol is general and can be used in conjunction with other MAC-layer scheduling protocols. The scheme is, however, effective only in network environments where events do not happen very frequently. If events occur frequently, the energy wasted by continuously transmitting wake-up signals may offset, or may exceed, the energy gained in sleeping modes.
3. T-MAC: The timeout-MAC (T-MAC) is a contention-based MAC-layer protocol designed for applications characterized by low message rate and low sensitivity to latency. To avoid collision and ensure reliable transmission, T-MAC nodes use RTS, CTS, and acknowledgment packets to communicate with each other. Furthermore, the protocol uses an adaptive duty cycle to reduce energy consumption and adapt to traffic load

variations. The basic idea of the T-MAC protocol is to reduce idle listening by transmitting all messages in bursts of variable length. Nodes are allowed to sleep between bursts. Furthermore, the protocol dynamically determines the optimal length of the active time, based on current load. Since messages between active times must be buffered, the buffer capacity determines an upper bound on the maximum frame time. Based on the T-MAC protocol, nodes alternate between sleep and wakeup modes. Each node wakes up periodically to communicate with its neighbors. A node keeps listening and potentially transmitting as long as it is in the active period. An active period ends when no active event occurs for a predetermined time interval. Active events include the hearing of a periodic frame timer, the reception of data over the radio, the sensing of an activity such as collision on the channel, the end of transmission of a node's own data packet or acknowledgment, and the end of a neighboring node's data exchange, determined through overhearing of prior RTS and CTS packets. At the end of the active period, the node goes into sleep mode.

4. B-MAC: The Berkeley media access control (B-MAC) is a lower-power carrier-sense media access protocol for WSNs. In contrast to traditional IEEE 802.11-inspired MAC-layer protocols, which include mechanisms for network organization and clustering, the B-MAC protocol embodies a small core of media access functionality. B-MAC uses clear channel assessment (CCA) and packet backoffs for channel arbitration, link-layer acknowledgments for reliability, and listening for low-power communication. B-MAC does not provide direct support for multipacket mechanisms to address the hidden terminal problem, handle message fragmentation, or enforce a particular low-power policy. However, in addition to the standard message interface, provides, B-MAC, a set of interfaces that allow services to tune its operation. By exposing a set of configurable mechanisms, protocols built on B-MAC make local policy decisions to optimize power consumption, latency, throughput, fairness, or reliability. To achieve low-power operation, BMAC employs an adaptive preamble sampling scheme to reduce duty cycle and minimize idle listening. Each time the node wakes up, it turns on the radio and checks for activity. If it detects activity, the node powers its radio transceiver up and stays awake for the time required to receive the incoming packet. After reception, the node returns to sleep. If no packet is received within the specified timeout, the node goes to sleep. BMAC supports onthe-fly reconfiguration and provides bidirectional interfaces for system services to optimize performance, whether it is for throughput, latency, or power conservation.
5. S-MAC: The sensor-MAC (S-MAC) protocol is designed explicitly to reduce energy waste caused by collision, idle listening, control overhead, and overhearing. The goal is to increase energy efficiency while achieving a high level of stability and scalability. In exchange, the protocol incurs some performance reduction in per-hop fairness, and latency S-MAC uses multiple techniques to reduce energy consumption, control overhead, and latency, in order to improve applicationlevel performance. In the following we provide an overview of the S-MAC-layer protocol and discuss the techniques it proposes to achieve energy efficiency while keeping latency low. S-MAC exploits the bursty profile of sensor applications to establish low-duty-cycle operation on nodes in a multihop network and to achieve significant energy savings. During the long periods of time during which no sensing occurs, S-MAC nodes alternate periodically between listening and sleep modes. Each node sets a wakeup time and sleeps for a certain period of time, during which its radio is turned off. At the expiration of the timer, the node becomes active again. To further reduce control overhead while keeping message latency low, the protocol uses coordinated sleeping among neighboring nodes. Periodic sleeping reduces energy consumption at the expense of increased latency. The importance of message latency strongly depends on the requirements of the sensing application. S-MAC focuses on applications that can tolerate latency on the order of seconds. However, when nodes follow their schedule strictly, latency can increase significantly. To address this shortcoming and keep message delay within the targeted-second-level latency, S-MAC uses adaptive listening.S-MAC design is focused on cooperating applications, such as monitoring and surveillance applications. The applications cooperate to achieve a common single task, such as protecting a critical infrastructure. The nature of these applications is such that at any particular point in time, one sensor node may have a large amount of information to communicate to its neighbors. To accommodate this requirement while further reducing overhead, S-MAC sacrifices channel access fairness and uses the concept of message passing, whereby a node is allowed to send a long message in burst. Message passing reduces control overheard and avoids overhearing.
6. SCHEDULE-BASED PROTOCOLS: Schedule-based MAC protocols for WSNs assume the existence of a

schedule that regulates access to resources to avoid contention between nodes. Typical resources include time,a frequency band, or a CDMA code. The main objective of schedule-based MAC protocols is to achieve a high level of energy efficiency in order to prolong the network lifetime. Other attributes of interest include scalability, adaptability to changes in traffic load, and network topology. Most of the scheduled-based protocols for WSNs use a variant of a TDMA scheme whereby the channel is divided into time slots. A set of N contiguous slots, where N is a system parameter, form a logical frame. This logical frame repeats cyclically over time. In each logical frame, each sensor node is assigned a set of specific time slots. This set constitutes the schedule according to which the sensor node operates in each logical frame. The schedule can be either fixed, constructed on demand on a per-frame basis by the base station to reflect the current requirements of sensor nodes and traffic pattern, or hybrid, in which case the structure varies over different time scales and sensor behavior. Based on its assigned schedule, a sensor alternates between two modes of operation: active mode and sleep mode. In the active mode, the sensor uses its assigned slots within a logical frame to transmit and receive data frames. Outside their assigned slots, sensor nodes move into sleep mode. In this mode the sensor nodes switch their radio transceivers off to conserve energy.

B. DYNAMIC ROUTING PROTOCOLS

1. E-ADCR: Energy-efficient Asynchronous low Duty-Cycle Routing (E-ADCR) is paired with an asynchronous, blind and opportunistic MAC protocol running at a low-duty period and EADCR is an important flood-based routing protocol. While the E-ADCR protocol allows the shortest possible use of simplicity and usefulness, it is not ideal for mission-critical applications in WSNs. In comparison, the flood-based process absorbs a large amount of node power and thus contributes to fast network partitions.
2. E2DSR: Energy Efficient Dynamic Source Routing (E2DSR) is based on a Dynamic Source Routing protocol which uses the current control packet structure. The Dynamic Source Routing protocol is based on E2DSR. In addition, the protocol alters sensor node routing habits, generates a new ’energy table’ and creates a new algorithm for caching paths and selection. E2DSR uses a basic discovery method on demand using tiny routing tables to calculate a path priority. However, the protocol can manage resource consumption between various nodes in the network, but it also requires overheads for storage and connectivity.
3. LINK STATE ROUTING: Link state routing protocols maintain complete road map of the network in each router running a link state routing protocol. Each router running a link state routing protocol originates information about the router, its directly connected links, and the state of those links. This information is sent to all the routers in the network as multicast messages. Link-state routing always try to maintain full networks topology by updating itself incrementally whenever a change happen in network.

Each router in the network keeps a copy of it, without changing it. After obtaining the complete picture of network topology, each router will independently calculate its own best paths to reach the destination networks.

Link state protocols are based on Shortest Path First (SPF) algorithm to find the best path to a destination. Shortest Path First (SPF) algorithm is also known as Dijkstra algorithm, since it is conceptualized by Dijkstra. In Shortest Path First (SPF) algorithm, whenever a link’s state changes, a routing update called a Link-State Advertisement (LSA) is exchanged between routers. When a router receives an LSA routing update, the linkstate algorithm is used to recalculate the shortest path to affected destinations. Each router constructs a map of the complete network. An example of Link State protocol is OSPF (Open Shortest Path First).

V. HIERARCHICAL ROUTING PROTOCOLS

A. LEACH

Low-energy adaptive clustering hierarchy (LEACH) is very energy efficient routing protocol. In this protocol each WSNs are divided into cluster, and every cluster consists of a cluster head (CH) and number of cluster relationship, multiple cluster heads form the high-level network. In terms of operation, a HRP consists of two stages: In the first stage is the set-up, when the sensor nodes are organized to form hierarchical structural design either in a cluster based or chain based manner or, In the second stage is the steady state, when data are routed from sensor nodes to the BS. The hierarchical structural design of a cluster-based can be set up by using distributed algorithm or centralized algorithm. LEACH is totally distributed and no needs a global knowledge of network. It reduces energy consumption by insignificant the communication rate between

DOI: 10.48175/IJARSCT-4451

sensors and their cluster heads and turning off non-head nodes as much as possible. LEACH utilize a one hop routing where every node can transmit directly to the cluster-head and a sink because of this reason LEACH is not capable for to distributed in large area. It is closes in a finite number of iterations, but not surely about good CH deployment and guess uniform energy consumption for CHs. There are some drawbacks of LEACH; so much research has been done to make LEACH perform better. Some of researches are: E-LEACH, TL-LEACH, M-LEACH, LEACH-C and V-LEACH.

1. E-LEACH: It is abbreviation of ENERGYLEACH and it is improves the cluster head selection procedure of LEACH protocol. Primarily all nodes have the same probability to be CH, but in next round of iteration, the node with high residual energy will be chosen as CH rather than those with less energy. This protocol provides life span of network and energy saving compared to LEACH protocol.
2. LEACH-C: It is abbreviation of CENTRALIZED LEACH. LEACH has no information and knowledge about the number of cluster head and the location cluster members. LEACHC improves the LEACH By BS is responsible for forming clusters for each round by running centralized cluster formation algorithm by getting remaining energy and position of each sensor node.
3. LEACH-B: It is abbreviation of BALANCED-LEACH. LEACH does not consider the energy for the selection of CH. LEACH-B use decentralized algorithms for the CH by evaluating the energy need for the path between itself and destination.
4. LEACH MOBILE: It is support mobility, involves the mobility of non -cluster head nodes and cluster head during the setup and steady state phase.
5. LEACH-A: It is abbreviation of ADVANCED LEACH. LEACH protocol work in homogeneous network and does not support reliability. LEACH-A, a heterogeneous energy protocol and it's purpose is energy saving and reliable data transfer. It achieves the minimum node's failure probability and for extending the time interval before the death of the first node which can be referred to as stability period.
6. V-LEACH: It is abbreviation of VERSION OF LEACH. In LEACH, cluster head has no sufficient energy to transmit data or collected cluster member to the BS. To overcome this problem V–LEACH is introduced. In V-LEACH, There is a vice-CH that takes the role of the CH when the CH dies. Cluster nodes data will always reach the BS. There is not necessary for electing a new CH when CH dies each time. This will extend the overall network life time.

B. ADAPTIVE CLUSTERING APPROACH

It is a routing protocol in which load traffic is shared among cluster members in order to reduce the dropping probability due to queue overflow at some nodes. It is a novel hierarchical approach, called Hierarchical Energy-Balancing Multipath routing protocol for Wireless Sensor Networks (HEBM). The HEBM approach aims to fulfill the following purposes: decreasing the overall network energy consumption, balancing the energy dissipation among the sensor nodes and as direct consequence: extending the lifetime of the network. In fact, the cluster-heads are optimally determined and suitably distributed over the area of interest allowing the member nodes reaching them with adequate energy dissipation and appropriate load balancing utilization. In addition, nodes radio are turned off for fixed time duration according to sleeping control rules optimizing so their energy consumption. HEBM protocol increases the profit of energy, and prolongs the network lifetime duration.

C. PEGASIS

Power-Efficient Gathering in Sensor Information Systems (PEGASIS) is an energy dissipation chain protocol that expands the network's existence by allowing nodes that only connect with nearer neighbors. Each node is presumed to know all other nodes' location information.It is an extension of LEACH protocol, that kind of a chain from sensor nodes so that each node transmits and receives from a neighbor and only single node is selected from that chain to transmit to the base station (sink). Data is gained and moves from node to node, combined and finally send to the base station. That chain can be performed in greedy style. PESASIS reject cluster formation and use only one node to transmit to the sink (base station) alternatively using more than one node. In PEGASIS routing protocol, the structure phase assumes that all the sensors have global knowledge about the network like a mainly, the positions of the sensors and use a greedy approach. If a sensor fails or dies due to low battery power, then chain is structured utilizing the similar greedy approach by bypassing the failed sensor. At every round, a particularly select sensor node from the chain will deliver the aggregate data to the BS, so reducing the per energy spending compared to LEACH.

D. HEED

Hybrid Energy-efficient Distributed (HEED) Algorithm is an algorithm spread that takes energy and coordination costs into account when choosing CHs. HEED is a balanced clustering system that is energy efficient. It also offers a stable and flexible environment. The protocol has one drawback: several iterations will lead to additional charges. In comparison, the HEED Protocol does not fix the fault-tolerance dilemma either.

E. TEEN

Threshold Sensitive Energy Efficient Sensor Network Protocol (TEEN) is a hierarchical clustering protocol that is group's sensors into clusters with every node conduct by a CH. Each sensor inside a cluster reports their sensed data to their CH. The CHs sends collective data to higher level CH till the data reaches to the sink. Hence, TEEN is closer nodes from clusters and this process goes on the next level till the BS is reached. TEEN is useful for applications where the users can control a trade-off between energy efficiency, data accuracy, and response time dynamically. This protocol is not capable for sensing application where periodic reports are required so the user may not get any data at all if the thresholds are not reached.

F. APTEEN

Adaptive Periodic Threshold Sensitive Energy Efficient Sensor Network Protocol (APTEEN) is a protocol of advance to TEEN to overcome it's drawback and goal at getting periodic collection and responding to time-critical events. So APTEEN is a hybrid type protocol that permit the sensor send to their sensed data randomly and response to any quick change in the value of the sensed assign by reporting the similar values to their CHs. It's architecture is same as TEEN, that is uses the concept of concept hierarchical clustering for energy efficient communication between source sensors and the sink. APTEEN supports three different query types namely (i) historical query, to study past data values, (ii) onetime query, to take a snapshot view of the network; and (iii) persistent queries, to examine an event for a period of time. APTEEN guarantees lower energy dissipation and a larger number of sensors animate.

G. UNEQUAL CLUSTERING

Unequal clustering is one of the promising methods to avoid hot spot problem which decreases the size of clusters nearer to the BS and the size of clusters keep on increasing as the distance between BS and CHs increases. This approach maintains energy balance between the clusters which is achieved with less intra-cluster energy consumption in the clusters closest to the BS. Eventually, high intra-cluster traffic is in the faraway clusters. This maintains a fair balance between inter and intra-cluster communication load in order to reduce energy consumption. The process of cluster head selection and unequal clustering. An attribute-based CH selection method, based on the parameters: neighborhood proximity value, the remaining energy of SNs, and communication link quality factor (LQF), has been used.

H. EECF

It is a distributed clustering protocol for sensor networks, called Energy-Efficient Cluster Formation protocol (EECF). It is a novel distributed clustering algorithm where cluster heads are elected following a three-way message exchange between each sensor and its neighbors. Sensor's eligibility to be elected cluster head is based on its residual energy and its degree. Minimizing energy dissipation and maximizing network lifetime are among the central concerns when designing applications and protocols for sensor networks. Clustering has been proven to be energy-efficient in sensor networks since data routing and relaying are only operated by cluster heads. Besides, cluster heads can process, filter and aggregate data sent by cluster members, thus reducing network load and alleviating the bandwidth. This protocol has a message exchange complexity of and a worst-case convergence time complexity.

I. CAST-WSN

It is Clustering Algorithm based on Steiner Tree and C-Means. It is based on three criteria: the node distance from the gravity center of the cluster, the node distance from the gravity center of cluster nodes and the node distance from the energy center of nodes in each cluster. Based on these distances and Steiner tree structure, there exist two types of clustering. In this research, we present a function to evaluate the quality of cluster by means of which the quality of clusters in the two presented states can be examined and the best type of clustering can be selected. CAST-WSN method has improved a main criterion called cluster density.

J. PEACH

It is Power Efficient and Adaptive Clustering Hierarchy (PEACH). By utilizing the over heading functionality of wireless networking, the PEACH protocol forms cluster without any extra overhead. With adaptive multi-level clustering and lowered overhead transmission costs, PEACH increases the network life and energy usage greatly. However, all network SNs are considered to be similarly appropriate by the protocol. PEACH cannot however be matched to heterogeneous WSNs.

K. GRID

Grid shape can be rectangle, hexagons triangles etc. Algorithms used in MS scenarios must keep track the latest location of MS to deliver data. But periodic location updates create overhead. This problem is solved by using a virtual grid structure in (Khan et al., 2014). In this approach only few number of nodes need to re-adjust the routes for data delivery to MS. Firstly, Dividing te sensing field to number of grids. Then in each cell cell head is selected based on closeness to the mid point of cell. Through gateway nodes communication make possible between adjacent CHs. These gateway nodes together with CH constitute virtual backbone structure. MS moves through the periphery of the sensing field and collect data from border CH. In order to reduce the overhead in CH selection process, a threshold based approach is used. A virtual grid based routing algorithm is proposed in (Bhatti et al., 2017). Sink is moving along sensing field which is divided as equal size grids.In each grid a cell head is selected they are responsible for collecting data from the corresponding grid. MS moves along the periphery of the network and collect data from CH of border grids. CH selection at border grids is based on minimum distance, hence data transmission need only few hops. This method is very energy efficient because it reduces cost of route construction and take minimum distance rout to sink.

L. TREE

In tree based methods create a logical tree is formed by all nodes. An energy-aware and scalable data dissemination approach for environmental monitoring is suggested in (Mir et al., 2007). The protocol is called quad tree based data dissemination. Nodes detect mobile stimulus(workers) and they determine set of RPs by dividing network into equally sized quadrants. The source nodes send sensed data to the nodes situated at centroid of quadrants. MS initiate querying the immediate RPs until it get required data. The proposed protocol reduced energy consumption as well as maintain data delivery ratio.

Tree structure based approach in (Chang et al., 2016) help to reduce the data forwarding distance of nodes. The protocol create an energy efficient routing structure by considering distance nodes, MS location and sensor nodes residual energy.This design organized as two phases. Setup phase includes tree structure formation, determining hop nodes and selecting CH nodes. The tree-cluster members are assigned with a TDMA schedule based on number of nodes in the tree-cluster. This scheme minimizes data forwarding distance of nodes thereby achieving improvement in energy saving and increased network lifespan.

M. RENDEZVOUS-BASED METHODS

Rendezvous-based methods construct a rendezvous region. Rendezvous nodes in the rendezvous region collect data packets form source nodes. When sink request for data, these rendezvous nodes forward the stored data. A Rail based virtual infrastructure is suggested in (Shin et al., 2005), which is used in applications like habitat monitoring, target tracking etc. A rectangular area(rail) is formed at the middle of the network and act as rendezvous area. The source node send metadata to the nodes in the rail. Upon receiving this metadata rail nodes create a station and share the meta data among nodes situated on the station. Sink initiate uni-cast query to rail for the meta data, it propagate and reaches to the station nodes. The station node share sink position with the source node, source node directly send data to sink. This protocol possess better energy efficiency and scalability but suffers due to high latency and data loss.

To overcome data loss created from a source node failures in rain based approach a line based data dissemination protocol is suggested in (Hamida et al., 2008). Here a virtual vertical line divides the sensing area into two portions. This line is created at the centre of the field hence it is easier to accessible by nodes. This line area is called rendezvous region and nodes at the boundary of the line is called in-line nodes. The source node generate data and transmit it to closest in-line node. Ms forward query to line and it is propagated through the line until it reaches the data storing in-line node. Then direct transmission of data to sink occurs. This protocol is very simple and overhead reducing but for large network due to broadcasting queries through the line increase energy consumption.

A honeycomb architecture is proposed in (Erman et al., 2012), which divide network into hexagonal grids and can be used in emergency situations. This protocol is called hexagonal cellbased data dissemination which utilize the idea of rendezvous area for queries and events. These areas lie on main direction of the sensing field, hence sink can access fastly. The protocol also make the network against node failures and quick coverage hole recovery is possible.

VI. OPTIMAL ROUTING TECHNIQUES

A. PROACTIVE ROUTING

In this category nodes have routing table to find best path towards receiver. The content of the table includes path between node and its neighbors along with cost of each path. This routing type used in applications needs periodic data detection like monitoring temperature variation over a specific area. Two-tier data dissemination is proposed in (Luo et al., 2005). Here the source node proactively build a grid around itself and act as crossing point of constructed grid. Sink send queries by local flooding within the cell and this query forwarded to source node. By using the reverse path of data request source send data to sink. In some applications it is not possible for MS to move freely in the sensing field. Hence predefined path is not possible. In order to avoid the overhead due to the sink location updation, when future location of sink is nit known in advance, (Liu et al., 2011) proposes a proactive data reporting scheme called sinkTrail. The two key features of this protocol area flexibility in motion of MS and usage of logical coordinate system instead of GPS devices. This coordinate system helps the nodes for selecting nearest path to MS. But cause delay because by using neighbor information nodes have to find best route.

B. REACTIVE ROUTING

In this category nodes responds to the sudden changes in the sensing field. Nodes does not maintain an established rout hence it add delay for finding the route before sending data. suitable for time critical applications like explosion detection. In other words we can define a reactive protocols, in which the sensor which have data to send is responsible for finding location of sink. Proactive routing protocols always keep routing information, even when there is no events to report. Hence it cause unnecessary energy consumption, (Aranzazu et al., 2017) solve this issue by using a reactive routing protocol. This protocol includes two main methods,Firstly during the absence of events node does not keep routing information to track path of MS. Secondly use a shortcut mechanism to reach sink for reporting an event using shortest path. In order to avoid the periodic updation of data delivery path, the protocol use anchor nodes.

C. HYBRID ROUTING

This category includes, nodes react to the sudden variations in the sensing field as well as they send the data monitored at periodic intervals to sink. A hybrid approach is considered in (Wohlers et al., 2009). In proactive scheme, sensor nodes send their data to the selected storage node, from these storage nodes roaming sink collect data. In reactive scheme MS advertise their location updates continuously to the closest node. This process is similar to flooding but controlled by tree depth parameter. Each sensor keep both history of sink visiting, required for proactive scheme and track sink position as it reach in and out of the coverage area specified by reactive scheme. The use of storage nodes make the method suitable for delay aware applications but it also create hotspot problem at storage nodes. An energy efficient hybrid scheme which can be used in battle field and a vehicle as MS is proposed in (Kaleibar et al., 2016). This protocol consist of three phases. Firstly, sink discovery which again consist of two sub phases that include proactive discovery and reactive discovery. In proactive,sink follow predefined path and periodically broadcast location updates. Reactive discovery is used by the nodes which fail to receive discovery messages. Secondly, the rout planning phase by using a spanning tree method. This scheme reduces network traffic as well as enhance life time of network. Applications like planetary applications need large scale deployment of sensors, hence clustering will cause large end-to-end delay in data delivery. A space exploration application of WSN with multiple unmanned ground vehicle as MS is considered in (Aldabbas et al., 2016). The proposed protocol is called optimum mobile sink selection algorithm(OMSS). It uses hybrid MS discovery method that combine both reactive and proactive method. Proactive approach uses after network deployment and reactive approach used to include orphaned node to the network. The protocol defines a parameter called connection expiration time(CET), is the time interval during which sensor remain connected to MS without disconnection. When node receive sink advertisement messages it select best MS path based on CET. OMSS provide best performance for a long period because it allows sensor to choose MS.

D. QUERY-BASED ROUTING PROTOCOLS

In query based routing protocols source node forward data to sink as a response to the query received from sink. In query based data collection it is necessary to consider delivery latency and energy consumption of query and response packets. Query-based data collection scheme(QBDCS) proposed in (Cheng et al., 2009) address these problem by using MS,which is aware about its mobility features through GPS. Ms send query packet to ROI in the sensing field. The packet contain position information of ROI. The sensor node nearest to the centre of ROI select itself as CH. CH aggregate data and through multihop send to MS. In order to solve the problem of delivery latency and energy consumption this protocol uses two main approaches. Firstly find packet delivery velocity and predict the location at which MS meet response packet. Hence by using geographical routing response packet can be send to the determined meeting position. Secondly, finding optimum opportunity for transmitting query packet by MS. Through these approaches this scheme attain reduced delivery latency and reduced energy consumption. A mobile sink based routing protocol was proposed in (Nazir et al., 2010). MS moves through a clustered network and its movement is based on residual energy of CH. The protocol consist of set-up phase ans steady state phase. set-up phase include clustering and MS location advertisement to CH through broadcasting of beacon messages. In steady state phase MS allocate TDMA schedule to the selected CH¿ CH collect data from cluster members and forward to MS. Then based on residual energy of CH MS select next CH for data collection.

E. COHERENT AND NON-COHERENT ROUTING PROTOCOLS

In non-coherent way of data processing, source node locally process data before forwarding to the aggregator. While in coherent approach, the aggregator perform major part of processing and sensor node responsible for minimum processing. In coherent method, processing include three phases. First phase include detection of target, data collection and processing of collected data. Second phase include membership declaration and in third phase select central node or aggregator which perform main processing(Al et al., 2004). Generally in coherent methods node perform local processing such as duplicate suppression, time stamping etc. Coherent method is more energy efficient. A coherent based approach is considered in (Kostin et al., 2016) known as any-cast tree based routing. Sensor nodes are responsible for collecting data includes motion of objects, detection of intruders, humidity and temperature and they conduct few preliminary processing on monitored data. The final processing is done by MS/ BS. A non-coherent based approach called multichain PEGASIS is considered in (Jafri et al., 2013), which reduce data delivery delay and distance between nodes by using small chains. The protocol involves major phases such as construction of main chain, chain leader election and data transmission. Data aggregation is done by using discrete cosine transform(DCT) in each node. That is each node accept data from child node and by using DCT compression of data occurs. These nodes combines its own data and received data through compressive sampling.

F. BACKBONE BASED PROTOCOLS

In backbone-based methods, the source node find the fresh sink position through the backbone structure, then forward data packet to the MS using multiple hops.

Broadcasting overhead is the main problem related with MS, that is the overhead created during broadcasting of MS position. In ring routing(Tunca et al., 2014), sink position deliver to a ring and node attain the fresh sink position from ring. In order to mitigate hotspot problem, the nodes in the ring and regular nodes can change their roles. sink mobility is random here, because ring routing does not need information about sink motion. Three type of nodes are under consideration, ring node, regular node and anchor node. Regular node forward data to anchor node,that placed in the path of sink and forward to sink.The regular nodes attain sink position from ring. This protocol can be used in time sensitive applications because fast delivery of data is available due to the quick accessibility to the ring. But if radius of ring is small then time for sink localization is increases at border nodes. Similarly the same problem faced by central nodes if radius is high.

A fish-bone structure based backbone construction is introduced in (Sutagundar et al., 2014). The backbone structure is formed by using distinct level of aggregators. Source node forward data through backbone in a multi-hop fashion. This method is efficient in terms of communication infrastructures but resulted in higher latency due to multi-level aggregation. A novel strategy for the formation of routing backbone which is inspired from water vascular system of star fish is proposed in (Habib et al., 2018). The routing backbone includes several radial canals along the network and a central ring canal. In this approach nodes can be accessed by source nodes in a single hop. The source node transmit data to MS through the backbone nodes. The backbone nodes collect data from sensor node using single hop and forward to MS. This approach improves network performance, reduce energy consumption and decrease delay in data delivery.

A multi-ring routing scheme which employ solar powered sensor nodes is considered in (Kang et al., 2019). The sensor node use part of harvested energy to build a ring. The ring nodes only utilizes surplus energy to provide sink location information. This is not effect the general operations of nodes such a s sensing, processing and forwarding. Sink node select the closest node having higher energy as anchor nodes, they inform their location to the ring. If a source node wish to deliver data to sink then these node acquire anchor position from ring nodes. By using location based routing source node deliver data to anchor node. Due to the existence of multiple rings, overhead for attaining sink position reduces but if network size is larger overhead get increases.

VII. CROSS LAYER APPROACHES

A. CROSS LAYER JOINT ROUTING

The protocol is an optimal cross-layer joint routing and scheduling problem for WSN with periodic data collection. The problem is formulated as an Integer Linear Program (ILP) model such that a joint scheduling and routing is developed to maximize network lifetime. An ILP model for Energy-Efficient Distributed Schedule-Based (EEDS) protocol. The main objective of the ILP model is to build an energy efficient joint routing tree and TDMA scheduling framework considering the EEDS assumptions.

B. FAMACRO

The FAMACRO protocol presents Fuzzy and Ant Colony Optimization (ACO) based MAC/Routing cross-layer protocol (FAMACRO) for Wireless Sensor Networks that encompasses cluster head selection, clustering and inter-cluster routing protocols. This work combines ideas of energy efficient hierarchical cluster routing and media access. It uses a fuzzy based cluster head selection technique for selecting nodes with high residual energy, having more number of neighbouring nodes and high quality of communication link.

VIII. ENERGY HARVESTING TECHNIQUES

A. FFC

The “Finer Force Care-up (FFC) in underground mining” protocol proposed by estimates the quantity of available energy for each sensor node and shares the overall collected energy in the whole WSN for underground mining. In this protocol, a sink node perceives battery power from the neighbour sensor nodes using wireless power transfer technology by means of a microwave power transmitter. The authors used the MonteCarlo-Localization method to compute the distance between the BS and each sensor node.

B. SHE-WSN

The “Solar Energy Harvesting for Smart Agriculture Monitoring (SHE-WSN)” protocol proposed by is based on the dynamic source routing (DSR) protocol and IEEE 802.15.4 standard communication protocols. The sensed data is delivered to a gateway or sink node through a multi-hop routing technique. The sensing procedure of the nodes is guided by the duty cycle. In this protocol, batteries of the sensor nodes are recharged through solar energy harvesting.

C. ESO-EAMP

The “Energy Storage Overflow (ESO)-aware multiple path (EAMP) protocol” by utilizes a data delivery technique in which several routes from the source node to the BS are formed. The sensed data is split and transmitted through the different routes. This technique, according to the authors, assists in mitigating ESO and alleviating the “energy hungry and surplus co-existence" problem. This problem refers to a scenario where some sensor nodes are starved of energy while some other nodes within the same WSN have reached their energy storage capacity and can no longer accommodate the extra energy being harvested.

D. TIME-DRIVEN EHWSN

It is an "optimal routing protocol for TimeDriven EH-WSN under Regular Energy Sources". This protocol operates in such a way that nodes regularly detect the environmental conditions and cooperatively transmit information to a sink. The authors prioritised the concept of Minimum Hop Count (MHC). The so-called "energy-neutral condition" for EHWSN is applied in this routing protocol.

IX. CONCLUSION

This paper provides a brief view about the existing routing protocols that can be used in WSNs for energy management. The protocols can be selected depending up on the application. The routing protocols should be selected in such a way that they meet the required performance criterion's. Direct hop to sink routing protocols avoids the need of construction of an intermediate path but they suffer due to high energy consumption. Multi hop routing protocols save energy by avoiding long distance communication. Duty cycle based protocols improves the performance of the overall network by pre defined sleep and wakeup schedule. Hierarchical protocols provides an easy way for attaining sink position information but leads to the formation of hotspot at head nodes. The protocols provides a solution for energy consumption problem by distributing load uniformly along the created virtual structure. The cross layer optimization techniques provides the shortest path along with location information. Energy harvesting helps to extend the life time of the network by scavenging energy from the external source. So, this paper provides the idea of different routing protocols based on different applications to extend the life time of the wireless sensor networks.

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