CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION

Wireless Sensor Networks (WSNs) provide a convenient way to monitor the physical environment. Research effort in the field of wireless sensor communication network mainly focuses towards minimizing the energy consumption, low cost and size reduction as well as improvement of multifunctional sensor lifetime. The focus is mainly driven on the energy efficient hierarchical clustering routing protocol. Clustering mechanism helps to reduce the complexity of network overhead that is proportional to the number of nodes in the network. In this chapter work available in the literature related to routing in WSN, QOS Enabled Routing for WSN, energy conservation in WSN, cluster head selection and optimization in WSN are reviewed.

The routing protocols are based mostly on efficiency of energy and some deal with real-time requirements (Al-karaki & Kamal 2004). The introduction of Quality of Service (QoS) into routing decision suffers from overhead of tables and states maintenance for each sensor node (Sohrabi et al 2000). Routing is a locale, where efficient deployment of energy is to be made. These criteria use stable (crisp) metrics for building energy-conscious routing decisions. As WSN's application area is certain, gateways are chosen to be commanding over the sensor nodes. By this, the energy-constrained sensor node takes in a straight line communication with the remote sink. The
strict energy constraints, huge mass of sensor nodes, minor cost and inactive nodes state make WSN (information gathering) differ from ad-hoc net (distributed computing) (Akkaya & Mohamed Younis 2005).

Chipara et al (2006) designed a Real-time Power-Aware Routing (RPAR) protocol that achieves application-specified communication delays at low energy cost by animatedly adapting transmission power and routing decisions. An Adaptive Routing Protocol (ARP) proposed that energetically adjusts the transmission rate of data packets during the end-to-end transmission (Peng et al 2007). In this paper an energy efficient method for packet transmission in WSN based on fuzzy logic is proposed. A fuzzy logic based approach for energy-aware routing in WSNs is flexible and so that it can put up sensor networks comprising various types of sensor nodes having varied energy.

2.2 ROUTING IN WSN

Ahmad et al (2013) proposed a new clustering technique for ad-hoc WSNs. From energy conservation perspective in WSNs, clustering of sensor nodes was a challenging task. A new routing protocol was evaluated for WSNs named Divide-and-Rule (DR) scheme used a hybrid approach of static clustering and dynamic CH selection technique that selects fixed number of CHs in each round instead of probabilistic selection of CH. In MATLAB simulation the results were compared with LEACH and LEACH-C. Results were better than its counterparts, in terms of stability period, network life time, area coverage and throughput. However, large network area and greater number of nodes decrease DR efficiency in terms of energy consumption.
Recent WSN routing protocols were classified into 3 types of approaches based on network architecture and analyzed by Tyagi & Kumar (2012). WSN consist of small nodes with sensing/computation and communication abilities. Wireless networks are dependent on specific applications and constrained by energy, storage capacity and power. To increase networks life, energy awareness is essential when routing protocols are analyzed. Sensor networks routing protocols must maintain network routes.

Zahariadis et al (2010) suggested a solution to detect and avoid malicious nodes which was implemented in state-of-the-art sensor nodes for real-lifetime. The new type of networking set apart by strictly controlled node resources, limited network resources and the necessity to operate in an Adhoc manner, implementing security functionality to protect against adversary nodes becomes a challenging task.

Singh et al (2010) surveyed and summarized recent research works focused mainly on the energy efficient hierarchical cluster-based routing protocols for WSNs. Based on the topology, the protocol and routing strategies was applied. The survey of the energy-efficient hierarchical cluster-based available routings was performed. Though the performance of the protocols was promising in terms of energy efficiency, further research was needed to address issues related to QoS posed by video and imaging sensors and real-time applications.

Elrahim (2010) proposed an energy efficient data forwarding protocol called Energy Aware Geographic Routing Protocol (EAGRP) for WSNs to extend the life time of the network. WSNs consist of small nodes with sensing, computation and wireless communications capabilities.
Many routing, power management and data dissemination protocols have been designed for WSNs. Geographic routing in sensor networks has been a challenging issue for researchers considering the energy constraints in these networks.

Saleem et al (2009) proposed an enhanced ant colony inspired self-organized routing mechanism for WSNs and it was based on delay, energy and velocity. Advancements in WSN enabled a wide range of environmental monitoring and object tracking applications. Moreover, multihop routing in WSN was affected by new nodes constantly entering or leaving the network. Therefore, the self-optimized and self-aware mechanism was required to handle the problems.

Saghar et al (2009) considered the modeling and analysis of a simple routing protocol (TinyOS Beaconing) using SPIN. Securing a WSN against attack was a particular challenge. Other researchers had already described its vulnerability to attack and the results have been confirmed using the proposed formal framework. Furthermore, the formal framework that was adopted had revealed flaws in the Rumor Routing and Directed Diffusion protocols. A simple requirement property needed that whenever a source node transmits a data message it was received eventually by the base station. The requirement property has been checked both in the presence and absence of various attacks. Analysis showed that the property may not be satisfied in the presence of any of the attacks that have been considered. The counter-examples generated by SPIN were extremely useful in determining the reason for the failure of the required property in each case. These results encouraged to believe that formal analysis by model-checking can be used successfully to discover flaws in WSN routing protocols that was not discovered by visual inspection or simulation.
Hancke & Leuschner (2007) stated a Simple Energy Efficient Routing Protocol (SEER) to improve network lifetime by limiting the number of messages that were sent through the network. SEER uses a flat network structure for scalability and source initiated communication, along with event-driven reporting to reduce the number of message transmissions. Computational efficiency was achieved by using a relatively simple method for routing path selection. Routing decisions were based on the distance to the base station as well as on remaining battery energy levels of nodes on the path towards the base station. SEER minimizes the number of messages that were sent through the network and thus reduces the overall energy consumption. Simulation results showed that SEER achieved a significant energy savings for a set of specific conditions. The results from the six tests confirm that overall the routing protocol was novel and made an important contribution to the literature by being simple enough to be physically implemented on a variety of existing WSN nodes while still achieved a very high level of energy efficiency.

Celik et al (2010) made a survey on swarm intelligence on WSNs. Recently, wireless sensor networks have attracted many researchers. One of the main topics adopted by researchers on WSN was to develop routing protocols for wireless systems. Routing protocol development concerned to deal with problems such as complexity, scalability, adaptability, survivability, and battery life in wireless systems. Routing protocols grounded for wireless systems were developed in order to solve these problems. When literature was investigated, it was obviously seen that routing protocols for WSNs were implementations from wired networks. The researches done have shown that swarm intelligence based routing protocols was removed at least one. Ant based approaches were attracted to researchers than other approaches.
Hu & Sharma (2005) analyzed security challenges in WSNs and summarized key issues that were solved for achieving the WSN security. Security was the key player of good sensor network design. So far, the main research had been focused on making sensor networks feasible and useful. Hence less emphasis was placed on security. Some secure methods were designed to achieve security in WSNs. It gave an overview of the current state of solutions on key issues as secure routing, prevention of denial-of-service and key management service. Finally the integrated approach was presented for the secure wireless sensor networks. Also, integrated wireless security scheme was summarized and it had been considered as a specific routing characteristic of sensor networks such as large-scale, dynamic topology and low-energy.

Musunuri & Cobb (2005) proposed a Hierarchical-Battery Aware Routing (H-BAR) protocol. WSNs were envisioned to help many monitoring applications. To make nodes discharge pulsed, cluster heads role was changed periodically between nodes. Battery recovery capacity depends on the batteries remaining capacity. A node with higher remaining capacities has high recovery probability than nodes with lower remaining capacities. So to improve recovery capacity, each node’s discharge must be uniform. Probabilistic election fails to provide uniform discharge from nodes. To ensure uniform discharge in H-BAR nodes with higher remaining capacities were chosen as cluster heads. Simulations reveal that H-BAR improves WSN life nearly three times over life of WSN using LEACH protocol.

Biradar et al (2011) analyzed the design issues of WSNs and presented a classification and comparison of routing protocols. Most attention was given to routing protocols as they differed depending on application and network architecture. To prolong sensor nodes life, designing efficient routing
protocols was critical; though sensor networks were originally designed to monitor and report events, as they were application dependent. Also a single routing protocol was not efficient enough for sensor networks across applications. The comparison made revealed the important features that needed to be taken into consideration while designing and evaluating new routing protocols for sensor networks.

Ko et al (2011) evaluated the performance of the IETF RPL routing protocol using an implementation of TinyOS 2.x. Responding to the increasing interest to connect WSN to the Internet, the IETF has proposed standards that enable IPv6-based sensor networks. Specifically, the IETF 6LoWPAN and Roll working groups developed standards for encapsulating IPv6 datagram's in 802.15.4 frames, neighbor discovery, and routing that allow sensor networks to exchange IPv6 datagram's with Internet hosts. However, given that these standards, especially the RPL routing protocol, were relatively new, there has not yet been a study that measures the actual performance of these proposals using real implementations. The BLIP and TinyRPL implementations was used in TinyOS 2.x to evaluate the performance of the newly proposed standards and compare them with CTP, the de-facto routing protocol standard for TinyOS. Results indicated that the performance of TinyRPL was comparable with CTP and at the same time, TinyRPL provided additional functionalities that traditional WSN routing protocols could not provide.

Suh et al (2008) projected an advanced IEEE 802.15.4 called TEA-15.4 that is based on traffic information, which adaptively regulates the active period of transmission. This TEA-15.4 utilizes two mechanisms Arbitrary Traffic Signal (ATS) and Traffic Time-Out (TTO) to identify the data traffic in the network. Using these 2 mechanisms the TEA-15.4 promotes
multimedia communications by sufficient data throughput and also presents a smaller amount of energy consumption to sense device in WSNs. The full-standard IEEE 802.15.4 is employed on TinyOS to estimate the performance of the proposed TEA-15.4. Hence, TEA-15.4 is proved to be the apt mechanism for Wireless Multimedia Sensor Networks (WMSNs) as seen from the results discovered from the test bed experiments and the TinyOS Simulator (TOSSIM).

Chen et al (2007) studied a new multipath routing method termed Directional Geographical Routing (DGR), to deal the problem of real-time video streaming on a bandwidth and energy constricted WSN by combining Forward Error Correction (FEC) coding, the small number of isolated Video-Sensor Nodes (VNs) to a sink. For transmitting parallel FEC-protected H.26L real-time video streams on a bandwidth-limited, undependable networking environment, the DGR develops an application-unique number of multiple disjointed paths for a VN. The fast packet delivery, load balancing and aggregation are assisted by the multiple paths in DGR. The presentation of DGR is experimented through simulation on randomly generated WSNs that reveal the benefits:

1) Considerably long network life-time,
2) Enhanced received video quality and
3) Lower delay.

Particularly, DGR improves up to 3dB the average video Peak Signal-to-Noise Ratio (PSNR) when compared to the other existing geographic routing methods.

Zhang et al (2008) studied a Multi Priority Multipath Selection (MPMPS) method in transport layer to select the highest number of paths from every node disjoint found in routing paths to increase the outcome of
streaming data transmission. The maximum number of paths for video transmission is capably selected by the MPMPS is illustrated through its simulation results.

Lu et al (2002) proposed novel real-time communication architecture for WSN, RAP for large-scale sensor networks. For distributed micro-sensing applications, RAP ensures convenience, query at high-level and event services. A light-weight and scalable network stack supports the new location-addressed communication prototypes. The velocity monotonic scheduling was a new packet scheduling policy that is introduced and estimated essentially for both distance and time limitations. This policy is specifically appropriate for communication scheduling in a large number of wireless devices that are in corporate impeccably into a physical space to implement real-time monitoring and control. The observation from the detailed simulation of RAP in representative sensor network environments reveals the decrease in the sensor network's end-to-end deadline miss ratio.

2.3 QoS ENABLED ROUTING FOR WSN

Kumar et al (2013) personalized the Ant Colony Optimization (ACO) technique to avoid some capabilities in terms of sensing, communication and computation in homogeneous environment. However, deployment of a homogeneous sensor network suffered with poor performance. A novel QoS routing scheme provided an optimal routing strategy, depending on multiple optimization goals. Here the local pheromone updating rule, the global pheromone updating rule and the state transition rules in an ant algorithm were extended to combine ants’ pheromone with the QoS requirements of the network traffic. Entire traffic was classified into routing traffic and data traffic. Data traffic was further categorized into multimedia traffic and scalar traffic and the routing decision was based on its
QoS requirements and thus it has been achieved the performance improvement. Simulation results showed that the performance of the proposed protocol outperforms the standard AODV in terms of packet delivery fraction, end-to-end delay and jitter for HWSN with dynamic topology.

Leone et al (2013) declared that in WSN several remote clients were interested in receiving the information collected by the nodes of a WSN. Main aim is to improve the overall network lifetime, while meeting requirements of external applications in terms information freshness. Constrained Application Protocol (CoAP)-HTTP proxy was used to evaluate the performance of our caching system. Based on information from routing packets and estimations of nodes power consumption, an optimization strategy was derived which allows to either maximize the user satisfaction, expressed in terms of freshness of cached data, in the presence of constraints on network lifetime, or jointly maximize network lifetime and user satisfaction, obtaining a set of non-dominated Pareto optimal solutions. Simulation results showed that the introduction of a caching architecture had an impact in terms of energy saving on the system performance, since it allows reducing the transmissions inside the WSN.

Wang & Tsai (2013) addressed problems in controlling WSNs, QoS. QoS is the number of awakened WSN sensors. A novel QoS control scheme had been proposed that periodically swaps active and sleeping sensors to balance power consumption. An enhanced QoS control scheme, called Shuffle was used which maintains the force of the Gur Game-based system comparable to self-optimization. The assessment of Shuffle in different environments showed that Shuffle significantly improves network lifetime. The WSN lifetime were extended and maintained with desired QoS.
Further simulation results prove that the gains of Shuffle depend on the period of shuffles. A short shuffle period achieves high power consumption, whereas frequent shuffles lead to system instability. Also, the simulations were compared with previous schemes in various environments which showed that new scheme built a tough and long-lasting sensor network competent of dynamically changing active sensors.

A low-complexity joint power allocation and route planning algorithm for multiple antennas WSN using dynamic programming was proposed by Wu et al. (2012). The joint optimization problem of channel coding, resource allocation and route planning for WSN were provided using demodulation- and -forward protocol at each relay node. The objective function was to find out the packet forwarding route with minimum Frame Error Rate (FER) subject to the end-to-end energy consumption constraint. Specifically, it cast this energy and QoS aware packet forwarding problem into the framework of dynamic programming. Then, a low complexity, suboptimal approach was provided by performing the route planning and power allocation separately. Simulation experiments were carried out to assess the performance of the projected forwarding protocol. The results indicated that the new protocol significantly out performs classical routing algorithms, and achieves comparable performance with the optimal method.

Agarkhed et al. (2012) proposed a multi-sink wireless sensor network architecture where the network was separated into clusters with multiple sinks to augment the manageability of the network and also to decrease the energy wastage at each node. The proposed Energy-Efficient QoS Routing (EEQR) protocol ensures end-to-end delay requirement of real time data, as well as maximizes the throughput of non-real-time data by transmitting the gathered data to the appropriate sink. Simulation results
showed that multi-sinks network deployment provided better performance with respect to single sink model. Here the delay and energy problem in routing were analyzed based on clustered and multi sink WMSN attributes.

Pawar et al (2012) affirmed that WSNs applications had weakness in area of security. In WSN, security was important at all layers because they were susceptible to security attacks which directly affects the energy consumption and due to the large amount of energy consumed at the MAC layer, it was particularly vulnerable to many different security attacks. The behavioral modeling of Medium Access Control (MAC) was performed to learn the security attacks in WSNs. The MAC layer was responsible for energy consumption, delay and channel utilization of the network and attacks on this layer introduced significant degradation of the individual sensor nodes. The UML based behavioral modeling of MAC security attacks gave the understanding look on the behavior of the attacks and the interaction of the system.

Konieczny (2012) clued-up that the Internet suffered from a variety of unique problems such as low throughput, inadequate support for mobility and non-compatible application environments. However, the characteristic of physical environment often provided an opportunity to address these problems. The concepts of enriching were explored in the WNS environment with context-based information. Two types of context information were presented which had the greatest potential such as location and bandwidth quality. In addition, a specific use cases was presented where context data can be used. However, presented opportunities came with many challenges. By context all data available in sensors environment had been considered, not only data processed by them. This data were not utilized by sensors presently, but they were used to improve overall functionality of the sensor network.
The practical challenge faced in the integration of such an approach into the sensor application stack was noted.

Kumar et al (2012) pronounced that the main ability of WSNs was communicating and sensing between nodes, which were deployed in a wide area with a large number of nodes with limited energy resources. To gather sensed information in energy efficient way was critical, since energy was limited. The limiting factors of the sensor nodes, like finite energy supplies and moderate processing abilities, the unreliable wireless medium restrict the performance of WSN. While contemporary best-effort routing approaches address unconstrained traffic, QoS routing was usually performed through resource reservation in a connection-oriented communication in order to meet the QoS requirements for each individual connection. Owing to their versatility and efficient features, routing protocols played an important role in the operation of energy-efficient WSNs. Based on application area and network architecture, several routing protocols had been introduced that ensure energy-efficiency to prolong the network life. QoS-aware routing protocols were designed to minimize bandwidth consumption and latency. Minimum-cost paths were selected for data communications to ensure integrity. This article surveyed a sample of existing QoS-Aware Routing Protocols for WSN and highlighted their key features, including merits and limitations.

Fdili et al (2012) designed many routing protocols to ensure that WSNs capacities were compatible with numerous applications. An area not well investigated was queue management. The aim was to analyze queue buffer size awareness impact on Real-Time (RT) routing protocols QoS in WSNs. SPEED protocol yields RT routing for only one class of traffic, which maintains a desired packet’s Progression Speed (PS) across the WSN.
Multipath Multi-Speed (MMSPEED) protocol extends SPEED by offering various service types to packets based on class of traffic. The contribution was routing decision being made on neighbors’ queue buffer size at every level in addition to PS metric. Simulations proved that metrics were compatible, routing decision was efficient for single and multi service e protocols in addition to improving 2 QoS domains including timeliness and reliability.

Sumathi & Srinivas (2012) stated that with the increasing demand for real time applications in the WSN, the real time critical events anticipate an efficient QoS based routing for the data delivery from the network infrastructure. Designs for such QoS based routing protocol to meet the reliability and delay guarantee of critical events while preserving the energy efficiency was a critical and a challenging task. Considerable research had been focused on developing robust energy efficient QoS based routing protocols. The research had summarized the work on QoS based routing protocols that had already been published and by highlighting the QoS issues that were being addressed. The reliability, delay, and energy efficiency performance of these protocols had been highlighted. The performance comparison of QoS based routing protocols such as Sequential Assignment Routing (SAR), Multi-Path and MMSPEED, Multi Constrained QoS Multi-Path Routing (MCMP), Message-Initiated Constrained-Based Routing(MCBR), and Energy efficient and QoS aware multipath based Routing(EQSR) had been performed and analyzed using ns-2 for various parameters.

Hamid et al (2008) studied a new QoS-aware routing protocol for WSN. The proposed protocol enhances high data rate for wireless multimedia sensor networks. The routing decision was performed for the real-
time data, with regard to the alteration of the necessary bandwidth dynamically and path-length-based on proportional delay demarcation. The performance of the protocol was in a distributed manner in order to guarantee bandwidth and throughout delay necessities for real-time data. Simultaneously, an adjustment is made at the service rate of real-time and non-real-time data to improve the throughput of non-real-time data. In terms of average lifetime, network throughput, and average delay the proposed procedure outperforms well which is demonstrated by estimating the simulation results.

Augustine & Paramasivan (2011) explained about the localization and it was considered of great importance in the design and working of WSN. The current successful technology employed to solve the localization problem is the DV-Hop. Drichlett Tessellation, a refinement of DV-Loc had been employed. It used the Drichlett tessellation and helped in development of robust and scalable WSN. This algorithm aims at converting distance to beacon nodes from hops to meters by computing the average size of the hop. The work proved that the algorithm helps in reducing the errors occurring during localization and utilizes the less processing resources than the other algorithms, relying on relevant co-ordinates and RSSI distance estimation. Other works like convex optimization, multidimensional scaling or semi definite programming are useful to solve localization problem in a centralized manner. Consider the nodes being deployed in distributed grid and the random zero Gaussian error disturbs the location of node and the nodes tend to occupy the sensor field uniformly. The communication cost and energy consumption were the major disadvantages of this algorithm which limits its applications to small and middle sized networks.
Zogovic et al (2009) research on WSN focused mostly on providing energy-efficient operation for every node that ensures long life for WSN. It was important to consider QoS provisioning in addition to taking into account energy-efficiency. A quantitative modeling based approach on energy-efficiency vs. delay trade-off, founded on information theoretic and WC principles, was proposed. Only WSN MAC scheduler based on the model was suggested. Keeping in mind, that throughput, average delay and jitter (delay variance) were important QoS parameters at MAC layer, it led to reviews of fundamental energy-efficiency vs. delay trade-off, and throughput vs. capacity in wireless communications. Existing energy-efficient WSN MAC protocols, with some QoS-aware features were described. Finally, a MAC schedulers review based on results of delay-constrained communications over wireless medium were provided. Combining approaches based on QoS support in computer networks and delay-constrained WC yields methods to fine-tuning energy-efficiency vs. QoS trade-off.

Nikravan et al (2011) affirmed a routing protocol in wireless sensor networks to achieve real-time communication besides the energy efficiency. With demand increasing for real time WSN services, QoS based routing is now an emerging research topic. Providing QoS guarantee in sensor networks is challenging. A fuzzy logic-based Energy Efficient scheme for real-time packet transmission in WSN was proposed. Here a Fuzzy Logic System (FLS) was used as a decision mechanism for next hop node selection. Both transmission rate and energy were chosen parameters for choosing the next-hop node in real-time packet transmission. Simulation results showed that this scheme provided improvement on real-time transmission and energy efficiency performance, low energy consumption and high packet delivery
Bansal et al (2011) said WSN's has led to speedy expansion of real time applications. Numerous routing protocols were designed for these applications where timely delivery of the message is of utmost importance. Here, a comparative analysis of differing and existing real time WSN routing protocols were performed to emphasize their strengths/weaknesses. A protocol which integrates parameters like energy, bandwidth, buffer size and processing capabilities was desired. Also, the protocol not only met QoS standards but was robust, extensible and supported cross layer design. Cross layer design demands merging protocols at various layers and maintaining network simplicity. An analysis of various hard real time and soft real time WSN routing protocols was performed. The study revealed that soft real time routing dominated hard real time routing protocol regarding deadline flexibility. Hence it was concluded that WSN energy metric is inversely proportional to time domain in real time systems.

Jager et al (2013) stated about wireless sensor network technologies that can be used for industrial embedded system design to save cabling cost and weight. However, the environment, architecture, and design issues were quite different from original sensor network applications. A more detailed wireless sensor network was created to check against the application requirements concerning QoS, reliability, and lifetime. An avionics application example was presented. Quality of service parameters of an application had been evaluated more accurately: operational phases and their influence on system operation were specifically addressed. Simulation showed the transient effects, for instance after mode changes. The application example showed how the model evaluation was used to check if MAC
parameters were chosen well or if overloads situations occurred. Future work will be to predict lifetime by adding an energy map to the environment and abstracted energy harvesting components to the sensor nodes.

2.4 ENERGY CONSERVATION IN WSNS

Chong et al (2011) addressed WSN energy conservation issues and suggested concepts/techniques to extract environmental information useful to control sensor operations to enable sensor nodes conserve energy, thereby prolong network life. Concepts/techniques were consolidated in a generic framework called Context Awareness in Sensing Environments (CASE) framework. CASE targets network level energy conservation. A subset CASE framework termed CASE Compact, targets sensor node level energy conservation. These 2 frameworks elaborate/elucidate requirements for operating together in a WSN. They evaluate applications applicable to energy conservation.

Alippi et al (2010) proposed an adaptive sampling algorithm to estimate sensors optimal sampling frequencies online. This approach required designing of adaptive measurement systems minimizing sensors and radios energy consumption. It maintains very high accuracy in collected data. The proposed algorithm - as a case study - considered a sensor for snow-monitoring applications. Simulation showed that suggested adaptive algorithm reduced acquired samples number up to 79% regarding traditional fixed-rate approach. It functions similar to a fixed-rate scheme where sampling frequency was known in advance.

An attractive direction was exploiting WSN’s context-aware capability to ensure energy conservation in intelligent buildings. Yeh et al
(2009) proposed an iPower (intelligent and personalized WSN energy-conservation system) system that combined WSNs and appliance control devices to ensure personalized energy conservation services. A WSN in each room monitors electric appliances usage and determines if electric appliances there can be turned off to conserve energy. The iPower system is intelligent adapting to personal need by automatic adjustment of electric appliances to satisfy requirements.

Francesco et al (2010) proposed an adaptive discovery strategy exploiting distributed independent reinforcement learning to meet these 2 requirements and carried out an extensive simulation analysis to demonstrate the energy efficiency and effectiveness of the proposed strategy. The obtained results showed that solutions provided superior performance in terms of both discovery efficiency and energy conservation.

In response to such issues, Kandris et al (2009) described SHPER (Scaling Hierarchical Power Efficient Routing) the development of an efficient routing protocol. Wireless ad-hoc network includes wireless mobile nodes forming a temporary network without any infrastructure/centralized administration. It is characterized by highly dynamic network topology with limited energy. MANET efficiency depends not only on control protocol, but also on topology/energy management. Clustering strategy improves network flexibility and scalability. Aided by graph theory, genetic algorithm and simulated annealing hybrid optimization algorithm,

Jin et al (2005) suggested a new clustering strategy for topology management/energy conservation. Performance comparison was between original algorithms and 2 new algorithms, i.e.; an improved weighting clustering algorithm and a new Genetic Annealing based Clustering
Algorithm (GACA), regarding aspects of average load-balancing, cluster number, topology stability, and network life. The experimental results showed that the proposed clustering algorithms had a better performance, on average.

Kumar (2011) proposed a novel approach with an energy efficient hierarchical clustering technique using the Fuzzy Logic method. The Fuzzy search algorithm was applied for cluster formation and cluster head selection in the distributed hierarchical clustering environment. The fuzzification functions and rules optimized the simulation. The proposed approach resulted in MAT Lab simulation outperforming the existing results. The evaluation of the proposed approach was compared with LEACH protocol. The result showed the algorithm scaled well in dynamic and energy deficient wireless sensor networks.

A sensor network can obtain state based data from their deployed area. To reduce cost, data sent to the sink through intermediate sensors is aggregated (compressed) by a sensors subset called “aggregators”. As sensors are equipped with small and un-replenishable energy reserves, a critical issue is deploying appropriate number of aggregators strategically to minimize energy consumed by transporting and aggregating data. Chen et al (2006) after reviewing single-level aggregation proposed an Energy-Efficient Protocol for Aggregator Selection (EPAS) protocol. It was later generalized to an aggregation hierarchy and EPAS was extended to Hierarchical EPAS. Aggregators optimal number with generalized compression and power consumption models was derived and distributed algorithms for aggregator selection were presented. Simulation results proved the algorithms greatly reduced data collection energy consumption in WSNs. Also, algorithms did not rely on specific routing protocols and so were applicable to a wide range of application environments.
This problem is dealt by Wan et al (2003) proposing an energy efficient congestion control scheme called COngestion Detection and Avoidance (CODA) for sensor networks. Three mechanisms are incorporated in CODA: 1) detection of receiver-based congestion, 2) open-loop hop-by-hop backpressure; and 3) regulation of closed-loop multi-source. A detailed design, accomplishment, and estimation of CODA employing simulation and testing are presented. Two significant performance metrics: energy tax and fidelity penalty were presented in order to estimate the effect CODA on implementation in sensing applications. An experimental sensor network test bed based on Berkeley motes implementing CSMA to illustrate the advantages in performance and problems faced by using CODA in practical engineering are discussed.

In WSN for the optimization of energy consumption several schemes and methods are developed recently. For efficient utilization of energy many efforts are taken in the field of “routing”. Fixed (crisp) metrics are implemented in these efforts in order to create energy-aware routing decisions. In WSN (Haider & Yusuf 2009) presented a generalized fuzzy logic based scheme developed for energy-aware routing.

Nikravan et al (2011) utilized a Fuzzy Logic System (FLS) as a decision mechanism for the purpose of selecting next hop node. In real-time packet transmission, to select the next-hop node both transmission rate and energy are selected to be the essential parameters. The results obtained by simulation of the proposed approach reveals that when operated in differing real-time environment the proposed approach affords enhancement in real-time transmission and energy efficiency performance (i.e., it is able to obtain low energy consumption and high packet delivery ratio within deadline).

Shen & OHare (2007) investigated one of the famous agent architecture, the BDI architecture in this perception. In terms of energy-
awareness and utility using classical reasoning augmented with a fuzzy component in a hybrid fashion supports to discover the basic problem of belief generation within WSN limitations. Therefore by combining fuzzy reasoning with traditional BDI scheme the energy-aware utility-based agents provided a hybrid approach to deliberative reasoning.

2.5 CLUSTER HEAD SELECTION

Deployment and coverage of the sensor nodes in the network is dependent on the application where WSN is used (Heinzelman et al 2002). Some applications need denser deployment and some sensors need sparse deployment. If the location of placement of the sensor is fixed, then the deployment is called as deterministic, otherwise deployment is non-deterministic. Sensors will communicate either by direct communication or multi-hop communication paths. The energy spent for sending a single bit of data is approximately equivalent to the energy spent for performing 1000 operations in a sensor node (Anastasi et al 2004). Consequently, large energy is spent by the communication subsystem. Therefore, energy efficient routing and forwarding protocols should be used for communication.

In WSN, the neighborhood nodes may collect redundant set of data from the environment. To reduce the processing power and the amount of data forwarded to the sink node, clustering approach can be used. Total number of sensor nodes in the network is divided into little number of clusters. Data to be forwarded from the sensor nodes to the sink node are aggregated and sent. Each cluster has a cluster head whose main role is energy conservation. To increase the lifetime of clusters, cluster role is rotated to other sensor nodes of the cluster periodically. This clustering approach is used in Low Energy Adaptive Clustering Hierarchy (LEACH) protocol
(Heinzelman et al 2000). LEACH-Mobile protocol is an improvement of LEACH protocol when the sensor nodes are mobile nodes (Kim & Chung 2006). Whenever a sensor node moves within the cluster or leaves from one cluster and joins into another cluster, the membership to the cluster is redefined and time schedule to reach the new location of moving node is confirmed in TDMA schedule. Any typical decision system needs accurate and whole information of the domain.

Whenever there is uncertain information, Fuzzy logic is used to make a decision (Godbole 2012). Fuzzy logic is used to make a real time decision based on a set of predetermined rules. In networking, genetic algorithms can be used to find an optimal route between a source and a destination node (Nagib & Wahied 2010). The objective function can be set as finding the low energy cost route between the source and the destination node. In this study, for efficient energy management, a fuzzy logic genetic approach is proposed. Possible fuzzy rules are formed based on the number of packets to be transferred, available energy in the node and the number of hops to reach the destination. Best rule is selected by using genetic approach.

Dutta et al (2013) presented A Fuzzy Logic Controlled Cluster Head Selection algorithm for Wireless Sensor Networks. A fuzzy controller was designed to select a cluster head. CH must have efficient energy, enough neighborhood nodes. Therefore residual energy, neighborhood density and node centrality were used as input parameters and a chance of selecting a node as CH was selected as an output variable. Low, medium and high were taken as linguistic variables for residual energy and neighborhood density. Close, Adequate and Far had been taken for node centrality linguistic variables. Based on the information about the WSN and input variables IF-
THEN rules were formed. This Fuzzy rule based system was used whenever a cluster head was selected.

Musale & Borde (2013) presented Analysis of Cluster Based Routing Protocol for Mobile Wireless Sensor Network Cluster based routing protocol. WSN nodes had heterogeneous energy levels and many of the cluster head selection algorithms were based on the node’s residual energy. To distribute information about routing, clusters maintained inter and intra cluster link which was useful for routing. Whenever a node was selected as a cluster head, the details of new cluster head were broadcasted to other nodes in the cluster. Moving nodes decided to join into the cluster based on the distance from their location to the new CH. This LEACH algorithm supported mobility of nodes and confirmed about whether a mobile node was able to transmit the data with new CH. This new algorithm had less power consumption than LEACH algorithm.

Jabbar et al (2013) presented Intelligent Optimization of Wireless Sensor Networks through Bio-Inspired Computing. To maximize the lifetime of the nodes of WSN, an optimal routing was performed by Ant Colony algorithm. Objective function was generated by considering different energy levels, cost and states of the nodes. At MAC layer the best routes were selected that satisfied the objective functions.

Abirami & Thangaraj (2013) presented Association Rules for Wireless Sensor Data Based On Fuzzy - Genetic Algorithm. Each node in WSN transmitted huge amount of data and communication overheads affected the performance of WSN. Data mining methods could be used to decide what data was essential for sink node to make useful information to the user. In this
work, fuzzy logic and genetic algorithms were used to extract effective rules to reduce the communication overhead and enhance the network performance.

BabuKaruppih & Kannadhasan (2013) presented A Novel Approach to Detect the Shortest Path for Secure Data Aggregation Using Fuzzy Logic in Wireless Sensor Networks. In WSN, routing decision was made by fuzzy rules. Rules were formed based on the trust value of a node and the available power level of a sensor node in the network. Clustering approach was used for aggregation of data which reduced the energy consumption. Fuzzy logic approach uses trust level and power level of a node as input variables to select secure and normal operating nodes for aggregation of data.

Kashyap et al (2013) presented a new clustering algorithm named Threshold Constrained member Clustering (TcC) in WSNs previously which contained some WSN design issues and limitation like limited capacity of battery for Sensor nodes, highly costly Routing schemes. Hence a new scheme of Cluster head selection in WSN was designed. The proposed clustering approach selected a cluster head from the available list of eligible sensors based on a new weight function. The new weight function considers three major parameters for the selection criteria and they were as follows, residual battery level of sensor, energy consumption of communication device on sensor and distance of sensor node to the base station. The performances of clustering algorithms improved when extended the transmission range of a base station. Different WSN clustering algorithms like Maximum Battery Clustering (MbC), Minimum communication Cost Clustering(McC) and Minimum distance Clustering (MdC) were considered for comparison with the performance of proposed algorithm TcC. The
experiments for all these algorithms were performed and evaluated for Network lifetime, Response delay and Successful delivered packets.

Silva et al (2013) introduced a protocol, since the WSNs played an important role in pervasive and ubiquitous systems. Even though advances were made in embedded systems, the energy consumption was still an open issue in WSNs. Here, a hierarchical routing protocol provides energy-efficiency, scalability and reliability for WSN applications. A Cluster-based approach for ENERGY-efficiency in the WSN (CLENER) protocol was proposed. CLENER proposed two sub-phases for the setup phase, namely CH election and cluster formation. In the former, each node determines a new probability function to become a CH, based on its remaining energy and a stochastic equation. The cluster formation, the non-CHs select the most reliable CH based on residual energy, and the distance between them. This information had been used as input to TS, which seeks to overcome any uncertainties and thus be able to estimate the correct CH. Simulations were conducted to show the benefits of CLENER compared with LEACH and Energy Efficient Cluster- Head Selection (EECHS). According to the simulation results, CLENER extended the network lifetime by 19% and 18% and increased the packet delivery ratio of LEACH and EECHS by 15% and 14% respectively.

Enam et al (2012) measured hierarchal and random WSN cluster head selection protocol. Energy consumed in cluster head setup phase was taken up in earlier research. This area was addressed and overhead energy - energy consumption in random cluster head setup phase, was calculated. LEACH protocol based basic model was redeveloped to calculate energy consumption in 3 data transmissions from sensor nodes to sink. Extensive simulations revealed that overhead consumes around 20% to 25% of total
Azizi et al (2012) stated about the energy constraint in WSN, as one of the most important restrictions. The energy balancing was essential for prolonging the network lifetime while considering the above issue. Hence, it had been considered as a main challenge in the research of scientific communities. Many clustering based routing algorithms had been proposed to prolong the network lifetime in wireless sensor networks. Many of them did not consider the energy balancing among nodes. The new clustering based routing protocol namely Hierarchical ClusTERing based routing algorithm (HCTE) was proposed that cluster head selection mechanism in it was done in two separate stages. So there were two cluster heads namely initial and second cluster heads in each cluster and was based on multi-hop transmitting mechanism in the data routing from the cluster heads to sink. Each of the cluster heads had separate tasks in the cluster. The routing algorithm used in proposed protocol was multi hop. Simulation results show that the HCTE prolongs the network lifetime about 35% compared to the LEACH.

Tan et al (2012) proposed a cooperative game theory to solve cluster head selection in clustered WSNs. A bi-directional cooperative clustering model was designed and it analyzed the energy consumption. Potential Cluster Heads (CHs) share common clustering cost which reduces single CH burden and ensures load balance through CH coalitions. In a cost sharing game-based CH selection scheme, CH selection rule and fair cost allocation was discussed. Analysis showed cost sharing game among PCHs was sub-modular, thus obtained the fair cost allocation through the shapely
value. The Cost Sharing Game-based Clustering (CSGC) algorithm was then detailed. In dynamic clustering, CSGC continuously adapts CH selection process to change constraints like residual energy and node position. Simulations evaluated CSGC performance regarding transmission capacity, energy efficiency and network life. The results showed CSGC outperformed LEACH on network lifetime, transmission capacity and energy efficiency. Also, CSGC had a latent benefit of higher transmission success. Hence cost sharing game-based cluster head selection was effective and efficient.

Lakshmi & Neelima (2012) proposed a solution to improve the lifetime of the WSN by reducing the number of active nodes that participated in wireless communication. Life time of a WSN was improved through optimizing communication and minimizing energy usage. One way of optimizing, communication was through cluster head selection. An Initial set of active nodes were identified based on the residual energy using the hit set. Further, the list of active nodes was reduced using hit set. One among the active nodes was selected as cluster head by considering the degree of the node. The election of cluster head was done based on the connectivity of the selected nodes in the wireless sensor network. It had been observed from the above analytical example that as the network was fully connected, more number of nodes was sent to sleeping mode, and hence high node reduction ratio and maximum network lifetime was achieved.

Dawood et al (2012) developed routing protocols based on clusters protocols to overcome the battery problem in WSN. A standard WSN comprises of a huge number of sensor nodes with data processing and communication capabilities. The sensor nodes pass the gathered data using radio transmitter, to a sink either straightforwardly or through other nodes in a multi-hop approach. WSN has a power consuming system, since nodes
performs on restricted power batteries which decreases its lifetime. Well-organized energy routing protocol was extremely vital technique in wireless sensor networks since sensor nodes are exceedingly energy based. Therefore, numerous routing protocols for sensor networks have been developed, but the usage of cluster based routing has numerous advantages like reduced control messages, re-usability of bandwidth and most importantly better power control. The cluster heads, which form a leading set in the network, choose the topology and were in charge for its stability. A Weighted Clustering Algorithm (WCA) was used in QoS Enhanced Base Station Controlled Dynamic Clustering Protocol (QBCDCP) which considers the ideal degree, transmission power, battery power and mobility of a mobile node. The simulation results showed that the proposed approach had more number of alive nodes than the existing technique.

Kumar et al (2011) surveyed the state-of-art of different clustering algorithms in wireless sensor networks along with LEACH and descendant’s reported in the literature of WSNs till today and presented the comparison of different LEACH descendant, to maximize network lifetime in WSNs. The paths for data transfer were selected in such a way that the total energy consumed along the path was minimized. To support high scalability and better data aggregation, sensor nodes were often grouped into disjoint, non-overlapping subsets called clusters. Clusters create hierarchical WSNs which incorporate efficient utilization of limited resources of sensor nodes and thus extends network lifetime. Thus, taxonomy of energy efficient clustering algorithms in WSNs was provided. Every effort had been made to provide a complete and accurate state-of-the art survey on energy efficient clustering algorithms. The timeline, description of LEACH and its descendant in WSNs had been provided.
Katiyar et al (2010) introduced a key technique to extend the lifetime of WSNs by reducing energy consumption. In the last few years the potential use of WSN had been increased in various fields like disaster management, battle field surveillance, and border security surveillance as described by Quaritsch et al (2010) and Dudek et al (2009). In such applications, a large number of sensor nodes were deployed, which were often unattended and worked autonomously. Hence, clustering is a key technique that can be used to increase the network scalability. They were classified according to energy efficiency and stability of network. Researchers in all fields of wireless sensor network believed that nodes were homogenous, but some nodes may have different energy to prolong the lifetime of a WSN and its reliability. The impact of heterogeneity and surveying different clustering algorithms for heterogeneous WSNs was studied by highlighting their objectives, features and complexity.

Ran et al (2010) introduced LEACH Fuzzy Logic (LEACH-FL) protocol to improve LEACH functionalities. The energy of nodes was an important consideration because the lifetime of WSN was limited by the energy of the nodes. LEACH was one of the most well-known clustering mechanisms. However, LEACH depends only on probability model; some cluster heads may be very close to each other and was located at the edge of the WSN. These in-efficient cluster heads could not maximize the energy efficiency. LEACH-FL was used which takes battery level, distance and node density into consideration. This method asks for the nodes for more calculations and communications to get the data of the node density and the distance. The proposed method had proved in making a enhanced selection by comparison simulations using MAT Lab.
Munaga et al (2009) presented a novel trajectory based clustering solution to overcome the hot spot problems in WSNs where the sensor nodes closest to the base station were in need to relay more packet than the nodes farther away from the base station. Thus, lifetime of sensory network depends on these closest nodes. Clustering methods were used to extend the lifetime of a wireless sensor network. But clustering algorithms use 2 techniques; selecting cluster heads with bigger residual energy and rotating them periodically to distribute energy consumption among nodes in clusters thereby lengthening network life. Most of the algorithms used random selection for selecting the cluster heads. New algorithm named as Trajectory clustering algorithm enables sensor nodes to reduce data packets by data aggregation. The wireless communication cost is decreased by reduction of data packets and thus the clustering technique extends the lifetime by reducing the energy consumption of the network. The simulation results improved the lifetime and reduced the energy consumption of WSNs when compared with existing clustering protocols.

Zytoune et al (2009) proposed reducing the power consumption of wireless sensor networks. Therefore, a communication protocol named LEACH was modified. LEACH was extended as a stochastic cluster-head selection algorithm by modifying node’s probability to become cluster-head depending on energy required to transmit to the sink. An efficient energy aware routing algorithm had been provided for the wireless sensor networks. It consisted in rotation of selection of cluster-heads by considering the distance of the nodes to the sink and the network nodes residual energy. This choice allowed a best distribution of the transmission energy in the network. The cluster-heads selection algorithm was completely decentralized. Simulation results showed that the energy was significantly reduced when
compared with the preceding clustering based routing algorithm. Also, the proposed algorithm allowed a large stable network lifetime compared to the most known clustering algorithms and so, the network coverage was extended.

An algorithm to select cluster leader to perform data aggregation in partially connected sensor network was proposed by Mozumdar et al (2009). Though the algorithm works in fully connected sensor networks, it best suits partially connected networks. In earlier work data aggregation in WSN eliminated redundancy to improve bandwidth use and sensor nodes energy-efficiency. A cluster leader node collects data from other nodes and sends summarized information to upstream nodes. This algorithm reduced traffic flow inside network by selecting shortest route to forward packets to cluster leader. The algorithm found a cluster leader in a robust way by using fewer packets than previous work, thus reducing the energy consumption of the sensor network. A simulation framework for functional analysis of WSN applications was performed.

Imran et al (2012) modified the architecture of cluster based wireless sensor networks by proposing a coordinator node. This not only increased the life time of the network but also the scalability of the network. It eliminates inter-cluster communication need to reach BS. The goal is increasing life of homogeneous WSN by minimizing long range communication and energy balancing. A K-theorem based cluster head selection algorithm was proposed and parameters like residual energy distance to coordinator node, reliability and degree of mobility were considered. K-theorem selects candidate cluster heads based on many cluster sensor nodes. The new algorithm achieved high energy efficiency by reducing communication and balancing energy.
2.6 OPTIMIZATION IN WSN

Singh et al (2013) proposed a new algorithm model, new Ant Colony Optimization (nACO) which was very effective for communication from source node to destination node. A reliable, nature-inspired routing algorithm called nACO was partly based on the efficient Max-Min algorithm and it was suitable for flexible structure of wireless sensor networks. A new ACO based routing algorithm found minimum route of nodes in WSN the basis for pheromone updating. Simulations show that new method boasts many attractive features, including improved power consumption, throughput, and latency performance.

Sobral et al (2013) proposed a Fuzzy Inference System to help the Directed Diffusion routing protocol to choose a route for the communication between any nodes in the network. A new approach helped to choose the best route based on Fuzzy Inference Systems (FIS) and Ant Colony Optimization (ACO). The Fuzzy Inference System was used to estimate the degree of the route quality, based on the number of hops and the lowest energy level among the nodes that form the route. The ACO algorithm was used to adjust the rule base of the fuzzy system in order to improve the classification strategy of the route, and hence increased the energy efficiency and the survivability of the network. The simulations showed that it was effective from the point of view of the energy, the number of received messages, and the cost of received messages when compared against other approaches.

Yang (2013) proposed to find an optimal topology control strategy in 3-Dimensional (3D) WSNs. The issues discussed were related to the topology control in 3D WSNs, with a review of 2D model for WSNs and introduced a 3D model for WSNs. An Immunity-Based Ant Colony
Optimization Topology Control Algorithm for 3D WSNs was introduced, which had better performance with the nature of feedback and paradigm of ant colony and immunity algorithm reduced the redundancy iteration. Also, distributed approach of Topology Control Algorithm for 3D WSNs CDS-ACO was proposed. The advantage of both the ACO and Connected Dominating Set (CDS) were fully considered in this algorithm. The performance of simulation results showed that the CDS-ACO had the better performance in WSNs.

Bhuvaneshwari & Balamurugan (2013) proposed a Bee Hive Optimization (BHO) algorithm to increase the lifetime of wireless sensor network. Its performance was better than other algorithms like ACO and PSO. BHO approach was proposed for increasing the lifetime of WSN. BHO algorithm finds optimized path and improves network efficiency. BHO generates a new path by using energy as fitness value to analyze various paths to select best optimized path whose energy consumption is very low compared to others. The advantage was that, it provided a clear mechanism of decision making to the specified problem and it can be applied to different areas such as web search, mobile computing, hierarchical optimization and neural networks. The result obtained by performing this operation in BHO was better than compared to other algorithms like ACO and PSO.

Ahmed et al (2012) proposed an ACO algorithm for WSNs to maximize the network lifetime. Developing solution for the routing problem in this kind of network was one of the main topics considered by researchers in order to maximize the network life time. The life time network depended essentially on the density and the rate of communications of sensors which affect the battery level. Indeed, the ACO algorithm outperforms when compared to LEACH and AODV protocols. Comparative performance test
results of the proposed approach were included. The effectiveness of the ACO algorithm had been verified by several simulations under NS2 simulator in terms of residual energy and life time network. Also, simulation results showed that ACO algorithm provided a promising solutions allowing node designers to efficiently operate routing tasks for maximizing the network lifetime.

Sowmya et al (2012) proposed a very simple and effective way of providing security against black hole attack by introducing some modifications to ACO. The algorithm was based on an asynchronous and autonomous interaction of agents; it was self-organizing, thus robust and fault tolerant implied that there was no need of defining path recovery algorithms; it was essentially traffic adaptive without the required intricate and yet inflexible metrics, adaptive to all kinds of long-term variations in topology. Prevention schemes detect malicious nodes and isolate it from active data forwarding/routing. It reacts through sending ALARM packet to neighbors. Thus the malicious node was used as a denial-of-service attack where the packets were dropped. It prevented black hole attack and consequently improved the overall performance of ACO.

Liu & Song (2012) investigated the problem of uneven energy consumption in large-scale many-to-one sensor network with constant data reporting, which was known as an energy hole around the sink. Hence, the lifetime maximization and the energy hole problem could be solved by searching optimal transmission range for the sensors in each corona and then prove that was an NP-hard optimization problem. In view of the effectiveness of ant colony algorithms in solving combinatorial optimization problems, an Ant-based heuristic algorithm (ASTRL) was proposed to address the optimal transmission range assignment for the goal of achieving life maximization of
sensor networks. Experimental result showed that the performance of ASTRL was very close to the optimal results obtained from exhaustive search method. Further, extensive simulations had been performed to evaluate the performance of ASTRL using various simulation parameters. The simulation results showed that new algorithm significantly improved the network lifetime; actually, it was close to Optimal List (OL) in terms of the network lifetime and performed equally well in the non-uniform node distribution.

Das & Chaki (2012) proposed an algorithm for an event-driven routing methodology to handle multiple events at a single instance with minimum energy drainage. Some of the algorithms concentrate on setting up an event path to send that information; some other algorithms flood that information throughout the network. It was showed that most of the power saving algorithms failed to take care of timeliness of delivery and the probability of multiple event occurrences at the same instance. These techniques suffer from extra power requirement, making them unsatisfactory in case of WSNs. The proposed method was concerned about the infinite loop problem, data loss and takes care of the congestion within the network.

Zhou et al (2012) proposed a multiple dimensional tree routing protocol for Multi-sink WSNs based on listening and ACO. The advantages were (i) In the process of the routing establishment and maintenance, the wastage of resources was avoided and the reliability of routing was improved by utilizing the listening mechanism and the power control, respectively. (ii) The fault tolerance and robustness of routing were increased because multidimensional tree routes from each sensor node to all sink nodes were set up. (iii) The QoS optimization of Multi-sink WSNs was achieved by using the proposed ACOMSR. Taking into consideration hops, packet losses,
retransmission, and delay account, a distributed ant colony algorithm was proposed. When nodes selected routes in the data transmission, the algorithm was utilized to realize the real-time optimization by coordination between nodes. The simulation results showed that the ACOMSR protocol realized the QoS optimization for Multi-sink wireless sensor networks, and its performance was better than the routing protocol of minimum hop numbers.

Bharathi & Kumar (2012) introduced a novel technique of power efficient data aggregation in order to address the power drainage during communication in wireless sensor network. Hierarchical routing was adopted, where node clusters were formulated based on nodes geographical location and associate node to aggregator node and other aggregator node to sink or aggregator node to aggregator node to sink routing mechanism was followed. LEACH, a leading work which does not achieve a power and QoS parameter optimization tradeoff. The Reverse Game Theory based Aggregator Node Selection Ant Colony Optimization based Routing (RGT-AGN-ACO-R) were proposed to maximize network life. The proposed protocol was simulated, and it was evaluated and compared to LEACH on parameters including power inconsistency, life assessment and residual power against many rounds.

Shah et al (2011) studied about key constituents of Computational Intelligence (CI) and how different classes come under the paradigm of CI. Comparative analysis of different classes in CI paradigm was done to find the most appropriate class for optimization of clustering design and data aggregation techniques. This analytical survey article proved as a guiding light for the future researcher to delve into more detail of CI and finding the optimal solution in different social fabric of life. It was concluded that this
nature inspired paradigm has the key role for moving to the “optimized solutions” for almost every field of life.

Fidanova et al (2010) proposed a coverage problem for wireless sensor networks with its connectivity constraint. The sensors sent their sensing results to a special station called the High Energy Communication Node (HECN). The sensing area of the WSN was the union of the individual sensing areas of the nodes. While deploying a WSN, the major objective was to achieve full coverage of the terrain (sensor field). The terrain was modeled with 500×500 points grid and both sensing radius and communication radius are set to 30. Also, it aims to use a minimum number of sensor nodes, to keep the connectivity of the network. ACO algorithm was proposed to solve this problem and to compare it with existing evolutionary algorithms.

Juneja et al (2010) proposed an ant-based method for detecting congestion and various routing attacks in WSNs. The prime parameters under consideration were Energy, Age and Reliability (EAR) to detect anomalies. Researchers proposed many mechanisms to detect WSN congestion and routing attacks, very few deployed ants as intelligent and computationally efficient entities. Also, earlier works focused on parameters like energy, hop and distance but none used age and node reliability. The proposed approach was decentralized, active and extensible. Here, an ant-based detection algorithm was designed that considered all of the above mentioned attributes. The simulation results showed the efficiency of using minimum number of ant to discover maximum number of routing faults and consume less energy which was an important constraint in Wireless Sensor Network.

Yang et al (2009) proposed a novel Multipath Routing Protocol (MRP) based on ACO and dynamic clustering for monitoring the burst events
in WSNs. Such approaches maximize the network lifetime and reduce the energy consumption. An important WSN attribute is limited power supply, and so in MRP, metrics like energy communication consumption among nodes, path length and residual energy, were considered important criteria, when designing routing. First, a CH among nodes was selected and located in event area according to parameters like residual energy. Second, an improved ACO algorithm searched for multiple paths between CH and sink node. Finally, CH dynamically chose a route for data transmission with probability depending on many path metrics like energy consumption. The simulation results showed that MRP had prolonged the network lifetime, as well as balanced the energy consumption among nodes, achieved better load balancing and reduced the average energy consumption effectively.

Okazaki & Frohlich (2009) presented an adaptation of the HOPNET algorithm in WSNs. HOPNET was a novel hybrid routing protocol based on ACO and Zone Routing Protocol (ZRP) for Mobile Ad Hoc Networks (MANETs). The HOPNET algorithm was presented in real ad hoc WSNs, which was more critical than MANETs in terms of energy amount, processing power, memory and communication. The most important change in the HOPNET algorithm was the removal of InterRT which allowed obtaining some benefits. The algorithm became more simple and efficient in terms of data packet transmissions and pheromone diffusion. The messages exchanged between the nodes were reduced, mainly when the destination was out of zone and its route was unknown. A new manner was to perform the routing with just one table through routing using dynamic zones. These dynamic zones allowed to improve the routing and to avoid the necessity of an interzone routing table. A measure about overhead, data delivery ratio, latency, and evaluating the routing algorithm in a sensor network environment
had been collected. New algorithm has been validated through a prototype implementation for ZigBee, an IEEE 802.15.4/ZigBee (TM) OEM module.

Gerla & Xu (2003) proposed deployment of limited number of mobile "swarms" in order to advance the sensor network. In terms of both networking capabilities and hardware functionalities, the swarm nodes possess improved capabilities than the sensor nodes. Mobile swarms are directed to present the complete information about intended area to sensor network hot spots. Streams supported by mobile swarms with low-cost high quality multimedia. To support wireless network backbone connecting swarms and routing methods, a combined model is described/validated through simulation.

2.7 CONCLUSIONS

This chapter includes the literature survey based on QoS enable routing in WSN, Cluster head path selection, Energy conservation in WSN and an optimization in WSN.