CHAPTER 1

INTRODUCTION

Wireless Sensor Network (WSN) is a collection of spatially distributed and contributed sensors for observing and recording the environment conditions with the collected data arranged at central location. WSNs are planned to facilitate the military process however its application has extended to health, traffic, other consumer and industrial areas. WSN is from any area with hundreds to thousands of sensor nodes. The sensor node equipment comprises radio transceiver with antenna, microcontroller, an electronic circuit and an energy source called battery. The dimension of sensor nodes changes from shoe box to the grain dust sizes. The cost of sensor node changes depending on the functionality of sensor like energy utilization, speed rate, etc.

WSN has low-cost, low-power and battery-powered sensor nodes. When sensor nodes include inadequate and non-rechargeable energy resources, energy is used to increase the lifetime of sensor networks. Wireless sensor networks comprises many number of small sensor nodes with limited computation capacity, limited memory space, not enough power resource and short-range radio communication device. In military applications, sensor nodes are used in hostile environments like battlefields to observe the actions of enemy force. A wireless sensor network has many sensor nodes with robust sink nodes to execute the powerful communication. WSN collects the data through the individual nodes where it is routed to the sink nodes. The monitoring process uses the ideas to forward the packets with essential
topological structure. The topological structures of different forms are used in sensor network field. WSN is organized on the earth (ground), in air, in vehicles, under water and within the constructions. WSN is a developing technology with many potential applications. The topological structure of WSN is depicted in Figure 1.1.

Figure 1.1 Topological WSN Structure
A sensor node is a small device with three fundamental units, namely sensing unit for data realization from physical environment, a processing unit for local data processing as well as storage and a wireless communication unit for data transmission to sink node or base station. The sensor nodes are provided with less amount of energy and it is difficult to recharge the batteries because these nodes are used in hostile or unpractical atmosphere. It is also revealed for both powering off redundant nodes and reducing the radio power while preserving node connections to effective power saving.

1.1 WIRELESS SENSOR NETWORK (WSN)

The group of large number of sensor nodes used in an area to identify physical phenomenon called as Wireless Sensor Network. A common design of WSN uses sensor nodes/sink node where the Base Station (BS) exists. Sink is linked to internet by wired or wireless network. Sink has effective instructions to sensor nodes and gathers the sensed data. Depending on the application needs, sensor nodes sense the required physical phenomenon and perform the data aggregation to avoid the communication of redundant data. It sends the sensed aggregated data to sink through hop-by-hop communication. When the sink obtains the sensed data, it processes and sends the data that are available to user through internet. The process of grouping of data from source sensor nodes to sink is a demanding action in WSN applications.

Wireless Sensor Networks (WSNs) has many number of sensor nodes. Every node used in target area senses particular physical and chemical data like temperature, intensity of illumination, vibration and awareness of particular substances. The collected data are post-processed for improving the communication efficiency and sent to the gateway node by a series of wireless communication steps. It also sends it to server computer for time and
compute-intensive processing. For using the sensor data while taking the decisions, data arrives at server computer in particular time interval. But the permitted delay changes with application, the real-time applications place deadlines on permitted delay from source of data event to gateway node. A forest fire monitoring system receives smoke detection information in preset deadline for reacting efficiently to potential forest fires.

WSNs are susceptible to the security issues like cooperating, tampering and malicious interruptions, eavesdropping of sensor data adversarial, packet injection and DoS attacks. The combination of security analysis with QoS design requires addressing of both defense from attacks and assure QoS necessities from the analysis. WSNs nodes are observed for essential QoS needs for increasing the availability and serviceability of the system. The conventional techniques with the sensor nodes use the three phenomenon like reliability, availability and serviceability that achieve QoS effectively.

In WSN, the sensor node failed to contain the power and communication range to send the sensed data to BS. A sensor node senses and sends the own data. In addition, it acts as a router and transmits the data of their neighbors. In WSN architecture, the sink is static and through multi-hop communication, all nodes in the network send their data to sink. The nodes closer to the sink with reduced battery power are called as hot spot issue. The nodes distant from the sink have large energy left but their energy is not used as nodes closer to sink node has reduced the energy level. The sensed data are not sent to sink across hot spot near sink. It reduces the network lifetime. Sink is key cause of problem as all time same nodes near sink forward the data. The benefit of static sink approach includes less end-to-end delay.
1.1.1 WSN Applications

WSN applications like vehicular and biomedical have many data traffic with QoS requirements. The wired networks send data between nodes lacking the carried data and employs end-to-end communication model parameters such as delay, bandwidth, jitter and loss with QoS when directed correctly. In WSN, the parameters are not suitable as sensor nodes communicate through the non-end-to-end model. Every node communicates with the neighboring nodes without any connection created between the source and destination at the transmitting process. An additional issue takes place from intermediate sensor nodes to create the data besides routing with demanding issue is energy. All the factors occur with QoS parameters such as coverage, exposure, energy cost and network life time.

Monitoring through WSNs is employed in the industrial world. Monitoring applications require many needs that are functioned cost-effectively. The key essential need is low power utilization using each sensor node as many sensor nodes are controlled with small batteries. The process of controlling the battery is difficult to restore in the field. The modules manage sensor node like the microcontroller, RF radio and sensors for low power utilization. The efficient technique is used for power conservation and utilization of periodic sleep-wake cycles with long sleep periods tracked by short wake-up periods where essential communication and sensing actions occur.

Geographic or localized routing is used for WSN. It includes the scalable techniques to global information routing in networks where nodes are fixed or with low mobility. The localized routing protocols are the utilization of localized information that chooses the next router between neighboring nodes which are geographically near the destination. Though, the selection
plan changes from one protocol to an additional one based on the limitations. The route selection is depending on QoS ideas.

1.2 QUALITY OF SERVICE (QoS)

Quality-of-Service is a set of service requirements to be met by the network while transmitting a packet flow. A packet flow is a packet transmission from source to destination (unicast or multicast) with QoS. QoS is assessable level of service sent to the network users classified with the parameters. QoS are presented through the network service providers with Service Level Agreement (SLA) between network users and service providers.

![Quality of Service (QoS) Diagram]

**Figure 1.2 Security Analyses with QoS**

QoS is a term with many usages in research and technical communities. QoS is defined as measurements of application reliability with
enhanced energy efficiency. An alternative definition links QoS to spatial resolution. A QoS control is planned depending on a Gur game model where base stations broadcast feedback to network’s sensors. QoS parameters are used to the particular application like sensor node measurement, usage, coverage and number of active sensor nodes. The QoS maintains communication network that gathers application requirements while using network resources like bandwidth and power consumption.

For effective utilization of sensor node energy and for reporting the imaging and multimedia data inside acceptable range, QoS energy aware routing protocol is used. WSN application with QoS aware protocols are military observation, real time target tracking in battle environments, tsunami alarm, smart hospitals, seismic recognition, biomedical health monitoring, hazardous environment sensing, fire recognition, intrusion identification, disaster monitoring and real-time management. The applications manage the real time data and require bandwidth with less possible delay. To assure the consistent delivery of real-time data, service differentiation method is required. QoS aware energy efficient routing in WSN presents an energy efficient path and assures definite bandwidth with less possible delay. The requirement of QoS aware energy efficient schemes increase the network lifetime and assure QoS.

WSNs increased the worldwide interest using Micro-Electro-Mechanical Systems (MEMS) technology with smart sensors. The sensors are small with less processing and computing resources, and available at low-cost depending on the traditional sensors. The sensor nodes sense, determine and collect information from environment depending on the local decision process and also send out the sensed data to user. WSNs are employed to sense the physical world that is essential part in next generation networks. QoS assure the network gain that improving the interest because of the difficulty of
applications running over WSNs. WSNs is used in many applications in same platform. Many applications have different QoS needs. In fire monitoring system, the event of fire alarm is reported to sink at earlier stage. Many applications need packets to arrive at sink despite when they arrive.

1.2.1 QoS Routing

QoS routing is concerned with problems to select the path for QoS needs like bandwidth or delay. For generating the sensible choices in path selection, it is necessary with the knowledge of global network QoS state in network. In QoS routing method, two essential problems are addressed, namely attaining of few knowledge of global network state and choosing a path for flow. The key answers to the problems changes the results and cost tradeoffs in QoS routing. Many QoS routing techniques are designed with the periodic exchange requirement of link QoS state information between the network routers to attain global analysis of network QoS state. The key technique to QoS routing is denoted as the global QoS routing technique.

When the network resource availability changes with the arrival and departure, preserving accurate network QoS state needs information transactions between network nodes. The prohibitive communication and processing overheads required with new QoS state stops the chance of presenting every node with network QoS state. The network QoS state information at source node developed into outdated when QoS state update interval is in relation to the flow dynamics. With this condition, exchanging QoS state information between the network nodes is redundant. Path selection by the algorithms treats stale QoS state information as exact one and fails to be sensible. The global view of network QoS state resulting in the synchronization issues. After QoS update, source nodes choose the paths by the links with high bandwidth resulting in overutilization of the links. Following the next QoS state modernization, the source nodes eliminate the
paths by the links lead to underutilization. The fluctuating actions have large
drawbacks on the system performance while the QoS state update interval is
huge.

1.2.2 Localized QoS Routing Approach

QoS update interval is highly in relation to flow dynamics and so
the performance of global QoS routing techniques reduces extensively. The
remedial answers are provided to manage the inaccuracy at source node and
the essential issue is not removed. Due to the possible option to global QoS
routing schemes, a localized approach is designed for QoS routing. The
approach failed to require global QoS state information exchange between the
network nodes. The source nodes gather the network QoS state depending on
the flow blocking statistics and execute flow routing by localized analysis of
network QoS state. The localized QoS routing approach includes many
benefits. Initially, through lacking the requirement for global information
exchange, the communication overhead is lesser. Then, core routers failed to
maintain and modernize any QoS state database required for global QoS
routing by Ting Yang et al. (2013) minimizes the processing and memory
overhead at core routers. Localized QoS routing approach failed to need any
change or development of routing protocols like Open Shortest Path First
(OSPF). The source routers require QoS routing improvement to routing
element. It creates the localized QoS routing schemes organized at low cost.

The main problem in designing of localized QoS routing scheme
describes the process of selecting the paths depending on local analysis of
network QoS state which reduce the possibility of flow blocked and increases
the resource usage. The issue of path selection in localized QoS routing is
difficult through several features. Because of complex network topology,
paths between source–destination pairs distribute the links whose capacity
and load are not same to the sources. The network load changes are created
the unloaded link that is rapidly overloaded. Path selection decision created by one source changes the results of an additional source. An adaptive proportional routing approach is designed for localized QoS routing schemes. The path-level statistics like number of flows blocked is QoS state information at source.

Depending on the statistics, adaptive proportional routing distributes the load from source to destination between many paths consistent with perceived quality. An adaptive proportional routing uses the intrinsic uncertainty in path selection between many paths. The deterministic path selection algorithms are used in many global routing schemes that selects feasible path. An adaptive proportional routing eliminates the synchronization issues with global QoS routing systems. The three aim of adaptive proportional routing by Ting Yang et al. (2013), namely adaptive, stable and simple. With localized viewpoint of network QoS state, it is required to change the flow proportions with changing network load.

WSNs include two fundamental QoS needs such as Low Delay and High Data Integrity termed as delay sensitive uses and high-integrity applications. In a network with light load, the needs are addressed. A heavily loaded network experiences the congestion that improves the end-to-end delay. The key objective is to increase the fidelity for high-integrity applications and reduce the delay for delay-sensitive ones when overcrowded. A new potential routing algorithm termed as Integrity and Delay Differentiated Routing (IDDR) was designed by Jiao Zhang et al. (2013).

IDDR uses two tasks. IDDR increases the fidelity for high-integrity applications. The key aim is to find the buffer space from the idle and/or under-loaded paths to cache large number of packets that reduced on the shortest path. The initial process is to identify the idle paths. The second process is to cache the packets capably for the transmission. IDDR plans a
potential field with queue length information to recognize the under-used paths. The packets with high integrity are sent to next hop with less queue length. A method named Implicit Hop-by-Hop Rate Control generates the packet caching as effective one. IDDR reduces the end-to-end delay for delay-sensitive applications. All the applications are allocated a weight that denotes the degree of sensitivity to delay. By the design of local dynamic potential fields with slopes by packets, IDDR permits the packets with larger weight to select shorter paths. IDDR uses the priority queue that minimizes queuing delay of sensitive packets.

1.3 CLUSTERING IN WSN

Clustering in WSN includes the collection of the sensor nodes into many clusters. Every cluster has one leader termed as Cluster Head (CH). The CHs collect and combine the data from the members and send to the BS. Each sensor node in one cluster sends and receives the packet only with CH. The selection of CHs requirements is addressed for balancing the energy consumption of CHs. Many cluster based routing algorithms choose CHs randomly or through probability and forms the clusters. Clustering in WSNs is an efficient method that reduces the energy consumption of sensor nodes. Clustering executes the data aggregation and exploring combination to reduce the number of transmitted messages to BS and minimizes the transmission distance of sensor nodes.

1.3.1 Location-Energy Spectral Clustering Algorithm

The flow of Location-Energy Spectral Clustering Algorithm is explained in Figure 1.3. A collection of sensor nodes into clusters are used to assure the scalability goals and attain high energy efficiency as well as increases the network lifetime in large-scale WSN.
Figure 1.3 Location-Energy Spectral Clustering Algorithm

An energy-efficient environmental monitoring algorithm in cluster based WSNs are described. The algorithm termed Location-Energy Spectral Clustering Algorithm (LESCA) is designed by Ali Jorio et al. (2015). LESCA with spectral clustering and graph theory partitions the network to many clusters. The algorithm has three phases, namely cluster setup, cluster heads selection and data transmission. LESCA chooses CHs with cluster with
residual energy, the distance from BS and cluster’s centroid of sensor node. The nodes of a cluster send and receive the information with the particular CH. Then, it gathers, processes, and sends the information to BS. LESCA increases the network lifetime through distributing energy usage, reducing the control overhead, creating well-distributed CHs and clusters. The designed system uses denser deployment plan where distances between the adjacent sensor nodes are small.

Hierarchical routing and data gathering protocols involve cluster-based organization of sensor nodes so that data fusion and aggregation are feasible. The cluster formation process results in a two-level hierarchy in which the CH nodes create the higher level and the cluster-member nodes create the lower level. The sensor nodes send the data to the equivalent CH nodes. CH nodes join data and send to the BS directly or by an intermediate communication with additional CH nodes. CH nodes send all data to higher distances than nodes.

The initial point of the system is a group of wireless sensor nodes placed in delimited place that form WSN was developed by Juan R. Diaz et al. (2014). Each wireless sensor node has more power, processing, transmission ability and memory. They also choose additional wireless sensor nodes as adhoc neighbors when they are in the radio coverage area. Wireless sensor nodes are used for retransmitting the multimedia flows in the form of audio or video signals and employ large range of codes. Figure 1.4 shows the elements of cluster. In WSN, the sensor nodes present the sensed data as audio IP or video IP services.
Figure 1.4 Cluster Elements and Possible Communications

There are three kinds of communications as function of source or destination of the communication. The first one is communication from outside the WSN to node located inside the WSN. The second one is communication from node located inside WSN to destination outside the WSN. The third one is communication from node located inside WSN to node of WSN. A node from external network presents the multimedia contents as well as the real-time audio and video communication services. Wireless sensor nodes sense the multimedia data or forward the data between nodes. They send to an additional node under the coverage area. The new nodes select reachable cluster with the features and transmitted multimedia traffic kinds.

1.4 NODE AUTHENTICATION IN WSN

WSNs are employed to observe the environment and have large range of applications like monitoring, controlling and tracking areas. Many applications group and preserve the secured data. The large numbers of sensor nodes are used and there is no physical preservation and monitoring. Nodes are affected by many physical attacks that result in node compromise, node
cloning, man-in-middle attack and replay attack. The packet entering in WSN has to be secured sooner than it is used for higher level applications. Authentication is carried out in one hop as uni-cast, multi-hop uni-cast and broadcast methods.

- **One-hop authentication** - A shared link layer key connects the neighboring nodes. The design presents the authentication and encryption called TinySec.

- **Multi-hop Authentication** - End to end shared keys preserves multi-hop authentication. However, it does not execute when one of the nodes in the path gets compromised.

- **Broadcast Authentication** - When source node needs some message such as command, it transmits the message. Every broadcast packet is authenticated in order that no false data is included.

1.4.1 **Node Authentication Steps**

The security in WSN is reliant on the cryptographic keys. The organization of the keys is complex one. The key management is creating, accumulating, and transmitting using cryptographic keys.

- **Use of network and keys** - Network is used in targeted areas and number of keys required is computed.

- **Organization of keys** - Keys are inserted between nodes for better communication.
• **Authentication Protocol** - When any node needs to connect the network, it needs to follow conditions provided by authentication protocol. It depends upon the request of the node.

• **Node addition/deletion** - The nodes are inserted into network when they are performing with the authentication protocol. The authentication protocol allows the node to start secured communication with node members.

### 1.5 PROBLEM DEFINITION

WSN is required when the topological changes occur. Existing Distributed algorithm for Time-bounded Essential Localization (DTEL) was developed by Wei Cheng et al. (2013) over a sensor network minimizes broadcasting time of packets. But, the throughput level on different topological route paths is not focused. Topological changes in the wireless sensor network measure the throughput level using Ternary Content Addressable Memory (TCAM)-based packet classification systems was introduced by Chad R Meiners et al. (2011). TCAM based sensor network system improves the throughput level but the topological transformation sometimes lead to the misdirected routing in WSN.

Clustering in distributed sensor network has large computing structure in high-speed networking technology and increasing the processor speeds. However with the development of modern networking and web technologies, a new generation of applications is aimed for clusters in wireless sensor networks. However, the designed technology failed to provide any QoS support. Clusters use uneven topologies and linked deadlock-free routing schemes. Dislocate separation of nodes in cluster for different jobs failed to result in the disjoint paths for inter-processor communication and node Input/output jobs.
For exactly directing the route, Energy-Aware Distributed Clustering algorithm (EADC) was designed by Jiguo Yu et al. (2012). The EADC uses in opposition, a range clusters of same size for routing. The cluster maintains the cluster head with less energy consumption. Though, EADC fails in balancing the load factor. Wei Cheng et al. (2013) was planned by Distributed algorithm for Time-bounded Essential Localization (DTEL) over the sensor network that minimizes the time taken for the broadcasting of packets and combined the regular payload transmissions. However, the throughput level on different topological route paths is not focused in DTEL method. DTEL are not developed on social network applications.

The routing along shortest paths in the sensor field concentrates on reducing the energy consumption. A multi constraint routing by fuzzy logic was developed to increase the performance of Wireless Mesh Network (WMN) and reduces the possibilities of congestion in network. However, group communication is not focused in WMNs. An efficient method called Dynamic Routing for Data Integrity and Delay Differentiated Services (DR-DIDDS) was designed by Jiao Zhang et al. (2015).

Depending on the concept of potential in physics, a multi-path dynamic routing algorithm was designed to provide low delay and high data integrity. The DR-DIDDS method with Lyapunov drift technique authenticates the stability of method. However, a heavily loaded network experiences the communication overhead and increases the transmission delay. Distributed Token Reuse Detection (DTRD) technique provided reduces the data loss by planning Distributed Privacy Preserving Access Control scheme for WSN. An adaptive push system as described broadcast the packets in underwater acoustic wireless networks and attains the low latency broadcasting of packets. But, throughput rate is lesser.
1.6 PROPOSED WORK

Initially to reduce the time taken for reaction and packet transmission without overload, QoS framework guarantees bandwidth for communication in WSN. The framework comprises a cluster node with Network Crossing Point depending on Time Control and Synchronized Access Scheduling mechanism (NCP-TCSA). A crossing point is designed using general Message Transitory Crossing point (MTC) standard that identifies the bandwidth needs of their flows to wireless sensor network.

Next to increase the routing scheme on topological structure, Topological Transform Adaptive Relational Quality of Service Routing (TTA-RQoSR) scheme is designed. TTA-RQoSR scheme develops the framework with three main objectives like adaptively, avoiding the misdirected route and improving the throughput level. TTA-RQoSR scheme uses the abstained misdirected routing to remove the misdirected route path of packet transfer from the source to the destination. The abstained misdirected routing adjusts the flow relationship exclusively on locally observed paths using the Erlang’s C Formula. Erlang’s C Formula uses the Poisson arrival process with arrival rate to avoid the misdirected route.

Finally, a Zonal Sensor Node Authentication (ZSNA) model is designed to render data delivery with better QoS differentiation quotient as described by service provisioning mode. Node Authentication-based Service provisioning is combined with the benefits of Zone-based Data Forwarding using distance measure. The Node Authentication-based Service provisioning ensures data forwarding and Zone-based Data Forwarding using distance measure ensures network lifetime. QoS differentiation quotient with bandwidth is presented for all sensor nodes for minimizing the transmission delay and data loss rate.
1.7 **OBJECTIVES OF RESEARCH**

The major research objectives are spelt out as under:

1. To evolve a QoS framework that guarantees bandwidth for communication in WSN to reduce the time taken for reaction and packet transmission without overload.

2. To increase the QoS packet broadcasting efficiency, the synchronized access scheduling mechanism is developed to use the master and salve concept to transfer the source data to the destination with the minimal time.

3. To design a Routing scheme to suit different topological structure that uses the abstained misdirected routing to remove the misdirected route path of packet transfer from the source to the destination.

4. To increase the throughput level on changing mobility of sensor node and sink node in WSN, the Relational QoS Routing is used.

5. To build a model that would render the energy-efficient data delivery with energy-aware QoS with better QoS differentiation quotient such that it minimizes the transmission delay and data loss rate.

6. To validate and thereby establish the above evolved and designed schemes through simulation experiments by using Destination Sequence Distance Vector (DSDV) routing protocol with different metrics on varying topological structure.
7. To draw conclusions on the research findings from the results of packet broadcasting efficiency, avoidance rate of misdirected route and transmission delay of the above works.

1.8 ORGANIZATION OF THE THESIS

In this first chapter describes the fundamental issues and challenges faced while routing the Quality of Service and performing the node authentication in wireless sensor networks.

Chapter 2 devises the review of literature and discusses the cluster-based routing protocol, data aggregation in WSN, data broadcasting methods, QoS routing algorithms and techniques, energy and density aware QoS routing and reason of their constraints in difficulties in the clustering techniques for WSN with their advantages and disadvantages in detail.

Chapter 3 guides that QoS framework guarantees bandwidth for communication in WSN to reduce the time taken for reaction and packet transmission without overload. The framework has cluster node with Network Crossing Point depending on NCP-TCSA.

Chapter 4 describes Topological Transform Adaptive Relational Quality of Service Routing scheme to increase the routing scheme on topological structure. TTA-RQoSR scheme uses abstained misdirected routing to remove the misdirected route path of packet transfer from the source to the destination.

Chapter 5 describes the rendering of data delivery with better QoS differentiation quotient as described by service provisioning mode using Zonal Sensor Node Authentication model. Node Authentication-based Service
provisioning combined with benefits of Zone-based Data Forwarding using distance measure.

Chapter 6 explains the result analysis on NCP-TCSA Mechanism, TTA-RQoSR Scheme, and ZSNA Model in terms of execution time, redundancy rate, running time, memory complexity rate, memory consumption, huddle based clustering rate, entropy level and so on.

Chapter 7 summarizes the key results, conclusions of this thesis and outlines the potential scope for future work.

1.9 SUMMARY

This chapter explains the basic concepts about QoS routing in WSN. It introduces the basic issues and challenges experienced while clustering of sensor nodes in WSN. Besides, many techniques for addressing the node authentication issues are identified and described in a brief manner. Furthermore, the research problem identification, objectives of the research and different phases in the proposed research methodology and organization of the thesis are described.