CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

WSN comprises of many low-powered sensor nodes with few relatively robust sink nodes to perform the communication. WSN continues to develop an efficient routing scheme when the topological changes take place. Clustering in distributed sensor network has emerged as powerful computing of recent developments in high-speed networking technology for improving the processor speeds. Sensor node clustering is accepted one for providing cost-effective and inexpensive computing environments for day-to-day computational needs of large applications. These clustering applications are used in large databases, data mining, imaging, shared interactions, multimedia responder, web responder, distributed revelation, collaborative computing, telemedicine, etc.

Due to the development of popular wireless media, the quantity of obtainable sensor nodes has increased and the requirement for QoS provisioning became apparent. Simultaneously because of various nature of traffic, different classes of QoS requirements are the recent topics in literature study. The major essential problems in WSN is time controlled process and efficient scheduling applications. A significant development in WSN has resulted in the introduction of misdirected route avoidance in QoS framework and effective data deliver application through the authentication mechanism.
In order to determine a certain clustering approach with better QoS support, the applications have extensively been developed with the help of literature.

2.2 CLUSTER QoS FRAMEWORK IN WSN

WSN nodes with few resources are using the energy, processing power and memory. It is beneficial to use self configurable plans where competition is to access the channels. Error control is network distributed. WSN is significant arrangement for IoT (Internet of Things) structural plan in the same universe as IP networks recommend the use of transit network plans. Diogo Ferreira Lima and Jose Roberto Amazonas (2013) planned Trellis Coded Network execution of QoS-aware Routing Protocols in WSNs. The main aim is to perform the idea of Trellis Coded Network (TCNet). The model uses Mealy Machine-(MM) network nodes removing the use of any routing tables.

Many antennas are employed to increase the results of the system by the spatial diversity or spatial multiplexing. Alami Chaibrassou &Ahmed Mouhisen (2016) was planned by distributed Energy Efficient Cooperative MIMO (EECMIMO) routing protocol for cluster based WSNs. EECMIMO is employed for minimizing the energy consumption in multi-hop WSNs. In EECMIMO, sensor nodes are classified into clusters. Every cluster head uses weighted link function to choose an optimal cooperative node and to receive the traffic from additional neighboring clusters using cooperative Multiple Input Multiple Output (MIMO) method.

Transmission delay of data packets is computed as number of hops as of sensor to Base Station (BS), Tolerable Delay (TD) of packets signify the initial value of aging tag (AT) to design QoS metric. The value of AT is reduced by one each time while sending by a node. Due to Time Division Multiple Access (TDMA) schedule, a Self-stabilizing Hop-constrained
Energy-efficient (SHE) protocol is designed by Da-Ren Chen (2015). It is for planning minimum hop and energy networks for QoS routing. The protocol plans ad hoc multi-hop paths inside a cluster while calculating the number of nodes in cluster to meet TD of data packets from member nodes to CH.

Ravindra Navanath Duche & Nisha P. Sarwade (2014) considered sensor node failure detection depends on round trip delay and paths in WSNs. An enhancement in microelectronic fabrication technology minimizes the cost of moveable wireless sensor nodes. It uses the huge numbers of moveable wireless sensors in WSNs which raises the QoS. The QoS of WSNs is concerned with malfunction of sensor nodes. Probability of sensor node malfunction rises with large amount of sensors usage. For preserving the enhanced QoS in malfunction states, recognizing and separation of faults are required. The faulty sensor node is identified through calculating the Round Trip Delay (RTD) time of discrete round trip paths.

2.2.1 Cluster-based Routing Protocol

A cluster-based routing protocol is designed by Jiguo Yu et al. (2012) for WSNs with non-uniform node distribution that comprises an EADC Algorithm and a cluster-based routing algorithm. EADC employs the competition range to create the clusters of same sizes. The routing algorithm improves forwarding tasks of nodes in covered areas through forcing the cluster heads to select nodes with higher energy and member nodes as their next hops and attains load balance between the cluster heads. Srikanth Jannu et al. (2015) planned grid-based clustering and routing algorithms termed GFTCRA (Grid-based Fault Tolerant Clustering and Routing Algorithms). The algorithm ensures the malfunction of CHs. The algorithms use the distributed approach. A distributed run time management is perform the member sensor nodes of any cluster in failure in CHs. The routing algorithm is revealed to tolerate the abrupt malfunction of the CHs.
A new cluster-based routing protocol termed artificial bee colony protocol was designed by Ado Adamou Abba Ari et al. (2016). The designed technique uses biologically encouraged fast searching features of Artificial Bee Colony meta-heuristic to plan low-power clusters. For cluster heads selection, multi-objective fitness function is planned with Linear Programming formulation. The routing problem is solved using a cost-based function which creates the trade-off among energy efficiency and number of hops of the path. The clustering process is attained at BS with centralized control algorithm that uses an energy level and neighborhood information of location-unaware sensors.

A cluster head weight selection technique named Cluster Chain Weight Metrics (CCWM) approach is designed by Shilpa Mahajan et al. (2014) where the service parameters are for improving the results of overall network. In clustering based approach, the main issue is choice of cluster heads in network and the formation of balanced clusters. Cluster heads are selected in a network depending on the weight metric and after that the cluster formation occurs. The key aim of the technique is to protect the energy of sensors and balances the load. A local clustering mechanism is implemented inside the cluster to reduce the computation and communication cost.

A hierarchical clustering scheme termed Location-Energy Spectral Cluster Algorithm (LESCA) is designed by Ali Jorio et al. (2015). LESCAl establishes the number of clusters in a network. It is depending on the spectral classification and takes both residual energy and properties of nodes. The technique employs the K-ways algorithm and designs new features of network nodes and to choose the cluster heads of WSN.

A clustering routing method depending on Preventing Energy Consumption Efficiency (PECE) is designed by Dean Zhang et al. (2015) for WSN. It comprises two stages known as cluster formation and stable data
transfer. In cluster formation stage, an energy-saving clustering routing algorithm is designed depending on the node degree, comparative distance between nodes and rest of the energy of nodes. If the node selects the cluster head, the node degree and relative distance among the nodes are taken. The selected cluster has improved coverage results and short average distance from additional member nodes in formative cluster and so the cost of communications inside the clusters is lesser. In constant data transfer stage with Bee Colony Optimization (BCO), PECE plan is designed for data transmission.

Fuzzy and Ant Colony Optimization Based Combined MAC, Routing, and Unequal Clustering Cross-Layer Protocol for WSN (FAMACROW) was developed by Sachin Gajjar et al. (2016). The protocol has many nodes which send sensed data to Master Station (MS). FAMACROW includes cluster head selection, clustering, and inter-cluster routing protocols. FAMACROW employs fuzzy logic with residual energy, number of neighboring nodes and quality of communication link for cluster head selection. For eliminating the hot spots issue, FAMACROW employs an unequal clustering method with clusters closer to MS in smaller sizes.

2.2.2 Data Aggregation in WSN

An energy Efficient Structure-free Data Aggregation and Delivery (ESDAD) protocol is designed by Prabhubutta Mohanty (2016). This protocol collects the superfluous data in intermediate nodes. In designed protocol, waiting time for packets at every intermediate node is computed where data are combined effectively in routing path. The sensed data packets are sending to aggregation point for data aggregation. The ESDAD protocol computes the cost function for structure-free, next-hop node selection and executes the source data aggregation. The buffer of every node is divided to preserve many
flows for efficient data delivery. The transmission rates of sources and intermediate nodes are changed in congestion process.

Data aggregation is a necessary technique used to avoid the redundancy and reduce the transmission cost that saves the energy. Dynamic clustering based routing is designed by Zhengmao Ye & Habib Mohamadiano (2014) achieves better results through adaptive algorithms. The generalized Ant Colony Optimization (ACO) increases the reliable lifespan of sensor nodes with minimum energy limitations. Every sensor node is modeled as non-natural ant and dynamic routing is modeled as ant foraging. The ant pheromone is free when energy efficient channel from source to sink is protected. Route discovery, data aggregation and information loss are formed as development of pheromone diffusion, gathering and evaporation.

The key aim of data aggregation algorithms is to collect the data in an energy efficient way where the network lifetime is improved and bandwidth reserved for all nodes get increased. By removing the collisions and idle listening for low energy utilization in network is a key problem handled by the deterministic access protocols as TDMA. It is power efficient as the nodes in the network enter dormant conditions until slot times are allotted to them. The major aim of increasing the bandwidth reserved for all sensor nodes. Spiral-Based Cluster with Data Aggregation (SBCDA) architecture approach is designed by Tarek Azizi & Rachid Beghdad (2016) joins the data aggregation with TDMA protocol in WSNs for increasing the connectivity and avoiding inter-cluster collisions. It also improves the bandwidth reserved for every sensor node through calculating the length of superframe created though all sensor nodes in the network.

Chien-Ming Chen et al. (2012) designed rectifiable hidden data aggregation for data integrity in WSN. The data aggregation technique presents better security with traditional aggregation as cluster heads aggregate
the ciphertexts lacking decryption. The base station recovers the aggregated outcomes and not individual data with two issues. The utilization of aggregation functions is restrained. The base station failed to recover the maximum value of all sensing data when the aggregated result is summation of sensing data. The base station failed to verify the data integrity and authenticity through including message digests to every sensing sample. The base station improves all sensing data where the data are aggregated called recoverable.

A Data Aggregation Ant Colony Algorithm (DAACA) has been designed by Chi Lin et al. (2012). DAACA has three phases known as initialization, packets transmission and process on pheromones. In transmission phase, every node calculates the residual energy and quantity of pheromones of neighbor nodes to probability for choosing the next hop. Subsequent to definite rounds of transmissions, the pheromone changes are carried out with the benefits of both global and local for evaporating or depositing pheromones.

2.2.3 Scheduling in WSN

Ungjin Jang et al. (2012) designed an optimal wake-up scheduling of data gathering trees for WSN. A constrained version of relay node placement trouble is addressed where relay nodes are placed at candidate locations. In connected relay node placement problem, small number of relay nodes is employed to guarantee each sensor node with base station by bidirectional path. In survivable relay node placement problem, small number of relay nodes guarantees the node where each sensor node is associated with two base stations via two node-disjoint bidirectional paths. For addressing the two issues, a framework of polynomial time $O(1)$-approximation algorithm is designed with less approximation ratios.
Ricardo Severino et al. (2014) designed dynamic cluster scheduling for cluster-tree WSNs. A solution is provided to allow the networks with capability to self-adapt the cluster’s duty-cycle and scheduling to present large QoS in many traffic flows. The designed approach allows network to vary the cluster scheduling exclusive of the requirement of long detachment times or re-association of nodes. The method to IEEE 802.15.4/ZigBee cluster-tree WSNs is considered without large variations to the protocol.

The issue of data aggregation scheduling in WSN minimizes the time latency. Interwined Path formation and MAC Scheduling (IPS) is a new cross-layer method designed by Miloud Bagaa et al. (2014) for data aggregation scheduling. The method also enables the choice of parent from all nodes neighbor with scheduled ones. IPS attains minimum data delivery latency by three key design features. They are: the first one is intertwining aggregation tree creation and arrangement. The second one is for every node where a parent is chosen from scheduled nodes in order that the time latency is reduced and cycles are avoided. The third one is relating the parent selection criterion to increase reuse of the time slot.

For snapshot data collection, new Cell-based Path Scheduling (CPS) algorithm is designed that attains the capacity of $O(1/5\omega \ln n \cdot W \ln n)$ in worst case and order-optimal capacity in expectation, where $n$ is number of sensor nodes, $\omega$ is constant and $W$ is data transmitting rate. For continuous data collection, Zone-based Pipeline Scheduling (ZPS) algorithm is designed by Shouling Ji et al. (2014). ZPS increases speed of continuous data collection process through a data transmission pipeline and attains capacity gain of $N \frac{\sqrt{n}}{\sqrt{\log n}} \ln n$ or $\frac{n}{\log n}$.
A Probability-based Prediction and Sleep Scheduling (PPSS) protocol is designed by Bo Jiang et al. (2013) improves the efficiency of proactive wake up. A target prediction method is planned depending on kinematics and probability. With prediction results, PPSS choose the nodes to awake and reducing the active time to improve energy efficiency with less tracking performance loss. By combining the traffic engineering and distributed agent technology, a new distributed agents QoS routing algorithm is designed. The algorithm discovers the fast forward path with multi agents and assures the transmitting quality with even traffic allocation. The mathematical analysis is used to establish the validity of the algorithm. The average end-to-end delay, routing overhead, and the bandwidth occupation ratio of links are determined to estimate the algorithm results. The new algorithm presents short end-to-end transmission with most favorable used communication resource.

### 2.3 MISDIRECTED ROUTE AVOIDANCE IN QoS ROUTING FOR WSN

An effective Position-based Opportunistic Routing (POR) protocol is designed by Shengbo Yang et al. (2012) with benefits of stateless property of geographic routing and broadcast environment of wireless medium. When data packet is transmitting, neighbor nodes overhear the transmission forwarding candidates when it is not sent by particular forwarder in exacting time. Through the backup, communication is preserved by lacking the interruption. The additional latency acquired through local route recovery gets minimized and duplicate relaying through packet reroute is reduced. In communication gap, a Virtual Destination-based Void Handling (VDVH) scheme was designed to function with POR.

Chi Zhang et al. (2012) designed price of security in large-scale wireless ad hoc networks (WANETs). Security problems are addressed with
performance degradation that is quantified. WANET present communications over shared wireless channel lacking the preexisting infrastructure. Creating end-to-end secure paths in WANETs is demanding than conventional networks exclusive of the central authorities. The drawbacks on network performance are untouched. Depending on the random network model, the asymptotic performances of secure throughput and delay with common transmission range $r_n$ and probability $p_f$ of adjacent nodes are calculated. The main security association is measured when network size $n$ is large. The advantages of secure-link-augmentation processes on secure throughput and delay are determined.

Francis Ogwu et al. (2007) designed the framework for QoS in mobile ad hoc networks. A framework is designed for denoting probabilistic QoS that assures in MANET (Mobile Ad Hoc Network). The structure employs the mobility profiles of nodes in network to create probabilistic QoS. The network sent to the destination in particular period of time. A mobility model is used to describe the probabilities of path accessibility connecting two communicating nodes and QoS deliverable on path. A mathematical model was designed for possibility of link, path availability and bandwidth by continuous time stochastic system. An opportunistic cooperation is designed by Wing Ho Yuen et al. (2009) in contention sharing of selfish mobile networks. All nodes contain large interest in all files. A social contract specified with a bilateral file exchange when node attains something from the exchange. The capacity is based on mobility, number of files disseminated and node density. With the existence of multiuser diversity, the existence of data diversity-throughput improves the number of files to all nodes that get increased.

A token-based robust deadlock-free dynamic reconfiguration protocol is designed by Mohiadeen Abdul Kadhar (2014). As device
examines topology variations or detecting the faulty nodes, it activates the reconfiguration development and developed into Reconfiguration Controller (RC). ‘Hello’ message was sent by reconfiguration controller to all devices that react with network status message. RC plans the new routing function depending on received network status messages. For coordinating the old and new routing tasks, the reconfiguration controller allocates reconfiguration token in ordered manner. Every device maintains the packet till it obtains packet consistent with new routing function and subsequently initiates the transmission.

2.3.1 Data Broadcasting in WSN

Mala Chelliah et al. (2012) designed adaptive data broadcasting in underwater wireless networks. Many routing techniques are utilized for ad-hoc networks. As data transfer in wireless mesh networks and from the Access Point (AP), the protocols resulted in congested routes. For minimizing the congestion, routing protocols like traffic balancing select the routes depends on the medium usage of the route. Routing is multi constraint issues. For creating the routing decisions depending on buffer occupancy, node energy and hop count with an efficient routing technique for wireless mesh networks, a fuzzy multi-constraint Ad Hoc On-Demand Distance Vector (AODV) routing is designed.

Mohammad S. Obaidat & Tarik Guelzim (2010) presented Counter Disassociation Mechanism (CDM) for Wireless LANs and its performance simulation analysis. IEEE 802.11 Wireless LANs present the capability to plan cost efficient flexible network infrastructure. The technology presented a security mechanism, Wired Equivalent Protocol (WEP) to secure the network. Though, the technology failed to attain the desired security goals because of holes found. The problem is addressed through planning WiFi Protected Access (WPA) scheme with improvements to both encryption and
maintenance for authentication. In spite of verification and encryption features, WPA experiences few flaws that allow attackers to tamper with used network and accessibility. A new security technique CDM tries to attach flaw in disassociation method of WPA protocol. The vulnerability allocates an attacker to shut down an entire network for users that allowed using the resources.

Evy Troubleyn et al. (2014) intended broadcast aggregation to improve QoS in WSN. In-network aggregation is utilized in WSN to reduce the energy consumption on sensor nodes with limited abilities. The packets with similar destination are combined with the routing path and the packets are sent through the unicast. When the packets are sufficient for classical multipoint-to-point sensor network applications, it is not suitable when wireless sensor nodes are linked in full mesh topology. In full mesh topologies, queues are filled with packets with several destinations that limit the aggregation possibilities. QoS level reduced as the packets to discover the aggregation of candidates. Broadcast aggregation is used to aggregate packets regardless of their destination.

Petros Nicopolitidis et al. (2010) designed adaptive data broadcasting in under water wireless networks. Below the water acoustic networks are used in wireless networking. The networks maintain large quantity of applications like environmental and underwater equipment monitoring. Considerable design on protocol design aimed on MAC and network layer protocols. In spite of the networking primitive, data broadcasting attained user consideration in the context of below the water networks. An adaptive push system is planned for distribution of data in below the water acoustic wireless networks. The designed technique combats the issues of high latency of underwater acoustic wireless environment.
The authentication and topology control are used in many works in MANETs. Both the authentication and topology control techniques have necessary drawbacks on throughput. The efficient throughput with upper layer authentication schemes and physical-layer schemes are connected with channel conditions and relay selections for Cooperative Communication (CC). A Joint Authentication and Topology Control (JATC) scheme is designed by Quansheng Guan et al. (2012) through increasing the throughput. JATC is devised as discrete stochastic optimization issues that failed to need prior perfect channel status.

Rocio Arroyo-Valles et al. (2011) planned optimal selective forwarding for energy saving in WSN. The stochastic tools were designed to increase choosy message forwarding techniques. The techniques were based on the parameters. The forwarding techniques were designed for three cases, namely when sensors increase the importance of transmitted messages, when sensors increase the significance of messages that are retransmitted through its neighbors and when sensors increase the significance of messages that reaches the sink. Suboptimal schemes based on local estimation algorithms and minimized the computational cost.

2.3.2 Routing Protocols and Algorithm

Shaiful Alam Chowdhury et al. (2012) planned routing protocols and simulation analysis of Wireless Routing Protocol (WRP), Dynamic Source Routing (DSR) and Adhoc on Demand Distance-Vector (AODV) in WSN. The communications networks combine the fast development in the field of WSN. WSNs are not similar to the traditional Ad hoc networks. The variation among WSNs and traditional Ad hoc networks has less energy supply, less storage capacity, power of computation, and bandwidth. Due to the limitations and random use, it is necessary to design an unblemished routing layer protocol for WSN. The issues are addressed for routing
protocols in WSNs with limits of routing protocols for WSNs. GloMoSim-2.03 was used to locate the limitations of traditional ad hoc routing protocols (DSR, WRP and AODV) when applied to WSN.

A two energy-aware routing algorithms for wireless ad hoc networks termed Reliable Minimum Energy Cost Routing (RMECR) and Reliable Minimum Energy Routing (RMER) is designed by Javad Vazifehdan et al. (2013). RMECR fulfills three essential needs of ad hoc networks, known as energy-efficiency, trustworthiness, and prolonging network lifetime. It also considers the energy consumption and residual battery energy of nodes. The quality of links is used to find energy-efficient and reliable routes for improving the operational lifetime of network. RMER is energy-efficient routing algorithms that locate the routes and minimizes the total energy needed for end-to-end packet traversal. RMER and RMECR are designed for networks where hop-by-hop or end-to-end retransmissions guarantee the reliability.

Vikas Bhandary et al. (2016) planned routing in wireless multimedia sensor networks. The growth of multimedia nodes results in the formation of an extra intelligent distributed system that transmits real-time multimedia traffic. Wireless Multimedia Sensor Networks (WMSNs) are used in large areas with the area observe and video surveillance. However, because of untrustworthy error-prone communication medium and application specific QoS needs, routing of real-time multimedia traffic in WMSNs creates a key issue.

Naveen &Anurag Kumar (2013) designed relay selection for geographical forwarding in sleep-wake cycling WSN. Local forwarding algorithms are altered to swap the end-to-end delay beside total cost like the hop count or total energy. The key aim is to address the forwarding node that enroute to sink, the local forwarding issues of one-hop waiting delay expose
lower bound limitation on appropriate prize provided by the next-hop relay. The restraint provides modify to the tradeoff. The reward metric is employed for local issues depending on end-to-end total cost objective. The forwarding node is uncertain regarding relays, wake-up times and reward values however it identifies the probability distributions of quantities. At every relay wake-up, when relay exposes the reward value, the forwarding node's issue sends the packet or waits for the relays to wake-up.

2.3.3 QoS Routing Algorithms and Techniques

Ting Yang et al. (2013) planned a Distributed Agents QoS Routing Algorithm to Transmit Electrical Power Measuring Information in Last Mile Access WSN. The traffic engineering and distributed agent are combined as new distributed agents QoS routing algorithm to send out the electrical information flows with multi-QoS limitations. The algorithm searches the fast forward path with multi agents and assures the transmitting quality with even allotment of different traffic.

New protocol employs ad hoc cluster based architecture by Juan R. Diaz et al. (2014) adjusts the logical sensor network topology to delivered multimedia stream features and assuring the quality of communications. The designed protocol employs the QoS parameters like bandwidth, delay, jitter, and packet loss of all kinds of multimedia stream for the sensor clusters creation and organization in WSN presenting end-to-end QoS for every multimedia stream.

Shailendra Aswale & Vijay R. Ghorpade (2015) studied the QoS Routing Protocols in Wireless Multimedia Sensor Networks. With the distinctive features of WMSNs, addressing the QoS needs for many applications is an essential problem. QoS routing is backbone of WMSNs and it is an essential part in satisfying the QoS needs. The results of QoS routing
are based on the choice of an optimal path. Path selection is depending on the estimation of cost function by routing metrics. A careful blend of metrics in routing cost function assures dedicated level of QoS.

A QoS-aware routing mechanism is designed by Li Han et al. (2016) for OpenFlow-enabled WMSNs. The mechanism comprises the framework and routing algorithms on SDN controller. The framework has two operations, namely detection of link states between OpenFlow-enabled nodes and determination of flow’s QoS needs. The routing algorithms are attained in two processes. It finds the possible paths that assure QoS needs of flow. When there is no path that assures the necessary QoS, the path is chosen by the algorithms based on the flow types, namely delay-sensitive, bandwidth-sensitive, and best-effort traffic.

A distributed adaptive opportunistic routing technique for multi-hop wireless ad-hoc networks is designed by Bhorkar et al. (2012). The designed schemes are reinforcement learning structure to route the packets in absence of reliable knowledge regarding channel statistics and network model. The scheme is revealed as optimal with a predictable average per packet reward criterion. The designed routing scheme addresses the learning and routing in an opportunistic context where the network structure is classified by transmission achievement probabilities.

A heuristic neighbor selection mechanism is designed by Hind Alwan & Anjali Agarwal (2013) in WSNs that employs geographic routing mechanism with QoS needs to present Multi-objective QoS Routing (MQoSR) for many application needs. The issues of QoS routing is planned as link, and path-based metrics. MQoSR protocol is to achieve the delay needs because of optimum path selection method.
Claudio Cicconetti et al. (2010) planned to minimize the power consumption with QoS constraints in IEEE 802.16e wireless networks. Mobile Broadband Wireless Access (BWA) networks presented multiple and differentiated services to users with high mobility need linking through portable or wearable devices that runs on batteries. The IEEE 802.16 preserves mobile BWA defined power saving functions at MAC layer. It is functioned in open traffic sessions for large energy consumption minimization. The mutual interaction between power saving methods and QoS backing is executed in IEEE 802.16e. The two types of delay-constrained applications with needs are taken, namely Web and Voice over IP (VoIP) where IEEE 802.16e standard denotes two power saving classes.

2.4 ENERGY EFFICIENT DATA DELIVERY IN WSN

Simon S. Lam & Chen Qian (2011) designed geographic routing in d-dimensional spaces with guaranteed delivery and low stretch. A geographic routing protocol called Multihop Delaunay Triangulation (MDT) is planned for 2D, 3D and superior dimensions with guaranteed delivery for any connected graph of nodes and physical links. The protocol has low routing stretch from forwarding of packets beyond the local minima. The guaranteed delivery property maintained for node locations denoted by exact, inexact, or arbitrary coordinates. The MDT protocol comprises packet forwarding protocol for nodes to design and preserve distributed MDT graph for routing. The MDT protocols in 3D and 4D comparisons of MDT routing versus geographic routing protocols are calculated for nodes in 2D and 3D.

Yu Zhang et al. (2010) designed an adaptive location-oriented content delivery in delay-sensitive pervasive applications. A delay-sensitive service includes transmitting large quantity of location-based data to nodes at many locations. A limited amount of access points and an abundance of
service requests result from nodes moving around content delivery service that predictably plan the delay. The existing issues are addressed with the movement pattern of mobile nodes and estimated as semi-Markov process. Several components of service delay and APs utilize multicast plan reduces the queuing delay component. The feasibility of nodes are described with have local copies of location-relevant data to relay data for additional nodes in many communication channels.

Three-Dimensional Network-on-Chip (3D NoC) is designed to address the complex on-chip communication problems in 3D multicore systems. For maintaining the temperature below particular thermal limit, the thermal emergent routers are choked. The topology of 3D NoC developed into Non-Stationary Irregular Mesh (NSI-Mesh). For assuring the packet delivery in NSI-Mesh, routing algorithms are designed. A Topology Aware Adaptive Routing (TAAR) is designed by Kun-Chih Chen et al. (2013) equilibrium the traffic load for NSI-Mesh in 3D NoC. TAAR has three routing modes that are altered based on the topology status of routing path. For improving the routing flexibility, TAAR improves vertical and lateral path diversity to equalize the traffic load.

Topology control is an essential method to minimize the energy consumption and improves the network lifetime. A distributed topology protocol is planned by Mohamad Nikravan &Seyed Mahdi Jameii (2012) with transmission power adjustment depending on harmony search and learning automata algorithms termed as Harmony Search and Learning Automata based Topology Control protocol (HSLATC). In HSLATC, correct transition radius of sensor nodes is found. Due to the intelligent determining of transition radiuses of nodes, it presents full connectivity in sparse usage and minimizing the energy consumption of sensor network.
2.4.1 Energy Aware QoS Routing

A generalized QoS-aware routing model is designed by Huang Hai Ping (2014) depending on many routing metrics and priorities of packets. A 2D plain-based routing algorithm increases the standard ant colony algorithm through enhancing the distribution of artificial pheromone to speed up the algorithm convergence rate called Improved Plain-based Ant Colony Routing (IPACR) algorithm. A Clustering-based Ant Colony Routing (ICACR) algorithm is designed in a large scale network. ICACR is a difference of IPACR as it is appropriate for clustering cases to assure the larger scale conditions. The trade-off among the energy utilization and end-to-end delay in WSN are studied by Trong-Thua Huynh et al. (2016). A new distributed clustering approach is planned to determine the best cluster head for every cluster through taking energy and delay needs. A multi-hop routing algorithm from cluster heads to sink is introduced with new delay model to compute the minimum delay-energy cost.

A new technique is designed by Ridouane El Mezouary et al. (2016) is an energy aware cluster for WSNs. The algorithm is depending on the k-means clustering method in many fields of engineering. K-means clustering locates the clusters of comparable spatial extent. A clustering process is improved by choosing the nodes as clusters which are centric and contain high level of energy. It has similar QoS performances by the K-means approach with minimization of energy consumption and maintenance of lifetime of the sensor network.

Babar Nazir & Halabi Hasbullah (2013) planned Energy Efficient and QoS Aware Routing (EEQR) protocol for clustered WSN. Energy efficiency (hotspot problem) and high end-to-end delay issues are addressed with the mixture of mobile and static sink for data gathering. Delay sensitive
messages are sent during the static sink and delay tolerant message are sent during the mobile sink. EEQR acquires the less end-to-end delay and guarantees QoS. Energy Efficient Fault Tolerant QoS Adaptive Clustering Algorithm (FTQAC) is designed by Shiva Prakash et al. (2014) for WSNs to preserve the real-time traffic. The protocol attains the fault tolerance and energy efficiency through a dual cluster head mechanism and guarantees the preferred QoS with delay and bandwidth parameters in the route selection process. An energy efficient and QoS guaranteed service selection technique is designed by Endong Tong et al. (2014) in WSNs. By decomposing the global QoS limitations into collection of local QoS limitations, a group of QoS guaranteed candidate services are attained. By considering service profile, fuzzy logic method is designed to rank the candidate services and choose the optimal one.

A localized QoS routing protocol is designed by Djamel Djenouri &Ilango Balasingham (2010) for WSNs. The designed protocol aims WSN's applications with many data traffic. It is depending on distinguishing QoS needs consistent with data type that present customized QoS metrics for all traffic categories. With every packet, the protocol tries to perform the necessary data-related QoS metric(s) while taking the power efficiency. It is modular that removes the requirement of propagating the routing information. For link quality assessment, the protocol uses distributed, memory and computation efficient techniques. It employs a multi-sink -single-path approach to improve the reliability. The protocol employs the diversity in data traffic while taking the latency, trustworthiness, residual energy in sensor nodes and transmission power connecting nodes to transmit QoS metrics as multi-objective issue. The protocol functions with MAC protocol and uses an acknowledgment method.
Floriano De Rango et al. (2012) designed link-stability and energy aware routing protocol. Energy awareness for computation and protocol management is essential factor in the plan of protocols and algorithms. A new routing plan is designed. The designed techniques account for link stability and minimum drain rate energy consumption. For authenticating the accuracy of bi-objective optimization, new routing protocol termed Link-stability and Energy Aware Routing protocols (LEAR) is intended. A new routing scheme is compared with additional three protocols.

2.4.2 Multicast and Multipath Routing

Al-Sakib Pathan et al. (2008) designed Neighbor Aware Multicast Routing Protocol (NAMP) for MANET. NAMP is a tree based, hybrid multicast routing protocol for ad hoc networks. The routing protocol objective is to attain the robustness in the adhoc networks and the enhancement of end-to-end delivery of data packets. For route formation, the protocol employs neighboring information and leading pruning approach. It employs secondary forwarder method for route preservation as well.

Depending on the possible ideas, IDDR with a multi-path dynamic routing algorithm is designed by Jiao Zhang et al. (2013) address the issue. Through planning a virtual hybrid possible field, IDDR divides packets of applications with many QoS needs. It is also consistent with the weight allocated to all packets and routes them to the sink with many paths that increase the data fidelity for integrity-sensitive applications. It also minimizes the end-to-end delay for delay-sensitive ones. With Lyapunov drift method, IDDR is stable one.

Hui Zhou et al. (2012) planned a multiple-dimensional tree routing protocol for multisink WSNs based on ant colony optimization. For MultiSink WSNs, the routing protocol procedures and execution is complex because of
structure complexity. The protocol manages the issues of multidimensional tree routing protocol for multisink WSNs depending on ACO. The listening method is employed to create and preserve multidimensional tree routing topology. By considering the hops, packet losses, retransmission and delay account, a distributed ant colony algorithm is designed. When nodes choose the routes in the data transmission, the algorithm is used to recognize the real-time optimization through management between nodes.

A new distributed multi-channel MAC protocol is designed by Khaled H. Almotairi & Xuemin (Sherman) Shen (2010) using the fast and slow hopping series with dual radio interfaces. One interface uses fast hopping for transmission and the other interface uses slow hopping for reception. The designed protocol is in line with IEEE 802.11 MAC plan depending on multiple rendezvous approach. The approach is designed to improve the network presentation and determines the congestion. An analytical model is designed to calculate the network results in aggregate throughput.

Checkpointing is essential in Mobile Grid (MoG) systems than in conventional wired counterparts because of host mobility, dynamicity, less reliable wireless links, frequent detachments and changes in mobile systems. The globally optimal checkpoint arrangement is taken as NP-complete and Reliability Driven (ReD) middleware using decentralized QoS-aware heuristics to plan superior checkpointing preparations capably. With ReD, an MH (Mobile Host) sends checkpointed data to chosen neighboring MH and provides the stable point of storage for checkpointed data obtained from accepted neighboring MH. ReD executes to increase the possibility of checkpointed data recovery in job execution.
2.4.3 Privacy Preserving in WSN

DP$^2$AC (Distributed Privacy-Preserving Access Control) scheme is designed by Rui Zhang et al. (2012) for sensor networks. Users in DP$^2$AC obtain the tokens from network owner to query the data from sensor nodes that respond after authenticating the tokens. The utilization of blind signatures in token generation guarantees that the tokens are publicly verifiable. However, it is unconnected to user identity where the privacy-preserving access control is obtained. A component in DP$^2$AC avoids mean users from reuse tokens where a set of Distributed Token Reuse Detection (DTRD) schemes lacking the base station involvement. The schemes distribute the necessary plan where sensor node verifies whether token are employed with additional nodes.

A new mathematical model is designed by Mohammed Zaki Hasan & Tat-Chee Wan (2013) for QoS route determination. It also allows sensor to find out the optimal path for reducing the resource utilization while assuring the essential QoS limits. The mathematical model employs Lagrangian relaxation mixed integer programming technique to describe parameters and suitable objective functions for calculating the adaptive QoS constrained route detection process. Performance trade-offs connecting QoS needs and energy efficiency was increased by LINGO (i.e., C, C++, C# and so on) mathematical programming language. The designed technique increases the network lifetime while reducing the energy consumption and average end-to-end delays inside the sensor network through the optimized resource sharing in intermediate nodes with existing routing algorithms.

Kiran Mehta et al. (2012) designed the location privacy in sensor networks against a global eavesdropper. Attacks on components dishearten the network application. The techniques protect the outflow of location information from lesser adversaries who examine the network traffic in
minute region. The designed technique formalizes the location privacy problems in sensor networks below strong adversary model and calculates lower bound on communication overhead required for attaining specified level of location privacy. Two methods are designed to present the location privacy to examine the objects-periodic collection and two methods present the location privacy to data sinks simulation and backbone flooding.

2.4.4 Applications of WSN

In practical applications of WSNs, it is essential to achieve the localization of sensors inside the time bound. The traditional description of relative localization is inappropriate for calculating its real overhead. A new issue called necessary localization is addressed and designed the rigorous learning on essential localizability of WSN inside time bound. An effective distributed algorithm is designed by Wei Cheng et al. (2013) for time-bounded necessary localization over sensor network.

Ozlem Durmaz Incel et al. (2012) planned fast data collection in tree-based WSNs. A number of methods are designed with realistic simulation techniques under the many-to-one communication model called convergecast. The time scheduling on single frequency channel are taken with objective of reducing number of time slots needed to achieve a convergecast. The scheduling is joined with transmission power control that reduces the outcomes of interference and power control through minimizing the schedule length below single frequency. The scheduling transmissions by multiple frequencies are more effective. The lesser bounds on schedule length when interference is removed and algorithms achieve the bounds. The multi-frequency scheduling eliminates much interference.

The optimal policy is designed by Abhishek Agarwal & Aditya K Jagannatham (2012) reduces the average number of dropped packets for delay
limited wireless node with renewable energy source. The designed technique uses an adaptive modulation for transmission of optimal number of packets assuring the QoS limitations. The framework is planned as Markov Decision Process (MDP) that reduces the long term packet drop rate. In addition, the optimal policy is monotone regarding the every joint state components of the MDP.

Chad R. Meiners et al. (2011) designed with range reencoding by considering classifier semantics. Reencoding is used as topological transformation process as of one colored hyper-rectangle where color is the decision with given packet. The reencoding process is carried out to accomplish a classifier by classifier's decisions and then somewhat reencode only ranges in the classifier removing the classifier's decisions. Two orthogonal techniques like domain compression and prefix alignment are designed.

The main problems in MAC of WSNs are sleep/wake-up scheduling, idle listening, collision and energy used for retransmission of collided packets. An adaptive quorum-based MAC protocol called Queen-MAC is planned by Gholam Hossein Ekbatanifard et al. (2012). The protocol considers the node wake-up times and minimizes idle listening and collisions. The protocol also improves network throughput and network lifetime. Queen-MAC is dependable for data collection applications. A new quorum system, dygrid is designed to present a low duty cycle, $O(\sqrt{n})$ for regulating the wake-up times of sensor nodes.

Yuan He & Mo Li (2012) designed query-centric framework of collaborative heterogeneous sensor network where the sensor networks collaborate with every other for well-organized processing of queries. An optimal plan of query processing regarding energy efficiency is a key problem
in COSE formulated into an optimization problem termed energy-efficient query processing strategy. The NP-hardness of energy-efficient query processing was designed and heuristic approach called Implication-Aware Pipeline (IAP) through the correlation between dissimilar sensor networks was arrived at.

ZigBee is a unique communication standard designed by Yu-Kai Huang et al. (2012) for low-rate Wireless Personal Area Networks (WPAN). The technique has low complexity, cost and power consumption for wireless connectivity in low-cost, manageable and mobile devices. An adoptive-parent based structure is designed for ZigBee cluster-tree network to improve the lack of bandwidth utilization that creates some additional message exchange. A distributed algorithm is completely correspondable with ZigBee standard.

Zhen Yu et al. (2010) designed dynamic en-route filtering scheme for data reporting in WSNs. A dynamic en-route filtering scheme solves both false report injection and Denial of Service (DoS) attacks in WSNs. Every node has hash chain of authentication keys employed to support reports. A lawful report is established using certain number of nodes. Every node distributes its key to forwarding nodes. After sending reports, the sending nodes reveal the keys allocating the forwarding nodes to authenticate the reports. The hill climbing key distribution approach guarantees the nodes near to data sources with filtering capacity. The broadcast property of wireless communication overcomes the DoS attacks and implements the multipath routing to manage the changes of sensor networks.

2.5 RESEARCH GAP

Dynamic Routing for Data Integrity and Delay Differentiated Services (DR-DIDDS) was designed. Depending on the idea of potential in physics, a multi-path dynamic routing algorithm was designed to present low
delay and high data integrity. The DR-DIDDS method is used a virtual hybrid potential field. DR-DIDDS method also applied Lyapunov drift technique to verify the stability of the method. Even though, a greatly loaded network experiences the communication overhead that enhances the transmission delay. Decentralized QoS-Aware Checkpointing Arrangement (DCA) in WSNs designed QoS-aware middleware for checkpointing arrangement minimizing the transmission delay. Although method DCA served as calculate for data recovery, the network coverage is reduced because of the energy constrained sensor nodes. Partitioning Multipath Routing (PMR) approach was related the real time WSNs depending on the Lagrangian integer programming method.

Dynamic en-route filtering scheme addresses together false report injection and DoS attacks in WSNs. Every node has hash chain of authentication keys employed to support the reports. Every node provides its key to forwarding nodes. Though, it is less efficient in authentication process. An adaptive modulation is designed for transmission with best number of packets towards gratifying QoS limitations. Markov Decision Process (MDP) reduces the long term packet drop rate. But, it consumes huge amount of time. A cluster-based routing protocol for WSNs with nonuniform node distribution is designed with an energy-aware clustering algorithm EADC and a cluster-based routing algorithm. But, energy efficiency remained unaddressed.

An adoptive-parent based structure is intended for ZigBee cluster-tree network to improve bandwidth use lack of generating additional message exchange. For increasing the throughput, model executes a vertex-constraint maximum flow issues and increases distributed algorithm that is completely well-matched with the ZigBee standard. Though, the required throughput level remained unaddressed. A joint authentication and topology manage
(JATC) scheme raises the throughput rate by discrete stochastic optimization technique. Joint authentication takes spanning over the complete protocol stack for whole wireless network presentation measurement. But, it is not working on the dynamic changing topology. Wi-Fi Protected Access (WPA) scheme presents an encryption and decryption process for dynamic changing topology. WPA experiences flaws on obtainable algorithm to interfere with the wireless network organization. WPA is inappropriate for distributing the QoS in wireless networks as it does not solve the delay time factor.

A Ternary Content Addressable Memory (TCAM)-based packet classification system measures the throughput level. TCAM space for an encoded classifier is three times lesser in space is compared with re-encoded classifier and its transformers. TCAM based sensor network system improves the throughput level. Though, the topological transformation results in routing failure. Adaptive Location-oriented QoS content delivery performs the packet movement on mobile sensor nodes. Semi-Markov process is used for the movement of packets in sensor network but not developed with energy effective routing protocol.

Distributed algorithm for Time-bounded Essential Localization (DTEL) as described over sensor network minimizes the time taken for the broadcasting of packets. It also integrated the regular payload transmissions. Though, investigating the throughput level on the different topological route paths is not aimed in DTEL method. DTEL are not developed on social network applications. A multi constraint routing using fuzzy logic was developed to improve the performance of WMN and minimizes the possibilities of congestion in the network. Though, group communication is not aimed in wireless mesh networks.
2.6 PROBLEM FORMULATION FROM LITERATURE STUDY

The elaborative literature study carried out and described in the sections 2.1 through 2.5 of this chapter could present the background sources of problem formulation. Based on the above literature, the research problem to address the three major aspects has been formulated. Table 2.1 summarizes the base literature that sounds as the background of this research.

**Table 2.1 Literature Support for Problem Formulation**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Authors &amp; Year of Publication</th>
<th>Approach</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Simon S. Lam &amp; Chen Qian (2011)</td>
<td>- Geographic routing in d-dimensional</td>
<td>- Guaranteed delivery and low stretch.</td>
</tr>
<tr>
<td>2</td>
<td>Abhishek Agarwal &amp; Aditya K Jagannatham (2012)</td>
<td>- Optimal policy</td>
<td>- Reduces the average number of dropped packets for delay limited wireless node with renewable energy source.</td>
</tr>
<tr>
<td>4</td>
<td>Shengbo Yang et al. (2012)</td>
<td>- Position-based Opportunistic Routing (POR) protocol</td>
<td>- Communication is preserved by lacking the interruption latency acquired through local route recovery gets minimized and duplicate relaying through packet reroute is reduced.</td>
</tr>
<tr>
<td>5</td>
<td>Javad Vazifehdan et al.(2013)</td>
<td>- Reliable Minimum Energy Cost Routing (RMECR) and Reliable Minimum Energy Routing (RMER)</td>
<td>- RMECR fulfills Energy-efficiency, trustworthiness, and prolonging network lifetime in addition the energy consumption and residual battery energy of nodes. - Improving the operational lifetime of network. - End-to-end retransmissions guarantee the reliability.</td>
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Table 2.1 (Continued)

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<tr>
<td>6</td>
<td>Naveen &amp; Anurag Kumar (2013)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Geographical forwarding in sleep-wake cycling WSN</td>
<td>• To address the forwarding node that enroute to sink, the local forwarding issues of one-hop waiting delay expose lower bound limitation on appropriate prize provided by the next-hop relay.</td>
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<tr>
<td>7</td>
<td>Babar Nazir &amp; Halabi Hasbullah (2013)</td>
<td></td>
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<tr>
<td></td>
<td>• Energy Efficient and QoS Aware Routing (EEQR) protocol</td>
<td>• EEQR acquires the less end-to-end delay and guarantees QoS.</td>
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<td>8</td>
<td>Ting Yang et al. (2013)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Distributed Agents QoS Routing Algorithm to Transmit Electrical Power Measuring Information in Last Mile Access WSN</td>
<td>• The electrical information flows with multi-QoS limitations.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The fast forward path with multi agents assures the transmitting quality with even allotment of different traffic.</td>
</tr>
<tr>
<td>9</td>
<td>Kun-Chih Chen et al. (2013)</td>
<td></td>
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<tr>
<td></td>
<td>• Topology Aware Adaptive Routing</td>
<td>• For improving the routing flexibility, TAAR improves Vertical and lateral path diversity to equalize the traffic load.</td>
</tr>
<tr>
<td></td>
<td>• QoS Routing Protocols in Wireless Multimedia Sensor Networks</td>
<td>• The choice of an optimal path.</td>
</tr>
<tr>
<td></td>
<td>• Heuristic neighbor selection mechanism</td>
<td>• To achieve the delay needs because of optimum path selection method</td>
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<tr>
<td>11</td>
<td>Ravindra Navanath Duche &amp; Nisha P Sarwade (2014)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Microelectronic fabrication technology</td>
<td>• Huge numbers of moveable wireless sensors in WSNs raises the QoS.</td>
</tr>
<tr>
<td>12</td>
<td>Shilpa Mahajan et al. (2014)</td>
<td></td>
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<tr>
<td></td>
<td>• Cluster Chain Weight Metrics</td>
<td>• The technique is to protect the energy of sensors and balances the load.</td>
</tr>
<tr>
<td>13</td>
<td>Zhengmao Ye &amp; Habib Mohamadiano (2014)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Adaptive algorithms and Data aggregation algorithms</td>
<td>• The network lifetime is improved and bandwidth reserved for all nodes get increased.</td>
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<tr>
<td></td>
<td></td>
<td>• Removing the collisions.</td>
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<tr>
<td>No.</td>
<td>Authors and Year</td>
<td>Method and Description</td>
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<tr>
<td>14</td>
<td>Shouling Ji et al. (2014)</td>
<td>Zone-based Pipeline Scheduling (ZPS) algorithm</td>
</tr>
<tr>
<td>15</td>
<td>Dean Zhang et al. (2015)</td>
<td>A clustering routing method depending on Preventing Energy Consumption Efficiency (PECE)</td>
</tr>
<tr>
<td>17</td>
<td>Ado Adamou Abba Ari et al. (2016)</td>
<td>Artificial Bee Colony protocol</td>
</tr>
<tr>
<td>18</td>
<td>Sachin Gajjar (2016)</td>
<td>FAMACROW</td>
</tr>
<tr>
<td>19</td>
<td>Prabhudutta Mohanty (2016)</td>
<td>Efficient Structure-free Data Aggregation and Delivery (ESDAD) protocol</td>
</tr>
<tr>
<td>20</td>
<td>Trong-Thua Huynh et al. (2016)</td>
<td>New distributed clustering approach</td>
</tr>
</tbody>
</table>
2.7 SUMMARY

The main contribution of this work is to minimize the time consumption for the reaction and broadcast of the packet without the overload, a QoS structure is designed to present bandwidth guarantees for communication in WSN. The structure has cluster node with Network Crossing Point depending on Time Control and Synchronized Access Scheduling mechanism. A crossing point is designed where the application by general Message Transitory Crossing (MTC) point standard denotes bandwidth need of the flows to the WSN. The structure is designed on KEGG (Kyoto Encyclopedia of Genes and Genomes) Metabolic Relation with Reaction Network and SMS Spam Collection Data Set.

Next to increase the routing on dissimilar topological structure, Topological Transform Adaptive Relational QoS Routing (TTA-RQoSR) scheme is designed. TTA-RQoSR scheme designed the framework that aims in avoiding the misdirected route and improves the throughput level. TTA-RQoSR scheme employs the abstained misdirected routing to remove the misdirected route path of packet transfer from source to destination. The abstained misdirected routing varies the flow connection on locally observed paths by the Erlang’s C Formula. Erlang’s C Formula that employs the Poisson arrival process with arrival rate to eliminate the misdirected route.

Finally, Zonal Sensor Node Authentication (ZSNA) model is designed to render the data delivery with better QoS differentiation quotient by service provisioning mode. The key idea of the solution is the Node Authentication-based Service provisioning combined with advantages of Zone-based Data Forwarding by distance measure. The former guarantees the data forwarding whereas the latter ensures network lifetime. QoS differentiation quotient with bandwidth is distributed for each sensor node minimizing the transmission delay and data loss rate.