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Research Article

Smart Agriculture Monitoring System based Data Aggregation Process in IoT and WSN using Multiple Sensor Nodes

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ABSTRACT

The Internet of Things (IoT) allows machines and devices in the world to connect with each other and generate a huge amount of data, which has a great potential to provide useful knowledge across service domains. Smart agriculture is a recent trend in this era, which adopts smart technology to increase farmland productivity. IoT gives a new dimension in the area of smart farming and agriculture domain. This research contains main modules are such as system model with energy model & objective model, CH selection-based data aggregation and shortest path routing in IoT. The proposed Agriculture Monitoring System (ACM) is focused to ensure the accurate data aggregation and reduction of energy consumption over WSN based IoT. Initially, the system model is constructed along with energy model and objective model for efficient data aggregation. The Grey Wolf Optimization (GWO) technique is used to find the more possible solution node and provides the better performance of the data aggregation process. It also checks the location accuracy and minimization of localization error. Then the shortest path routing is ensured by using by Enhanced Ad-hoc on-demand Distance Vector Routing (EAODV) protocol which is used for fast data aggregation during data communication for Smart Agriculture application. EAODV discovers the best path between sensor nodes and it denotes the node contain minimum distance and faster packet transmission in IoT. Also, it avoids congestion hence packet loss and routing overhead is reduced prominently. In the proposed framework, data from the agriculture sensors are routed while using a trusted network towards the CH and further towards the BS. In the area of agriculture production, IoT-based WSN has been used to observe the yields condition and automate agriculture precision using sensor nodes.

Keywords: Clustering, CH node, GWO, Congestion finding, EAODV, WSN and IOT

I. INTRODUCTION

IoTs are made up of small, low-power, battery-powered SNs. IoTs based application networks are made up of multiple low-cost nodes that are deployed in remote geographical regions for sensing environments. The selection of sensors in this application is motivated by the objective of boosting agricultural production [1]. The data gathered by these sensors are consistently sent to BSs (Base Stations) which are aggregator nodes, integrating data: soil sensor data; camera images and video captured by drones. Sensors and BSs used in agriculture fields have limited battery powers. BSs communicate with sensors using short-range wireless communications, while gateways communicate with sensors using long-range wireless communications.

WSNs are made of tiny SNs that communicate with one another and is deployed using tens to thousands of SNs for applications monitoring physical phenomena like temperatures, humidity, air pollutions, and seismic occurrences, alarm detections, and target categorizations/detections. SNs are tiny devices with three basic units: Processing unit with limited memory and computational power; Sensing unit for data acquisition from surrounding environments, and Communication unit like radio transceiver which transmit data to central collection points (BSs/ sink nodes) [2] [3]. Nodes are typically powered by irreplaceable tiny batteries. This limitation along with significant distances between SNs and BSs result in multi-hop communications where SNs transmit gathered data to nearby nodes, which in turn transfer them to their neighboring nodes and it goes on till the data reaches BSs.

WSNs designed for IoT confront a variety of problems, including the SNs counts, hardware, communication types, battery power, and computational costs. In addition to detections, IoT SNs have other capabilities and confront new issues in terms of QoSs (Quality of Services), security, and power managements [4]. These issues can be overcome using technological adjustments in basic protocols and WSN's methods. QoS requirements in IoT-WSNs confront considerable issues like high resource contents, data redundancies, dynamic network growths, less reliable medium, heterogeneous networks, and multiple BSs. Figure 1 depicts IoTs based WSNs

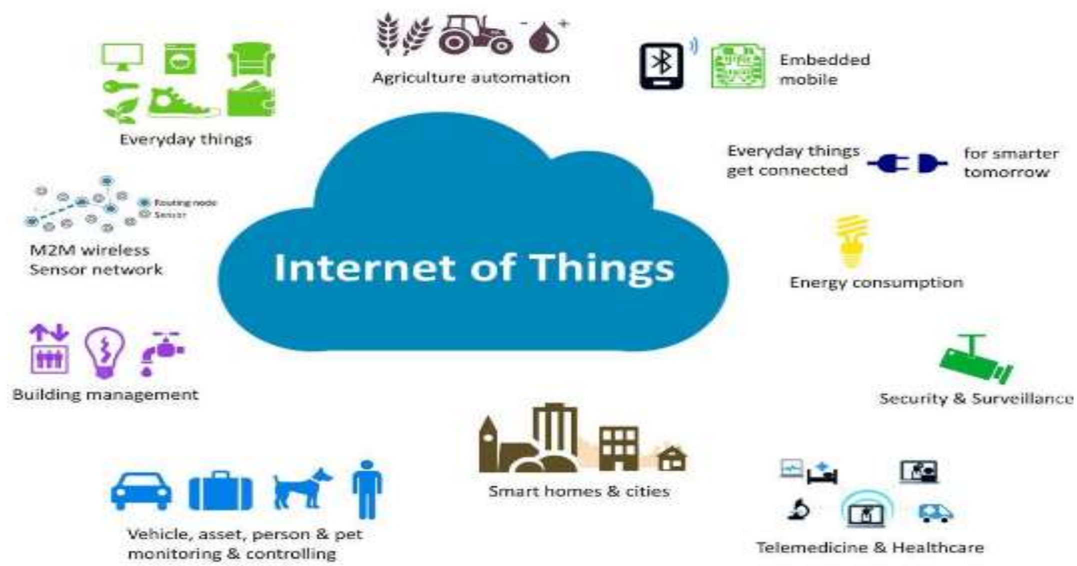

Figure 1: Example of IoT based WSN

Power consumptions of SNs have always been a major issue in WSN's design. Recent studies have yielded proposed schemes for reducing energy consumptions and extending network lifetimes by maximizing resource usage where routing algorithms play a significant role. Clustering creates a hierarchical structure of clusters or groups of SNs that gather and transfer data to their respective CHs, which then aggregate this data and send it to BSs thus functioning as middleware between end users and networks. LEACH (Low Energy Adaptive Clustering Hierarchy) is a traditional clustering-based routing protocol that considers SN's energy for transferring information [6]. Networks are divided into clusters where SNs send data to their associated CHs. For each round, the protocol selects CHs in a randomized manner which then interacts with each cluster node of the cluster. Choosing a CH is a complex task since several criteria must be examined in order to pick the optimal node in the cluster [7]. The distance between nodes, residual energy, and throughput of each node are among the considerations.

In general, there are two retentive reasons for WSN's issues in congestion. Buffer overflows and link collisions where buffer overflows occur when transmitted packets exceed a SN's packet handling capacity resulting in packet losses and wasteful communications while attempting to connect with the same node. Thus, resulting is in packet loss due to competitions and interferences. Congestion control algorithms detect, notify and reduce congestions [8]. Congestion control and avoidance techniques manage and control network traffic, reducing congestions in the network. Centralized solutions that manage congestions have drawbacks as they are not dynamic. Nodes are vulnerable to network congestions while aggregating data and result in reduced network metrics like throughputs, packet losses, and energy consumptions Routing (determining best path from source to destination nodes) is critical to IoT-based WSNs and needs to be handled with care. Routing mechanisms transfer data between SNs and BSs by establishing communications. In IoT-based WSNs, provisioning QoSs based routing techniques for BSs were introduced in [9]. WSNs based on IoTs have aided in the expansion of QoSs maintenance to agricultural sensors which collect pertinent data and use a multi-criteria decision functions to determine a set of CHs.

The main goal of this work is to use SNs to assess smart agriculture-based data aggregation processes in IoTs. Several studies and techniques have been proposed, but have failed to make substantial progress in optimizing data aggregations. Existing methods face limitations in terms of energy consumptions and network lifetimes of IoT-based WSN and to address this issue, this study proposes AMS to increase overall system performances. This study's primary contribution is system model which includes energy model & objective model, CHs based data aggregation using GWO Optimization and congestion aware shortest path routing using EAODV protocol. The proposed method is used to provide higher PDR and lower packet drop ratio results using effective protocols for the IoT based WSN.

The rest of the paper is organized as follows: a brief review of some of the literature works for data aggregation, agriculture based IoT using SNs, CH node selection and congestion aware routing in IoT based WSN is presented in Section 2. The proposed methodology for AMS–EAODV protocol is detailed in Section 3. The simulation results and performance analysis discussion is provided in Section 4. Finally, the conclusions are summed up in Section 5

II.RELATED WORK

The study by Prathibha et.al [2017] played a important part in smart agriculture. Smart farming, a new concept due to IoTs provided information in agricultural areas. The study intended to leverage on developing technologies like IoTs and smart agriculture through automations. Monitoring environmental variables is a critical process for increasing production of crops. The main aspect of this study was monitoring temperature and humidity in agricultural fields using sensors based on the CC3200 chips. They linked the camera to CC3200 for capturing photographs and sending them as MMS to farmers hand held devices over Wi-Fi medium.

Nguyen et.al [2017] examined the benefits of WSNs and energy-harvesting techniques for improving network communication performances. The authors concentrated on energy harvesting using IoTs where the major advantage was alleviating energy source replacement concerns by providing continuous power supply using ambient energy sources. Various techniques have addressed the issue of energy harvesting like creation of efficient power generation models and energy-aware routing protocols. Since, hardware implementations increase implementation costs, routing protocols are viewed as viable solutions to overcome energy issues. This study concentrated on energy harvesting by their proposed energy-harvesting-aware routing for heterogeneous IoT-based WSNs.

Ayaz et.al [2019] examined usage of wireless sensors and IoTs in agriculture, as well as issues found while combining this technology with traditional agricultural techniques. The study used a list of sensors available for specialized agricultural applications like soil preparation, crop status, irrigation, insect/pest detections. The study also detailed on technology’s assistance to producers throughout agricultural phases i.e. from seeding/harvesting to packaging/shipments. This study also considered the use of unmanned aerial vehicles for agricultural monitoring and other beneficial uses like estimating crop yields. The study emphasized on cutting-edge IoT based designs and platforms for agriculture.

The study by Karamitsios et.al [2017] focused on IoTs use in remote healthcare monitoring in linked health applications in [13]. According to the study healthcare practitioners used their first responders with remote access to sensor data generated by devices attached or monitoring people who had special needs. The effective connectivity of medical sensors, data aggregation to distant datacenters, and backend services necessitates the use of appropriate protocol stacks where the study compared several IoT protocol stacks aggregating data. The study tested on IEEE 11073 medical data transmission with TCP/UDP connections using CoAP and MQTT protocols for IoT data encapsulation and client-server connectivity.

Mixed integer programming formulations were proposed by Fitzgerald et.al[2018] targeting issues of energy optimal routing, multiple sink aggregations, combined aggregations and dissemination of IoT edge networks sensor measurements data. The study considered network optimizations for overall minimal energy usage with min-max SNs energy utilizations. The study’s formulations for optimal transmission throughput scheduling in pure aggregation scenarios used physical interference model. Their numerical analysis evaluated energy and time necessary to solve use cases in created network scenarios using various topologies and 10-40 SNs. Although their aggregations accounted for less than 15% of overall energy use in examinations, it resulted in significant energy savings. Their results demonstrate that direct, shortest-path flows from sensors to actuators consume energy more than 13 times when compared to aggregation and dissemination methods in forty SNs network.

Behera et.al [2019] proposed efficient selection of CHs using an election system where CHs node positions having with greater energy levels were rotated. The next set of CHs for the network was chosen to suit IoTs sensing environments, and smart cities. Their proposed algorithm analyzed initial, residual, and optimal value of CHs in SNs. According to their simulation results, their improvisations outperformed LEACH protocol and could increase residual energy by 64%, throughputs by 60% and lifespan by 66%

Farman et.al. [2018] developed a multi-criteria-based CHs/zone head selection technique for IoTs based WSNs. The study considered several aspects that could influence node energies and network longevities. Their considerations included energy levels, distance from surrounding nodes/ zone centers, counts on SNs becoming zone heads, and SNs that are merged as these directly influenced WSNs overall performances. The relative importance of each parameter in CHs/zone head selection was computed using multi-criteria decision based ANPs (Analytical Network Processes). Their scheme's simulations demonstrated their proposed scheme outperformed existing energy-efficient clustering approaches. The study also evaluated their findings by altering ZH selection factors, as well as their influence on a network stability/longevity.

Ajay Kaushik et.al [2019] Presents two algorithms DBSCDS-GWO and DBSC-GWO for CDS WSN and cluster based WSN respectively to achieve a stable and energy efficient network. Both algorithms ensure deterministic dominator CH selection, minimize the effective transmission distance involved in the transmission of sensed data to the sink and balance the network load. GWO algorithm is incorporated to spot the correct Position of unknown nodes, so as to handle the node localization problem. It can be used to minimize the energy consumption by SNs.

N. A. Al-Aboody et.al[2016]An optimal energy efficient cluster head selection was presented to guarantee a CH presence for every round and thus to distribute the payload among nodes. Centralized selection was used for nodes in Level One, and deterministic selection was used for other levels. Proposed algorithm is to improve performance of the longer network lifetime, longer stability period, and more residual energy when compared with the other algorithms.

Daud et.al [2019] examined performance comparisons of routing protocols in IoTs based VANETs (Vehicular Ad hoc networks). The DSDV (Destination Sequenced Distance Vector routing) and AODV (Ad hoc On Demand Distance Vector routing) were compared using CBRs (Constant Bit Rates) which rose gradually and reached half of the total SNs, while other SNs were stable but declined exponentially. Their topology maintained the total number of SNs. CBRs source nodes moved at varying speeds to different destinations during various time frames. The study's comparisons of the two routing protocols used the parameters of delay, jitter, packet dropped ratios, transferred/generated throughputs.

IV. PROPOSED MODEL

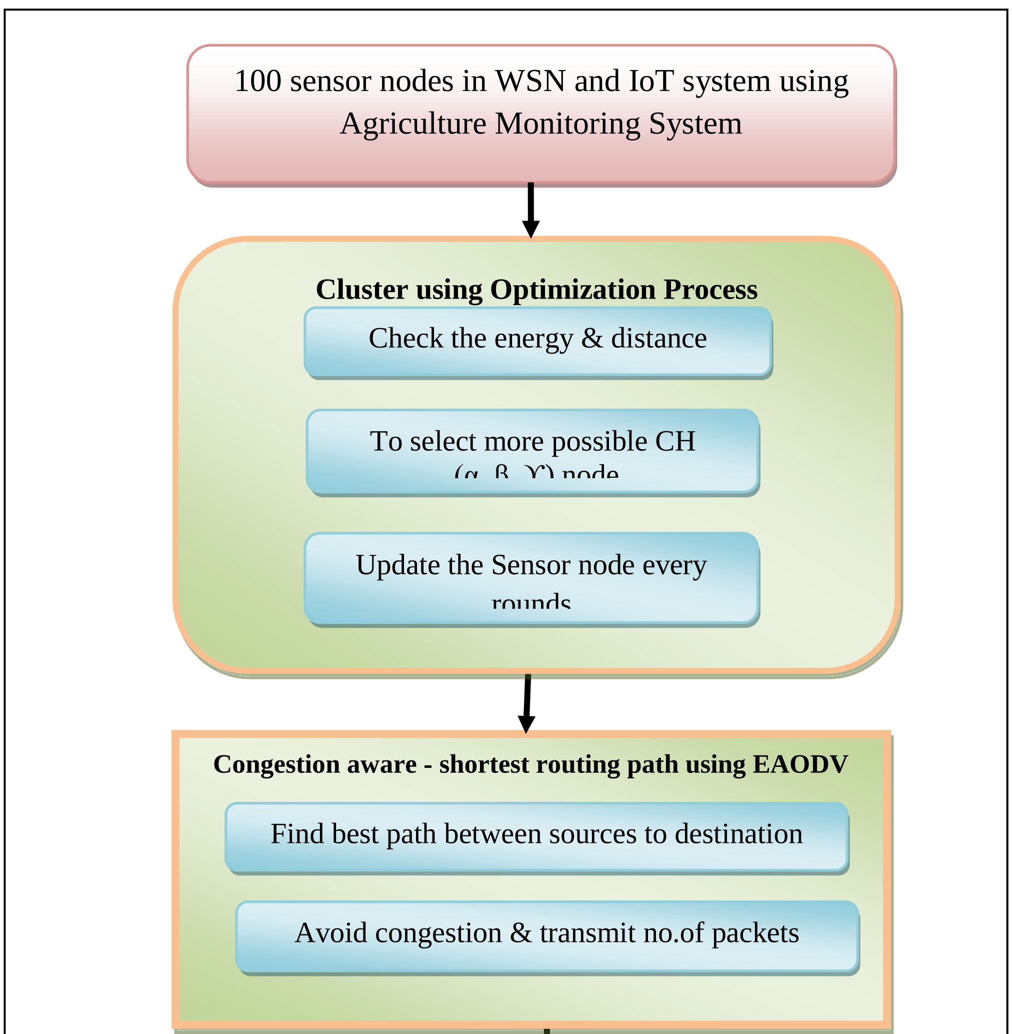

Figure 2: Architecture of ACM-EAODV using IOT and WSN

The present system is composed of two phases: The first phase of GWO techniques is consists of some behavior of sensing, clustering, data transmission node finding and also very important process of transmission path selection. Hence, Grey Wolf Optimization technique is sensing all the nodes are divided into number of cluster and each cluster has a 5 to 12 sensor node only. Because during the data transmission time, packet losses and communication link losses are minimized. In WSN, Sensor nodes update their positions imitating the sensing behavior during the optimization around α,β andγ. The sensing of α is mentioned for First solution node, β is second best solution node and γ is represent for Third solution nodes. GWO hunting behavior is led by the α,β and γ nodes because they have better knowledge of potential CH node (or)NCH location therefore the minimum three best solution selection obtained so far are used by the energy level to update their position. The neighboring anchor node helps to calculate the location of localized node. In the vast amount of sensor, the purpose of optimization is improved to be best in choosing CH node to the clustering model. The GWO outperforms in tackling CH node search related problems and improved investigation with several node position, distance calculation and energy computation formulas.

The second phase of congestion aware shortest path routing is performed by Enhanced Ad-hoc on-demand Distance Vector Routing (EAODV) protocol. It reduces the amount of transmissions through generating routes on-demand. This protocol checks the route table when source needs to broadcast information. AODV is a loop-free, single path, distance vector protocol based on hop-by-hop routing approach. In the proposed framework, data from the agriculture sensors are routed while using a trusted network towards the CH and further towards the BS. In the area of agriculture production, IoT-based WSN has been used to observe the yields condition and automate agriculture precision using sensor nodes. These sensors are deployed in the agricultural environment to improve production yields through intelligent farming decisions and obtain information regarding crops, plants, temperature measurement, humidity, and irrigation systems. The architecture of congestion aware data aggregation describes clustering the all sensor node based on distance and performance of nodes energy level. In Congestion Aware Data Aggregation technique is to evaluate the following process; finding congestion node and best shortest route. During the data transmission time congestion has been occurring then the data packets are retransmitted. In mean while don’t be occurring the congestion data packets are thoroughly transmitted for Base station via CH node or another possible CH node. In congestion detection phase, three methods are followed namely Buffer management, Traffic prediction and Fairness mechanism. When there is congestion, it is appropriate to verify the node's energy level and buffer capacity. On the completion of steps, data is sent through the CH or other possible CH through the BS when the node's energy level and buffer capacity are high. When one node's energy level (or buffer size) is low the repeat request procedure is initiated.

4.1 System model

Thus, study uses 100 agricultural SNs. Agriculture sensors and BSs are static after random deployments. Symmetric transmission connections are used where SNs have varied energies. BSs are powerful nodes and GPSs (Global Positioning Systems) locate agricultural SN locations. SNs are organised into equal-sized clusters (C), where cluster count is $TC = \{C1, C2, C3 \ldots . Cn\}$. On the formation of a cluster, one-hop neighbour SNs are discovered and as a result, each cluster node stores its immediate one-hop neighbour information in a buffer whein is subsequently used by CHs to compare adjacent neighbour SNs data. This is done as it reduces comparison count while conserving network's overall energy. Different types of SNs constitute greenhouses that agricultural environment monitoring system data like temperatures, humidity, and light intensities. This work's monitoring system uses sensor datasets to determine the best growing conditions for farmed crops. On encountering insufficient data for processing, this feedback is transmitted from the control centre to SNs to normalize the environment.

SNs generate time series data of greenhouses which is a replication. For example, producing strawberries requires 30 °C during the day and 15 °C in the night for a year. Agricultural systems need to maintain this temperature. When a SN's temperature is greater or lesser than the defined value temperature is adjusted to maintain consistency, which implies SNs are programmed to provide identical data in order for maintaining optimal crop growing conditions. This smart agricultural environment in IoTs based WSNs is depicted in Figure 3.

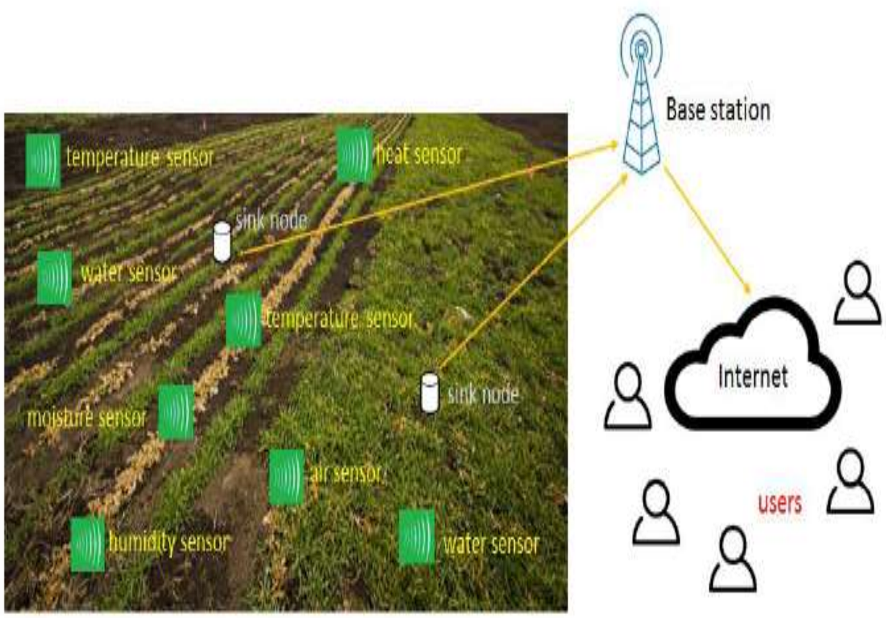

Figure 3: Smart agricultural environment in IoT based WSN

4.2 Energy model

This study assumes that the starting energy of SNs is E_I gets depleted on information reply/broadcast. The power consumed by SN I, while sending information to a nearby node j is P_T and P_R implies its power consumption while receiving information j. BS is assumed to have unlimited energy and continue to operate till the end of the network's lifespan and defined as the period until the first SNs death due to energy depletion. Thus, the goal of optimization is to effectively aggregate data, choose best CHs for BSs, and maximize network lifespan for a given sequence of visited locations. Thus increases network's lifespan by using a linear programming paradigm. Equation (1) shows the power consumption while transmitting L bits of information at distance $D_{t \text{ and}}$ Eamp is the power of dissipation during amplifications.

$$P_T = \begin{cases} P_{cons} * L * P_{amp} * D_t^2 & if\ D_t < D_0 \\ P_{cons} * L * P_{amp} * D_t^2 & if\ D_t \geq D_0 \end{cases} \quad (1)$$

$$P_R = P_{cons} * L \quad (2)$$

Where P_T – SNs power consumption in transmissions, L – information bits, P_{amp}- amplification of power, D_t - distance between SNs, D_0 - threshold distance values and P_R - SNs power consumption while receiving information

The node's power consumption is lowered even more, while data transfer and the quickest routing path are successfully assured.

4.3 Objective model

In this research, the objective model is considered such as energy, delay and lifetime on the given IoT based WSN. In this research, GWO technique is introduced to select best optimal CH node that develops the optimal solutions for scalable network. The formula is defined for delay, energy and lifetime is given below

$$delay\ (d) = \frac{\sum_{i=1}^{n}(T_{ri} - T_{si})}{n} \quad (3)$$

Where T_{ri} is the receive time of i-th packet, T_{si} is the sending time of i-th time and n is the total number of packets

Lifetime is the time a network operates until the first SNs or the group of nodes in the network runs out of energy. It can be simply defined as the overall network lifetime that is determined by the remaining energy in the network.

$$Lifetime\ \mathbb{E}[L] = \frac{\varepsilon_0 - \mathbb{E}[E_w]}{P + \lambda \mathbb{E}[E_r]} \quad (5)$$

Where P is the constant continuous power consumption of the whole network, ε_0 is the total non-rechargeable initial energy, λ is the average sensor reporting rate.

The objective model O_M is derived as follows:

$$O_M = n(L_d * I_{lt}) \quad (6)$$

Where N is number of nodes with best energy, hop count, delay and throughput values

L_d- Less delay

I_{lt} - Improved lifetime

It is further used to select the multiple optimal CH selection

4.4 CHs based data aggregations using GWO algorithm

This work uses GWO technique is to choose the best more possible solution CHs in IoTs based WSNs. Aggregating data in significant to IoTs using WSNs as IoTs have heterogeneous data collected from multitude of sources, and data transmissions requires more energy. One way to save energy is by analyzing data to be aggregated before transmissions and send them summarized.

- ***Cluster formation***

SNs get grouped into clusters where groups have one SN as the CHs node while the rest SNs join the cluster. In cluster formations, SNs send packets to BSs until they are successfully received. SNs gradually deplete their energies. SNs capabilities of processing, transmitting, and storing are restricted due to limited energies, necessitating adoption of WSNs clustering to save energy, the primary goal for increasing network's lifespan. To save energy, BSs adjust both cluster memberships and CHs regularly. CHs collect and combine SN's data before sending them to BS. Energy consumption is spread equally by this randomized rotation of CHs in SNs.

- ***CH node selection***

GWO is a basic but high performing clustering technique. The technique positions CHs around the centre of selected cluster members where each cluster has its own centre. SNs are allocated a cluster their nearest centre where number of clusters k is pre-defined. A higher value of k indicates more clusters and hence cluster counts are dependent on the value of K, a critical decision.

Assuming that n number of SNs form k clusters, GWO chooses n SNs at random to be CHs and SNs are assigned to CHs based on the lowest Euclidean distance values. The centroid of each cluster is also computed during allocations. This works SNs are agricultural sensors split across farm fields. In terms of residual energies, SNs carry heterogeneous values with energy higher than normal SN energies. The deployed agricultural sensors have CHs which receive agricultural field information and send it to BSs in an error-tolerant and energy-efficient way. The proposed system balances SNs loads by selecting appropriate CHs using a multi-criteria decision function.

Here quality of factors considered is residual energy R_E, and bandwidth B_w. CH will be updated dynamically for every particular period of time to ensure cluster head is available with required energy level always. This ensures avoidance of data aggregation failure due to node dead. Cluster size is maintained for particular level to ensure accurate aggregation outcome. In case of more cluster members with more data to be aggregated, macro clusters will be divided into micro clusters. Thus data aggregation will be carried out in each micro cluster which will lead to increased data aggregation accuracy. Figure 4, shows cluster based smart agriculture on IoT with WSN

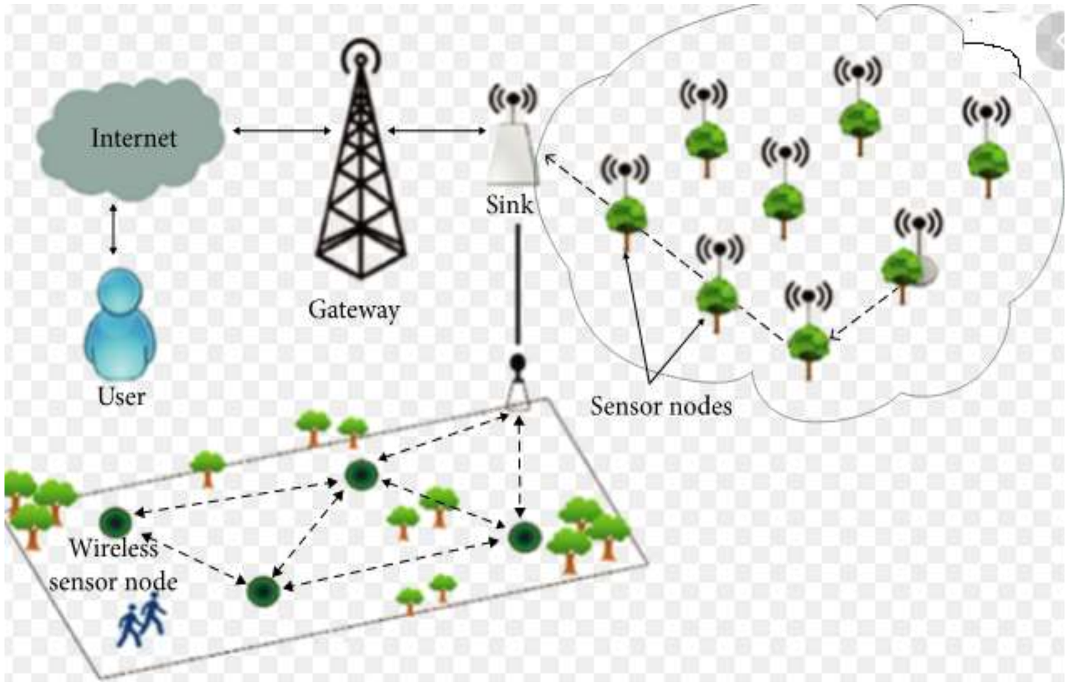

Figure 4: GWO using Cluster based smart agriculture on IoT with WSN

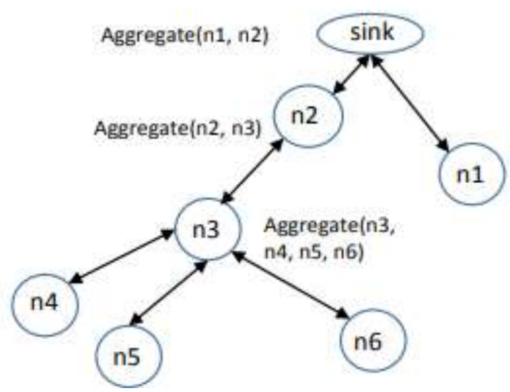

Figure 5: Example of data aggregation process

Figure 5 depicts data aggregations (Eliminating repetitive data / consolidating data) of sensor networks. SN n3 consolidates data from other SNs (n4, n5, n6) which is then forwarded to SN n2 and aggregated with the SN's data. The consolidated data from SNs n2 and n1 are pooled to the BS. These operations on items divided into groups reduce computations. On locating the cluster centers, the nearest and most suitable SNs that have higher energy than CH threshold values become CHs. GWO forms clusters using an objective function J (sum of distances between cluster SNs and its centroid) where lower values indicate lower computations. The cluster generation is minimized by the objective function stated as Equation (3).

$$J(Z,A) = \sum_{i=1}^{n} \sum_{j=1}^{k} a_{ij} dist(x_i, z_i) \quad (7)$$

Where, Z –cluster's centre, and A - matrix containing SNs allocation information. a_{ij} is 1 when i_{th} node is allocated to j_{th} cluster; else it is 0. Dist(x, z) –function that computes distances SNs between x and z. GWO has issues in deciding on the starting value of the center with a computational complexity of O(n) and hence consumes lesser computational time when compared to other clustering methods. GWO power usage is proportional to the SNs cluster counts in a cluster.

Grey Wolf Optimization (IGWO)

Step 1: Initialize the sensor node population S_i (i = 1, 2... n)

Step 2: Calculate the fitness of each search leader nodes (α, β and ϒ)

Step 3: while ($r < r_{max}$) do

for each r=round

Update the current search node position

End for

Step 4: Check, Energy level > Packet size

Step 5: Evaluate the fitness of possible solution of leader nodes based on distance and energy; make r = r + 1;

Step 6: End while

The p … es and residual energies of SNs. SNs selected as CHs store their current residual energies and use it for data transmissions to their nearest CHs/BSs. CHs energy below 20% of recorded energy, broadcast a beacon message inside their clusters and gather leftover energy information from member nodes before forwarding it to top layer CHs/BSs. BSs then search the best CH node within clusters and on finding a SN that be a CH it broadcasts the new CJ information across the network, else it remains silent. New CHs record their current residual energy. This clustering solution reduces the total distance of cluster communications and mitigates the energy required for data transmission. Moreover, by considering sink location in CH selection process, it consumes less energy and improves the WSN's lifetime

4.5 Congestion aware - shortest path routing using EAODV protocol

This study uses EAODV protocol to achieve congestion aware shortest routing. On a broadcast, the protocol checks the route table and reduces transmission loads by creating routes dynamically. EAODV is a single-path, loop-free distance vector protocol that uses a hop-by-hop routing. In this work, data from farm SNs send data to CHs which then forward it to BSs. IoTs based WSNs have been used in this work to monitor farm yields and automate agriculture precision as the use of SNs in agriculture leads to increased production yields by taking intelligent farming decisions based on collected information on crops, temperatures, humidity, and irrigations. The EAODV protocol used in this study discover: route directions free from congestions; bi-directional paths and maintain routes.

1) Route Discovery: It entails the learning from sources to destinations by broadcasting an RREQ packets towards destinations which respond by sending RREP packets. RREPs then follow the path of RREQs and record this information as their route

database. SNs use two routing tables: PRTs (Primary Routing Tables) and ARTs (Alternate Path Routing Tables). PRTs correspond to specific destination nodes and denote entries in the routing table of SNs X (source) and D (Destination).

2) Early Congestion Detection: Congestions occur at any point along a network path and the main cause being, arrival of packets at SNs exceeding their buffer capacity, thus causing congestions at SNs which lose data packets. An advance detection of congestion leads to proper transmissions without losses.

3) Bi-directional Path Discovery: The principal path for SN's forecasts are congestion states and broadcasts CSPs (Congestion status packets) regularly with TTL (Time To Live) = 1. CSPs contain node's congestion status in addition to information on routing table's destinations: Source S; Destination D; prior Zone I node P; Zone I, previous Z one I hop count P, Z hop; next Zone I node N Zone I, and next Zone I hop count N Z hop. When predecessor SNs receive packets from primary paths of node X for destination D, the predecessor node learns about X's congestion status, non-congested node in the primary route, and hop counts. The primary table of predecessor and successor nodes is correspondingly updated which help in locating a bi-directional non-congested alternative path [24].

4) Route Maintenance: When a route failure is identified on the route, the route maintenance procedure begins or it is started.

These steps aim at stopping congestions where SNs in paths inform preceding nodes when it is crowded and alternative routes are better to avoid congestion and thus directly transmit through non-congested SNs on the principal routes. It also reduces packet latencies; minimize bypasses to reduce protocol overheads. As a result, traffic splits occur, thus adaptively responding to network congestions. This results in power usage efficiency, avoiding congestions and marginal packet losses.

EAODV is a simple, efficient, and effective routing protocol for IoTs based WSNs to build congestion-aware shortest path routings. The use of node sequence numbers, on-demand route discovery and maintenance, and hop-by-hop routing allow the protocol to deal with topology and routing information. Information from agricultural fields is thus appropriately channeled to BSs and thus enhancing agricultural land monitoring and increased productivity. The ability to obtain routes only on demand makes EAODV a highly valuable and convenient tool and desired algorithm for smart agriculture over IoTs based WSNs. In IoTs based WSNs, all nodes work cooperatively and efficiently by sharing multiple information depends on the bandwidth, minimum distance and energy consumption and partial routes. The EAODV utilizes the best CH for the multipath routing via improved metrics to select the best multiple routes.

<u>Pseudo-code: EAODV protocol</u>

Start
100 nodes in given network
Do cluster formation
Select CH node from the cluster member
Cluster member send the data packets to CH node
Establish the route using route discovery and maintenance process
If valid route in routing table then start the data transmission
Else
Start the route discovery
Detect early congestion
If Particular node > buffer capacity
Assign the particular node as congestion node

The before described Pseudocode demonstrates how multiple routes are selected using optimum parameters. The AMS-EAODV protocol enhances energy usage, distances, and SN throughputs and constructs the best congestion aware shortest path routing. This proposed multi objective smart agricultural SNs compute optimal values for efficiently transmitting information to specific SNs in IoT based WSNs. Many SNs for soil, moisture, temperature, wind direction, wind speed, camera, drone co-operatively send agriculture information to BSs for monitoring. As a result, BSs have varying power SNs including low, medium, and high power modes at any one moment.

It is common in agriculture to discover equipment working in the area of information to interact with one another and share acquired information. A realistic example of point-to-point communications may be a drone that gets data directly from field sensors or a communication between tractors covering the same farm node.

IV.**EXPERIMENTAL RESULT**

This work was simulated on NS 2.34 tool where 100 SNs travel in a 1000 meter *1000-meter square space in 60 seconds. Each node moves independently at the same average speed and has the same 1000-meter transmission range. CBRs (Constant Bit Rates) are used in the simulated communication. This work assessed data aggregation for cluster formation and congestion avoidance and experimental results-built data aggregation to build cluster formation from 100 nodes. The proposed AMS-EAODV system is compared with other existing systems including GWO-SPFA and CADA in terms of End-to-end latencies; throughputs, energy usages, PDRs, packet drop ratios, and network's lifespan. Table 1 lists the simulation parameters used in this research work.

TABLE 1: SIMULATION PARAMETERS

Parameter	**values**
No. of Nodes	100

Area Size	1000 * 1000(Meter)
Mac	802.11
Routing protocol	EAODV
Total energy	150 Joule
Initial value of energy	1.5 Joule
Radio Range	1000m
Simulation Time	60 sec
Packet Size	4000 bits

Performance Evaluation

4.1Packet Delivery Ratio

Packet delivery ratio is defined as the number of packets successfully received by the destination. Figure 4.1, depicts results GWO and CADA with the proposed AMS-EAODV approach in terms of end-end delay performances where x-axis is the number of seconds and y-axis PDRs values.

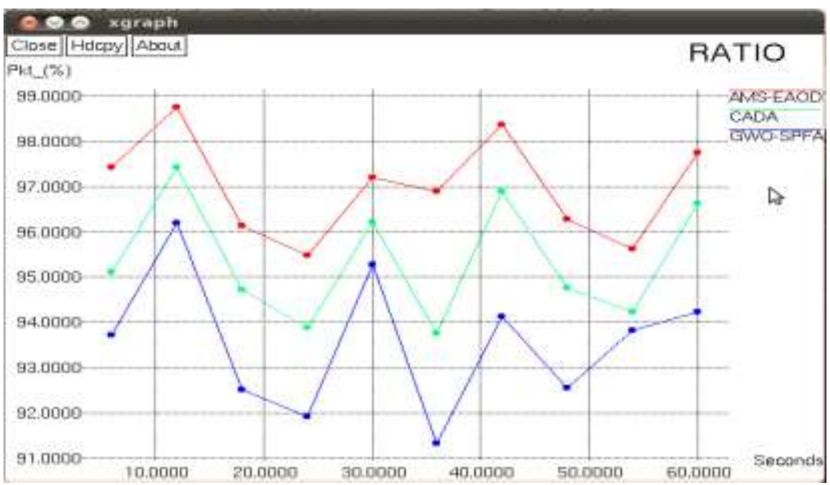

Figure 4.1 : Packet delivery ratio

Using the GWO-SPFA and CADA techniques, the PDR values in the current case are lower. The suggested AMS-EAODV method greatly increases the PDR value in the proposed system. As a result, the proposed AMS-EAODV technique enables effective smart agriculture-based data aggregation in IoT-based WSNs.

4.2 End-to-end delay

The average time taken by a packet to transmit from source to destination across the network is well-known as End to End delay.

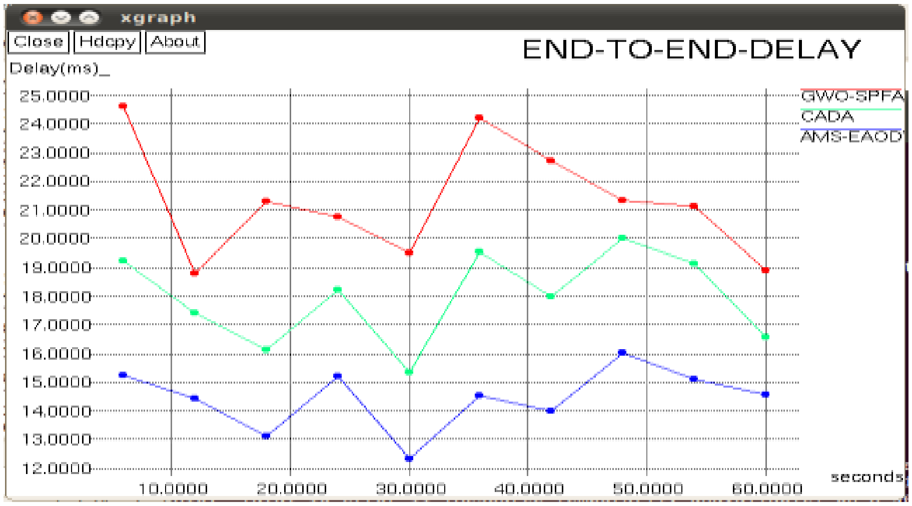

Fig 4.2 End-to-end delay comparison

Fig 4.2, depicts results GWO-SPFA and CADA with the proposed AMS-EAODV approach in terms of end-end delay performances where x-axis is the number of seconds and y-axis end-end delay metric. During the data aggregation process, the time taken to aggregate data is significantly minimized by the proposed AMS-EAODV approach in IoT based WSNs. Lower energy SNs transmit information to SNs with higher energy level for enhanced data gathering, thus BSs collect agriculture data from higher energy SNs and aggregate the received information. The proposed AMS-EAODV method for smart agriculture enables effective congestion aware shortest path routing in IoT-based WSNs. The results of the experiments demonstrate that the suggested AMS-EAODV technique has a lower end-to-end latency than the existing GWO-SPFA and CADA approaches.

4.2 Throughput

The rate in which the data packets are successfully transmitted over the network or communication links is defined as throughput.

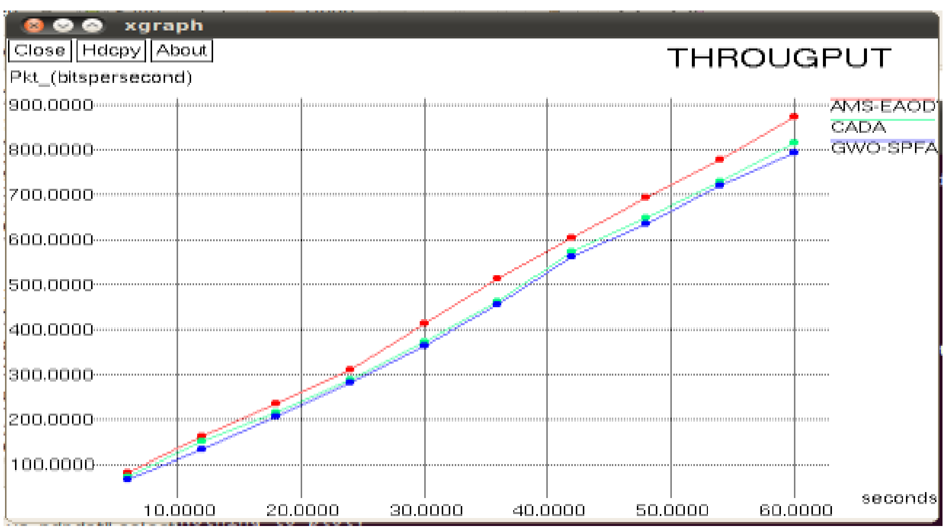

Figure 4.3: Throughput comparison

Figure 4.3 depicts results GWO-SPFA and CADA with the proposed AMS-EAODV approach in terms of end-end delay performances where x-axis is the number of seconds and y-axis throughputs metric. Using CHs based data aggregation model, the proposed AMS-EAODV method categorises SNs as high, medium, or low energy levels. Higher energy nodes are chosen from the node classification results for data collection in an IoT-based WSN. This allows for the correct collection of smart agricultural data at multiple nodes without information loss. It demonstrates that the conventional GWO-SPFA and CADA techniques have lesser throughput, but the new AMS-EAODV method has greater throughput.

4.3 Energy consumption

Energy consumption refers to the average energy necessary for transmitting, receiving or forwarding operations of a packet to a node in the network during a period of time.

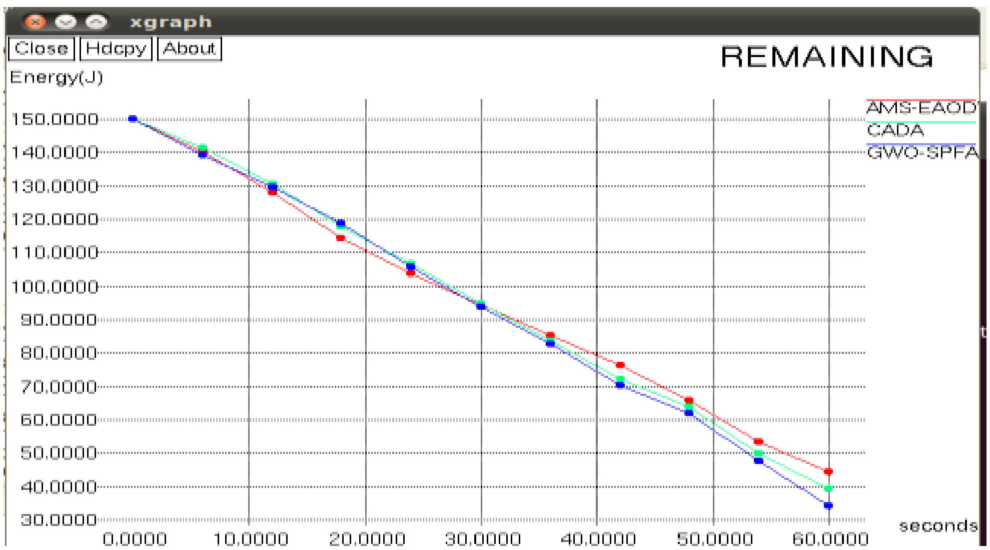

Figure 4.4: Energy consumption comparison

Figure 4.4, depicts results GWO-SPFA and CADA with the proposed AMS-EAODV approach in terms of end-end delay performances where x-axis is the SNs count and y-axis energy consumption metric. The suggested AMS-EAODV method over the IoT-based WSN considerably reduces energy usage during data packet aggregation. SNs are categorized based on residual energy level using CH-based data aggregation. It identifies SNs with greater, medium, and lower energy levels. In this case, the higher energy node effectively captures smart agricultural data for the data aggregation process. The AMS-EAODV method is utilized to enhance the energy utilization node, with the goal of constructing the optimum congestion aware shortest path routing. It demonstrates that the conventional techniques consume more energy, but the suggested AMS-EAODV approach consumes less energy.

V.CONCLUSION

Smart agriculture-based data aggregation is assured efficiently across an IoT system utilising SNs in this study. Agriculture is one of the most important commodities for increasing global food supply and economic prosperity. WSNs based on IoT have been utilised to monitor yield conditions and automate agriculture precision utilising SNs. Initially, the IoT-based WSN is built using a number of SNs, adjacent nodes, and CH nodes. The energy model and objective models are then built for precise smart agricultural data aggregation through IoTs based WSNs. In this study, GWO is used to choose the optimum CH node for developing optimal solutions for scalable IoT systems. The suggested framework's main goal is to select the best CH based on a multi-criteria decision function. The decision is based on residual energy, the distance to the BS, and the longer network lifetime. The data aggregation procedure is then carried out utilising the fuzzy SNs approach. It also reduces the likelihood of bottlenecks between agricultural sensors and BS. During aggregation and data forwarding to the sink node, the CH expends additional energy. The EAODV protocol is used in this study to achieve congestion aware shortest route routing. It avoids congested nodes, resulting in significant reductions in packet loss. The sensors are used in agricultural settings to increase production yields through intelligent farming decisions and to collect data on crops, plants, temperature, and humidity. The EAODV selects the best multiple routes by utilising the best CH for multipath routing via better metrics. In the agricultural area, the suggested framework offers an intelligent decision for data routing and reduces the ratio of energy consumption with enhanced data delivery performance. The results show that the proposed AMS-EAODV strategy outperforms the existing GWO-SPFA and CADA techniques in terms of network lifespan, throughput, PDR, and energy consumption, as well as end-to-end latency and packet loss ratio. The suggested framework's performance in a mobile-based IoT network and Intelligent Transportation may be analyzed in future study. The work may be expanded to enable a multi-hop communication paradigm for monitoring a broad field.

REFERENCES

1. Salam, Abdul, and Syed Shah. "Internet of things in smart agriculture: Enabling technologies." *2019 IEEE 5th World Forum on Internet of Things (WF-IoT)*. IEEE, 2019.
2. Samara, Ghassan, and Mohammad Aljaidi. "Efficient energy, cost reduction, and QoS based routing protocol for wireless sensor networks." *arXiv preprint arXiv:1903.09636* (2019).
3. Yarinezhad, Ramin. "Reducing delay and prolonging the lifetime of wireless sensor network using efficient routing protocol based on mobile sink and virtual infrastructure." *Ad Hoc Networks* 84 (2019): 42-55
4. Gubbi, J., Buyya, R., Marusic, S. and Palaniswami, M., 2013. Internet of Things (IoT): A vision, architectural elements, and future directions. *Future generation computer systems*, *29*(7), pp.1645-1660.
5. Bhuyan, Bhaskar, et al. "Quality of service (QoS) provisions in wireless sensor networks and related challenges." *Wireless Sensor Network* 2.11 (2010): 861.
6. Bhola, Jyoti, Surender Soni, and Gagandeep Kaur Cheema. "Genetic algorithm based optimized leach protocol for energy efficient wireless sensor networks." *Journal of Ambient Intelligence and Humanized Computing* 11.3 (2020): 1281-1288.
7. Purkovic, Dalibor, Marian Hönsch, and Tobias Raphael Maria Karl Meyer. "An energy efficient communication protocol for low power, energy harvesting sensor modules." *IEEE Sensors Journal* 19.2 (2018): 701-714.
8. Heikalabad, Saeed Rasouli, et al. "DPCC: dynamic predictive congestion control in wireless sensor networks." *International Journal of Computer Science Issues (IJCSI)* 8.1 (2011): 472.
9. Verma, Sandeep, Neetu Sood, and Ajay Kumar Sharma. "QoS provisioning-based routing protocols using multiple data sink in IoT-based WSN." *Modern Physics Letters A* 34.29 (2019): 1950235.

10. Prathibha, S. R., Anupama Hongal, and M. P. Jyothi. "IoT based monitoring system in smart agriculture." *2017 international conference on recent advances in electronics and communication technology (ICRAECT)*. IEEE, 2017.
11. Nguyen, T. D., Khan, J. Y., & Ngo, D. T. (2017, May). An effective energy-harvesting-aware routing algorithm for WSN-based IoT applications. In Communications (ICC), 2017 IEEE International Conference on (pp. 1-6). IEEE.
12. Ayaz, Muhammad, et al. "Internet-of-Things (IoT)-based smart agriculture: Toward making the fields talk." *IEEE Access* 7 (2019): 129551-129583.
13. Karamitsios, Konstantinos, and Theofanis Orphanoudakis. "Efficient IoT data aggregation for connected health applications." *2017 IEEE Symposium on Computers and Communications (ISCC)*. IEEE, 2017.
14. Fitzgerald, Emma, Michał Pióro, and Artur Tomaszwski. "Energy-optimal data aggregation and dissemination for the Internet of Things." *IEEE Internet of Things Journal* 5.2 (2018): 955-969.
15. Behera, Trupti Mayee, et al. "Residual energy-based cluster-head selection in WSNs for IoT application." *IEEE Internet of Things Journal* 6.3 (2019): 5132-5139.
16. Farman, Haleem, et al. "Multi-criteria based zone head selection in Internet of Things based wireless sensor networks." *Future Generation Computer Systems* 87 (2018): 364-371.
17. Sasikumar, P., and Sibaram Khara. "K-means clustering in wireless sensor networks." *2012 Fourth international conference on computational intelligence and communication networks*. IEEE, 2012.
18. Ajay Kaushik1 · S. Indu2 · Daya Gupta" A Grey Wolf Optimization Approach for Improving the Performance of Wireless Sensor Networks" Wireless Personal Communications, pp(1-21),Springer-2019.
19. N. A. Al-Aboody and H. S. Al-Raweshidy "Grey Wolf Optimization-Based Energy-Efficient Routing Protocol for Heterogeneous Wireless Sensor Networks" 4th International Symposium on Computational and Business Intelligence, pp(101-107), IEEE-2016.
20. Daud, Saqib, et al. "DSDV and AODV protocols performance in Internet of Things environment." *2019 IEEE 11th International Conference on Communication Software and Networks (ICCSN)*. IEEE, 2019.
21. Arya, Rajeev, and S. C. Sharma. "Energy optimization of energy aware routing protocol and bandwidth assessment for wireless sensor network." *International Journal of System Assurance Engineering and Management* 9.3 (2018): 612-619
22. Abbasi-Daresari, Samaneh, and Jamshid Abouei. "Toward cluster-based weighted compressive data aggregation in wireless sensor networks." *Ad Hoc Networks* 36 (2016): 368-385.
23. Zhang, De-gan, et al. "Extended AODV routing method based on distributed minimum transmission (DMT) for WSN." *AEU-International Journal of Electronics and Communications* 69.1 (2015): 371-381.
24. Ahmed, Nurzaman, Debashis De, and Iftekhar Hussain. "Internet of Things (IoT) for smart precision agriculture and farming in rural areas." *IEEE Internet of Things Journal* 5.6 (2018): 4890-4899.
25. Torres, Andrei BB, et al. "Multilevel data fusion for the internet of things in smart agriculture." *Computers and Electronics in Agriculture* 171 (2020): 105309.