Study and Implementation of Routing Protocols in Wireless Sensor Network for IoT Applications

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Abstract: Internet of Thing (IoT) connects physical artifacts to form a network. Maximizing network existence and maximizing use of the network is a key priority. Study is performed on parameters such as network existence with an Internet of Thing (IoT) viewpoint and routing protocol efficiency measurements utilizing parameters such as network resilience, network life, reliability, throughput, etc. We are focusing on an algorithm to improve IoT Low Energy Adaptive Clustering Hierarchy (LEACH) routing. The primary objective of our paper is to carry out simulation studies on routing protocols, in particular Low Energy Adaptive Clustering Hierarchy (LEACH)[6], Cycle-Based Data Aggregation Scheme (CBDAS)[6], Grid Based Hybrid Network Deployment (GHND), Improved Grid Based Hybrid Network Deployment (IGHND) for an Internet of Thing (IoT) and to use the MATLAB simulator for Low Energy Adaptive Clustering Hierarchy (LEACH) for Internet of Thing (IoT) output evolution.

Keywords: Internet of Thing (IoT); Base Station(BS); Wireless Sensor Network (WSN); Cluster Head (CH)

I. INTRODUCTION

The planet is now at a stage where the Internet of Thing (IoT) is reflecting more things. The amount of goods that link to its intelligence infrastructure via a broad variety of connections.

Wireless Sensor Network (WSN) are very useful for an Internet of Thing (IoT) for data collection applications for end-users. However, insufficient battery capacity and network life are some of the greatest obstacles in the design phase of any sensor network.

The IoT integrates current and emerging Internet with potential network technologies, such as self-configuring capacities and extended network existence with proper energy management [1]. There are three key types of local internet, simple modules designed as an interconnected IoT communication part. The first is the hardware consisting of Sensors, Actuators, Radio Frequency Identification (RFID), Wireless Sensor Network (WSN), etc. Second is middleware that offers on-demand storage and computer software analytics data. And the introduction and simulation of the latest novel is an easy-to-understand and dialogue method that can and would be commonly used on a number of websites tailored for a variety of applications[18]. Emerging Internet of Thing (IoT) has diverse applications look equipped with different categories of heterogeneous equipment [2]. The main design criteria of Wireless Sensor Network (WSN) is data communication in an IoT environment when trying to extend the network lifespan. The design process should be done so as to prevent any connectivity loss by planning efficient energy management mechanism.

WSN acts as a middleware that takes the modern technological environment to a specific realistic world. Small sensor or actuator attached to each other is responsible for data sensing, and transportation of data to each other via internet values. The WSN has sensor nodes that deployed many physical and the network field parameter. The routing route from client node to server node or base station(BS) should be predicted in power efficient way as battery of sensor almost impractical[2], [3], [11].

The Internet of Things (IoT) program, known as WSN, poses various obstacles. Sensor nodes, hardware, and sensors used in IoT images have been given new functions and challenges for management of QoS (Quality of Service), defense and intensity [4]. Various technological improvements to primitive standards and proposals used by Wireless Sensor Networks have taken each of these considerations into consideration (WSN). In an Internet of Thing (IoT) base Wireless Sensor Network (WSN), Quality of Service (QoS) specifications face major challenges such as severe resource material, data redundancy, complex network complexity, low stable media, heterogeneous networks, and numerous (Base Station) BS or sink nodes [5]. Authenticity and secrecy, data privacy, and data freshness are all important protection concerns in Wireless Sensor Networks (WSNs) [6].

Recent research has generated findings of various ideas for reducing electricity and expanding the network Longevity for efficient resource use. Routing algorithms play a key role in process of clustering which establishes organization of cluster or group of sensing node that collect and transmit data to cluster head (CH)[2]. After that, cluster head (CH) divides data and passes or fuses it to a node or base station (BS) that act as a middleware between end user and network. LEACH (Low Energy Adaptive Clustering Hierarchy) is classical clustering algorithm which recognizes the power of hierarchical data routing [8],[14],[16],[17]. Researchers have often introduced major improvements in the LEACH protocol in order to improve network stability. The creation of current Internet of Thing (IoT) algorithm for machine production is financed by science researchers[9],[18],[19].

Wireless Sensor Network (WSN) is widely use in an agriculture sector to increase productivity and to monitor crops, improve the quality and quantity of agricultural products [10],[20]. Maintaining sensor coverage and network connectivity are most important requirements for designing an efficient monitoring network in an agricultural field that spans many acres [11],[12].A variety of factors affect WSN deployment in agriculture, including optimizing agricultural land coverage, tracking sensor node capacity, and employing an energy-efficient routing protocol. As modern citizens of the country, I designed AgroWeeder: A self-powered weeder for farmers based on IoT that is energy efficient.

II. LITERATURE REVIEW

The Internet of Thing (IoT) primarily communicates from a source to target devices that help to collect, store and analyze knowledge. Efficient protocols must facilitate the exchange of data between low-energy devices [7]. Routing is a method for transferring data packets from source to destination, maintaining a route between node in a wireless network, and also helping us to choose the shortest path for contact[21],[22].

1. LEACH (Low Energy Adaptive Cluster Hierarchy):

LEACH (Low Energy Adaptive Clustering Hierarchy) Protocol provides design of round. LEACH (Low Energy Adaptive Clustering Hierarchy) runs with amount of round. Each round comprises two states: state and steady state [4]. In a cluster setup condition, clusters are formed in a self-adapting mode. During first point, cluster head sends an advertisement packet to inform cluster node that they become cluster head based on the following formula[8]:

$$T(n) = \begin{cases} \frac{P}{1-P*(r mod \frac{1}{P})} & \text{if n} \in \text{G} \\ 0 & \text{otherwise} \end{cases}$$

P – Desired percentage of cluster heads
T(n) – Decision threshold
r – current round
G – Set of nodes which have not been cluster heads in the last 1/P rounds

However, data transfer is carried out in a steady state. The period allocated to the second state is normally longer than the time allotted for the first state to save the payload of protocol.

2. **CBDAS (Cycle Based Data Aggregation Scheme):**

In CBDAS (Cycle Based Data Aggregation Scheme), the whole region of the sensor is separated into grid of cell, each with head. They expand life of system by adding together all cell head to build cyclic series in such a way so that data collected can move in two direction. During data collection in each round, collected data is aggregated from node to node along chain. At last, designated cell leader, leader of the cycle, transmit it directly to Base Station (BS). Cycle Based Data Aggregation Scheme (CBDAS) implements data collection at each cell head to considerably decrease amount of information transmitted to Base Station (BS). Just cell head ought to disseminate information in such a manner that amount of data transmissions is greatly reduced. The sensor nodes of each cell are transformed as head of the cell, and all cell heads of cyclic chain are transformed as the leader of the line. Energy degradation is universally distributed in such a manner that the life of nodes is extended [5].

They used the first-order radio model to assess energy use of each node. The Eelect = 60 nJoule /bit radio dissipates the transmitter or receiver circuitry according to this model. Eelect is the circuit's own usage of electricity. Assuming d^2 energy loss, where d is node distance, the transmitting amplifier at sender node consume $Eampd^2$, where Eampl = 105 pJoule /bit /m^2. Eampl is electricity amplifier uses to transmit packets. Therefore, in order to relay the m bit message at distance ‘d’ using this transmitter model, radio uses:

$$E_{Tx}(m, d) = Eelect \times m + Eampl \times m \times d^2 \qquad (1)$$

To receive this message, radio expends [9]:

$$E_{Rx}(m) = E_{elect} \times m \qquad (2)$$

Receiving message is not low cost process utilizing values of these parameters. Protocols can also aim to limit not only transmission lengths, but also amount of transmission and receipt operation per packet [7]. Total transmission usage may be generalized as follow:

$E_{total}(k) = (E_{elect} \times m + E_{amp} \times m \times d^2) + (E_{elect} \times m)$ (3)

3. **GHND (Grid Based Hybrid Network Deployment):**

A Grid-oriented, dependable multihop routing protocol which optimize cluster head selection by integrating entity capabilities such as residual energy and node position, as well as general cognition that can balance energy usage between clusters through a cluster-based consultative execution based on cluster head life expectation, all while taking data into account. Complete utilization of propagation is as follow [15]:

$E_{total}(k) = (E_{elec} \times k + E_{amp} \times k \times d^2) + (E_{elec} \times k)$

Demonstration result for various metrics were obtained by adjusting those parameters:Initial energy, network scale, number of nodes, network lifetime, and overall energy consumed[6],[13].

4. IGHND (Improved Grid-based Hybrid Network Deployment):

Improved Grid Base Hybrid Network implementation (IGHND) for WSN is proposed. This procedure takes into account many criteria for the selection of CH. However, it suffers from load balancing and the rate of energy dissipation is strong. The radio model is used to measure the network's total energy efficiency. Energy consumed at transmission point for transmitting a m-bit message over distance of r metres is ET_X (m, r), as seen in Eq. below:

ETX (m, *r*) □□*Eelect*□□m □□*Eampl*□□m □□r^2

Where E_{elect} is energy consumed to run transmitter and receiver circuitry, E_{elect} =60nJ / bit. E_{ampl} is transmission amplifier energy consumption while transmitting m-bit of message over a distance of r meter, E_{ampl} = 105 pJ / bit / m. Energy consumption at receiver end is shown in equation below:

ERX (m) □□*Eelect* × *t*m

Total energy consumption calculated using equation below:

Etotal(m) □*ETX* (m, *r*) □□*ERX* (m)

III. IMPLEMENTATION

The network constraint measured for MATLAB simulations for system framework is represented in Table 1. Size of packet is considered as 5000 bits. And total 100 nodes have been organized arbitrarily through BS (Base Station) situated in a middle of network area. We have compared performance of LACH, CBDAS, GHND and IGHND for 70 rounds.

Table 1

SIMULATION PARAMETERS

Sr.No.	**Parameter**	**Value**
1	Network Diam	400 meter^2
2	Total Number of Node	40
3	Initial Energy	1.2 J
4	propagation model	Radio wave
5	Data transfer mode	Direct Transmission
6	Radio Model	BAN Model
7	propagation model	Ground Wave
8	Transceiver	CC2420,CC1000
9	MAC Protocol	ByPassMac
10	Maximum queue	50 packets
11	Maximum air data rates	IEEE 802.15.4: 250kbps

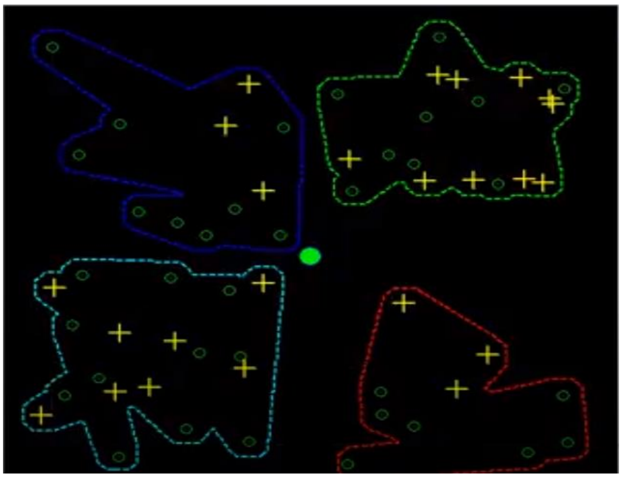

Figure 1: Simulation Network

The performance of LEACH, CBDAS, GHND, and IGHND based on different parameters such as network resilience, network life, reliability, capacity, etc. for all energy values as it can pick a reliable node as a cluster header. The results of different protocols based on different parameters for up to 70 rounds are calculated and shown in different tables. Performance of LEACH ((Low Energy Adaptive Clustering Hierarchy) Protocol for number of rounds with different parameters is as shown in Table 2.

Table 2

LEACH PROTOCOL

Round	Throughput (p/s)	Network Lifetime (Alive Nodes)	Packets to Base Station	Energy Consumption Rate (KWh/Round)	Death Rate (Dead Nodes)
10	693	70	77	0.9571	0
20	1304	67	148	0.4929	3
30	1858	56	210	0.2915	14
40	2246	36	259	0.0309	34
50	2501	21	293	0.0309	47
60	2644	13	321	0.0309	57
70	2685	13	410	0.0309	57

The performance of CBDAS (Cycle Based Data Aggregation Scheme) protocol for number of rounds with different parameters is as shown in Table 3.

Table 3

CBDAS PROTOCOL

Round	Throughput (p/s)	Network Lifetime (Alive Nodes)	Packets to Base Station	Energy Consumption Rate (KWh/Round)	Death Rate (Dead Nodes)
10	691	70	79	0.8110	0
20	1320	70	150	0.2677	0
30	1944	65	218	0.0007	5
40	2451	50	278	0.0007	20
50	2811	35	316	0.0007	35
60	3045	21	345	0.0007	49
70	3193	15	366	0.0007	55

The performance of GHND (Grid Based Hybrid Network Deployment) protocol for the number of rounds with different parameters is as shown in Table 4.

Table 4

GHND PROTOCOL

Round	Throughput (p/s)	Network Lifetime (Alive Nodes)	Packets to Base Station	Energy Consumption Rate (KWh/Round)	Death Rate (Dead Nodes)
10	690	70	79	0.95	0
20	1323	70	147	0.3645	0
30	1947	70	221	0.0081	0
40	2508	56	286	0.0058	14
50	2948	44	321	0.0058	26
60	3271	33	371	0.0058	37
70	3479	24	421	0.0058	46

The performance of IGHND (Improved grid Based Hybrid Network Deployment) protocol for the number of rounds with different parameters is as shown in Table 5.

Table 5

IGHND PROTOCOL

Round	Throughput (p/s)	Network Lifetime (Alive Nodes)	Packets to Base Station	Energy Consumption Rate (KWh/Round)	Death Rate (Dead Nodes)
10	693	70	77	1.003	0
20	1347	70	153	0.7865	0
30	1948	70	222	0.6588	0
40	2585	70	285	0.3620	0
50	3190	65	357	0.01516	5
60	3731	56	419	0.0001	14
70	4183	46	472	0.0001	24

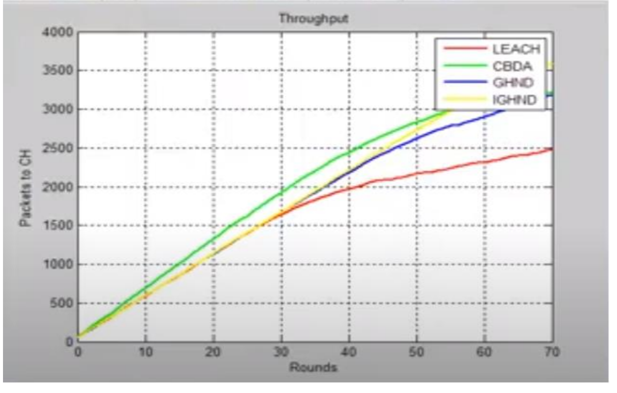

Figure 2: Throughput

The throughput reflects the ratio of currently sent data packet to successfully obtain at Base Station /sink. Performance is better at higher ratio. Fig.2 shows graph of through-put of two different protocols.

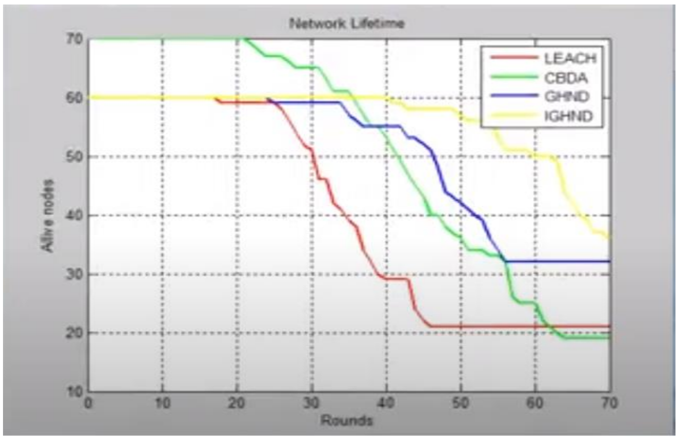

Figure 3: Network Lifetime

The routing protocol maximizes network life by protecting additional running rounds and adding further packets to the BS network (Base Station).

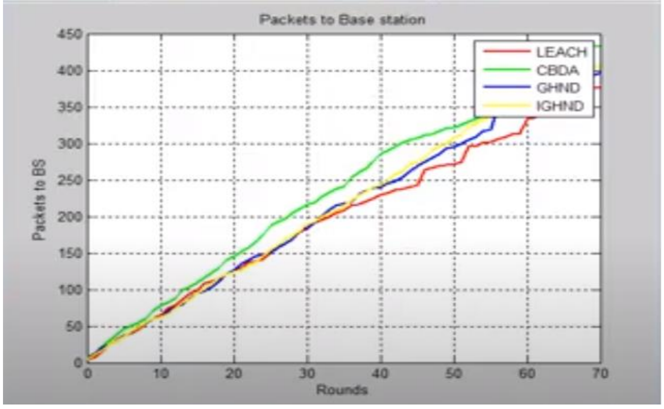

Figure 4: Packets to Base Station

The data packet propel to sink /Base Station is shown in Figure 4. Cluster head(CH) are chosen anchored in remaining power of every node. It effectively reduce energy waste during transferring data. Accordingly, information broadcast frequency boosts and the extra packets are with success transmitted to base station(BS) as weigh against to that in LEACH protocol.

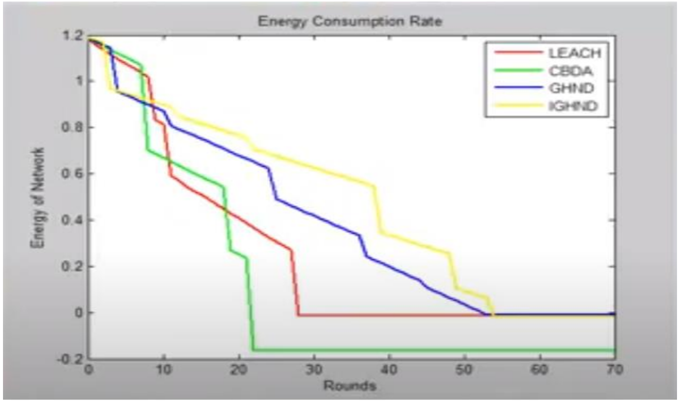

Figure 5: Energy Consumption Rate

Energy use is a major problem of the WSN. The energy demand of WSN has been minimize and the network life cycle has been extended by 40% compared to LEACH.

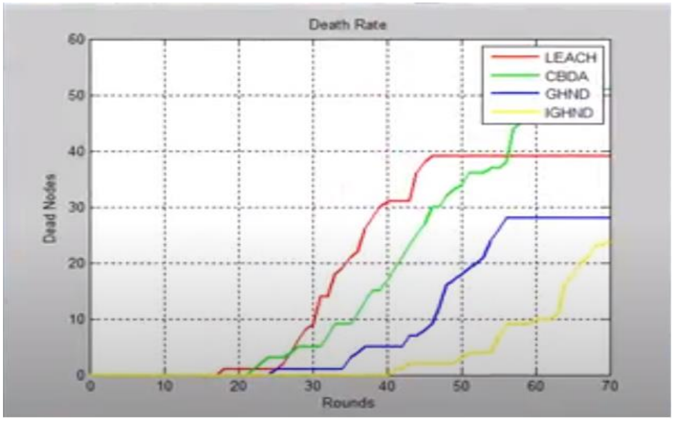

Figure 5: Death Rate

IV: CONCLUSION

We analyze the efficiency of LEACH, CBDAS, GHND, and IGHND routing protocol for data transmission over a wireless network using MATLAB simulation for (Quality of Service) QoS parameters such as network stability, network existence, reliability In this simulation process, latency, energy and throughput can be minimized by sending complete packets via the source to the destination, i.e. packet distribution ratio. Simulation study shows that IGHND performs superior to the LEACH protocol in throughput by 50% and lifetime by 40%.

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