LEACH Protocol based design for Effective Energy Utilization in Wireless Sensor Networks

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***Abstract*—**With the rapid expanding world population and negative impact of climate change and other unpredictable circumstances on agricultural sustainability and the ability of farmers to produce enough to feed the world population projected to hit the 9 billion mark by 2050. Meeting this challenge requires farmers to have a better monitoring and early detection system that enable them to have access to all the information about their farm on line real time. In recent years wireless sensor network WSN and cloud technology have been gaining increasing relevance in agriculture this is because they offer a vital tool for improved decision making in the areas of data and information collection, storage, analyses and dissemination. These technologies offers farmers tools for effective decision and timely application of control measure, they are also vital tools for understanding the changes brought on agriculture by climate change, decreasing arable land, and also provide solution for them to counter the negative impacts of these phenomenon. The proposed model consists of wireless sensor network which collect data from agricultural plants located at remote location and upload it to the cloud for further analysis. The main objective of proposed design is to apply the LEACH protocol for identifying the energy consumption of each node and also to identify the shortest path to reach the destination, further comparative study with other protocols also done. The simulation of the proposed protocol for data collection in an Agriculture environment is done using NS2 simulator.

***Keywords*—**Cloud Computing, Wireless Sensor Network, Climate Change, Food Security.

I. INTRODUCTION

Of primary concern to major farmer is the ability to be able to monitor and detect early environmental and physical factors militating against production and maximum crop yield to enable them take the necessary preventive measure to reduce negative impact of climate and other factors on agricultural processes. This become almost absolute impossible without the help of technology to help monitor factor that may not be feasible to the naked eye, how can farmer monitor and detect this phenomenon in very large farms and in remote places to enable them take timely control measures to apply the correct water, nutrient and fertilizer requirement to a particular crop. Despite technological advances, such as improved varieties, genetically modified cultivar, and irrigation systems, plant nutrient requirement, soil properties and weather are emerging as the major challenges being faced by farmers in agricultural production, as a result of these farmer have come to understand that if they will be able to tackle the effect of these factor on production and yields they need to put in place monitoring and early detection system to get timely and accurate information of event as they happen and also to find a way to send these information to expert, who can analysis the data and alert them on the actions to take.

While many studies have focused on cloud computing based monitoring and early detection mechanism in agriculture using wireless sensor network (WSN) only a fewer have examined the likely impact of such system on root crops such as cassava. In order to bridge this research gap this research is been carried out to analyze and study the most efficient and minimal power consumption sensor deployment method in the cassava farm, the impact of cloud computing based monitoring and early detection system in the cassava crop. Among several root crop varieties, cassava is a very important root crop, since it serves as a food source for over 800 million people in the world today and it is grown in many developing countries, its importance lies in its diverse uses as food, fiber, and energy sources. This research focuses on using a cloud computing based agriculture monitoring and early detection system in the cassava crop using wireless sensor network.

Figure 1. Public Cloud Service Market and Annual Growth Rate, 2010-2016

II. RESEARCH OBJECTIVES

The objective of this research is to:

- To explore how cloud computing based agricultural monitoring system using wireless sensors networks can be deploy for energy efficiency

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- Simulate Leach protocol using NS2
  Simulate and evaluate the performance of LEACH protocol against AODV, DSDV. And DSR
- Ascertain and present recommendation on the performance of LEACH compare to AODV, DSDV and DSR.

III. Related Work

These day cloud computing and wireless sensor network comes to the forefront when it comes to full autonomous, mobile and self-organizing system for monitoring, collecting, storing and analyzing of environmental and physical parameter of interest in various areas of human endeavors from motion detection, military use, health-care to lighting controls in our homes.

In [5], the authors proposed the use of Wireless Sensor Actor Network (WSAN) in conjunction with cloud computing services to help farmer optimize the use of available resources in the agricultural activities and to build a decision support system for agriculture with information support by expert's.

In [10], the authors proposed an architect for agricultural machinery scheduling using Wireless Sensor Network WSN and Internet of Thing IoT model to investigate resource allocation in agriculture and other aspect of agricultural machinery and control.

In addition, some researchers have undertaken the research of the performance analysis. In [19], the author proposed a technique for the integration of lightweight WSNs and Cloud Computing using dynamic
proxies that aggregates the features of message-oriented and component-based approaches in which each dynamic sensor component has its own individual connectivity and global interoperability as the middleware is located in the proxy, less energy is consumed.

In [18], the authors build and deploy a WSN network in a sugar farm in order to study how current irrigation practices affect the environment, the system acquires data from the sensor network in the field and transmits the data through microwave link to back-end server for storage and further analyses based on the information so gather the authors were able to understand the effect of current irrigation practices in sugar farm affect the environment and proposed ways of controlling such impact on the environment.

In [7], the authors proposed integration of cloud computing platform with animal husbandry to take advantage of advanced computer imaging technology to evaluate the animal meat, select and cultivate superior varieties, establish the magneto-therapy database and animal nutrition demand model, optimize feed formulation, to meet a number of animals nutritional needs indicators and exert the maximum production potential of livestock and poultry. In addition the authors believe that tracking and monitoring of agricultural products quality and safety can be fully realized in the cloud computing platform.

In [22], Chen et al. studied the state-of-the-art of QoS management in WSANS exploring existing proposal, challenges and open issues in the field. Existing middleware and protocols are surveyed and the challenges and open issue in the field are presented.

Optimizing sensor networks involves addressing a wide range of issues. These issues stem from limited energy reserves, computation power, communication capabilities, and self-managing sensor nodes.

In [21], the author gave a comparison of routing protocol in MANET, where DSDV, AODV, DSR are compared using NS2 simulator. Author shown that DSR performance is better in compression of AODV and DSDV due to a smaller amount of routing overhead when node have high mobility, counting the metrics throughput, Average End to End Delay and Packet Delivery Ratio.

IV. Overview of Leach Protocol

Low Energy Adaptive Clustering Hierarchy (LEACH) is integrated with clustering and simple routing protocol in a wireless sensor network is a TDMA based MAC protocol high energy-efficiency is one of its important functional index it significantly lower the energy required to create and manage cluster thereby improving the life time of a wireless sensor network.

Leach is an hierarchical protocol in which nodes transmit to cluster heads, and the cluster heads aggregate, compress the data and forward it to the sink node , each node uses a stochastic algorithm at each round to determine the node that becomes the channel head at the round, nodes that have been cluster head cannot be again for P rounds, P represent the percentage of cluster head. After each round each node has a 1/P probability of becoming a cluster head in the next round. The cluster head create a rule for each nodes to transmit its data.

$$T(n) = \begin{cases} \frac{p}{1-p(r \bmod (1/p))} & \text{for } n \in G \\ 0 & \text{otherwise} \end{cases}, \quad (1)$$

Properties of Leach Protocol

LEACH protocol is the protocol of choice for sensors networks for monitoring of environmental parameter in remote locations. It is an ideal protocol for use in agriculture because monitoring of agricultural field mostly covers a vast area of land in remote location, traditional protocols have limitations the does not make then suitable for agricultural monitoring and as an early detection mechanism. The properties of LEAH are:

- Distributed cluster formation
- Local processing
- Random cluster head selection
- Energy-efficient
- Cyclic sleep mode

These properties make LEACH protocol much more energy-efficient than traditional routing protocols.

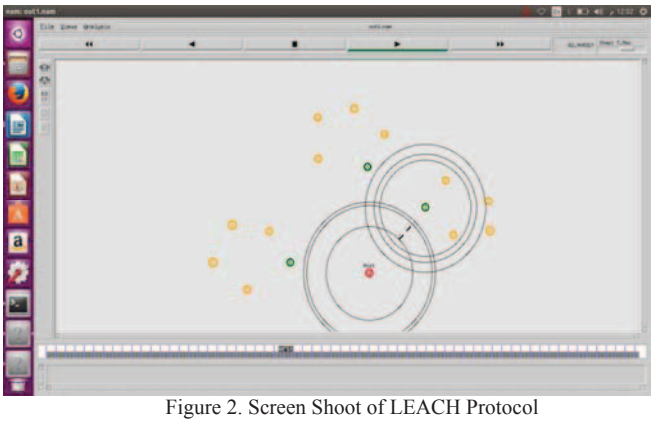

Figure 2. Screen Shoot of LEACH Protocol

V. ANALYSIS

To conduct the experiments on LEACH and AODV, DSDV and DSR protocol, we used a sensor field of 100 nodes which are randomly distributed between (x=0, y=0) and (x=500, y=400). The BS is located at (x=50, y=50) in a 500m*400*m field. The channel bandwidth is set to 1Mb/s and message length is considered as 500 bytes long with the header length 25 bytes. The initial energy of each node starts with 1 joule. The optimum number of clusters used in our simulations is 4. The duration of each round is 10s. We have run the simulations for 100s. The simulation parameters are given in Table 1.

TABLE I. SIMULATION RESULT

Simulation Parameter for Routing Protocols				
Protocol	LEACH	AODV	DSDV	DSR
Input				
Packet Delivery rate	100	100	100	100
Through put(bits/sec)	0.29	2.86	18.00	18.57
Instant-jitter	0.60	0.685	0.689	0.692
Output				
Mean time Between Arrival	0.010	0.010	0.010	0.010
Mean Time Per Service	3.45	0.35	0.00056	0.00056
Traffic Intensity	344.83	3.50	0.0556	0.0556
Average Utilization Rate of Server	34482.8	349.7	5.6	5.6

From the simulation carried out in NS2 to analyze the performance of LEACH protocols against AODV, DSDV and DSR using three network matrices (i) Average end-to-end delay (ii) packet loss out (iii) packet delivery fraction (PDF) the results clearly shows overall that LEACH protocol has the less average end-to-end delay and packet loss among the other protocols

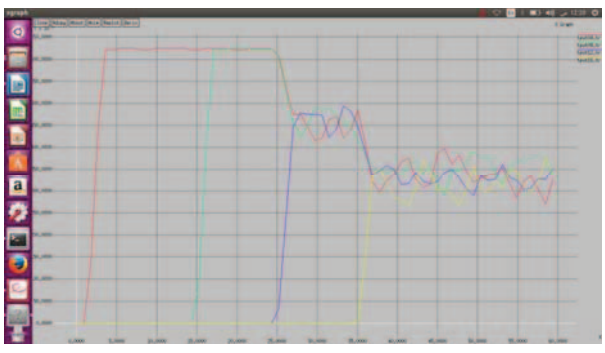

Figure 3. Throughput Delivery rate over time

The graph in this first analysis s a screen shot of a node A that start transmitting data at time (T) = 1.4 (sec) and initial using all the network resources, after node two (2) start transmitting at time T =15 there was a drop in performance due to resource contention as the other nodes start transmitting there was further reduction in performance due to higher resource contention between the nodes because all the nodes are now sharing the network resources at the same time.

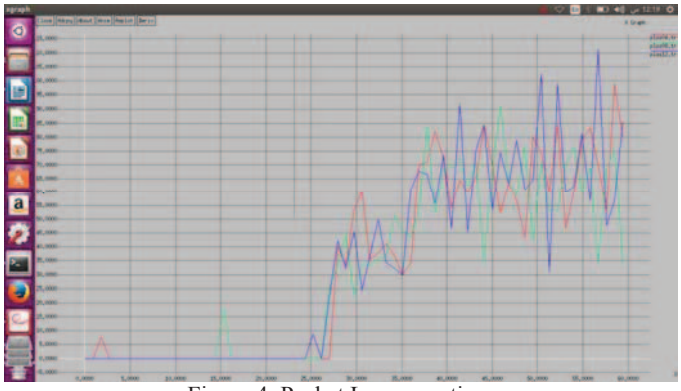

Figure 4. Packet Loss over time

The graph in this second analysis shows that with increasing numbers of nodes sharing the network resources the delay also increases and it take a longer time to readjust the CW of each nodes.

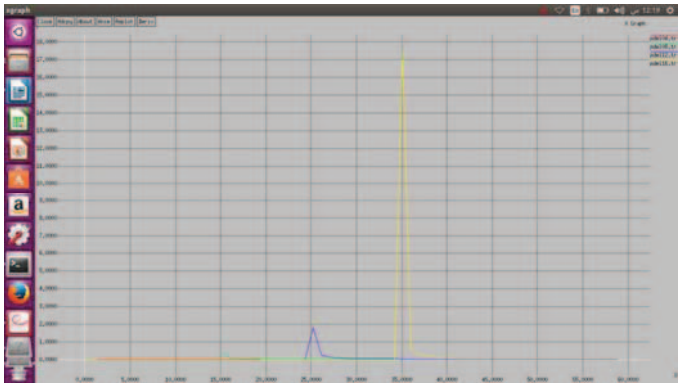

Figure 5. Packet Deliver over time

The graph in this third analysis shows a significant packet drop rate when the numbers of nodes sharing the network resources at a particular time increases. This leads to a high deterioration in network performance.

From the tcl.tr file generated from the simulation we evaluate and compare the performance of LEACH against AODV, DSDV and DSR using three (3) network matrices (i) Average end-to-end delay (ii) packet loss out (iii) packet delivery fraction (PDF) the results clearly shows that leach protocol achieves lower average delay, higher packet delivery ratio and its more energy efficient than the other three (3) protocols.

WINDOWS AZURE

Windows azure an integrated services platform, offers a comprehensive set of storage, computing and networking infrastructure services that reside in Microsoft's network of datacenters, extending existing applications to take advantages of cloud technology and delivers a consistent ways to store, share and access information easily and securely in the cloud and access it on any device from any location

In Azure there are four important parts:

- EvetHubs which collect event data from the arduino gateway
- Azure CloudService worker Role which recive those data from the EventsHubs and store to azure blob storage
- A Website written by WebService and support Soap protocol
- A Website written by WCF+Enable REST support

UPLOADING SENSOR DATA TO THE CLOUD

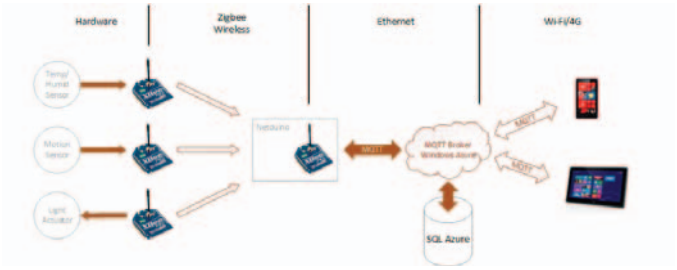

Figure 6. XBee integration with Azure Cloud

The sensor node in our experiment consists of XBee Pro 900 wire antenna ZigBee wireless sensors which gather environmental parameters, the sensed data is send to the Arduino microprocessor which aggregate the sensed data and log it to Microsoft Azure cloud through the Azure API for further analysis, storage and management. The Arduino is also used for executing sensor readings and it also serves as gateway for the system. Integrating the wireless sensor network to the cloud using Microsoft Azure cloud enables the farmers to take the full advantage Microsoft Azure cloud offerings as an inexpensive way to store, manage, receive timely information on critical events that may need urgent attention to enable them take control or corrective actions, it also provide a means to get the field data to agricultural expert for expert advice.

Microsoft Azure application and API is use to store and retrieve data from the Arduino via Ethernet, WI-FI or 3G/GPRS protocols depending on the available connectivity options in the location. In addition to storing and retrieving numeric and alphanumeric data, Azure API allows for numeric data processing. It supports JavaScript Object Notation (JSON), Extensible Markup Language (XML), and comma-separated values (CSV) formats for integration into applications. We used REST based Web service using standard GET and POST requests that return (JSON) responses to communicate between the base station and the Microsoft Azure server. JSON is a lightweight data-interchange format. JSON data interchange format is easy for to understand for human to read and write and simpler for machines to parse and generate messages than using XML. In order to read current sensor data value, an HTTP GET request is sent to the resource of the sensor. The response will include a textual representation of the present sensor value. A soon as the Coordinator decodes the received data packets from the End Devices, an HTTP POST request is sent from the base station to a pre-specified URL, containing the updated value.

VI. SUMMARY

In this research, a comparative analysis of LEACH protocol is carried out against three (3) other routing protocols to determine the most energy efficient routing protocol best suited for deployment to measure environmental and physical parameter of interest in remote location and uploading the data to the cloud for further analyses. Based on the network performance matrices used in evaluating the Leach protocol gives an overall best performance.

VII. CONCLUSION

The main aim of the cloud computing and wireless sensor network is to provide a platform to study, share monitor, collect, store and analysis parameter of interest at divers' location to facility control or timely decision. Cloud and sensor networks are very important in a highly intensive information dependent agricultural sector, sensors that could monitor various environment parameter in remote area and wireless upload the sense data to the cloud are of paramount important in agriculture, these study seek to understand the most energy efficient deployment for agriculture.

VIII. RECOMMENDATIONS

The recommendations hold for agriculture organization, farmers government organization on ways of leverage the advantages of clouding computing to minimize the effect of climate change, rodent infection and diseases on agricultural yield and production

1. **Key Benefits:** The key benefit of using a cloud computing monitoring and early detection system are numerous range from-Monitoring disease spread and assess its impact: Key outputs include (a) the development of disease distribution maps, (b) estimates of yield loss, and (c) identification of targets for quarantine.

2. **Key Outputs:** (a) implementing an effective monitoring and early detection mechanism system will lead to better understanding of the effects of the viruses in plant (b) examining the characteristics of virus spread, (c) creating diagnostic tools for viruses and diseases in crop, and (d) using digital-enabled

field surveillance tools for real time reporting and a monitoring.

3. **Best Medium Selection:** In this, if we choose LEACH protocol over the other routing protocols for deployment we are sure it has the capability to be able to provide the monitoring of crop from planting to harvesting which for some crops is about 8 to 10 months with enough power to collect, store and upload the data to the cloud which the other protocols cannot be able to provide, because if the sensors are running on an AA size battery they will run out of energy in about 3 months which is shorter than the cultivation period for most root crop.

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