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Energy Efficient Techniques for IoT based Smart Agriculture

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***Abstract*:**
Internet of Thing is a fundamental building block connecting objects or things, sensors, actuators and other intelligent devices that enable object-to-person and person-to-object interaction. The Internet of Things brought a huge change in technology that gifts the future of computing and communications. Smart agriculture plays a major role in our country and we are using on demand popular network i.e IoT in agricultural system. IoT network benefits not only in the agriculture but also in society and business sectors etc. Due to this certainty IoT network save time and money. Through IoT, the smart irrigation with smart intelligent technique to take decision and focused on the correct real time field data. Agricultural sector has been facing great challenges in order to design the energy efficient data collection method in IoT based network. It will be very difficult to rely on the traditional farming techniques to improve energy efficiency. In this Research work we providedthe energy consumption to the farmer’s trough end-to-end farming solution by using duty cycle and efficient path selection through clustering techniques. Lastly we are trying to enhance the energy efficiency and sustainable smart agriculture through the use of IoT.

Keywords: IoT, Agriculture, Energy Efficient, Duty Cycle, Data Aggregation

Introduction

In recent times, no other technology has created quite a buzz in the world of computing as much as the Internet. It is virtually present in every sphere of human enterprise through sheer power and sweep of its boundless applications. It has revolutionized the global workspaces by introducing new age technologies such as the Internet of Things (IoT) with mind blowing applications, often disruptive, in almost every conceivable field- creating smart homes, smart grids or providing smart solutions in education, smart city, data communication, retail, government services business and agriculture etc [1].In contemporary times, we have witnessed remarkable agility and ease with people and businesses connect, thanks to the help of a wide network of wireless sensor networks, healthcare services, smart phones as well as multiple types of pervasive real-time monitoring systems [2]. With the introduction of Internet of Things, people as well as devices seamlessly connect in real time, thus creating great services and values for millions of people around the world [3]. IOT has organically evolved into a massive technology platform by utilizing the inherent strength of the Internet in the collection, analysis and distribution of massive amounts of data, which is simply turned into information and knowledge in a real time environment.

Riding on the enormous network of the Internet, today, IOT has emerged as the new age convergence technology with its ability to effortlessly integrate multiple technologies from different domains into a unique arrangement. The omnipresent devices empowered by Wireless technology openly such as RFID, Wi-Fi, Bluetooth and Information services in telephones including implanted sensors and actuator nodes.A host of

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technologies such as RFID, data Communication, Networking, Wireless sensor networking, RTS, Machine to Machine Interaction, Cloud computing, Mobility support are amalgamated to form an IOT cluster. However, despite the fast advancement of IOT in recent times, it is still in the process of firming up as a mature and universally validated system [4-6]. Hence, a lot of research is still required to make IoT attain optimum levels of interoperability and mutual trust between various stakeholders through seamless connectivity. An IoT system can attain energy autonomy in a number of ways, primarily due to its association with multiple domains. In recent times, IoT has registered tremendous growth, especially in developing effective mechanism for energy autonomy in systems, wherein effective implementation holds the key to energy efficiency.

Smart agriculture is a revolutionary technique in the industry of agriculture which helps in guiding the steps needed to modify and restructure the agriculture systems to support the development and guarantee of food security effectively and efficiently in the adverse effect of climate change [7-9]. The main emphasis of using smart agriculture is to raise the agricultural production and incomes. The Green House gas emissions can be reduced or removed by the help of Climate-smart agriculture [10]. The increase in uncertainty of Global climate change is driving the market. The risk of rising food security combined with productivity output of lands and crop production in the market of Smart Agriculture due to the adoption of high technology in developed countries like U.S., Canada, and France among others. The emerging markets like China, India and Southeast Asia, Brazil etc are expected to change the nature and volatility of the markets in the future. The demand for Smart Agriculture may be hampered due to its high cost. Most of the country's population depends on the agriculture, so the overall growth impacts on the country's growth [11]. These agricultural sectorsdepend on the IoT driven solutions to improve the yield, supply chain and farmers practices. Exactly Smart Agriculture means doing agriculture by using cost-intensive, modern automated system to grow crops or food grains efficiently and sustainably for the population.IoT based smart agriculture is a system built for controlling environment of the crop field using sensors. It is used to automate the irrigation and pesticide spraying system that can be controlled from anywhere.

The remaining part of this research paper is organized as follows: Section 2 briefly representssome challenges of IoT agriculture. Section 3 represents different methods of energy autonomy in IoT technology. Duty cycle management and efficient shortest path selection method through clustering technique is adopted in Section 4. Section 5 contain the simulation parameter and analyze the result. Later part in Section 6 briefly describes the IoT applications in agriculture and benefits to the farmers. Finally in Section 7 we conclude our paper with future directions with some references.

2.Some challenges of IoT in agriculture

i. Hardware: To build the agriculture in IoT, we needed to be first selecting the most important things that is sensor for the device. And the selections of the sensors are dependent on the different types of requirement, information and related solutions.

ii. Brain: The core part of the agricultural product system is data analytics. So we require understanding the capabilities for powerful data analytics and it should be applied in the predictive algorithm and machine learning to get actionable insight on the basis of data.

iii. Maintenance: The challenges in agricultural IoT products are its maintenance. So the field sensors used in the agriculture grounds can be damaged easily. So we need to ensure that the hardware devices are robust and easily maintainable.

iv. Mobility: Mobility issues can be effectively handled if customization of farming applications is done before they are used in the field. In this process, data can be easily accessed by the farm managers or businessmen on the site or remotely by using smart phones or desktop.

3. Methods of Energy Autonomy in IoT Technologies

Amongst the host of prevailing IoT technologies, RFID [4], Networking and Communication, wireless sensor network (WSN) [10] and Real temperature system (RTS) [12] are selected as for the analysis purpose.

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3.1 RFID Technology

In IoT design, distinctive infinite objects could be a vital issue. such objects typically mimic the functions of animate things like an observance heart trans- plant or inanimate things like sensors arefixed in the automobile system. Such objects might have natural characteristics or artificial like static plants. Kevin choreographer pioneered the IoT movement in 1999 when he applied a singular symbol to associate animate object, thereby signal the advent of digital illustration on the online. Radio frequency Identification (RFID) has tested the potential to technologically link distinctive symbol to things exploitation tags. The article fitted with RFID chips contains all its info that is shifted and allot with the reader devices throughout the operation, whereas the antenna transmits/receives the radiation from the reader in shut proximity. Then the knowledge data forwarded to the back-end server by the reader for confirming the received information, before any appropriate action is initiated.

3.2 Networking and Communication Technology

Steve Leibson created a pioneering move in 2008. Once the proposal to assign a singular information science address to any or all 'things' within the world through IPv6 address area was formalized. Such a postulation brought problems like knowledge isolation and security hazards to the notice of the scientific community. The IoT devices operated within different devices via a wireless network over Zigbee, Bluetooth. With a growing range of devices preferring to work through the worldwide network of the web, there arose associate imperative would like to form a transition to 128-bit address area from the restricted 32-bit address area of IPv4, made doable by the appearance of IPv6 attributable to the efforts of the IETF in 1994. In IPv6, the larger packet header size packets packs way more energy into the transmission section yet whereas, receiving packets, thereby increasing the prospect of bit-errors throughout the transmission.IoT possesses the wherewithal to transmit data over any network, thus avoiding human to human (H2H) or human to machine (H2M) interface. Since the available energy optimization techniques employed in H2H or H2M connections fail in case of M2M connections, researchers must focus on this significant domain in future.

3.3 WSN Technology

In IoT devices, smart sensors abound in number as well as applications with their capability in sensing an object as well as the ecosystem. In a global digital ecosystem, such sensors operate freely collecting information in the form of raw data, before transmitting to base stations.The vital environmental conditions like temperature, vibrations, pressure and motion are monitored at the base station. After processing the information, the output is used to take suitable decisions as seen while controlling vehicular movement, military services, traffic monitoring, and agriculture among others [13]. What makes it most remarkable is its ability to generate valuable data in spite of its low processing and storage limits. In such a scenario, IOT applications require the assistance of low power wireless communication.Though some research initiatives have already been undertaken in IoT, yet much more needs to be done before sensor networks are made energy efficient and self-sustainable with low profile, low power.

3.4 RTSTechnology

At the core of its focus, IoT seeks to tackle adverse environmental conditions like pollution, disaster and global warming by applying real-time data. The physical objects in the IoT ecosystem display higher levels of awareness of the context for better sensing of the environment, besides enhanced interaction among objects. In such scenarios, objects were shown responding by taking real-time decisions like, for example making safe switching in lanes on roads as well as automatic maneuvering switches in rooms when not occupied. Some of the methods such as Dynamic Voltage/Frequency Scaling (DVFS), Dynamic Procrastination Scheduling (DPS), Mix of DPS, DVFS and Migration methods are applied by Energy Efficient RTOS (Real-Time Operating System)styles for attaining time period task planning [14]. However, in the future, such techniques still need to be fine-tuned for attaining energy autonomy in transportable devices.While implementing EH-based algorithms, the typical problems encountered include evaluation of energy output, energy storage and schedulability test. In such a scenario, the researchers must work on sources capable of operating under lesser time constraints for management of the limited amount of harvested energy while developing scheduling algorithms in RTS with renewable energy sources.

3.5 Cloud Computing Technology

IoT devices offer enormous capabilities in providing access to cloud computing by overcoming problems arising out of shortcomings or hardware,inadequacies in software, firmware, data processing, memory and capacity. In recent years, Cloud computing has scripted a novel computing paradigm, literally endowing the users with almost limitless resources.In such a backdrop, developing energy efficient scheduling algorithms i.e.virtual machine (VM) becomes critical to effective resource management in to the cloud computing arena [15].Typically, a nature-inspired consolidation algorithm like VM algorithm are based on the Ant Colony Optimization (ACO) , which may applied to counter for idle times in a system.

4. Methodology Used

In recent years, a number of research initiatives in IoT have been under taken on energy efficiency in WSN, whichare largely focused on tracking and monitoring physical phenomena. IoT has many applications to monitor processesin health, environment, and infrastructure like water, gas and oil. Farm beats is a benchmark research work on theprecision agriculture [21]. Out of many applications, IoT mainly contribute brilliant application i.e. flight path planning, weather forecasting, station design for aerial imaginary data, drone monitoring and planning for agricultural services. By applying optimization technique and data aggregation methods, researchers can aware about the weather and energy, later it can be optimized under cloudy environment through Duty Cycle algorithm[16]. In a normal WSN design of nodes having partial resources which is battery-powered,operation lasts a good five year in the minimum with any need for maintenance. In such a scenario, to reduce energyconsumption the node requires to turn off its radio temporarily [17][18]. When the sensor node periodically active and inactive state, it goes under wake up and sleep mode, under this a short period is called duty cycle. Assuming all sensor nodes have same initial energy, pre-charged and broadcast in nature [19][20]. Selecting the region sender can send the data packets to the destination.The intermediate nodes broadcast their locations to the neighbours by neighbour discovery method. Each sensor node generally operates in two states 1) charging and 2) Active. Active state helps in transmitting and receiving the data packets as depicted in Figure 1.

Duty-cycling as a technique refers to onewhere in the nodes have periodic relapse between sleep state through for a short time period. In fact a scheduledduty cycling has wider acceptance. In this technique, nodes awake at a scheduled time, which signifies transmissionoccurrence only when the active time is reached [21][22]. The on-demand technique is designed on the basis of dynamicawaking of the node as per necessity, through it normally involves use of some other communication channels [23-25].

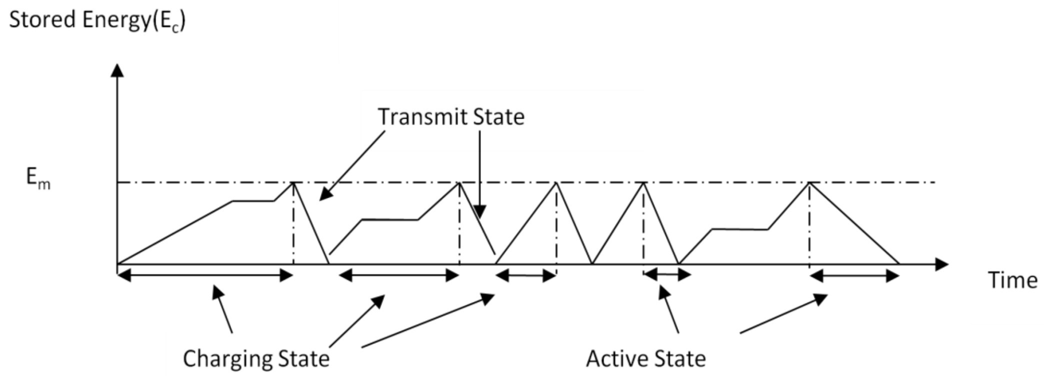

Figure. 1: Energy Management States ina Sensor Node

4.1 Duty Cycle Methods

At the base station (BS), energy efficient data aggregation using residual energy parameterscan be monitored by Duty Cycle (DC). We proposed a modified farmer beat DC, called farmer beat duty cycle (MFDC) that uses two thresholds on residual energy such as one for network and the other is for the path. Algorithm 1, is showing the farmer beat duty cycleat BS with conditions of the network before transmission phase of data. Algorithm 2 is showing selection of optimum path by using clustering method adopted in wireless sensor networks.

Algorithm 1:Modified Farmer Beat Duty Cycle(MFDC)
Input:G=(N,A,B) /* G is a Duty-Cycled graph for WSN consisting of N Sensors, where the network size if A*B */ **Output:** Minimum Energy Consumption σ1: threshold value for remaining energy in the network, DC=0;// time interval of duty cycle
1.Deploy the duty-cycled network G 2.InitializeDC = 1; /* At time period DC set BS in Inactive State */ 3. Set BS= Active State 4. **IF (event) { /*** If in the event of bad or cloudy weather etc.*/ 5. Find the path to aggregate data (Algorithm-2) 6. Select to return the path for data consisting of minimum number of hopsto initiate data sending from S to T at time period DC+1 7. Set Sensor Nodes to sleep state DC+1 8.**END IF }** 9.Wakeup the BS at time interval DC+2 10.Transmit collected data to sink 11.Check the sensor nodes status at each time interval DC++ 12. { IF(φi<σ1) 13.Select another node for BS and sleep the pervious BS 14. { ELSE 15.Continue , wakeup the new BS and keep others fixed 16.END IF } 17.IF data sending processes completed 18.sleep BS 19.END IF }

Algorithm 2: Efficient Path Selection by applying Clustering Technique
Input: R: Set of source/Root sensors; S:Sink node(IoT Base Station) **Output**: Shortest Path Calculation using Energy Efficient Technique σ2: Remaining energy for intermediate node, Keeping Threshold value fixed N: Number of nodes, CH: Cluster Head, BS: Base Station
1.Source node set R and sink node set S; 2. Let Dij = c ,where (c>0) and Pij =0; 3..Let the initial number of intermediate nodes stored at sink node be Φi = 0 4. **While** Cluster are made and CHs are chosen. 5. FOR { Each(S_Node) 6. Node select a random number S(n) between 0 & 1. 7. **IF** (S(n) < threshold value) a. S_Node becomes Cluster Head. b. S_Node Transmits a message announcing its CH status. 8. ELSE 9. S_Node becomes a typical node

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10. S_Node receives the announcing message of CHs
11.**END IF**
12.END FOR }
13.FOR {Each(CH)
14.Calculate a distance from Node to CH and from CH to BS
15. S_Node chooses the CH with minimum distance from it to CH to BS
16. S_Node apprises the selected CH and becomes a Cluster part
17. END FOR }
18.FOR { Each(CH)
  a. TDMA schedule is made by CH for each node to transfer data
  b. TDMA schedule is advice to each node in the cluster by CH
19.END FOR }
20. Calculate the threshold frequency S(n), *P* –Probability to become CH

$$T(n)= \begin{cases} \frac{P}{(1-P\left(rmod\left(\frac{1}{P}\right)\right))} & \text{if } n€G \\ 0 & 0 \text{ otherwise} \end{cases}$$

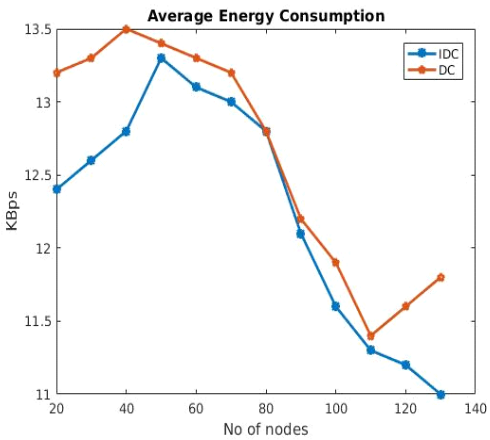
21.Calculate the next hop Pij in path

$$Pij= \frac{\frac{\phi i-\phi j}{dij}}{/_{Dij}} = \frac{Dij}{dij}(\phi i - \phi j)$$

22. For each Intermediate node entries, update the Routing Table
23. Calculate the total number of Hops
24. Return all the shortest path discovered
23. **END While**

5. Result Analysis

For performance consideration, we simulated and comparedthe MFDC algorithmotherwise called improved duty cycle (IDC)with other DC algorithms in NS2. Considering network simulation parameter, we used hierarchical type of addressing with 2.4GHz frequency. By using IEEE 802.11, energy aware WSN routing with radio propagation model we used drop-tail interface with 60sec simulation time period. From the result analysis we determine the scalability of the preferred protocol.Figure2,3,4 and 5representing an average throughput (performance of the n/w), processing time for both the cycle, energy consumption in different scenario and remaining energy of the network evaluation respectively comparing IDC with DC algorithms.



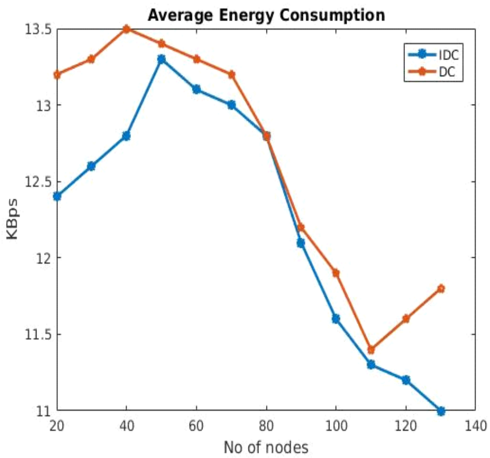
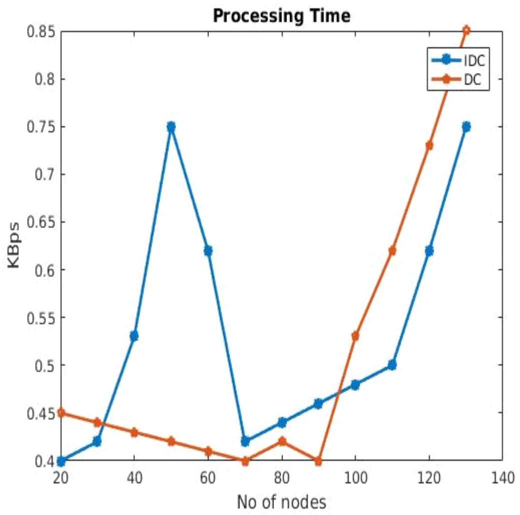


Figure2. Avg. Performance of the N/WFigure 3. Processing time Taken for Both



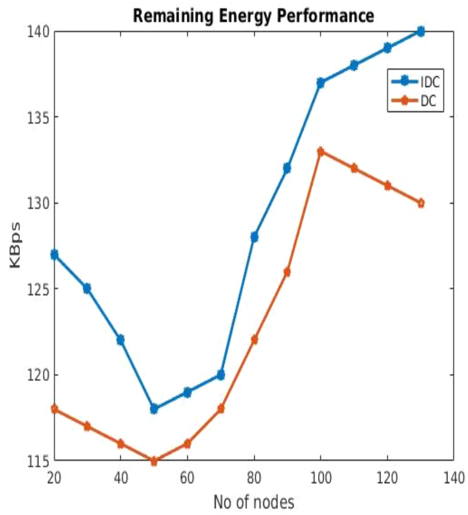


Figure 4. Avg. Energy ConsumptionFigure5. Remaining Energy of the N/W

Figure 2shows the throughput of the MFDC algorithm and the processing time is relatively reduced as compared to DC algorithm as depicted in Figure 3. The average energy consumption is less (overall) in MFDC protocol as well as average residual energy is slightly decreases and then increases, for which networks life time increases as depicted in Figure 4 and Figure 5 respectively. Result shows the improvement of MFDC over DC protocol. If we considered day wise performances/throughput, processing time and energy consumption, it also relatively decreases due to depletion of energy level at the sensor node.

6. IoT Applications in Agriculture

i. Crop water management: The farmers usually spray water manually to cultivate the land which is the cause of unnecessary loss of water or inadequacy to the plants. The use of IoT enables us to send messages to aware the agronomists when there is upsurge or shrinkage in moisture level of the soil.

ii. Soil moisture control: This is part of crop water management where, the moisture level in the soil is sensed by a sensor called ***soil moisture sensor***. According to the information given on soil moisture by the soils moisture sensor the water sprinkler is activated or de activated to maintain the appropriate moisture level in the soil for a particular crop or plant.

iii. Pest management and control works: Most of the times the due to predators or diseases caused by insects on the crops or plants leads to huge loss to the farmers. But the Agriculture IoT base systems have the ability to detect the presence or motion of predators by using PIR sensors. The information transmitted by the PIR sensors about predator attack or diseases on plants can be used by the farmers to take preventive steps which will reduce loss. A sensor can detect the motion predators around the crop field or unwanted movements of insects on the leaves of plants.

iv. Precision Agriculture: More accurate and controlled farming practice is raise livestock and growing of the crops. It uses IT and sensors, control systems, robotics, autonomous vehicle and irrigations systems etc.

v. Food production and safety: Live sharing the amount of food produced and condition of the food quality in food supply chain management systems (FDC).To take necessary actions to maintain food quality [25].

vi. Livestock monitoring: It is the process of recording and sharing the stock of crop on demand.

6.1. Benefits of the Farmer using IoT Based Smart Agriculture

Some of the benefits to the farmers are given below:

i. Crop production increases [26]. ii. Minimizes loss of Wateriii. Farmers get real time data and knowledge about better production. iv.The cost of operation is minimized. v. The quality of crop production increases. vi. Precise farm and land evaluation. viii. Farming on Live-stock improves. ix. Reduced environmental impression. x. The conditions of the environment can be controlled remotely. xi. The Equipment's can be monitored through the new technique.

7.Conclusion and Future Scope

In this paper, we applied energy efficient techniques for smart agriculture through IoT. It also provided a detail study of duty cycling problem duty cycling algorithm to find out the path efficiently for precision agriculture using IoT systems and introduced an improved duty cycling efficient farmers planning algorithm for IoT device based precision agriculture system. With different variation of number of the sensor nodes we verified the scalability performance of MFDC and it was discovered that the suggested algorithm is clearly presenting improvement in efficient energy consumption as well as throughput,in comparison to duty cycle techniques. After implementing and applying the IoT devices we can allow us to predict moisture content of soil, temperature, humidity and to detect predator's presence in the crop field. Irrigation system is controlled remotely thereby controlling water management and damage caused by the predators is reduced. It alsoincreases the productivity (profit increases) as well as precision farming can be done. In future we can extend the test of the improved MFDC algorithm on the hardware base station on the field and can be setup our green house farming.

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