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Research Article

Internet of Things Enabled Intelligent Mote with LoRa Architecture for Agricultural Use

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Abstract: —As the world's population grows, there is pressure to switch to more sustainable agricultural methods. This, together with dwindling supplies of raw materials, shrinking amounts of farmable land, and more extreme weather events, has caused widespread anxiety about national food supplies. As a result, more farmers are turning to IoT and DA in an effort to maximise output while decreasing input costs. Smart agriculture is now being driven mostly by the IoT and data analytics, rather than by wireless sensor networks (WSN). Some of the technologies that have been merged to form the Internet of Things include wireless sensor networks for radio-frequency proof of identity, cloud computing, middleware infrastructures and customer-facing software. The advantages and disadvantages of the IoT are discussed in this article. Here, we demonstrate how smart farming is being made possible by the convergence of IoT and DA, and how an IoT ecological map may be created. In addition, we categorise future advancements by technology, applications, economic feasibility, and consumer interest.

Index Terms— Smart agriculture; agriculture; data analytics (DA); IoT; IoT ecosystems; IoT in agriculture; IoT sensors.

Introduction

By using cutting-edge sensors and monitoring technology, "precision agriculture" improves crop yields and guides management choices[10]. PA is a cutting-edge technique used all over the world to boost crop yields with no increases in water use, labour requirements, or environmental impact [11]. Parameters including plant health, irrigation, crop production, soil health, and the influence of fertiliser and pesticides must be evaluated and measured in modern agricultural operations [12]. Keeping tabs on all that has to be done at once is a difficult task for farmers who produce crops. However, RS might be utilised to perform accurate monitoring of agricultural development and health [13]. Sensor factors such as short spectral range, poor repetition coverage, coarse spatial resolution, and slow reaction time are the greatest difficulties for remote sensing in Pennsylvania [14]. [15] Multiple wireless nodes collaborate to create a WSN, whose purpose is to monitor and report on environmental conditions. Sensors, wireless protocols, and microcontrollers make up the bulk of wireless nodes. Then, wireless nodes may communicate with gateways to send sensor data. WSN is used in a variety of agricultural contexts, including crop health forecasts using soil nutrient data and climate monitoring [16], and is the most cost-effective way for boosting agricultural productivity. WSN is also one of the most adaptable strategies for increasing crop yields. Some of the difficulties associated with deploying WSNs in agriculture include [[17]] issues with energy efficiency, communication range, scalability, locating suitable deployment methodologies, and failure tolerance. The kind of wireless communication protocol employed for the agricultural application will impact both the energy efficiency and communication range of the WSN. Zigbee, a kind of short-range wireless networking technology, is increasingly being used on farms throughout the United States to manage irrigation, measure water quality, and limit pesticide usage [18]. The greenhouse climate is monitored and controlled using technologies such as Zigbee and GSM/GPRS (Global System for Mobile communication/General Packet Radio Service). Most wireless sensor systems used in agricultural settings rely on short-range communication between nodes to keep them online while using little power. Short-range communication issues, however, prevent WSN from reaching its full potential. Long-distance communication through GSM/GPRS has been implemented; nevertheless, its transmissions are notoriously power-hungry. As an answer to the issues of power drain and maximum range brought on by WSNs, long-range wireless communication (or LoRa) was created.

Parameters	XBee	Bluetooth Low Energy	Wi-Fi	GPRS	LoRa	NB-IoT	Sigfox
Frequency range	868/915 MHz and 2.4 GHz	2.40 GHz	2.40 GHz	900 to 1800 MHz	869 to 915 MHz	Licensed LTE frequency bands	868 to 915 MHz
Transmission Range	100 m	10 m	100m	1-10km	5 km	NA	10 km
Network size	Approx. 65,000	Limited application	Approx 32	Approx 1000	10,000 no of (nodes per BS)	52,000 devices/ channel	1,000,000 no. of (nodes per BS [24]

Table.1 Wireless Communication Protocols' Detailed Technical Specifications

Table 1 presents the several protocols for wireless communications that are available today and may be used for the implementation of WSN. The table that follows contains information on several wireless communication protocols, including their channel bandwidth, range, power consumption, network size, and frequency bands, as well as their network structures. Wireless data transfer over extensive distances while using just a little amount of power is made feasible by the Lora protocol [19]. The LoRa alliance [20] states that Lora employs the Chirp Spread Spectrum (CSS) technology and has a transmission range of up to 5 kilometres (km) in urban areas and 20 kilometres (km) in rural areas. The deployment of Lora is accomplished with the help of an IP-based star architecture, in which gateways and cloud servers are connected with the help of IP. As can be seen in Table.1, the Internet of Things is required for a wide variety of applications. This table also includes a discussion of the following three forthcoming LPWAN innovations: LoRa, narrow band-IoT (NB-IoT), and Sigfox. LoRa is distinct from the other two LPWAN protocols since it runs on its own network and gives customers unrestricted access to the frequencies that are accessible [21]. NB-IoT is a licenced band in addition to being a dependant network that is required to make payments in order to access the spectrum. LoRa is better than Sigfox in terms of both power consumption and network security, and the LoRa network is established by network operators, to whom subscribers are given access. In addition, the deployment of nodes is playing an important role as nodes in the farm field. This is because it provides information on the number of nodes that are necessary to cover the whole agricultural field. In this case, the nodes themselves need to include a localization mechanism so that data may be sent to the sink node or gateway through the path that is the least time-consuming feasible. Because the position of the sensor node in a large agricultural field is dependent on its identification, the importance of localization cannot be overstated..

Because real-time monitoring helps in studying crop growth under unique real-time circumstances, such as the condition of the soil, water management, pH levels of soil, etc., it is now feasible owing to advancements in sensor technology and communication protocol. Real-time monitoring is helpful in analysing crop development under these unique real-time circumstances.Through the collection of time series data from geographical data and sensor networks, the internet of things (IoT) paves the way for real-time monitoring to become a reality. In Internet of Things-based agricultural systems, the data provided by sensors and imaging technology might potentially be utilised for predictive analytics to anticipate crop yields for the next growing season. Farmers are able to establish the optimal times to carry out activities such as planting and harvesting with the assistance of predictive analytics. Machine learning (ML) is a crucial facilitator for agricultural predictive analytics, which is required for forecasting which crop will be the most successful in the next growing season. ML is a critical enabler for agricultural predictive analytics. A kind of artificial intelligence known as machine learning (ML) is capable of producing a more accurate yield projection based on a variety of factors. The use of machine learning techniques, such as artificial neural networks (ANN), support vector algorithms (SVM), and deep learning, is becoming more important in the agriculture industry.

Monitoring of fields is an essential practise in Pennsylvania since it contributes to higher overall agricultural production. In this setting, wireless networking plays an extremely important part since it paves the way for dependable communication and communication between the farm and the customer. The currently available implementation of wireless networking for PA are not without flaws, the most notable of which are their restricted range and high power needs. The portable device enables farmers to keep an eye on their crops from a distance at a low cost and with a minimal amount of complexity. Because of the way things are now standing in the agricultural sector in India, I feel compelled to make this suggested effort. The challenges of farming, the unpredictability of the weather, and the widespread ignorance of "smart farming" are all factors that contribute to the existence of issues. Agriculture in India has, as of late, emerged as a central topic of conversation on the need for diversification in India's economy. One of the primary reasons for that is that the agriculture industry in India is unable to meet the growing demand brought on by the country's fast increasing population. This is one of the key reasons why this is the case. Inconsistency in the nation's exports of high-quality items, which are a direct contributor to the country's booming economy, is another explanation for this phenomenon. In a country like India, natural disasters almost always have catastrophic effects. We have reason to assume that cutting-edge technologies such as the internet of things (IoT) and data analysis (DA) might provide the most effective answers to these issues. Incorporating Internet of Things technology and data analytics that are particularly applicable to the agriculture industry is a critical component of our overall approach. In this method, we make use of a network that is based on LoRaWAN so that data may be transferred from sensor nodes to cloud-based services across long distances without having an influence on the battery life of the nodes.

System description

The authors provide a framework that may be used for the implementation of real-time field monitoring using LoRa and Wi-Fi modules. The proposed architecture is comprised of three basic components, which are the sensor motes, the LoRa gateway, and the portable device that is based on the Internet of Things. This design illustrates how information moves from sensor nodes to mobile clients by means of the gateway. In addition to this, the concept is helpful for establishing an Internet of Things-based agricultural monitoring system in areas of the world where internet connectivity is poor or nonexistent.

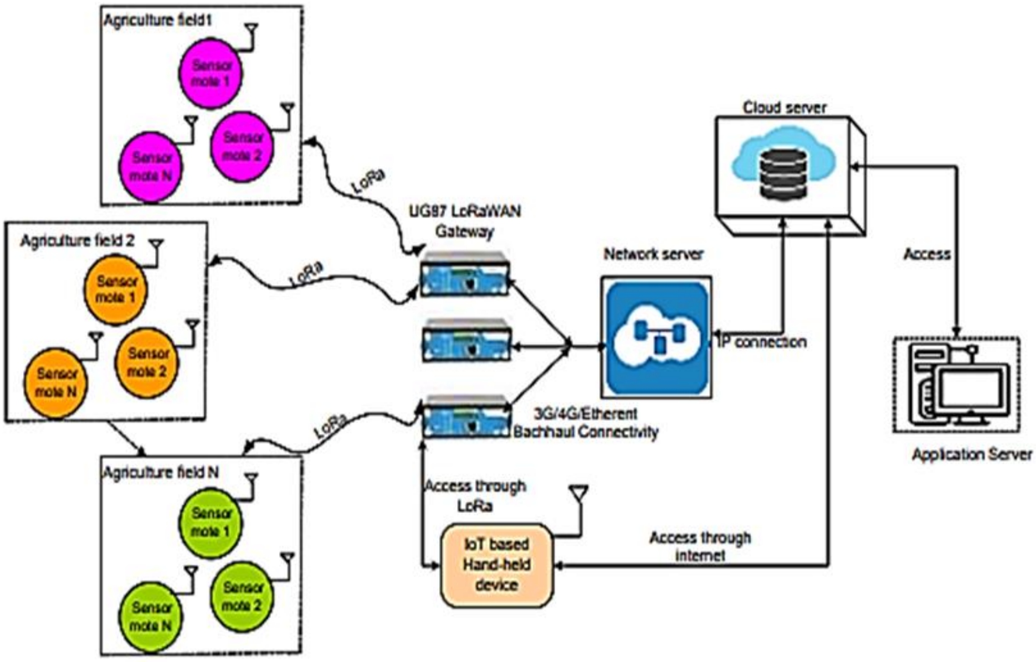

Figure. 1 Architecture based on Long Range Radio (LoRa) and Wi-Fi for monitoring farms and fields

Simulation model for LoRa network

A process schematic for sensor mote localization is shown in Figure 2. The programme starts by deciding whether to use a uniform or random distribution of nodes. The number of nodes per square metre is also determined by calculating the node density. The programme processes these inputs and generates distribution patterns for sensor rovers. A hybrid range-based localization strategy is advised when a communication link has been established between the sensor motes. For the sensor mote to track a moving object, localization is a must. In this context, we begin by classifying the algorithms as either free-range or hybrid-range. In addition, we analysed the most effective localization approach. Power efficiency makes range-free localization a top choice. However, hybrid range-based localization is often favoured. Due to the uneven topography of most farmland, hybrid range-based localisation has emerged as the method of choice. Most Internet of Things–based applications need sensor motes for localisation due to their ease of monitoring. The localisation of algorithms may be computed by use of simulation studies. We accounted for the impact of the network's topology, data throughput, and signal intensity in developing the optimal method. We've also shown how range-based and range-free localization compare, and we conclude that range-free localization is better for agricultural uses. Figure 3 shows a MATLAB implementation of a cluster-based sensor motes localisation in a farm setting. As can be seen in the illustration, the cluster stands in for senor nodes (PoIs) in a farm. Points of Interest are indicated by the yellow star symbol (*), whereas sensor nodes are denoted by the blue star symbol (*). The hybrid protocol's centralised node in an agricultural area is shown in Figure 4.

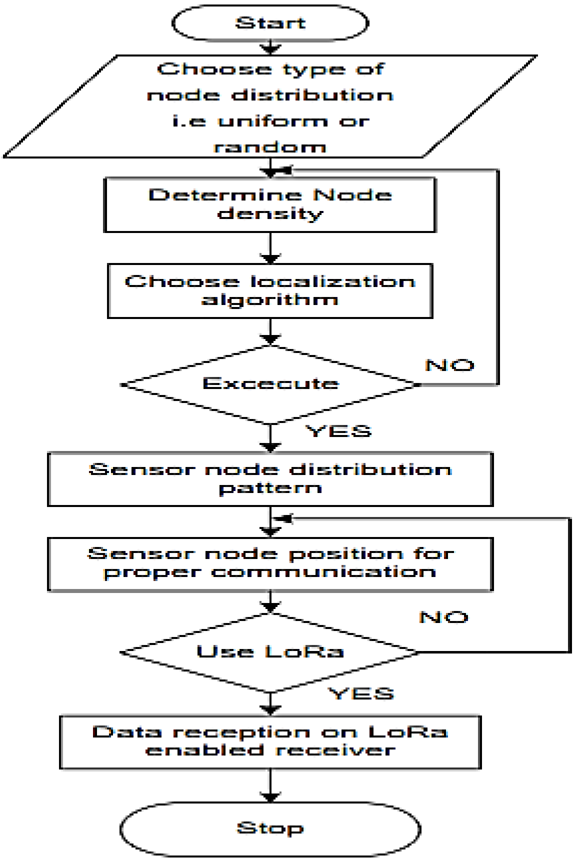

Figure. 2 Schematic depicting the localization process using Algorithm S

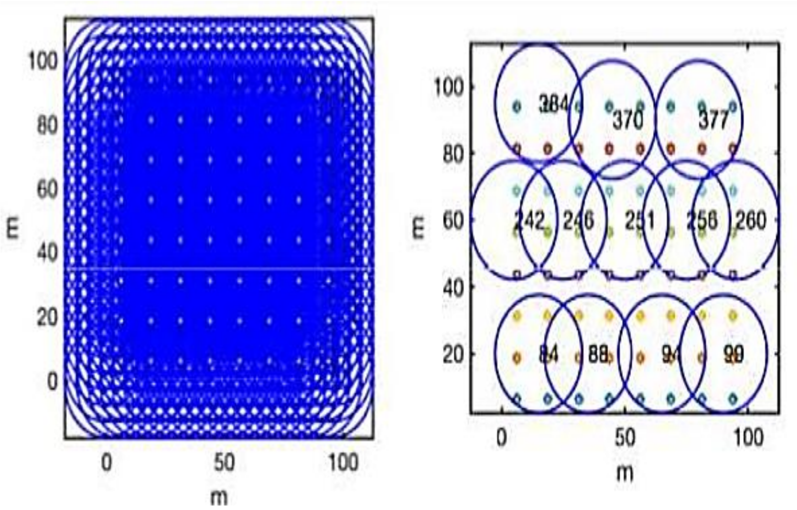

Figure 3. Localization of agricultural fields using sensor motes in clusters

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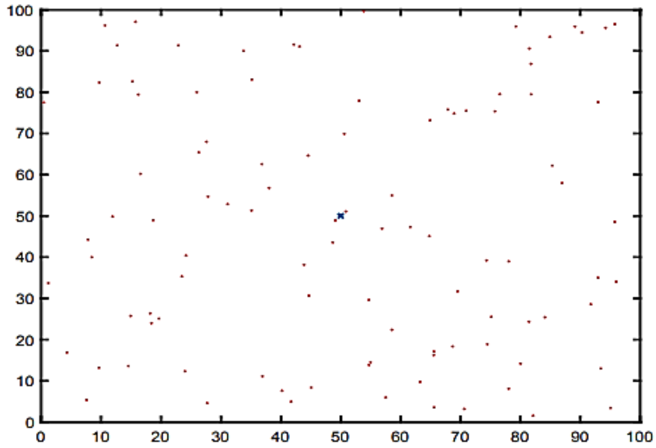

Figure. 4. Locating the Hub in an Agricultural Landscape

Simulation of energy harvesting

The vast majority of sensor motes used in agriculture are placed in the great outdoors. Furthermore, it is difficult to maintain the sensor mote's battery life since the battery drains at different rates in different environments. Therefore, it is the best option for powering sensor motes with renewable energy gathering. The sensor motes use energy harvesting, which is a superior technique for powering sensing, preprocessing, and data transmission operations. Sensor Mote's energy efficiency as powered by the sun and the wind is measured in cisco packet tracer. Cisco packet tracer is a graphical simulator that invites users to run multiple network simulations. Energy harvesting by the sensor motes' solar cells and wind turbine is simulated in the cisco packet tracer environment, as seen in figure.5

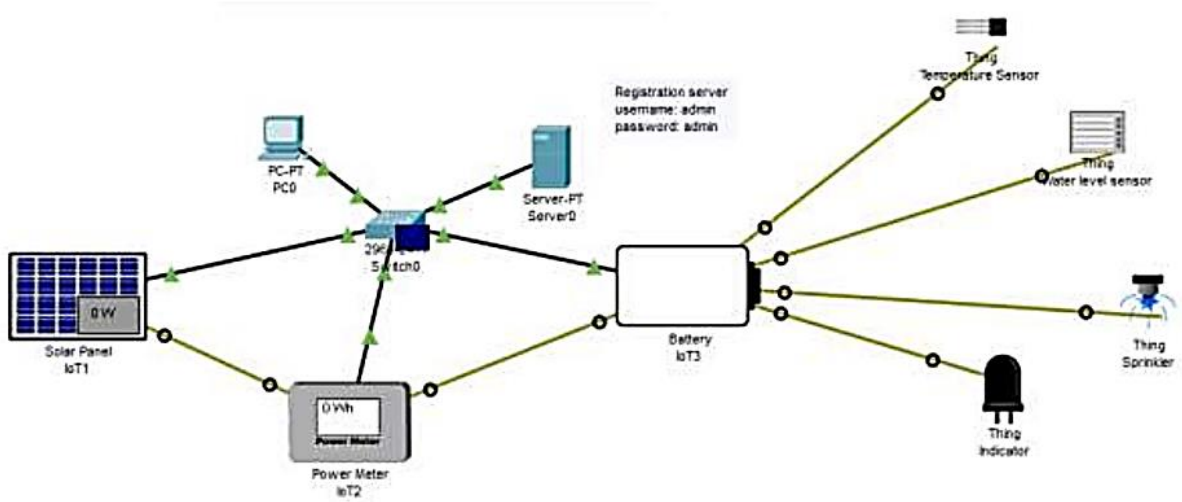

Figure. 5. Setting up a LoRa network for sensor-equipped mobile devices to communicate

In the graphic, a node's lifespan is displayed from the simulation. Mobile phones get data from end nodes through cell towers and a hub, which in turn receives data from a central server. The figure.6 simulation panel shows the total number of Internet of Things (IoT) gadgets currently linked to the network. A power metre is used to track the amount of energy produced by each renewable source. The information about the IoT devices' time stamps is shown in the time column. A similar amount of time, 0.129 seconds, is required for an IoT 2 device to connect to the network. Both IoT0 and IoT1 devices have established a connection in 1.011 seconds.

The total time it takes for a device to connect is specified as 77.660 seconds. The battery receives additional power for storage. In the case of the turbine, 11 kWh of power is considered, whereas 78 watts and 82 watt-hours of electricity are treated as a hypothetical.

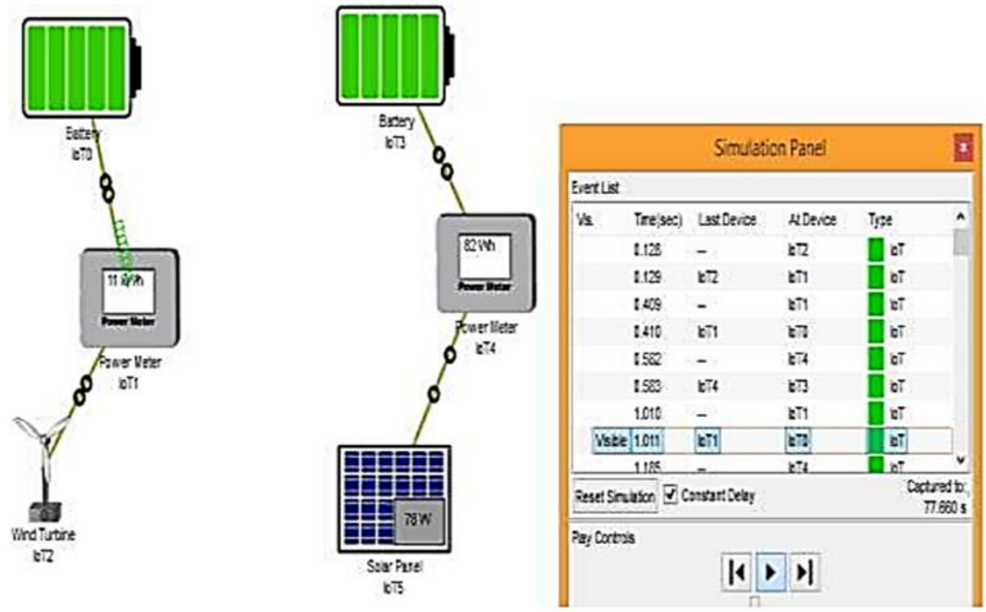

Figure. 6 Using renewable energy sensors to save power

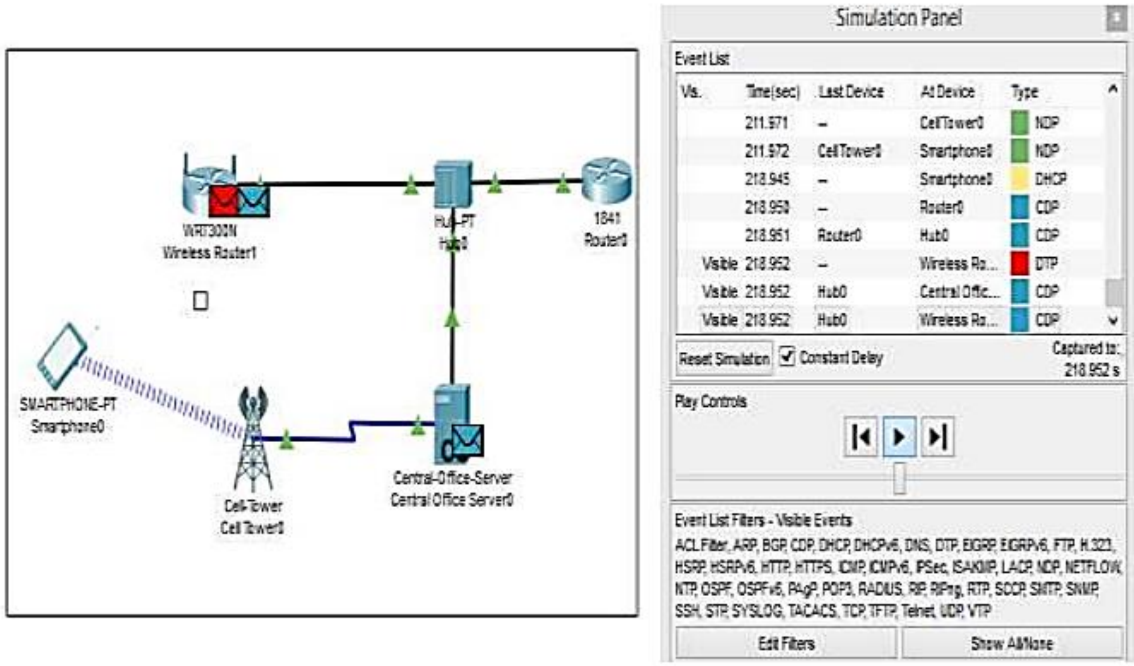

Figure.7 Platform for LoRa simulation with customizable settings

The graphic depicts the beginnings of a connection between a sensor mote and a mobile phone using LoRa technology.7 The figure depicts the simulation model.Connectivity between the sensor nodes' terminals and the gateway, via which data may be sent to a centralised server, is represented by the number 5.6. The amount of time it takes for data to go from the router to the hub and then from the hub to the smartphones is shown in the simulation panel in seconds. The virtual gearbox stands in for the actual one. Timestamped at 218.952 seconds, the three events describe the simultaneous connection of a wireless router, a central office, and a second wireless router. This means that with LoRa communication, the lag time between synchronising devices is negligible. The devices get synchronised and begin talking to one another as soon as the authentication key is accepted.

Conclusion

This article will teach you how to establish a LoRa network between sensor motes and a gateway. By modifying the link budget during interlink setup, it is possible to replicate the performance of a LoRa network in terms of range and battery life. We constructed an energy harvesting simulation in cisco packet tracer to evaluate the effectiveness of solar and wind power in powering the sensor motes. Although the node sensitivity and antenna gain were both kept at a constant -137 dBm and 10 dB, respectively, experiments showed that the wide-area coverage of a custom-built LoRa module changed with the change in link budget. Battery capacity testing revealed that Li-ion cells provided the optimum performance for the sensor motes. As the spreading factor is larger, the data rate grows smaller, and the coverage area grows larger, and vice versa. As a result, the SF value must be established in advance of the modulation.

References

1. M. S. Moran, Y. Inoue, and E. M. Barnes, “Opportunities and limitations for image-based remote sensing in precision crop management,” Remote Sens. Environ., vol. 61, no. 3, pp. 319–346, 1997.
2. N. Wang, N. Zhang, and M. Wang, “Wireless sensors in agriculture and food industry—Recent development and future perspective,” Comput. Electron. Agric., vol. 50, no. 1, pp. 1–14, 2006.
3. Y.-D. Kim, Y.-M. Yang, W.-S. Kang, and D.-K. Kim, “On the design of beacon based wireless sensor network for agricultural emergency monitoring systems,” Comput. Stand. interfaces, vol. 36, no. 2, pp. 288–299, 2014.
4. T. Ojha, S. Misra, and N. S. Raghuwanshi, “Wireless sensor networks for agriculture: The state-of-the-art in practice and future challenges,” Comput. Electron. Agric., vol. 118, pp. 66–84, 2015
5. J. J. Cancela, M. Fandiño, B. J. Rey, and E. M. Martínez, “Automatic irrigation system based on dual crop coefficient, soil and plant water status for Vitis vinifera (cv Godello and cv Mencía),” Agric. Water Manag., vol. 151, pp. 52– 97 63, 2015.
6. K. Mekki, E. Bajic, F. Chaxel, and F. Meyer, “A comparative study of LPWAN technologies for large-scale IoT deployment,” ICT Express, vol. 5, no. 1, pp. 1– 7, 2019, doi: 10.1016/j.icte.2017.12.005.
7. P. P. Jayaraman, A. Yavari, D. Georgakopoulos, A. Morshed, and A. Zaslavsky, “Internet of things platform for smart farming: Experiences and lessons learnt,” Sensors (Switzerland), vol. 16, no. 11, pp. 1–17, 2016, doi: 10.3390/s16111884.
8. D. R. Harris and D. Q. Fuller, “Encyclopedia of Global Archaeology,” Encycl. Glob. Archaeol., no. February, 2014, doi: 10.1007/978-1-4419-0465-2
9. J. J. Dethier and A. Effenberger, “Agriculture and development: A brief review of the literature,” Econ. Syst., vol. 36, no. 2, pp. 175–205, 2012, doi: 10.1016/j.ecosys.2011.09.003
10. R. E. Evenson and D. Gollin, “Assessing the impact of the Green Revolution, 1960 to 2000,” Science (80-.)., vol. 300, no. 5620, pp. 758–762, 2003
11. G. Brunori et al., “CAP reform and innovation: the role of learning and innovation networks,” EuroChoices, vol. 12, no. 2, pp. 27–33, 2013
12. G. Spaargaren, P. Oosterveer, and A. Loeber, “Sustainability transitions in food consumption, retail and production,” Food Pract. transition. Chang. food Consum. Retail Prod. age reflexive Mod., pp. 2–31, 2012
13. S. E. Díaz, J. C. Pérez, A. C. Mateos, M.-C. Marinescu, and B. B. Guerra, “A novel methodology for the monitoring of the agricultural production process based on wireless sensor networks,” Comput. Electron. Agric., vol. 76, no. 2, pp. 252–265, 2011

DOI: https://doi.org/10.17762/turcomat.v9i3.13904 *Vol.09 No.03 (2018), 1136-1144*

14. M. Carlos-Mancilla, E. López-Mellado, and M. Siller, "Wireless sensor networks formation: Approaches and techniques," Journal of Sensors, vol. 2016. Hindawi Limited, 2016, doi: 10.1155/2016/2081902
15. M. S. Manshahia, "Wireless sensor networks: a survey," Int. J. Sci. Eng. Res., vol. 7, no. 4, pp. 710–716, 2016
16. A. Baggio, "Wireless sensor networks in precision agriculture," in ACM Workshop on Real-World Wireless Sensor Networks (REALWSN 2005), Stockholm, Sweden, 2005, vol. 20, pp. 1567–1576.
17. T. Arampatzis, J. Lygeros, and S. Manesis, "A survey of applications of wireless sensors and wireless sensor networks," in Proceedings of the 2005 IEEE International Symposium on, Mediterrean Conference on Control and Automation Intelligent Control, 2005., 2005, pp. 719–724.
18. Y. Rao, Z. Jiang, and N. Lazarovitch, "Investigating signal propagation and strength distribution characteristics of wireless sensor networks in date palm orchards," Comput. Electron. Agric., vol. 124, pp. 107–120, 2016
19. A. Raheemah, N. Sabri, M. S. Salim, P. Ehkan, and R. B. Ahmad, "New empirical path loss model for wireless sensor networks in mango greenhouses," Comput. Electron. Agric., vol. 127, pp. 553–560, 2016
20. M. Azaza, C. Tanougast, E. Fabrizio, and A. Mami, "Smart greenhouse fuzzy logic based control system enhanced with wireless data monitoring," ISA Trans., vol. 61, pp. 297–307, 2016
21. E. S. Nadimi, R. N. Jørgensen, V. Blanes-Vidal, and S. Christensen, "Monitoring and classifying animal behavior using ZigBee-based mobile ad hoc wireless sensor networks and artificial neural networks," Comput. Electron. Agric., vol. 82, pp. 44–54, 2012