IoT Based Covered Agriculture Monitoring and Control System with Smart Sensing and Forwarding Algorithm

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Abstract:
Internet of Things (IoT)-based monitoring and control device model can be used on farms. The proposed systems play an important role in data collection for the tracking system, as well as signal transmission to actuators in the control process. On top of this situation, IoT concept was implemented to link devices through the Internet and enable user access to knowledge. This device allows users to save money on supplies, cut costs, and monitor the output process on the field. The processed data will be sent to the monitoring system via MQTT with QoS level 2. Sensing and forwarding algorithm (SFA) was developed to reduce the power consumption of the data collection and processing unit. The obtained results show that the proposed algorithm has save about enhanced the system power consumption about 65% when compared to non-SFA operation.

Keywords: IoT, Raspberry, MQTT, Agriculture

Introduction

IoT has received a great deal of attention over the last decade because of a wide range of applications in industrial, biomedical observation, smart cities, agriculture, environmental monitoring, and many more. The Internet of Things (IoT) refers to the interconnection of physical devices used in our daily lives that use standard communications architectures to deliver new services to end users [1]. Furthermore, a power source provides the energy needed by the computer to execute the programmed tasks. This power supply is often a battery with a finite energy budget. Military applications such as frontline observation prompted the invention of wireless sensor networks. However, due to numerous limitations resulting from their low cost, small size, weight, and ad hoc manner of deployment; each sensor has limited energy, WSNs are still used in several civilian application areas, including environmental and habitat monitoring. Furthermore, since nodes can be placed in aggressive or uncomfortable environments, charging the battery can be inconvenient. The aim at network layer is to find ways for energy effective route setup and stable data relaying from sensor nodes to sink so as to increase network lifetime. The main distinction between a wireless sensor network and a conventional wireless network is that sensors in a wireless sensor network are very responsive to energy usage. Furthermore, the efficiency of sensor network implementations is strongly dependent on the network's lifespan [2] .

Technological advancements have also had an impact on agricultural crop production. Farmers can obtain information about crop growth parameters such as soil humidity, weather conditions, and light by using various sensors and wireless devices. Farmers can respond in a timely and appropriate manner based on the information they receive. Sensors collect data on the procedure of agricultural machinery, allowing operators to adjust machine operation to working conditions in order to improve the efficiency and quality of the production process [3].

Literature Survey

Nikesh Gondchawar et al. [4]suggested work on smart agriculture focused on IoT. The paper's goal is to make agriculture smarter by using robotics and IoT. Weeding, spraying, moisture detection, and other tasks will be performed by a smart GPS-based remote operated robot. Smart irrigation with smart monitoring, intelligent decision making according to accurate real-time field data, and smart warehouse management are all part of it. It keeps track of temperature, humidity, and theft detection

in the factory. All activities would be managed by a mobile computer, which will interface sensors, ZigBee modules, cameras, and actuators with a microcontroller and a Raspberry Pi. Using the Raspberry Pi and wireless networking, both of the sensors and microcontrollers were effectively interfaced with three Nodes. This paper discusses field operations, irrigation issues, and storage issues utilizing a remote-controlled robot for a smart irrigation system and a smart warehouse management system, respectively. Rajalakshmi P.et al.[5] identified using soil moisture sensors, temperature and humidity sensors, light sensors, and an automatic irrigation device to track the crop-field. The data from sensors is wirelessly sent to the web server, and JSON format is being used for data encoding to manage the server database. When the moisture and temperature of the agricultural field drops below a certain threshold, the irrigation device would be automatic. Farmers' cell phones get updates on a regular basis, allowing them to track field conditions from anywhere. Soil moisture sensor, temperature and humidity sensor DHT11, LDR utilized as light sensor, and web server – NRF24L01 used for transmitter and receiver are the parameters used here. This device would be particularly effective in places where water is scarce. The data from the irrigation device was saved in a MySQL database using a PHP script. R A Atmoko et, al. [6] proposed MQTT, as one of the data communication protocols for IoT, was proposed as a communication protocol. Temperature and humidity sensors were used in this study since physical parameters are often required as environmental condition parameters. Data was collected in real time and saved in a MySQL database. This research is also accomplished through a web-based and smartphone platform for online surveillance. The study's findings provide improved data consistency and durability utilizing the MQTT protocol. G. Rajakumar et, al.[7] the Soil Moisture Sensor in the Plant Watering System tests the moisture level in the soil, and if the moisture level is insufficient, Arduino activates a water pump to supply water to the plant. When the machine detects more moisture in the surface, the water pump shuts down automatically. When the device turns on or off the pump, a notification is sent to the consumer through the IOT module, updating the state of the water pump and the soil moisture. The crane design is used to add the water pump and spray engine. This machine is widely used in farms, gardens, and homes, among other places. It is fully automatic, and no human interference is needed. In addition, sensor readings are sent to a Thing talk channel to produce graphs for review.
The aim of this work was to introduce the Internet of Things principle in a monitoring and control system model applied to farm development processes. Furthermore, the key emphasis is on gathering real-time data and uploading only the different values of the sensors to the monitoring system, which will help to minimize the power usage of the Raspberry Pi, where power consumption is the main problem for IoT systems, as well as controlling irrigation and climate system.

Proposed System
The experimental work main components utilized to achieve the desired goal is shown Figure (1).

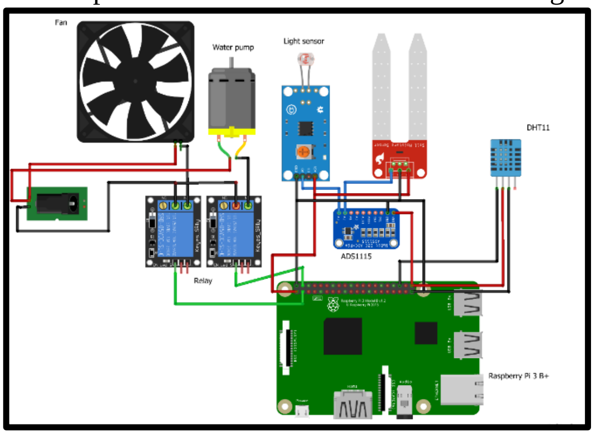

Figure 1: Schematic diagram of experimental device
The Raspberry PI 3 B+ is the main part of the system where the data collection and processing occur. The analog sensors of soil moisture and light intensity is connected via analog to digital converter model (ADS 1115), because Raspberry Pi has no analog port [8]. While DHT 11 temperature and humidity sensor is connected directly to the Raspberry Pi digital pin. Two relay modules are used to allow the control of a fan and water pump to control the climate and irrigation respectively.

Message Queue Telemetry Transport (MQTT)

MQTT is a lightweight broker-based publish-subscribe messaging protocol [9], used in this work to send the data from Raspberry Pi to the monitoring system. The MQTT protocol delivers application messages according to the three Quality of Service (QoS) levels defined. The delivery protocol is symmetric, and the clients and the broker can each take the role of either a sender or a receiver. The utilized QoS in this work is QoS level 2. Where messages are assured to arrive exactly once. This is for use when neither loss nor duplication of messages are acceptable [10].

Developed Algorithm

Sensing and Forwarding Algorithm (SFA)

The first purpose of the SFA algorithm is to sense the analogue data from the sensors connected to the Raspberry Pi via the ADS, while the digital sensor (DHT11) is connected directly to the Raspberry Pi. The Raspberry Pi is required to establish a connection with the MQTT broker before the actual data communication begins. Any device that is connected to the network and exchanges application messages through the MQTT broker requires an MQTT client. Therefore, an MQTT client is installed on both publisher (Raspberry Pi) and subscriber devices (monitoring server) to connect, disconnect, publish and subscribe data. The Raspberry Pi must specify a topic to publish data to the MQTT broker, and only the device that is subscribing to the same specified topic can receive that data from the MQTT broker. By establishing connections between the Raspberry Pi and the MQTT broker based on MQTT QoS (2), the important decisions taken are based on the SFA algorithm. Each sensor senses 7 bytes of data, obtained by sensing events from the test section. It is now proposed that the SFA algorithm also checks and compares simultaneously collected data with the previous record for each sensor individually. If the collected data in each sensor is not equal to the previous record, then it is sent to the broker via the internet. Otherwise, the SFA protocol detects no change in the data and then filters the duplicated data out and thus this data is not sent to the broker. As a result, the Raspberry Pi antenna goes into sleep mode. Of course, in the first round, all the collected data is sent to the broker because there is no previous data record for comparison. As a result, the proposed scheme minimizes the processing and transmission time for the Raspberry Pi. This, in turn, helps minimize the energy consumption of the Raspberry Pi. It also reduces the delay time and bandwidth used over the entire path of the network and improves the performance of the end-to-end system. The flowchart of the proposed algorithm to sense and forward the data is presented in Figure (2).

Remote Monitoring Systems

The system aims to monitor the condition, sensors and IoT device (Raspberry Pi). Here, the Raspberry Pi acts as the gateway, connecting the sensors to the internet. The data is gathered by the sensors and forwarded to the Raspberry Pi which uses its Wi-Fi connectivity to establish the connection and disseminate the data to the monitoring server (end-user) based on the MQTT broker. On the monitoring side, each item of data that is sent by each sensor requires the plotting of an individual sub-figure. Therefore, the end-user has a dashboard for displaying and the data for each sensor.

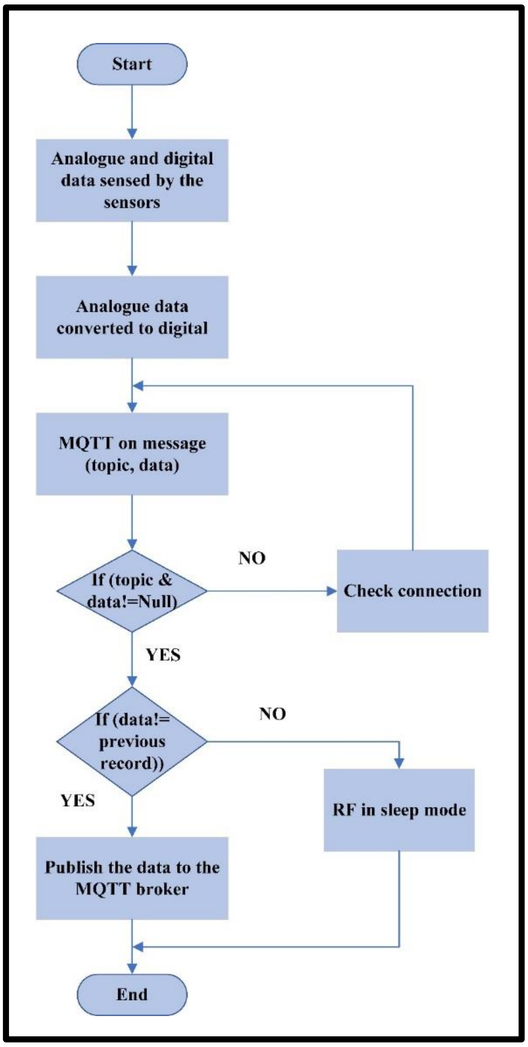

Figure 2: Flow chart of the SFA algorithm

Results and Discussions

Figures (3 to (5) show the graphic display of the data received from the sensors. Each figure presents the data from a particular sensor, and each has two panels. In each case, the upper panel, labelled (a), presents the actual data gathered by the sensor. The lower panel, labelled (b), presents the data published, transmitted from the Raspberry Pi to the monitoring server based on SFA policy. The SFA protocol eliminated the continuous reading of similar data and drops these data before published it to the MQTT broker.

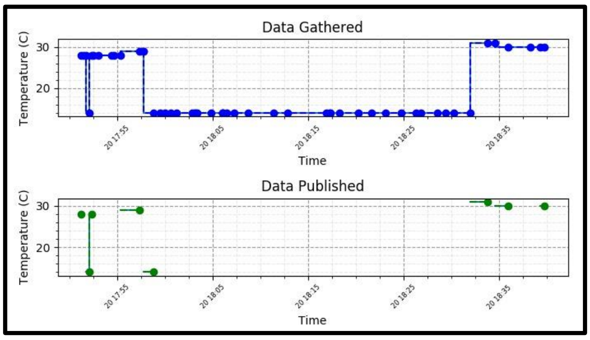

Figure 3: Temperature data

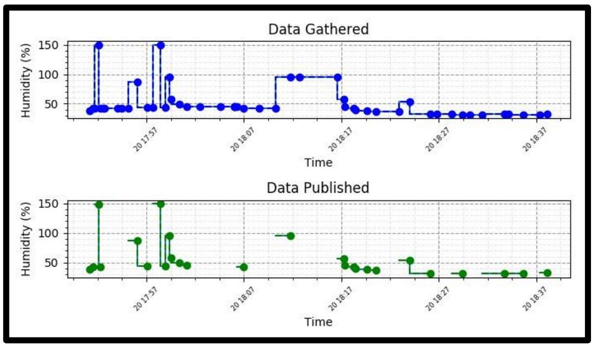

Figure 4: Humidity data

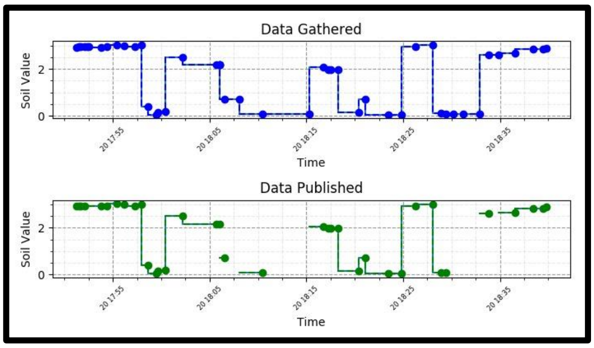

Figure 4: Soil moisture data

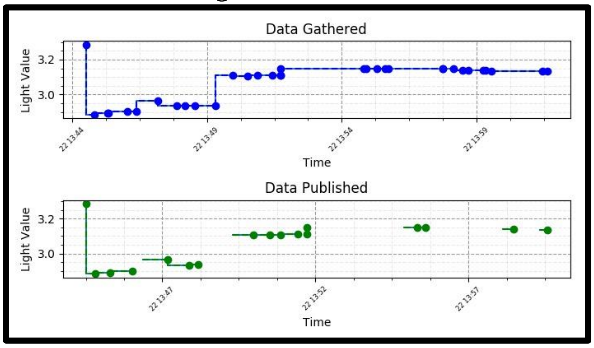

Figure 5: Light intensity data

For the operation period of the system of about 90 min, the total number of data transmission is 86 where only 34 data gathering were different. Each transmission of data cost about 0.11A so from this it can calculated that the proposed algorithm saves about 5.72 A which is about 29 watts. While if the system used without the SFA algorithm, the total power consumption would be about 48 watts. It can be noted that the SFA algorithm enhanced the system power consumption about 65% when compared to non-SFA operation.

Conclusion

The 'Internet of Things' is a far and large castoff in terms of connecting computers and collecting data. This agriculture monitoring system is reliable and effective, allowing for action to be taken based on the sensors data along with utilizing smart filtering algorithm to repetitive data, that can consume a necessary power. This paper's IoT-based monitoring and control device model can be used on farms. Autonomous sensor systems play an important role in data collection for the tracking system, as well as signal transmission to actuators in the control process. The Internet of Things-based device will attach physical objects on the farm and make them accessible through the Internet, allowing users to remotely track conditions and processes.

References

[1] L. Farhan, S. T. Shukur, A. E. Alissa, M. Alrweg, U. Raza, and R. Kharel, "A survey on the challenges and opportunities of the Internet of Things (IoT)," Proc. Int. Conf. Sens. Technol. ICST, vol. 2017-December, pp. 1–5, 2017, doi: 10.1109/ICSensT.2017.8304465.
[2] Z. Rezaei, "Energy Saving in Wireless Sensor Networks," Int. J. Comput. Sci. Eng. Surv., vol. 3, no. 1, pp. 23–37, 2012, doi: 10.5121/ijcses.2012.3103.
[3] D. Markovic, R. Koprivica, U. Pesovic, and S. Randic, "Application of IoT in monitoring and controlling agricultural production," Acta Agric. Serbica, vol. 20, no. 40, pp. 145–153, 2015, doi: 10.5937/aaser1540145m.
[4] J. M. P. Prathibha S R, Anupama Hongal, "IOT BASED MONITORING SYSTEM IN SMART AGRICULTURE," Int. Conf. Recent Adv. Electron. Commun. Technol., 2017, doi: 10.1109/ICRAECT.2017.52.
[5] P. Rajalakshmi, "IOT Based Crop-Field Monitoring And Irrigation Automation," 2018 2nd Int. Conf. Inven. Syst. Control, no. Icisc, pp. 478–483, 2018.
[6] R. A. A. R. R. M. K. Hasin, "IoT real time data acquisition using MQTT protocol," J. Phys. Conf. Ser., 2017, doi: 10.1088/1742-6596/853/1/012003.
[7] D. S. S. P. U. M. Dr.G.Rajakumar M.Saroja Sankari, "Iot Based Smart Agricultural Monitoring System Dr.G.Rajakumar1," sian J. Appl. Sci. Technol., vol. 2, no. 2, pp. 474–480, 2018.
[8] S. P. Sheshank Reddy Y, S. E. Saif, and M. Joseph Assistant Professor, "The Real Time Temperature Sensing using Raspberry PI," IJIRST –International J. Innov. Res. Sci. Technol., vol. 1, no. 12, pp. 232–237, 2015, [Online]. Available: www.ijirst.org.
[9] D. Soni and A. Makwana, "A survey on mqtt: a protocol of internet of things(IoT)," Int. Conf. Telecommun. Power Anal. Comput. Tech. (Ictpact - 2017), no. April, pp. 0–5, 2017, [Online]. Available: https://www.researchgate.net/publication/316018571_A_SURVEY_ON_MQTT_A_PROTOCOL_OF_INTERNET_OF_THINGSIOT.
[10] S. Lee, H. Kim, D. K. Hong, and H. Ju, "Correlation analysis of MQTT loss and delay according to QoS level," Int. Conf. Inf. Netw., no. January 2013, pp. 714–717, 2013, doi: 10.1109/ICOIN.2013.6496715.