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PLC BASED INDUSTRIAL IOT FRAME WORK FOR ARECANUT AGRICULTURE LAND FOR SMART IRRIGATION

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Abstract: Internet of Things (IoT) has been widely used in many applications. The trend of IoT has been extensively popularized in the last decade. Many researchers have persuaded the research on IoT. Among them, some researchers concentrated on developing IoT prototypes for industry applications. Some others have concentrated on medical applications and some have focused on home automation. The researcher's paper giving information about the IoT framework is very scanty. Therefore, this paper focuses on developing the IoT framework and simulated prototype for artificial control and monitoring areca nut agriculture farmlands. The SCADA software is used to simulate the temperature, humidity sensor, and soil sensor in the areca nut agriculture field. The simulated data has been sent to IoT to thingspeak.com IoT server using ESP8266. The efficiency of water consumption, efficiency in data congestion, and some related parameters by the proposed model are considered and compared with the conventional wireless protocols. The comparisons of the proposed IoT framework for sensor communication with conventional methods have been successfully conducted and overcome the limitations.
Keywords: IoT, CROPWAT, PLC, SCADA, RS Logic

1. Introduction

The vision of IoT technology is to create a smart environment in the sensor system. Much research work has been conducted to develop an IoT framework to simulate and conceptualize the agriculture scenario. Many publications have been come out regarding the IoT framework. Around 16515 publications come out from IEEE explore. Around 12911 publications come out from ACM publications. Springer has published around 76341 papers on IoT to date. Elsevier has published 26323 papers on IoT [1]. From the literature survey we have summarized the goals of IoT research from different researchers is as follows:

a) Light weight protocol
b) Energy efficiency
c) Congestion
d) Security
e) Identification, addressing and discovery
f) Data
g) Connectivity
h) Miniaturized devices

In lightweight protocol, Sang-soon Lim et al., concentrate on RPL, NanoIP, TSMP protocols up-gradation [2] Laith Farhan et al., concentrated on the improvement of energy efficiency [3]. Hanan aldowah et al. concentrated on the security issues concerned with IoT sensor networks [4]. Silvia Krug et al. focused on data transmission rate, delay, and miniaturizing the sensor devices [5].

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Many different approaches have been persuaded by researchers to simulate the IoT framework to monitor and control industrial and agriculture processes using PLC, SCADA. PLC software is used by many industries to maintain a high quality of reliability. It consists of an embedded system and communication system with WSN to achieve control wirelessly. The use of wireless IoT sensor networks leads to a considerable reduction in the use of a cable and also the ease of the fault detection system.

The IoT wireless network methodology may make the world smarter and also extensively faster than communication techniques like Zigbee, Wan, Bluetooth and PAN. This successfully overcomes the latency and data speed problems compared to conventional wireless protocols like Bluetooth, Zigbee, WAN and PAN. Using IoT network we can directly interact with objects. Use of a greater number of cables are greatly reduced. The amount of savings in cables quantity is explained in the following section.

n this paper we have concentrated the water consumption, data congestion, and false alarm and connectivity issues with IPV6 protocol. The complete sensor modelling with threshold test has been conducted in Allen Bradly SCADA branded factory talk studio software. The proposed IoT framework is tested for different environmental conditions viz., rainy season, summer season and winter season. The NPK value of the sensor calculated based the PH level reading of the simulated sensor. The NPK calculation based on the PH value is explained the following section.

2. Proposed model

The proposed model is conceptualized to design the sensor bed for the one acre of areca nut farm land. For the simulation we have considered 10Sq feet area of land. According to guidelines of horticulture department of India, farmers can plant 500 to 530 arecanut saplings per acre of land. The spacing between arecanut plants is around 8ftx8ft. According to this spacing around 3 to 4 plants is taken for consideration of simulation experimentation.

The proposed model consists of novel idea that fixing the threshold level for each sensor to actuate the alarm. Because aggregated data in agriculture farm land is not preferable [6-9] and also huge data from multiple sensors cause the congestion which impact the QoS to Communicating IoT server. The reason behind not preferring aggregated data in agriculture scenario is that, each tree has different temperature, humidity, PH value as its threshold. Some trees need less water consumption and some needs more water consumption. This property of diversity makes the designer to fix the threshold to individual tree. This idea may greatly reduce the data congestion in IoT server. As we have considered three trees for simulation, we analyzed the data of 9 sensors. The Temperature and humidity are data is readout directly but the PH values sensor data is processed mathematically to get the NPK value of the soil under the arecanut plant [10]. The calculation of NPK value using PH sensor data is shown in the 1equation (1).

The proposed model has an idea of installing the sensors to each tree so that the receiving sensor will receive the different data from each tree. The humidity,

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temperature and PH level is changing from tree to tree. Therefore, the proposed model has an opportunity to have the threshold based on the need of the tree. The technique of sensing the need of individual tree will greatly reduce the water consumption. The proposed model with IoT server is shown in the Figure 1.

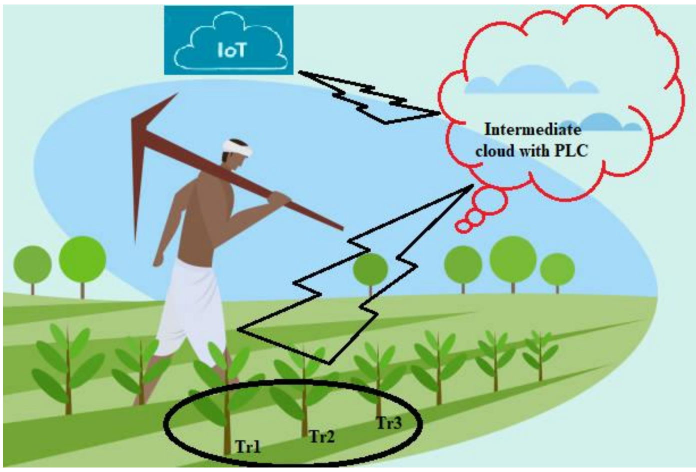

Figure 1: Proposed model for IoT frame work to areca agriculture farm land

The proposed model has PLC analyzing software at the intermediate cloud which segregate the data and select only the data from the sensor which is above the threshold. Then, only the data which is above the threshold level will be sent to IoT server to actuate the sprinkler fixed at the particular tree. The trees in the entire farmland is allocated with Id Tr1, Tr2, Tr3..., as shown in Figure 1. The algorithm flow diagram of the proposed model is shown in Figure 2.

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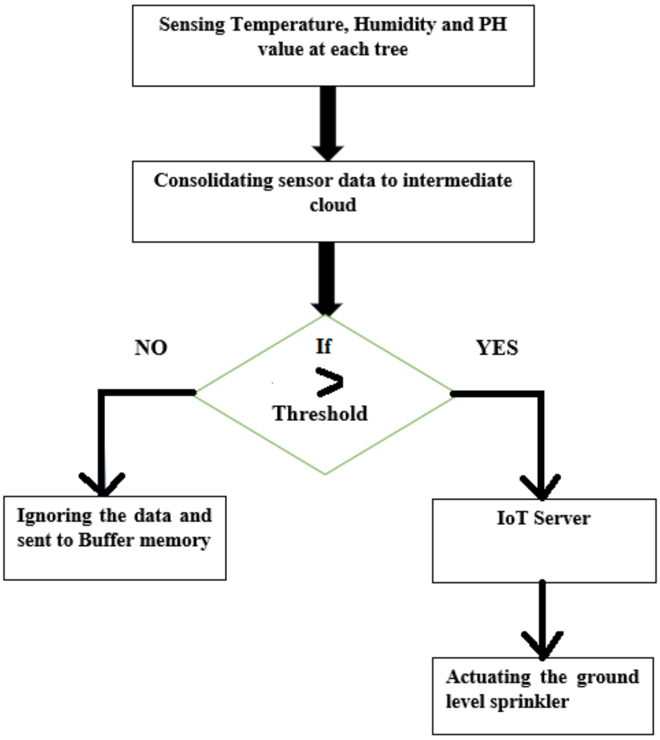

Figure 2: Flow chart of the proposed algorithm

3. Simulation

The simulation is performed using allen bradly brand SCADA software, the logic of sensor data transfer and threshold crossing scenarios are codded in RS logic500. Then the designed logic is tested in RS logix emulator 500. The designed logic is executed to front end HMI using factory talk view studio. Three temperature sensors, three humidity sensors and three PH sensor are taken for test simulation. The favourable temperature for arecanut ranges from 25 °C to 37 °C [11]. The test simulated data logging of temperature in SCADA system in 10sq feet of areca farm land is shown in Figure 3. As the favourable temperature for areca nut is 25 °C to 37 °C, the red alert is observed in the simulated data of Figure 3 which indicates that the data is out the threshold range and it indicates plant needs some actuation. This data from red alert will immediately sent to IoT server from intermediate cloud with SCADA PLC system. The data from the green indicator is not sent to IoT server which indicated no action is required for particular tree, only the data from the red indicator is segregated by PLC in intermediate cloud and sent to IoT server for further action.

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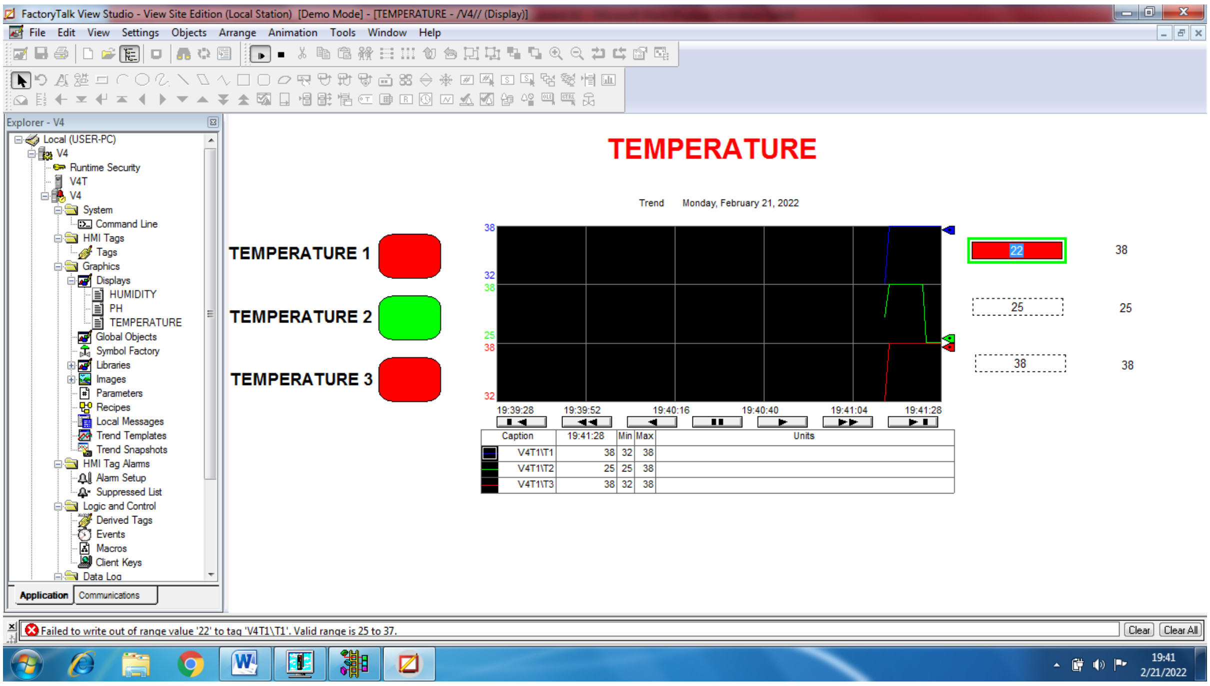

Figure 3: The real-time test simulation of temperature sensor data in SCADA

The test simulated data logging of humidity sensor in SCADA system in 10sq feet of areca farm land is shown in Figure 4.

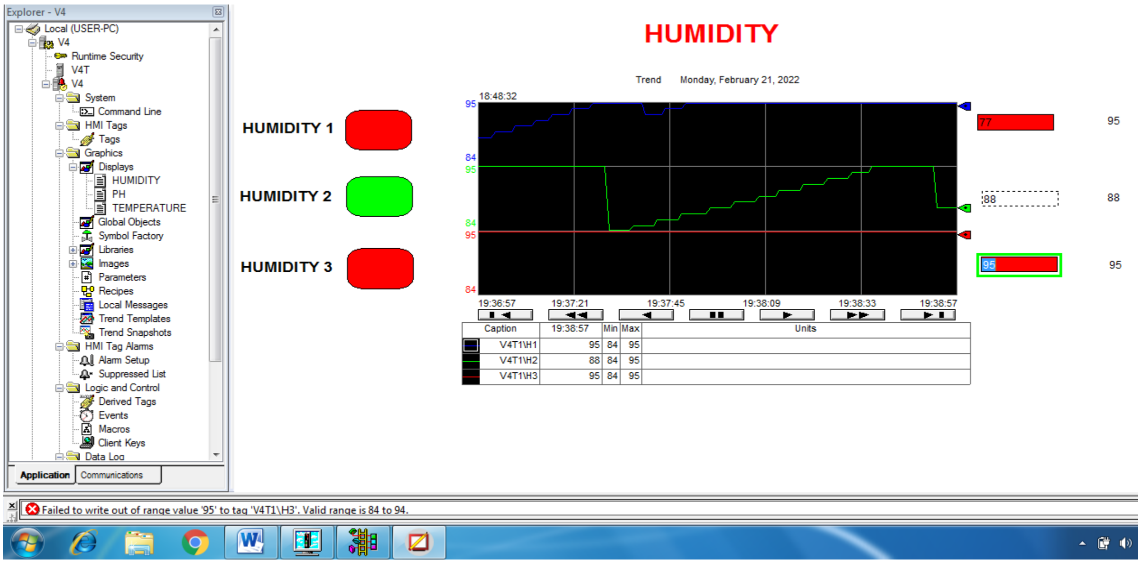

Figure 4: The real-time test simulation of humidity sensor data in SCADA

The test simulated data logging of PH sensor in SCADA system in 10sq feet of areca farm land is shown in Figure 5.

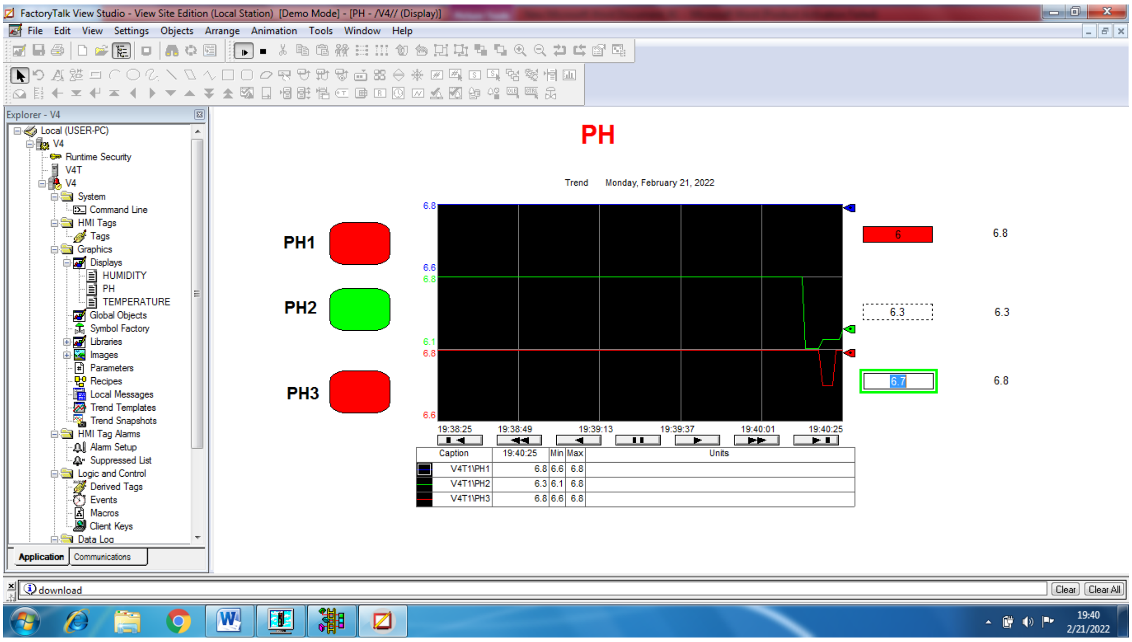

Figure 5: The real-time test simulation of PH sensor data in SCADA

Results and discussion:

The proposed algorithm for IoT framework to monitor the agriculture farm land is executed in this work. the arecanut farming scenario is taken for consideration in the simulation. The results obtained in the simulation and the comparison of the obtained data with conventional communication methods for WSN is discussed in this section.

a) **Efficiency in data congestion**: The network congestion is the most common problem in all the communication methods. This occurs due to the overload of packet data transmitting through the network. This overload occurs when data transfer through the network more than its capacity. This congestion causes the loss of connectivity from the sensor node to server. The proposed algorithm has shown considerable increase in the efficiency of the network with respect to the congestion. As only the data above the threshold is transmitted to the main IoT server, the communication network has very less traffic and the congestion has greatly reduced. The comparison of network congestion efficiency of proposed IoT network communication with conventional communication methods is shown in Figure 6.

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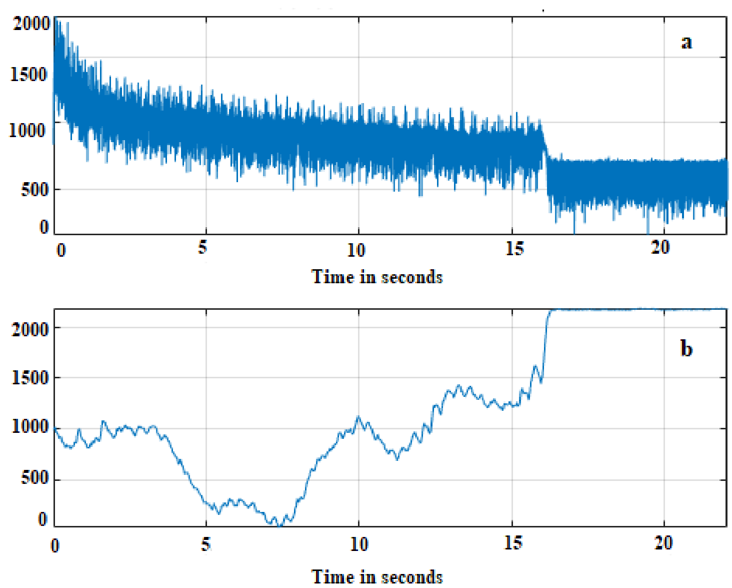

Figure 6: The comparison of network congestion efficiency of proposed algorithm

(a) congestion traffic monitoring of sensor data transmitting through Bluetooth protocol model HC05 (b) congestion traffic monitoring of sensor data transmitting through ESP8266 IoT wifi using proposed algorithm

b) **Connectivity issue:** The connectivity issue has been greatly solved by this method of segregating the data in the intermediate PLC server. Due to the very light traffic in network the connectivity with main server is continuously maintained in turn on state for 24x7 hours. This continuity helps to monitor the target area in real time with more accuracy. The efficiency of network connectivity of the system can be analyzed based on coverage area, Power consumption, Data throughput and latency of the data transfer through the network. The comparison of connectivity parameters of the proposed algorithm with IoT main server communication is compared with conventional communication methods and the results are reported in the Table 1.

Table 1: comparison of connectivity parameters of the proposed algorithm with IoT main server estimated using Traffic generator 5.6.

Connectivity parameters	Proposed algorithm using ESP8266 WIFI	Bluetooth	Zigbee
Coverage	400mtr	200mtr	250mtr
Power consumption	4.5V 80milli Amps	3.6V 100mA	4V 135mA
Data throughput	430Mbits/sec	300Kbits	900kbps
Latency	32 milli seconds	258 milli seconds	145 milli seconds

c) **Data speed:** The proposed algorithm uses ESP8266 Wi-Fi for communication. The data speed achieved in the proposed communication algorithm is 7.2 Mbps. The data speed achieved for the proposed algorithm in IoT framework experimental set up is shown in the Figure 7. The maximum data speed of Bluetooth HC05 is 2.1mbps uploading and 160kbps for downloading. The maximum data speed for ZigBee is around 250kbps. Therefore, by observing the results of data achieved in the proposed IoT framework, we can conclude that, the data speed of IoT framework using Wi-Fi module has achieved considerably very high-speed data transfer compared to Bluetooth and ZigBee.

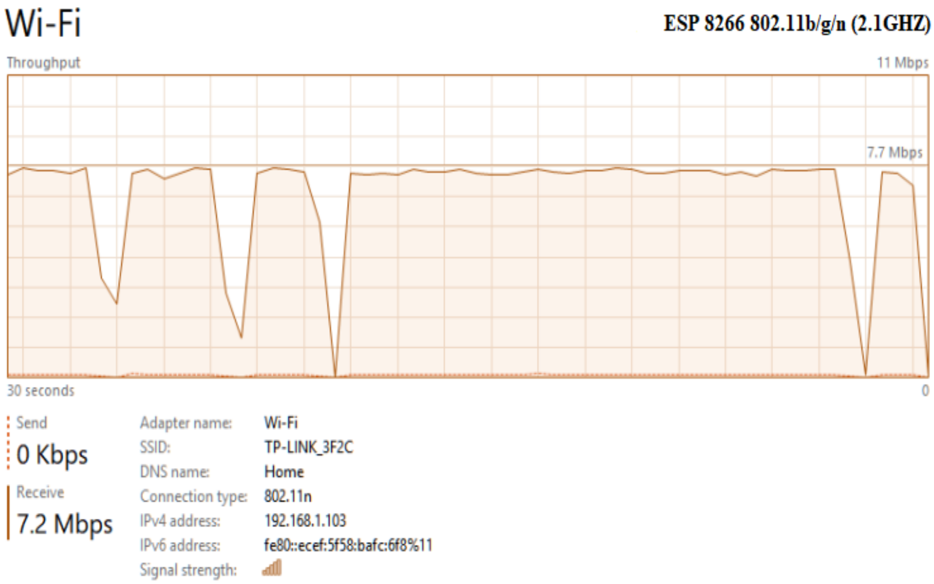

Figure 7: The data speed of proposed algorithm in IoT framework

d) **Percentage of false alarm:** The percentage of false alarm is greatly reduced by proposed algorithm due to the installation of threshold decisive PLC software in the intermediate cloud. Due to the continuous data from the multiple sensors the false alarm problem will occurs in the network. This causes the false data transmission to the main server to actuate the output. This problem has been successfully encountered by this decision algorithm that segregate the data before transmitting to main IoT server. This process greatly reduces the possibility of transmitting the false data to main server. The percentage of false alarm in the span of 24 hours of data fetching the from the sensor. The false data transmission rate reported for the proposed algorithm in comparison with the conventional method is shown in the Figure 8. The false alarm rate is defined as the ratio of data above the threshold mistakenly detected as below the threshold or vice versa to the total number of alarms. The FAR is given by equation 1.

$$\mathrm{FAR} = \frac{x}{y}$$

Equation (1)

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Where,

x = Number of data bits above the threshold mistakenly detected as below the threshold or vice versa.

y = Total number of alarms

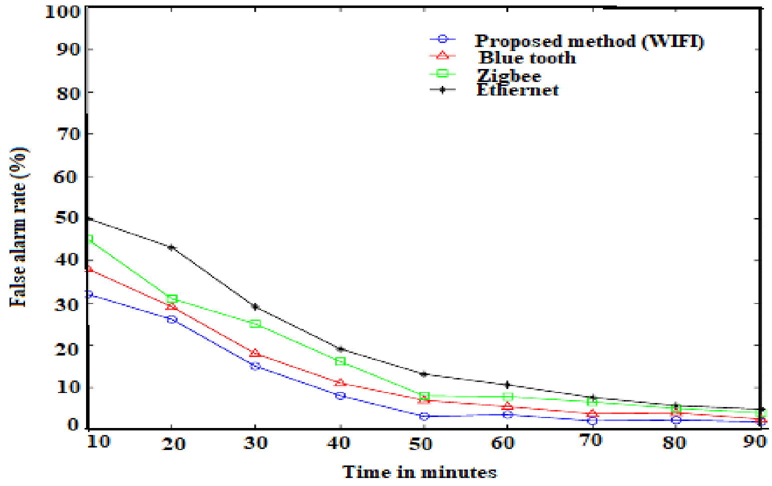

Figure 8: False data rate reported for the proposed algorithm for IoT frame work in comparison with conventional communication protocols.

e) **Redundancy:** Due to the mechanism of switching the actuation to on and off based on threshold level. The possibility of transmitting same data for long time is greatly reduced in this algorithm. The data transmitting continuously will stop once the actuation of the sprinkler is taken place. The data transfer to main server is stopped immediately after the actuation of sprinkler. This process reduces the redundancy the efficiency of redundancy results has been shown in the Figure 9. Increased redundancy always wastes the memory of the server. So, the efficient system should avoid the redundancy in the network.

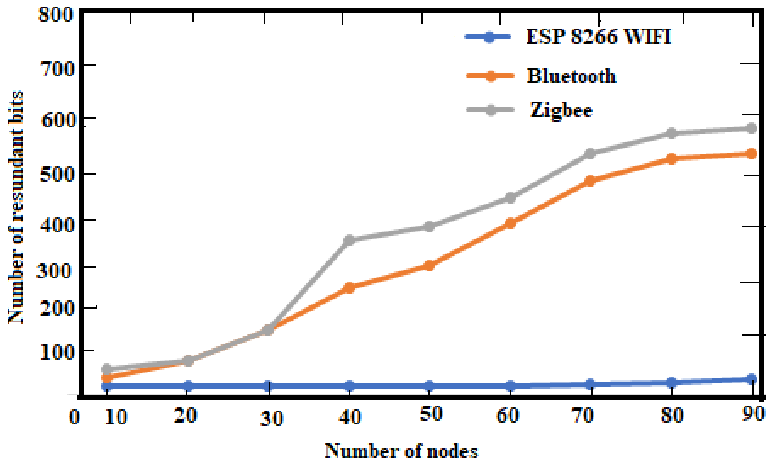

Figure 9: The redundancy of the proposed algorithm in comparison with convention methods.

f) **Efficiency of water consumption in summer season:** The water consumption for the crops is analyzed by evapotranspiration techniques [12]. The results of water consumption are estimated using the CROPWAT 5.7 software for the proposed algorithm in IoT framework. The water consumption estimation for the proposed algorithm in comparison with manual irrigation method is tabulated in the Table 2.

Table 2: The comparison of water consumption in manual irrigation with proposed IoT framework enable irrigation estimated in CROPWAT 5.7

Month	Liter/tree/day in Manual irrigation	Liter/tree/day in IoT enable irrigation
Jan	16	14
Feb	16	13.8
Mar	22	18.2
Apr	20	17.7
May	20	18.2
Jun	18	16.8
Jul	16	15.2
Aug	17	16.4
Sep	16	15.2
Oct	15	13.9
Nov	15	14.2
Dec	15	13.5

Conclusions:

In the present research work the IoT algorithm is proposed which has intermediate cloud with PLC decision software. The decision PLC software has successfully improved the performance in data congestion management, data speed, redundancy, False alarm rate. The estimated water consumption on implementing the proposed algorithm in large scale for real world augmentation. The real-world water consumption estimation is simulated in the CROPWAT 5.7 software. The estimated results show that, the water consumption has reduced in the IoT enabled irrigation method compared to manual irrigation method.

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