

Zigbee Based Monitoring System for Intelligent Green Roof Ecosystems

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ABSTRACT: Green roofs are constructed primarily because they provide valuable ecosystem services to humans and the urban environment. Monitoring them undergoes the variety of challenges including the collection of data from the sensors and incorporating how irrigation process is handled in the field along with the management and interpretation of collected sensory data. The proposed Zigbee based monitoring systems deals with the design of an automated fuzzy system for monitoring, controlling the shading and irrigation process. In this paper, the fundamental design and implementation of WSN featuring a Zigbee Technology together with the IEEE 802.15.4 compatible transceiver and the simple water irrigation control circuit is also proposed. The system consists of local station and base station which is equipped with the Zigbee transceiver. The location station consists of various sensors and Arduino microcontroller. This microcontroller reads and frames the readings and it is forwarded to the base station via Zigbee network. The base station is embedded with the fuzzy logic DSS framework is designed for the irrigation process. Before irrigation process the system monitors the status of rain using acoustic sensor. After that irrigation process is designed through the fuzzy controller system for automatic water valve ON/OFF. The developed platform is cost-effective and allows easy customization. The experimental results show that the system can quickly and accurately calculate water demand amount of plants, which can provide a scientific basis for water-saving irrigation. Several preliminary results of measurement reveal the reliability and effectiveness of the system.

KEYWORDS: Zigbee, Arduino, DSS, Simulink, Acoustic, Water Irrigation Control.

I. INTRODUCTION

Now a day's shortage in water resources occurs due to the process of industrialization. Water resource is in severe shortage and agricultural water consumption accounts for about 80% of total water consumption. The water demand for garden surrounding urban areas becomes questioned every day. Green roofs are heralded as "sustainable building practice" in cities uses waste water from the urban buildings for their irrigation process. Aiming for greener city and good use of recycled waste water resources, this paper lay ahead intelligent green roof ecosystems [1].

A wireless sensor network model is used for precise monitoring for rooftop gardens. Under monitoring process, water reservation control is the critical facility in the irrigation system for rooftop gardening. The recycled water from the buildings is stored in the reservoir. It is vital to make sure that amount of water in reservoir are preserved at its appropriate level.[7] Various kinds of sensors like temperature sensor, humidity sensor, soil moisture sensor and other sensors are deployed in rooftop area for monitoring and sent the received data to the base station for automatic irrigation and gate movement in reservoir. One important way to decrease the utilization rate of water is to implement precise controlled irrigation on the basis of demand data of water for plants. Therefore WSN is especially appropriate for precise irrigation. In general, Bluetooth, UWB, Zigbee and Wi-Fi are the four protocol standards have been widely used for short range communications in recent years [2]. As compared with other protocol standards zigbee has low data rate and fulfill the requirement for a low cost, easy to use, minimal power consumption and reliable data communication between sensor nodes [7].

Applying traditional irrigation method will fail to satisfy water saving constraint. It is pretty complicated to set up accurate mathematical model because of its large inertia, non linear and delay characteristics. Fuzzy control does not need to establish the mathematical model for controlled objects. Because of system sturdiness, purpose of water saving irrigation shows broad aspects [5]. After comprehensively analyzing on all the investigation at habitat and overseas, it was found out that there was controlled program that utilizes the combination of wireless sensor and fuzzy controlled technique for irrigation. Fundamental of fuzzy theory and its application in various aspects of agriculture science is presented in the survey paper [6]. This paper suggests the possible fuzzy logic based framework for DSS (Decision Support System)[4] integrating soil characterization, evatranspiration and prediction of available soil water at root zone. All these three factors are important to irrigation scheduling. By using Zigbee network [3], the information gathered from the various sensors helps to solve the transmission problem in irrigation field. By using fuzzy controlled system, by controlling irrigation time, helps to irrigate scientifically according to precision and necessity, thus improves the limited use of water resource.

II. SYSTEM ARCHITECTURE

The proposed intelligent ecosystem architecture for green roof garden is given in fig 1. The fundamental design and implementation of WSN featuring with IEEE 802.15.4 compatible transceiver are meant to establish the communication between base station and location station. In case of monitoring the single rooftop garden, a location station is enough to handle the irrigation. But for the urban apartments, base station is employed to irrigate the areas. The water level condition and gate movement data are sent over wirelessly with the other sensor information to the main monitoring base station for remote controlling of irrigation system through zigbee transceiver. The flow of water will be measured in real time by the sensor send data to the location station. Irrigation process is determined by the base station with the help of sensor information through microcontroller. The location station reads each sensor readings through the Arduino microcontroller that coordinates the watering process in base station through fuzzy logic based DSS framework. The base station is the stand alone model; it sends the control to the microcontroller for the automatic irrigation, when the user is absent. Base station capability is extended to monitor the several more facilities covering the rooftop area like monitoring rain status through acoustic sensor and send an alert to the microcontroller. Communication signals from the sensor network and irrigation controller were interfaced using low cost zigbee protocol. Location station consists of four parts sensor node cluster, and irrigation controller and irrigation pipe network and base station has coordinator node. Irrigation pipe network is placed on irrigated areas and electric control valves are installed on the pipelines. Deployment of various sensors such as temperature, humidity, soil moisture, acoustic, light sensors are grouped to form sensor node cluster according to the plant conditions and watering status of plants. Each node is responsible for gathering atmospheric conditions and sends information via coordinator node to the microcontroller with certain time interval. When arduino microcontroller receives information it sends the signal to the base station through zigbee transceiver. Fuzzy logic embedded with the base station carried out fuzzy inference and fuzzy decision in order to decide when to conduct water or not and how long the irrigation time should be. The base station sends the control to the microcontroller or the irrigation controller via zigbee transceiver. The microcontroller open or turn off the irrigation valve through the relay circuit inbounded in the irrigation pipeline. Thus the closed loop irrigation network control system is formed and it can implement water saving irrigation to plants.

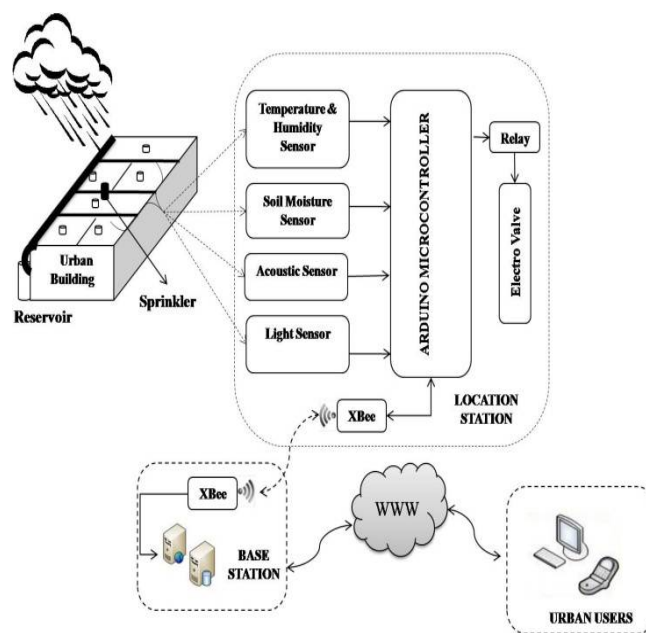


Fig.1 Architecture for Monitoring Roof Garden

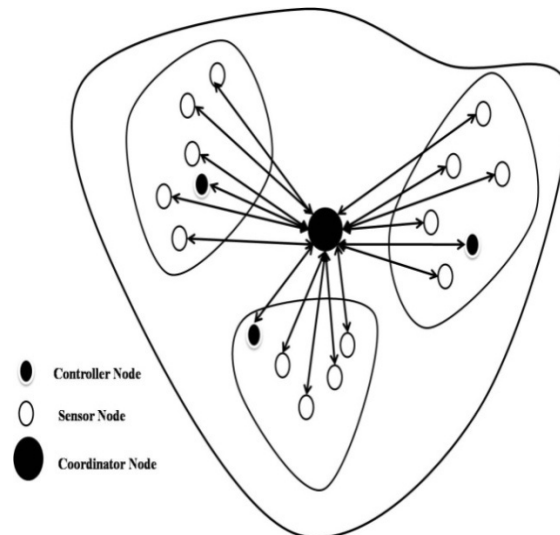


Fig.2 Intelligent Irrigation Network

The architecture has mainly three main tasks, data acquisition module, data communication module and automatic irrigation control module to design a system combining hardware with software. Except for the first module which only requires hardware implementation, the other two modules require imbed system knowledge to realize the zigbee protocol.

A. Data Acquisition Module

This module includes location station which is responsible for collecting atmospheric information and forwards it to the base station. Location station consists of sensor nodes such as temperature sensor, humidity sensor, soil moisture sensor, light sensor and acoustic sensor. The data acquisition module occupies Swiss Sensiron company productions, digital temperature and soil humidity sensor chip SHT11 type. Because of humidity measurement ranges from 0 RH to 100% RH and the temperature measurement ranges from -40 °C to 124 °C and its accuracy is +0.4 °C , responsive time is less than 4s and low power consumption is 30 mW. SH11will intensify temperature and humidity sensor to adjust, combine all second line interfaces in one chip and integrate CMOS with sensor technology so it could able to overwhelm many disadvantages like poor term stability, poor interchangeability, complicate designs in circuit and humidity influenced by circuit.

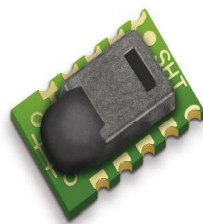


Fig.3 SHT11 sensor

In this project capacitative soil moisture sensor has been urbanized based on frequency division relectometry (FDR) [12]. Soil moisture sensor readings ranges from 11500 to 23000Hz. When the sensor placed in the soil gets dry, we get the high frequency readings from 22000-23000Hz and when gets wet, the readings ranges from 11500-12000Hz. The cheap soil moisture sensor consists of two probes (metal rods) held apart at a fixed distance by some insulating material over the structure of planar. Entire structure is connected to the IC555 timer circuit and the planar structure is inserted in the soil having two connectors to the arduino. The probe is laminated to avoid the sensor from getting short when placed in water. The system uses LDR to measure the light intensity and which would be provided to the arduino controller board to take necessary actions. The arduino based acoustic sensor gathers rain rate and RMS voltages. This sensor connects to the arduino controller inbounded with the arduino Ethernet shield and it is assemble up with the Zigbee transceiver, which connects to the network for remote data access through base station. This comprised of uninterrupted solar power supply, microphone and sound proofing materials.

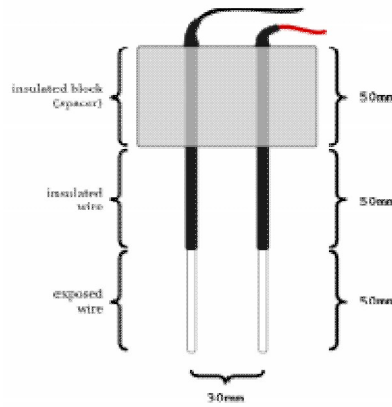


Fig.4 Soil Moisture Sensor

This measures the voltage, produced by the vibrations in the electrets microphone, and calculates the acoustic signal power. The sensor logs the acoustic signal power data in a CSV file and it is written in the mounted SD card. Using zigbee protocol the data files can be sent to the base station for the action to take place during irrigation process.



Fig.5 Acoustic sensor

B. Data Communication Module

The base station is in charge of starting a network and managing it to a convinced level. The location station consists of zigbee module that receives data from the sensor nodes wirelessly. As the coordinator needs to receive data continuously, it normally solar powered and main powered. Data received by the controller sent to the base station through the same zigbee module. Unlike Bluetooth technology, zigbee could support over a distance of 50 meters. Our irrigation system based on tree network because comparing all routing network this is the only network which provides sleep mode. And they provide low routing cost because they are in need, to send data to microcontroller through cluster head or coordinator node.

For data processing, we select Chipcon’s SOC chip CC2431 assimilate high performance zigbee transceiver integrated with arduino microcontroller. It supports zigbee low rate communication standards. Zigbee transceiver consumes 24~27 mA. Arduino microcontroller supports 4 grade low power node including storage and processing data collected by itself. Coordinator node connects to the irrigation controller through zigbee transceiver and automatically shut down to reduce power consumption. Energy supply modules CR2032 is selected due to its responsible for energy supply of entire node.

III. FUZZY LOGIC BASED DSS

Decision support system is the computer based system, which provides useful decisions on the basis of available data in case of partially known system; farming is the best contender to use fuzzy theory. An effective DSS needs accurate data set [7]. Availability of data like temperature, humidity, soil moisture is not always possible to collect accurately. It is quite natural to understand and define many variables in agricultural science in linguistic variables. Consideration of variable as a linguistic variable is suitable to fuzzy logic. Presented DSS for irrigation scheduling will be able to estimate variable factors. Fuzzy5 rule based computation is proposed for soil characterization, calculation of evatranspiration and daily management depletion d_{MAD} . Due to evatranspiration, soil moisture decreases continuously. Decision for irrigation has been taken on comparison of daily MAD (d_{MAD}) depends on available water capacity (AWC) and root zone of crop[7]. This relation is shown in the below equation,

$$d_{MAD} = \left(\frac{MAD}{100}\right) \times AWC \times D_{RZ} \dots\dots\dots (1)$$

Where,

D_{MAD} = Daily Management Allowed Depletion (mm),

MAD = Management Allowed Depletion (%),

AWC = Avail. Water Capacity in mm water/mm soil,

D_{rz} = Root Zone of Crop in mm.

Fuzzy inference system of root zone depth classifies it in linguistic variables like initial stage, crop development stage, mid season stage. Use of fuzzy logic gives accurate estimate of depth zone without actually measuring the root zone depth and to decide timing and amount of irrigation.

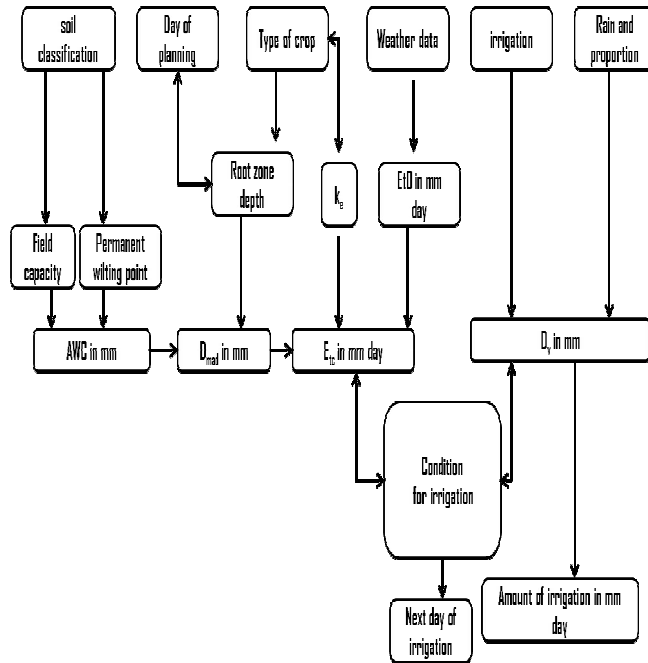


Fig. 6 Decision Support System

IV. FUZZY CONTROLLER SYSTEM

We define two fuzzy controller systems for irrigation process. Based on the integrated web system, we design smart shading and irrigation process. In shading system, the system takes rain as input and the acoustic sensors provide rainfall data to integrated web system. This system decides whether to irrigate or not. When irrigation mode is on, then the next controller checks for the temperature and humidity data and then irrigates the garden according to the irrigation time calculated by the controller system.

A. Fuzzy Controller System For Shading Process

Based on rain results from the integrated web system, design the fuzzy controller embedded in the coordinator node, its input variables are rain_type and time. The degree of rainfall is measured by the score in the interval [0, 0.25].

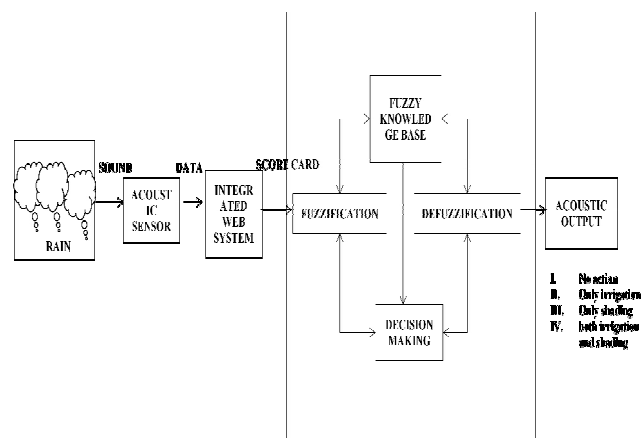


Fig. 7 Fuzzy Controller System for Shading Process

The fuzzy logic system is designed through some if then rules, for establishing relationship between input and output variables. In our system, we construct 4 rules for output variable and are shown in table 1.

Table 1 Fuzzy Rules for Smart Shading and Irrigation Process

Decision		Time		
		Short	Reasonable	Long
Rain_type	No_rain	Irrigation	Irrigation	Irrigation
	Drizzling	Irrigation	Irrigation	Both
	Normal	Irrigation	No action	Shading
	heavy	No action	Both	Shading

The membership functions for input variables are calculated by the following equations 1 and 2 and membership functions for output variable are also illustrated by the following equations 3, 4, 5 and 6.

$$\mu_{rain_type}(x) = \begin{cases} e^{\frac{1}{2}(\frac{x-0}{0.05})^2} & \text{if } x < 0.1 \\ e^{\frac{1}{2}(\frac{x-0.1}{0.05})^2} & \text{if } 0 < x < 0.2 \\ e^{\frac{1}{2}(\frac{x-0.175}{0.05})^2} & \text{if } 0.1 < x < 0.25 \\ e^{\frac{1}{2}(\frac{x-0.25}{0.05})^2} & \text{if } 0.15 < x \end{cases} \dots\dots (1)$$

$$\mu_{time}(x) = \begin{cases} e^{\frac{1}{2}(\frac{x-0}{0.5})^2} & \text{if } x < 3.5 \\ e^{\frac{1}{2}(\frac{x-2}{0.5})^2} & \text{if } 0 < x < 5 \\ e^{\frac{1}{2}(\frac{x-5}{0.5})^2} & \text{if } 1.5 < x \end{cases} \dots\dots (2)$$

$$\mu_{no_action}(x) = \begin{cases} 1 & \text{if } x = 0 \\ \frac{x-3}{0.3-0} & \text{if } 0 < x < 0.3 \end{cases} \dots\dots (3)$$

$$\mu_{irrigation}(x) = \begin{cases} 1 & \text{if } x = 0 \\ \frac{x-3}{0.33-0} & \text{if } 0 < x < 0.33 \\ \frac{0.67-x}{0.67-0.33} & \text{if } 0.33 < x < 0.67 \end{cases} \dots\dots (4)$$

$$\mu_{shading}(x) = \begin{cases} \frac{x-0.33}{0.67-0.33} & \text{if } 0.33 < x < 0.67 \\ \frac{1-x}{1-0.67} & \text{if } 0.67 < x < 1 \end{cases} \dots\dots (5)$$

$$\mu_{both}(x) = \begin{cases} 1 & \text{if } 0.7 < x \end{cases} \dots\dots (6)$$

Membership functions for input and output are defined below in table 2,3,4. Fuzzy controller deals with four degree for rain_type such as no rain (no rain), drizzling (when rainfall rate is low), normal (when rainfall rate is medium), and heavy (when rain fall rate is high). And then, three membership functions is assigned for time variable. They are short(less than 2 hours), reasonable (between 2 to 5 hours) and long (for greater than 5 hours).

These two inputs fed into knowledge base for generating fuzzy output. The output variable result in four actions and they are no action, irrigation, shading and both (irrigation and shading).

Table 2 Membership Function for Rain_type Input Variable

FUZZY SET	Universe of discourse					
	0	0.05	0.1	0.15	0.2	0.25
NR	1.0	0.4				
D		0.3	1.0	0.3		
N			0.7	1.0	0.7	
H					0.4	1.0

Table 3 Membership Function for Time Input Variable

FUZZY SET	Universe of discourse										
	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
S	1.0	0.8	0.6	0.3	0.2						
R	0.2	0.4	0.6	0.8	1.0	0.8	0.6	0.4	0.2	0.1	
L							0.2	0.4	0.7	0.9	1.0

Table 4 Membership Function for Shading Output

FUZZY SET	Universe of discourse										
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
NI	1.0	0.6	0.3	0.1							
I		0.3	0.5	0.8	0.7	0.5	0.3				
S					0.2	0.5	0.7	0.8	0.6	0.4	
B								0.1	0.4	0.6	1

Fuzzy inference engine performs actual decision making process which is the most important part of the fuzzy control. Here, we have used GMT as inference method. We define our rule and their consequences are approximately coordinated. We convert our fuzzy values into crisp values. Defuzzification is the process of transforming FIS output values into equivalent assured values. Thus the process makes the assured value by complying with input signals of the controlled system.

B. Fuzzy Controller System For Irrigation Process

Based on the fuzzy results from the shading process, fuzzy system for irrigation process is designed. For the fuzzy controller embedded in the coordinator node in the base station, its input variables are soil humidity data(X) and air temperature data(Y) and the output variable length of time for irrigation (T). According to the water demand for the crops calculated by DSS algorithm, corresponding control decision making can be derived from control rules. Then it can be obtained due to maximum membership degree. When the system a runs, the first step is to calculate X and Y according to the input data and quantify them to calculate the universes of discourse of fuzzy amount. Then by searching fuzzy control table, we can achieve the current water demand information of crops at any area of irrigation.

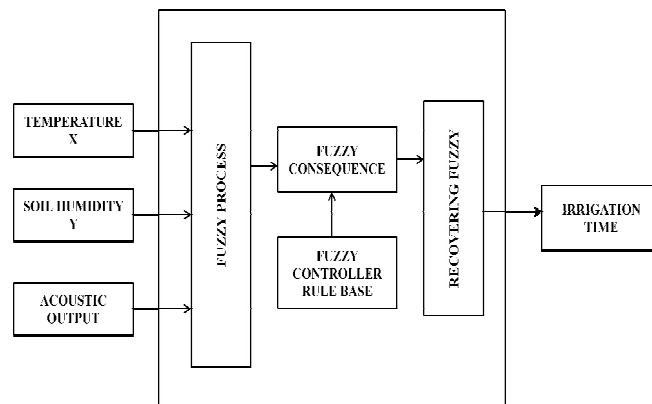


Fig.8 Structure Principle of Irrigation Controller

In this paper, we set soil humidity X between [0%, 90%], air temperature between [0, 50], irrigation time T between [0,20min].

The universes of discourse of input variable X are {0, 0.2, 0.4, 0.5, 0.6, 0.8, and 0.9}. Its fuzzy language values are {VD (very dry), D (dry), RD (relatively dry), ZO (moderate), RW (relatively wet), W (wet) and VW (very wet)}. The universes of discourse of Y are {0, 10, 20, 25, 30, 40, and 50}.Its fuzzy language values are {VC (very cold), C (cold),

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RC (relatively cool), ZO (moderate), RH (relatively hot), H (hot), VH (very hot)}. The universes of discourse of T are {0, 5, 10, 15, 20}. Its fuzzy language values are {ZO (no watering), S (watering for a short time), M (watering for a relatively long time), L (watering for a long time), and PL (watering for a very long time)}. Membership evaluation table for the controller system is shown in table 5, table 6 and table 7.

Table 5 X Membership Function Evaluation Table

FUZZY SET	Universe of discourse						
	0	0.2	0.4	0.5	0.6	0.8	0.9
VD	1.0	0.7	0.3				
D	0.7	1.0	0.7	0.3			
RD	0.3	0.7	1.0	0.7	0.3		
ZO		0.3	0.7	1.0	0.7	0.3	
RW			0.3	0.7	1.0	0.7	0.3
W				0.3	0.7	1.0	0.7
VW					0.3	0.7	1.0

Table 6 Y Membership Evaluation Table

FUZZY SET	Universe of discourse						
	0	10	20	25	30	40	50
VC	1.0	0.7	0.3				
C	0.7	1.0	0.7	0.3			
RC	0.3	0.7	1.0	0.7	0.3		
ZO		0.3	0.7	1.0	0.7	0.3	
RH			0.3	0.7	1.0	0.7	0.3
H				0.3	0.7	1.0	0.7
VH					0.3	0.7	1.0

Table 7 T Membership Evaluation Table

FUZZY SET	Universe of discourse				
	0	5	10	15	20
ZO	1.0	0.8	0.2		
S	0.8	1.0	0.8	0.2	
M	0.2	0.8	1.0	0.8	
L		0.2	0.8	1.0	
PL			0.2	0.8	

According to the water requirement of different crops at different growth stages, based on the fundamental: the lower soil humidity, the more water requirement, the lower air temperature, the more water requirement, we set up fuzzy control rule table and its query table which is shown in table 8 and table 9.

Table 8 Fuzzy Control Rule Table

FUZZY SET	Universe of discourse						
	VC	C	RC	ZO	VC	VC	VC
VD	L	PL	PL	PL	PL	PL	PL
D	L	L	L	PL	PL	PL	PL
RD	M	M	L	L	L	PL	PL
ZO	S	M	M	M	L	L	L
RW	ZO	ZO	M	M	M	L	L
W	ZO	ZO	ZO	ZO	ZO	S	S
VW	ZO	ZO	ZO	ZO	ZO	ZO	ZO

Two-input & single-output language control strategy shown in Table 1 is composed of 49 fuzzy conditional statements where each fuzzy conditional statement decides on a fuzzy relationship:

$$R_i = [X_j \times Y_k]^{M1} \cdot T_1 \tag{1}$$

Where X_j represents 7×1 column vector and Y_k represents the 1×7 row vector. M1 means to arrange the matrix by line in a column vector. T_1 is an 1×5 row vectors where its values stand respectively for row values in

membership function assignment table, Table 1, Table 2 and Table3. In this way we can obtain a total of 49 fuzzy matrixes and get a fuzzy matrix R by adding “and” operations to them.

$$\bigcup_{i=1}^{49} R_i \tag{2}$$

For all the X and Y precise amount in Table 4, we can obtain the fuzzy control outputs according to synthesis reasoning rules:

$$R_i = [X_j \times Y_k]^{M_2} \cdot R \tag{3}$$

Where M2 is also a kind of matrix computation relations, aims to arrange the matrix in a vector row. For all the combination of the elements on the domain for X_i and Y_j, we can work out green light delay time T_i corresponding to each combination according to the formula above.

Table 9 Fuzzy Control Query Table

FUZZY SET	Universe of discourse						
	0	10	20	25	30	40	50
0	15	20	20	20	20	20	20
0.2	15	15	15	20	20	20	20
0.4	10	10	15	15	15	20	20
0.5	5	10	10	10	15	15	15
0.6	0	0	10	10	10	15	15
0.8	0	0	0	0	0	5	5
0.9	0	0	0	0	0	0	0

V. SIMULATION RESULTS

Based on the analytical work explained in section IV to verify the proposed system, the fuzzy logic algorithm is simulated using MATLAB fuzzy logic toolbox. Two different fuzzy controller systems are inbouded in two different places. Fuzzy controller for shading process is programmed in base station and hardware prototype of the proposed system was built using off shelf components. The simulation result as shown in fig 9, shows the shading process for the controller placed in base station. Ten different inputs are selected to test the twelve rules. For an input rain_type of 0.125 and input time of 2.5, the simulation gave the output of 0.336 matches and conforms to the weight of 0.336, turns the irrigation process.

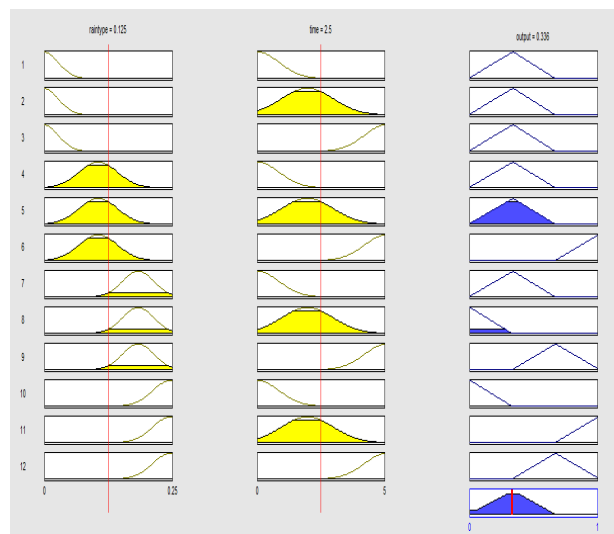


Fig 9 Simulation Example for Shading Process

Fig. 10 shows another case where the simulated input value turns into irrigation process. The simulated DSS algorithm is implemented in microcontroller using fuzzy logic library base on c program. Ten different inputs are used to test thirty rules. For an input temperature of 25°C and input soil moisture of 50%, the simulation actuates the water valve

ON with irrigation time of 13.5 minutes. However the litter water valve output weight differences between the experimental and simulations do not change any of the water valve status (includes irrigation time).

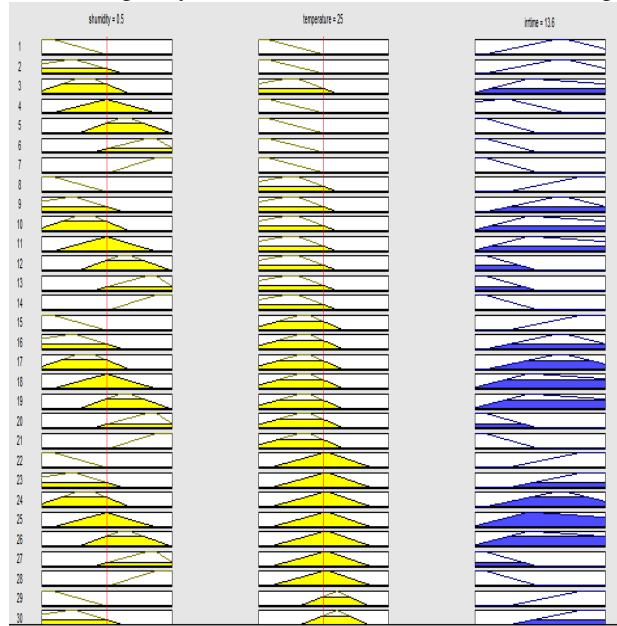


Fig 10 Simulation Example for Irrigation Process with Irrigation Time

Home users can access the web system for the input value from acoustic sensors. And turn on the fuzzy control system. The details of the web server, database and user privileges of the software development are not reported because it is standard do not add any new idea rather than it is common and easy development.

VI. PERFORMANCE ANALYSIS

Several measurements were carried out to measure the performance and effectiveness of Zigbee based WSN on the irrigation control system to conform the reliability and feasibility of using it for a monitoring purpose.

A. Node Power Consumption

In WSN deployment, low power consumption is the important aspect to make sure it is able to operate in long time with minimum maintenance. The power consumption measurement is carried only for end devices such as sensor nodes in roof top area and coordinator is practically mains powered at the base station. During the measurement, the end devices are configured with the timer sleep mode condition. The node is configured to wake up every 30 minutes interval for 100 ms to just to send the data to the microcontroller. For the rest of the time, the end device is in sleep condition. The following table shows the power consumption for end device, measured for both sleep and active mode states. Based on the result in table , the lifetime of the battery can be calculated below.

Table 10 End Device Power Consumption

State	Voltage	Current
Active	9.0	35.5
Sleep	9.0	28.5

Power consumption during active node:

$$= 35.5mA \times \frac{100ms}{60 \times 60 \times 1000}$$

$$= 0.00099mAH$$

Power consumption during sleep node:

$$= 28.8mA \times \frac{30 \text{ minutes}}{60}$$

$$= 14.4 \text{ mAH}$$

Total power consumption = 14.4 + 0.00099 \cong 14.4 maH

Battery capacity = 170 mAH

Extended battery life = $\frac{170}{14.4} = 11.81 \text{ hours}$

B. Coverage Performance

Coverage is another important stage of WSN that shows how large area of monitoring can be covered and to guarantee the delivery of data from the sensor nodes to the base station at reliable signal strength. The base station is located at

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the center of the area and sensor node is placed at certain intervals of distance of different angles covering 0° to 360°. The average signal strength is based on the value of LQI received at the base station for 20 cycles. All the sensor nodes and the coordinator at the base station is using a 2 dB gain Omni directional dipole antenna with the transmitted power of 100mW. Fig shows the coverage performance based on the LQI value. Between 10m to 50m distance from the base station, an average uniform signal strength is obtained comply with the use of Omni directional antenna. As shown in fig, reliable signal strength can still be obtained at 100% success of packet delivery up to the distance of 210 m. the decrease of the LQI value with the distance extension is expected.

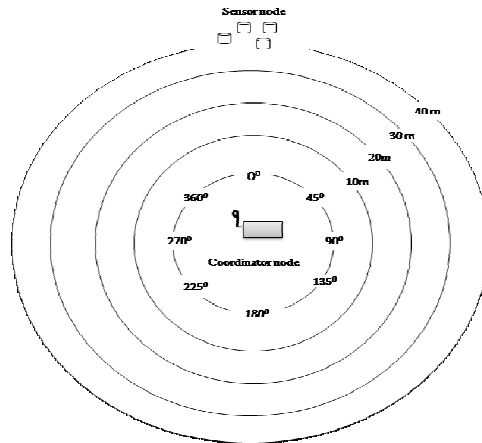


Fig.11 Coverage Measurement Method

The end device node able to operate for 12 hours without new battery based on the measurement result i.e. it can be used in an adhoc style for a short period of time. The module power supply is considered to use a component with low power consumption plus a smart power management that can reduce the voltage supply necessary for the module during sleep mode. The current consumption can be reduced by programming the task carried out in the module.

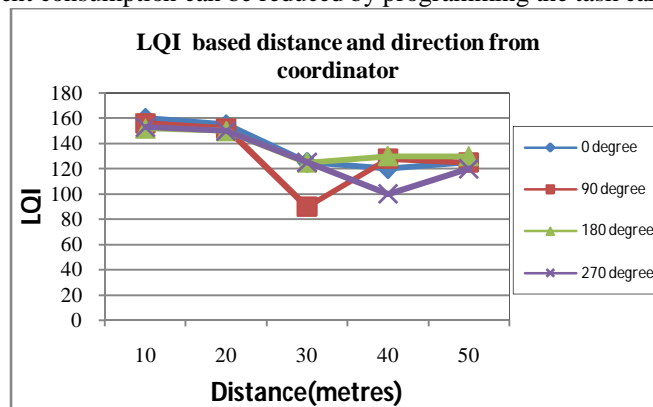


Fig.12 Value of LQI for the distance of 10-50 meters

On the coverage performance, with the use of high power transmission, minimum number of sensor nodes for maximum area coverage can be expected. However other measurement at several more environments is necessary to obtain a more reliable data that also considering the worst case scenario.

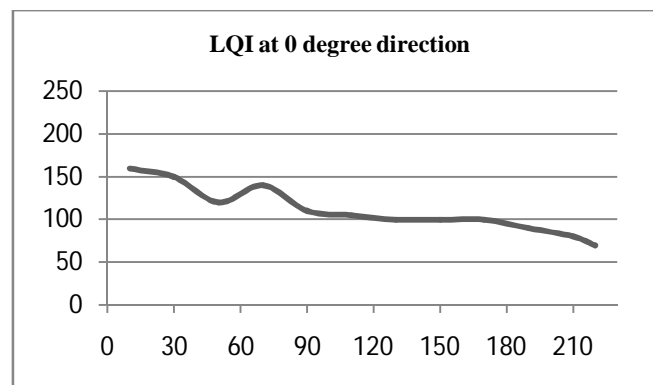


Fig 13 Value of LQI for the distance extended up to 210 meters

VII. CONCLUSION

A reliable monitoring system for water irrigation overcomes the human intervention in governing large areas under rooftop areas. Here we show the detailed design of the hardware architecture and the software algorithm for the grassland irrigation running system. Also we are proposing an automated system which takes decisions for different rain rate events to maintain the irrigation and the shading process together. As proper timing of irrigation over plants and routine management of irrigation is beneficial is nurturing of crops. It will be more beneficial when we implement this into the real time scenario bring the outstanding result in the green roof garden to save the crops form direct devastation of rainfall. We apply fuzzy logic technology to intelligent water saving irrigation, which can meet the water requirement and the development of intellectual and network based green roof ecosystems.

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