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Comparative Study of Networking Protocols in WSN Implementation for Greenhouse Monitoring

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***Abstract*—**Wireless sensor networks consist of number of small devices called sensor nodes formed by combining a sensing unit, processor unit, wireless communication unit and power source unit. WSN has gained a lot of importance in recent years because of its use in various fields where monitoring and controlling are important aspects. This paper discusses implementation of wireless sensor network in greenhouse for the growth of crop yields. Wireless sensor networkcan use various types of networking protocols for implementing WSN in greenhouse monitoring.Main focus of this paper is on comparative study of various networking protocols available for implementing WSN.

Keywords*-WSN, FFD, RFD,Greenhouse, Networking protocols.*

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I. INTRODUCTION

The vital factors maintaining the human existence and sustaining life on earth are food and water. Life of human being depends on agriculture and water for survival, so it is important for us to use our land and water resources optimally, profitably and sustainably. Also because of urbanization, industrial developments and excessive use of fertilizer and pesticide farm lands are no longer able to provide sufficient amount of food to society. In order to get solution to acknowledged problem an agricultural greenhouse can be considered as best solution to provide desired environmental parameters to grow crops rapidly[8]. Wireless sensor networks (WSN) are still rarely applied in greenhouse today[4]. This review gives an idea of available areas in agriculture, specially in greenhouse where wireless sensor networks can be implemented, with the comparative study of various networking protocols.

II. GREENHOUSE TECHNOLOGY

The man made framed or inflated structures which is covered with transparent or translucent material to provide partially or fully controlled environmental conditions to get expected crop yields are called as Greenhouse.

Classification of greenhouses:

Now adays there are various types of greenhouse. Each structure is designed from a specific application point of view. Mainly the greenhouses are classified by considering the shape, utility, material and construction.

A) Based on shape:

- Lean to type.
- Even span & uneven span type.
- Ridge and furrow type.
- Saw tooth &quonsettype.
- Interlocking ridges and furrow type

B)Greenhouse type based on Utility:

In this classification, the functions or utilities decides type of greenhouse.

- Greenhouses for active heating:
  In this type of greenhouse various methods are used to reduce the heat loss.
- Greenhouses for active cooling:
  Thisgreenhouse is designed to maintain expected temperature. This type allows a roof opening of 40% and in some cases nearly 100%.

C) Greenhouse type based on covering material:

Here the covering materials decides the type of greenhouse.

- Glass Greenhouses:Glass is used as covering material.
- Plastic Film Greenhouses:Flexible plastic films including polyethylene, polyester and polyvinyl chloride are used as covering material.
- Rigid Panel Greenhouses:

Polyvinyl chloride rigid panels, fiber glass-reinforced plastic, acrylic and polycarbonate rigid panels are used as covering material[1].

III. GREENHOUSE ENVIRONMENT PARAMETERS

A) Light:

The source of energy for plantsis visible light of the solar radiation. Carbohydrates are formed by the process of photosynthesis which combines the light energy, carbon dioxide ($C0_2$) and water.

$$CO_2 + \text{Water} + \text{Light energy} = \text{Carbohydrate} + \text{Oxygen}$$

The light energy plays essential part of carbohydrate formation. Diminishing light intensity causes to slow down the process of photosynthesis and hence the growth. And the light intensity higher than optimal, again causes to slowdown in growth because of the injury to the chloroplasts. The international unit of light intensity measurement is known as lux. It is the direct illumination on a surrounding surface that is 1m from a uniform point source of 1 international candle. Greenhouse crops are subjected to various range of light intensities generally varying from 130klux on clear summer days to 3 to 5klux on cloudy winter days[1].

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B) Temperature:

Level of heat present inside greenhouse is measured as temperature. All crops grow well in specific temperature range. Above and below this temperature range, the plant life processes stop. At lower temperature level,ice forms within the tissue tying up water, and cells are possibly punctured by ice crystals. Alsoenzymes become inactive at higher temperature level, and again the enzyme controlled processes are essential for life of tissue.

C) Humidity:

The relative humidity of greenhouse, which is in enclosed space is more as compared to ambient air.The moisture inside greenhouse keeps on changing because of the air leaving from the greenhouse due to ventilation. Sensible heat inputs also causes to lowering of the relative humidity of air to some extent. The processes like humidification or dehumidification are carried out for maintaining desirable relative humidity levels inside the greenhouses. The acceptable range of relative humidity is between 50 to 8O%for most of the crops[1].

D) Ventilation:

Generally the main reasons of greenhouse ventilations are either reducing the temperature of greenhouse air, for replenishing CO_2 supply and for moderating the relative humidity of the air. Generally air temperatures above 35^oC are not suitable to the crops in greenhouse. In spring and autumn, it becomes quite possible to bring air temperature of greenhousebelow upper limitsimply by providing adequate ventilation for the greenhouse[1].

E) Carbon Dioxide:

The essential plant nutrient is carbon and it is present in largequantity than any other nutrient in the plant. About 40% of the dry matter of plants is composed of carbon.And carbon dioxide ($C0_2$) gas in the air is the important source of carbon to plants for carbohydrate formation. In normal ambient conditions, CO_2 exits as a gas in the atmosphere slightly above 0.03% or 345 ppm. During the daytime, in photosynthesis process under natural light, the plants in a greenhouse draw down the level of $CO_2$to below 200 ppm. Under these circumstances, ventilation process or CO_2 generator increases CO_2 levels inside the greenhouse. Some times the air present outside the greenhouse isbrought inside to maintain the CO_2 at ambient levels[1,8].

IV. WIRELESS SENSOR NETWORK

Wireless sensor networks consist of number of small devices called sensor nodes formed by combining a sensing unit, processor unit, wireless communication unit and power source unit[3,4].The sensor node is a basic element of Wireless Sensor Network, as said earlier, it is composed of sensing, computation and wireless communication unit. These sensor nodes are having capability of observing physical phenomenon, then process the received information or data and communicate the processed information to the nearby sensor nodes to form a network of sensor nodes called Wireless Sensor Networks. Like wired sensor networks, wireless sensor networks are also carefully planned and deployed. The deployment of wireless sensor node requires communication protocols for self organizing of network of various sensor nodes[4,6].

A) Bluetooth:

Bluetooth is a wireless communications technology used to replace the cables for connections. Bluetooth is a IEEE 802.15.1 networking protocol low cost device works for short distance. It operates in ISM frequency band 2.4GHz (2.402GHzto2.480GHz) and uses FHSS technique through 79 channels. The Bandwidth of communication channels supported is up to 1 Mbps[2]. A single connection supports a maximum asymmetric data transfer rate of 721 Kbps maximum of three channels. Bluetooth has three different power classes as follows

Table I

Class	Range	Power Consumption
PowerClass1	100m	100Mw
PowerClass2	10m	1-2,5mW
PowerClass3	0.1-10m	1mW

Figure 1. Bluetooth powe class

Bluetooth dataisdividedinpackets namely accesscode, header and payload. Bluetooth connection modes explains the rules by which all bluetooth devices establish a link to communicate with one another: STANDBY,ACTIVE, PowerSaving Modes and further power saving mode includes three parts as SNIFF, HOLD and PARK.In bluetooth based WSN, apiconet consist of one master and 7 slave bluetooth enabled devices. During the establishment of piconet master's bluetooth address is used for defining the frequency hopping sequence. Slave devices use the master's clock to synchronize their clocks to be able to hop simultaneously. Means master device sets up frequency hopping sequence and slave devices synchronizes their signal to same pattern. Each piconet has different hopping pattern. Scatternet is formed by connecting number of piconet together. The problem of bluetooth devices is to have proper communication amongst various kinds of bluetooth devices to solve the problem of establishing wireless sensor networks. The bluetooth sensor node should collaborate during the task execution with data- centric nature. Because of its high complexity and inadequate power characteristics for sensors, the interest toward Bluetooth-based WSN applications has decreased[2,7].

B) ZIGBEE:

ZIGBEE is low data rate, low power consumption, small packet device technological standard created for control and sensor networks. It is based on the IEEE 802.15.4 standard and created by the ZigBee Alliance. Zigbee operates in unlicensed band ISM 2.4 GHz at 250kbps, 868 MHz american band at 20kbps and 915 MHz north-american band at 40kbps[4]. It was designed for wireless controls and sensors and it operates in Personal Area Networks (PAN's) and device-to-device networks. It is used for connectivity between small packet devices and also for Control of lights, switches, thermostats, appliances, etc. the topologies supported are star, cluster tree and mesh. Zigbee solves the problems of most of the remote monitoring and control and sensory network applications. It is standards-based technology that follows the standard Open

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Systems Interconnection (OSI) reference model, Zigbee protocol stack is structured in layers. The first layer is physical (PHY) and second layer is media access (MAC), are defined by IEEE 802.15.4 standard. Remaining layers are defined by ZigBee Alliance. Zigbee network participates two different device types: a Full-Function Device (FFD) &Reduced-Function Device (RFD). The FFD can operate as, a PAN(personal area network) coordinator, a coordinator or a device. An FFD can communicate with RFDs or other FFDs, but an RFD communicates with only FFD[4,8].

An RFD is implemented for simple applications, which requires minimum resources and memory capacity. However topology of zigbee wireless sensor networks includes simple star network, reliable mesh network and large scale mesh tree network,

C) Wifi:

Wi-Fi is wireless technology that uses radio waves to provide high-speed data transfer. Wifi is (IEEE) 802.11 networking protocol standard.
Wifi standards

Table II

Standard	Speed	Freq band
802.11	2 Mbps	2.4 GHz
802.11a	54 Mbps	5 GHz
802.11b	11 Mbps	2.4 GHz
802.11g	54 Mbps	2.4 GHz

Figure 2. Wifi Standards

WiFi-based wireless sensor network has characteristics, such as high bandwidth, a large range covering, direct accessing to the WiFi hotspots. The characteristics make it possible to decrease the costs, so it makes WiFi-based wireless sensor network is more suitable for building wifi based wireless sensor network[5]. As shown in above table, data transfer rate of wifi can reach 2Mbps, and the latest 802.11n protocol can reach 300Mbps data transfer rate. WiFi data transmission is more efficient, less delay and better real-time. Each WiFi sensor node can support about 100 wireless connections[5,6]. As WiFi-based sensor network can be formed using wireless mesh topology, star topology. As the routing protocols and security algorithms of the current WiFi technology are complex and also there is no consideration of node's energy saving.

V..Comparisionof Bluetooth, Zigbee&Wifi:

Table III

Specification	Bluetooth	Zigbee	Wi-Fi
Distance	10m	50-1600m	50m
Extension	None	Automatic	Depend on existing network
Power supply	Days	years	Hours
complicity	Complicated	simple	Very complicated
Transmission speed	1Mbps	250Kbps	1-54Mbps
Frequency range	2.4GHz	868MHz, 916MHz, 2.4GHz	2.4GHz
Network nodes	7	65535	50
Linking time	Up to 10s	30ms	Up to 3s
Cost of terminal unit	Low	Low	High
Security	64bit, 128bit	128bit AES	SSID
Integration levels& reliability	High	High	Normal
Ease of Use	Normal	Easy	Hard

Figure 3. Comparision of various protocols

The above table shows the comparison of various parameters of networking protocols: bluetooth, zigbee and wifi[3,7].

VI.CONCLUSION

WSN can be implemented to monitor the greenhouse environmental parameters such as temperature, light intensity, humidity, air ventilation, CO_2. It results in the growth of crop yields. All the studied networking protocols can be used to implement the WSN. Bluetooth has limitation of short range and interoperability problem however its use reduces cost significantly. Zigbee is suitable protocol for WSN in greenhouse only cost is more and data speed is low as compare to bluetoothand wifi is also suitable but complexity is more compared with bluetooth and zigbee.

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