Smart Agriculture with Conducting Polymers using UDP

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***Abstract*—**Precision farming in a greenhouse allows improvising the yield by performing timely monitoring of the fields. Monitoring of agricultural environmental factors such as temperature, humidity etc., is significant. This paper presents a conducting polymer sensor used to measure and monitor the environmental temperature. Sensor nodes process the temperature data, wirelessly transmits to a server using User Data Protocol(UDP). A comparison of UDP over TCP is also reported in this paper.

***IndexTerms*—Precision Farming, Greenhouse, Sensor Networks, UDP, Conducting polymers, PEDOT-PSS**

I. INTRODUCTION

Greenhouse is considered as a closed structure which safeguards the plants from extreme weather conditions such as wind, hailstorm, ultraviolet radiations, and insect and pest attacks [1]. The technologies are involving a set of sensors to monitor and control temperature, humidity, soil aeration, soil moisture and drainage, fertility levels and light. The linking of these technologies with systems to control them can lead to smart systems that not only help farmers effectively utilize their resources but also lead to diversification where a wide range of crops can be grown [2-3].

In conventional greenhouse environment control systems, a single computer with electric signal lines from all sensors (e.g. air temperature and humidity) and actuators (e.g. heater and roof ventilator) perform measurements. Integrated control coordination of the sensors and actuators are easy to realize. However they poses some disadvantages such as complicated control program, no extensibility and high risk of whole system failure due to breakdown of only the central computer. In contrast, a decentralized autonomous control system for the greenhouse environment is composed of nodes that are embedded with computer and several sensors and actuators. The computer has a communication port for networking with other nodes, and a measurement and control program for sensors and actuators [4-5].

In this work, we report that PEDOT-PSS (poly 3,4ethylenedioxythiophene – polystyrene sulfonic acid), a conducting polymer can be used to make sensors [6-7] suitable for greenhouse measurements, which are very flexible in nature and has the ability to be easily implanted into fabrics[8-10]. Because of the spurt in applications of conducting polymers[11-14] they are being extensively studied in sensing applications [15-16]. The aim of this work is to develop flexible, reliable and inexpensive sensors. This paper also reports the features of UDP and a comparison of UDP with TCP. The choice of one of these two protocols necessarily impacts on the performance of the remote handling system.

II. GREENHOUSE MANAGEMENT SYSTEMS

In this work measurements are made on thick films of PEDOT-PSS drop cast on epoxy glass substrate with copper as contact metal for electrical connection. PEDOT-PSS used is an aqueous dispersion, commercially available under the trade name CLEVIOS™ P VP AI 4083 from Bayers, Germany.Films of PEDOT-PSS are cast on copper contacts which are 0.5 mm wide, 5 mm apart and 25 mm long. Before casting of films, substrates are cleaned with acetone, triple distilled water and isopropyl alcohol. PEDOT-PSS films are formed on the substrate by evenly spreading (drop casting) the suspension over the required area and baked at 45ºC to fuse the film. The water evaporates slowly forming a film of PEDOT-PSS. However, the film is maintained at 45ºC for further one hour before use. The thickness of the film is measured using Mitutoyo dial gauge with 1 micrometer resolution at 5 places and its average value is taken. DC measurements are made using Fluke 287 multimeter and complete characterization of PEDOT-PSS films is done in a temperature controlled box maintained at 30 ± 0.1 degree centigrade.

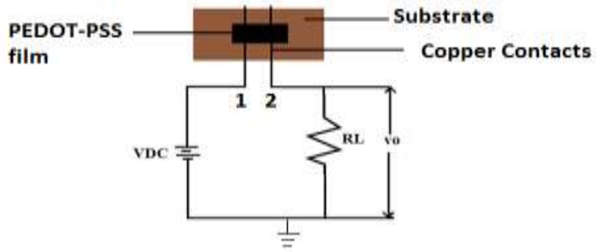

Fig.1 Circuit used to measure resistance andimpedance of films

Measurement of sheet resistance is made by potentiometer technique shown in Figure 1 using Fluke 287 digital multimeter by applying DC voltages between contacts 1–2. The resistance of the film between contacts are determined by measuring the voltages at terminals $V_1(V_{DC})$ and $V_2\,(V_O)$ and ground.

The effect of temperature on the variation of PEDOT-PSS film resistance for 30°C, 35°C and 40°C temperatures are shown in Figure 2. It may be observed that the film resistances increases with temperature and time and, higher the temperature larger the change with time. This clearly indicates that PEDOT-PSS can be used as temperature sensor. These temperature sensors can be placed on the sides of the greenhouse. Flexible sensors can be made by different methods. If substrates are hard and rigid, spin coating of film can be done. In case of flexible substrates, sensors can be formed by ink jet printing. In textile embedded sensors, the sensing material in this case PEDOT-PSS can be spray coated on the textile (sides of the greenhouse) and contacts can be made from thin silver wire penetrating into the textile.

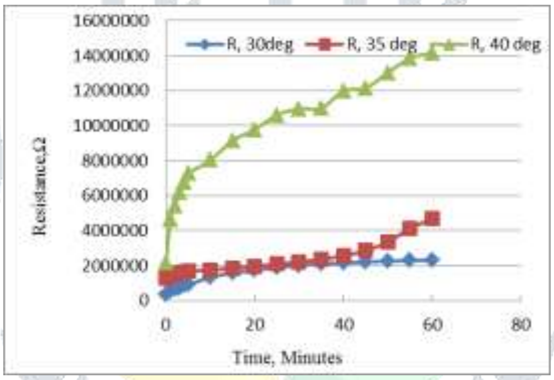

Fig.2 Variation of PEDOT-PSS film resistance with time at different temperatures for copper as contact metal

In order to process, validate and transmit the data obtained from the sensor, an efficient system is required. In this paper wireless sensor network (WSN) is considered for the same. WSN is a great tool to monitor environmental parameters as this technology can provide high-resolution spatiotemporal sensing extracted from real world physical/analog signals. A WSN in this context can be possibly used. The network of objects i.e. sensors nodes is created and linked through as WSN. The nodes communicate with one another via the internet, integrating embedded sensors, RFID, GPRS, computers, actuators and mobile phones etc. The nodes exchange and process information according to defined tasks and send reports to the aggregating node, through the network the aggregated data is transmitted to the server with the aid of internet. The internet sends the information regarding the conditions of the green house, to the intended receiver i.e. the farmer.

Figure 3 shows the basic block diagram of a WSN consisting of sensing elements embedded through nodes which can process the information sensed in the required format and transmit it through wireless mode by using transport layer protocols either UDP/TCP [17].As a brand-new information acquisition and processing technology, ZigBee has seeped gradually into the agricultural environmental monitoring domain. ZigBee nodes can obtain the temperature, humidity and illumination information in real time, and then transfer it to a server node. Power storage is also required to provide the supply to the systems, which can be a storage cell or rechargeable batteries.

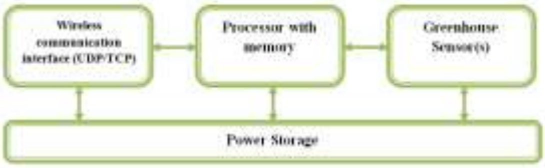

Fig.3 Block diagram of WSN

A detailed process flow is shown in Figure 4 which shows the organization of sensor nodes which communicate to a base station or a server node for data consolidation and the wireless transmissions are carried out through a secure network. At the receiving end a smart phone or a handheld device is required by the farmer for carrying out further action. The only concern during the transmission of signal are they experience serious multipath fading as they switch between line of sight and non-line of sight regions frequently. In such environments rate of transmission, maximum available transmission power and data delivery has to be considered using higher layer protocols such as UDP or TCP as it is a wireless environment through which direct MAC access is not possible. The transport layer protocols are responsible for not only the functionality and the procedural ways for transmitting messages of variable length through the destination but they should also maintain a good quality of service.

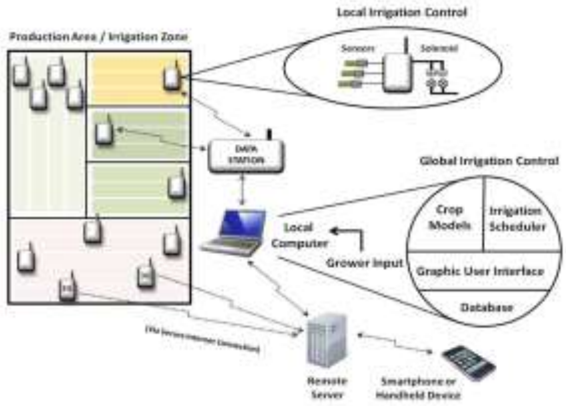

Fig.4 Process flow of greenhouse management system

Further TCP and UDP have their own priorities specific to application. In this scenario UDP can be used for reduced traffic/data transmission in order to increase the rate of transmission and thereof reducing the amount of energy consumption.

III. User Datagram Protocol

User Datagram Protocol (UDP) is an Open Systems Interconnection (OSI) transport layer protocol for client-server network applications. The dataflow in UDP is shown in Figure 5. It is a part of the Internet Protocol suite used by programs running on different computers on a network. UDP makes use of a simple transmission model, however it does not employ handshaking dialogs for data integrity, reliability and ordering. The protocol gives a better performance where the individual packets can be dropped and UDP packets can be received in a different order than that in which they were sent. The processing at the network interface level can be avoided as the protocol assumes that no error-checking and correction is required. UDP thus provides an unreliable but still a best effort to transport message to applications and upper layer protocols without inherent congestion control or reliability.

The network traffic in UDP is arranged in the form of datagrams. The first eight bytes of a datagram contains the header information, while the message data is present in the remaining bytes. A UDP datagram header contains four fields of two bytes each: Source port number, Destination port number, Datagram size and Checksum. UDP is more appropriate to be used on large distributed systems where each host communicates with many destinations at the same time. UDP helps to provide faster data transmission and reduces bandwidth in huge data communication systems. For example, when using UDP for large data communication as in media streaming, communication is still understandable even if a small content of a movie is not transmitted. Suherman et al., in their work have reported that though UDP is excellent in terms of delay they experiences huge packet loss of more than 40% [18]. UDP does not provide any communications security and applications that need to protect their communications against eavesdropping, tampering, or message forgery need to separately provide security services using additional protocol mechanisms. Hence, UDP can be used in applications like Voice-over-IP, DNS (Domain Name System), RPC (Remote Procedure Call), DHCP (bootstrapping) etc., that do not want reliability or bytestreams.

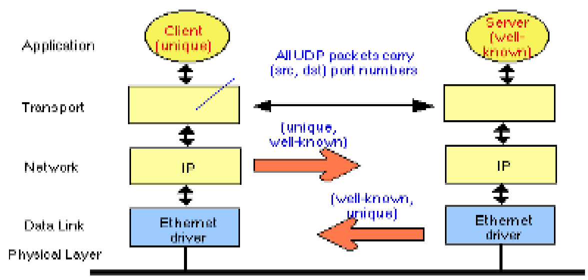

Fig.5 Data flow in UDP

On the other hand, TCP (Transfer Control Protocol) is the standard protocol for reliable delivery of data over the Internet. TCP relies on IP (Internet Protocol) a defacto standard protocol for inter-networking like routing and data transmission.

IP is intrinsically unreliable but provides best-effort services making Internet Protocol very simple, but still popular for the rapid growth of the Internet. TCP is designed to go hand in hand with IP making it a dominant reliable transport protocol. There have been reports in literature stating that TCP works well in a wire-line network compared to wireless network.

The main advantage of UDP is that it is simple to use for a network. There is very less processing that is involved at the transmitting and receiving hosts. Data transmission in UDP is faster than TCP. The overhead to detect reliability is not required for UDP. There is no need to maintain the unexpected deception of a data flow. The UDP connections information need not have to be maintained by the operating system.

The main disadvantage of UDP is that the packet may not be delivered, or may be delivered twice, or delivered out of sequence; there is no indication of loss of information unless the receiver identifies and requests for retransmission. Routers never retransmit the data packets in UDP when there is a collision, and when the router is falling short of memory this is the first packet to be dropped. Hence, UDP suffers from worse packet loss than TCP. UDP is non-elastic type of protocol indicating that it has no flow and congestion control.UDP does not provide security against eavesdropping, tampering or message forgery.

IV. CONCLUSION

This application provides full wireless connectivity by sending the processed data from the cloud to the farmers using mobile application. Graphical representation of data can be better understood and accordingly corrective measures can be taken. The farmers can be alerted for the readings and wirelessly control the devices for the field. In conclusion temperature sensors using conducting polymers have been designed and tested for different temperatures and can be wirelessly transmitted to a server using User Data Protocol(UDP).

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