Environment Monitoring and Control of a Polyhouse Farm through Internet

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Abstract- **Control and monitoring of environmental parameters inside a Polyhouse farm, so as to ensure continuous maintenance of favorable crop atmosphere is the objective of the work presented in this paper. The objective is achieved through the use of internet based technology. The system is also expandable to be integrated with mobile telephony.**

The concept encompasses data acquisition of thermal process parameters through a sensor network, data storage, post-processing and online transmission of data to multiple users logged on to their respective web-browsers. Further, control of process parameters of a Polyhouse (for example, toggle on/off control of pumps and accessories, louvers and ventilators, air flow rate, sunlight management, etc.) from one or more remote monitoring stations over the web server in real time is also integrated. A graphical user interface (GUI) is unified for the ease of operations by the farming community. System also allows transmission of process parameters, including emergency alarm signals via e-mail client server or alternatively sending a SMS on a mobile phone. A conventional chat has also been integrated with the GUI to add vibrancy to inter-user communication. This feature can be embedded in upcoming 3G mobile technology. Simulations and video tutorials can also be integrated in the web server for teaching the farming community. Such integrated approach greatly widens the socio-economic possibilities for farmers through interaction with modern technological resources.

Keywords: **Monitoring and Control through internet, Polyhouse farm environment management.**

I. INTRODUCTION

Modern technology, such as telecommunication and internet, is a vital element of all modern human activity. No other technology has made such an impact on modern society. Internet and web based services form one of the core foundations of a successful information technology based society. The web is not only used to gain visibility, share information, sell products and conduct business, but it can also be used to improve the way we design engineering systems, manufacture them and test the final products. A balanced and justified usage of internet facilities can lead to reduction in design cycles and subsequent improvement of overall quality [1]. Computer based data acquisition, web based experiments and virtual instrumentation and control applications have been an active area of interest in recent years [2-3]. The work reported by Regtien et al. [4] exemplifies the magnitude of interest in web-based systems on measurement techniques. Simultaneously, we have seen the exponential growth in mobile telephony in the last decade. It is natural that internet and mobile technology are going through a phase of fusion. India is the second largest mobile market in the world after China, with over 490 million subscribers in the mobile market according to the latest figures provided by Telecom Regulatory Authority of India [5]. In the context of large developing countries like India, it is increasingly becoming clear that mobile telephony coupled with internet services will prove to be one of the most efficient systems for penetration of services, products and knowledge.

Mechanization and modernization of agriculture must infuse these two technologies so as to make considerable impact. Agriculture and allied sectors contributes 24% of the total GDP and some two-thirds of Indian population depends on rural agro-related employment [6]; slow agricultural growth is a concern for policymakers. Poorly maintained irrigation systems and universal lack of good extension services are among the factors responsible. Access of farmers to markets is hampered by poor roads, rudimentary market, infrastructure, and excessive regulation[1]. Indian farmers also face several other challenges such as small land holding, intermittent power supply, poor yields due to reliance on inefficient methods of farming, too much reliance on natural phenomena such as rainfall and lack of knowledge of modern methods of agriculture.

Polyhouse farming is an alternative new technique in agriculture gaining foothold in rural India and can be successfully employed for niche areas of agriculture. A typical Polyhouse (metal structure covered with Polythene) is from 400 - 10,000 m^2; this makes them suitable for farmers with small land holding also. A low - to medium - cost Polyhouse could cost between Rs. 125 to Rs. 500 per square meter in India, whereas a high-cost, fully-automated Polyhouse costs Rs. 2,000 per square meter [7]. Most Indian farmers cannot afford such high costs but group of farmers and co-operatives can use such systems. Farmers do require expert guidance to use this new technology of Polyhouse farming. This methodology of farming reduces dependency on rainfall and makes the optimum use of land and water resources; typical gains may be three times those of traditional farming [8]. It

[1] *World Bank: India Country Overview 2008*

enables cultivation of regular crops in off-season too. Parameters such as moisture, soil nutrients, solar flux, air movement, humidity, dry bulb and wet bulb temperature etc., inside a Polyhouse needs to be controlled to ensure timely and abundant yields. Information on the installation of the Polyhouse, its economic viability, availability of subsidies for erecting them, and other technical information is available through various agriculture universities, district central nurseries and also by private consultants [6, 9, 10]. Currently, farmers from the states of Himachal Pradesh, Punjab and Maharashtra are taking interest in Polyhouse farming [11-12].

Other than usual agricultural processes, practices and methodologies like usual pre and post harvest operations, one aspect which differentiates a Polyhouse from conventional farm is the control and monitoring of the process parameters. This is exemplified through a recent work by Cha´vez [13] et al. wherein a remote irrigation monitoring and control system has been studied for precision control irrigation in areas having scarcity of water. Sometime back Rokade [14] has also addressed these issues. At present there are very few companies/service providers who are involved in such control, monitoring and automation of Polyhouses in India [15]; few examples can be seen in states of Maharashtra, Gujarat and Tamil Nadu [16]. Popularity of Polyhouses will naturally lead to increase in demand for better control and automation.

In this paper, we suggest and demonstrate an integrated system monitoring and control of a Polyhouse environment through internet based services. This is done by incorporating analog sensor network followed by integration with digital data acquisition and control platform through LabVIEW® interface. The developed system allows toggle on/off as well as implementation of sensor based control algorithms. Various analog parameters like temperature, humidity, pressure, etc. can be sensed and relevant controls like fan, pump, louvers, shades, air movement, etc. can be activated; All this is achieved through internet connectivity or alternatively through a mobile telephone network.

II. POLYHOUSE AUTOMATION

Polyhouse system protects the agricultural crops from sudden change in weather and regulates the environment inside the Polyhouse. This helps the farmers to grow the crops without any external obstruction. Thus, monitoring and control forms the core element of a Polyhouse deployment. Control of internal thermal environment is achieved by managing several elements like air movement, sliding louvers, exhaust fans, heaters, air conditioning systems, sunroof, etc. The complete Polyhouse automation control system will refer to a network of sensors and controllers/actuators, which in turn will detect the environmental changes of the Polyhouse and take necessary action against predefined set of normal values. A typical system, depending on the chosen complexity, can have different types of controls, ranging from simple on-off control to complex PID algorithms. Factors such as economics, size, and ambient environment shall determine the level of complexity of a polyhouse control system.

In this section we briefly review the various existing and upcoming technologies which can be incorporated for achieving Polyhouse automation monitoring and control.

A dedicated in-situ static toggle control system is the simplest case. The farmer or a service provider can set different datum control parameters. When the sensor network detects a value that is higher or lower than the predefined datum, a regulator gets activated to start or stop a mechanical/electrical element. Sensors are installed both inside and outside of the Polyhouse. The outside sensors collect the data about the ambient weather conditions, while the insides sensors detect the Polyhouse response.

In case of multiple control system, a logical advancement from single point static control, a single access point can control multiple devices or elements. For example, exhaust fan followed by switching on light and sliding louvers can be simultaneously activated based on single input parameter. For large-scale applications such control strategies can be implemented on an integrated control platform, e.g. microcontrollers or Programmable Logic Controllers (PLC). Individual microcontrollers can be networked in a modular fashion with a master controller, which manages multitasking.

Sensor networking can be achieved through a wired network (WLAN) or alternatively a Polyhouse wireless sensor networks (WSN) [17]. ZigBee, WiFi, and mobile device are the current technologies of wireless sensors. ZigBee [18] is a technology for a suite of high level communication protocols using small, low-power digital radios based on the IEEE 802.15.4-2003 standard for wireless personal area networks (WPANs), such as wireless headphones connecting with cell phones via short-range radio [19]. In such systems, multiple sensors are used to transmit the data to the data center or a field server. A field server is essentially a computer that should be durable, compact and economical enough to be installed universally in the fields throughout the year.

With deep penetration of internet services to remote countryside, it is possible to convert a field server into a web-server. In such cases, a field server will have its own Internet Protocol address. Such a system greatly increases the versatility of the monitoring and control strategy [for example, see [20]). The need for continuous in-situ monitoring by personnel is eliminated to a large extent, as farmers and stakeholders can be remotely connected to the polyhouse environment through a simple internet connection. The field server (Web server) collects all the sensor data and publishes it on the World Wide Web (WWW) in the form of HTTP; this is done in real-time and all the clients having authenticated access to the web server will get this data through the internet. Such a system can also be easily extended so that the control and monitoring of specified parameters can not only be done through the internet, but farmers can also use their mobile telephones to accomplish the same task. Benefit of using the mobile phone is that there is no limit to the distance as well as there is no need for proximity of the client to an internet connection.

In this paper, we demonstrate an internet based process monitoring and control system for a Polyhouse. The developed system, as noted earlier, has the possibility of integration with GSM communication platform.

III. SYSTEM ARCHITECTURE

The complete system architecture of a typical web based process control application is shown in Figure 1. The laboratory scale mock-up consists of the following basic elements:

- The primary process hardware/experimental set-up.
- A web server computer: It hosts the application and interfaces with the external world.
- A data acquisition/process server computer: these servers are capable of interacting with the web sever on one side and the process hardware on the other. Simultaneous acquisition and online post-processing is also possible.
- Sensors, actuators and servo controllers connecting the process hardware to the process server via suitable interface.
- Embedded primary system level databases necessary for smooth process operation.
- Remote client computers which connect to the local web server through LAN/WAN for data acquisition, retrieval and feedback control of process parameters.
- Mobile telephones/supporting networks for e-mail communication for sending alarm signals, if required to many clients who may be temporarily unconnected to the web server. These signals are generated by the process server in conjunction with primary databases, containing alarm parameters, and forwarded to the web server for further transmission.

The developed system allows the remote user, connected through the internet to the Field-Web-server, to fully access the GUI appearing on his/her web browser to online monitor the processes taking place in the Polyhouse (See Figure 2). While the data acquisition occurs on the on-site Field server, the remote user has complete control on the application. Individual web browsers, with permission to control, can initiate the measurement or automation application, as desired. The operator needs to log in, set certain pre-defined task parameters, and run the application directly. This is achieved by using a Common Gateway Interface (CGI). With CGI, we could communicate with a server-side program or script run by a Hypertext Transfer Protocol (HTTP) server in response to an HTTP request from a web browser. This program normally builds HTML dynamically by accessing other sources such as a database. Browsers can send the parameters to use in the application to the server based on the request. Other logged-in users also can point their respective web browsers to the same URL to view the real time data (pressure/temperature/pictures etc.). Simultaneously, conventional chatting and webcam facilities have also been incorporated to add vibrancy to inter-user communication.

The complete web based application is designed to perform the following major tasks: (i) Publishing Data (ii) Sharing Data (iii) Remote Control (iv) Distributed Execution.

The above tasks are achieved with the hardware architecture, executed and controlled by software support in LabVIEW® environment. With the built-in web server in LabVIEW®, the front panel of the application can be published. Once the web server is enabled, LabVIEW® generates front panel images that can be accessed from any web browser.

A. System Hardware Framework

In the present context, quite a few commercial vendors offer 'Real Time (RT)' hardware/software modules. We have incorporated the functionality of process measurement and control through RT-series hardware (Compact Field Point cFP-RT device) and LabVIEW®-RT Software[2]. This configuration was chosen so as to combine the tasks of data measurement, logging, and control on a single RT platform. This integrated module is an easy-to use, rugged and expandable industrial control and measurement system composed of multiple I/O and intelligent communication interfaces. We have incorporated the Ethernet Network Communication Module (cFP-1804) as the 'Resource Server'. The cFP-1804 connects directly to Ethernet networks, auto negotiating on it, depending on the applicable communication rates (for example, 10 Mb/s or 100 Mb/s). It includes an RJ-45 connector for connection to 10BaseT and 100BaseTX networks, using a protocol based on standard Transmission Control Protocol / Internet Protocol (TCP/IP) to maintain full compatibility with existing networks. The network interface monitors connected I/O modules and publishes I/O data only when the value changes. This Ethernet module uses event-driven communication, in which the network module (the Field-Point Resource Server) automatically sends updates to a client when data changes.

The advantage of an event-driven method, along with data compression avoids unnecessary Ethernet traffic, thus maximizing communication efficiency. The resource server then caches the data from I/O modules and uses it to respond to read requests. When signals do not change over long periods of time, the client sends periodic subscribed messages to verify that the system is still online. The peripheral devices include data acquisition card PCI-6024E (M/s NI Instruments) for the web-based control of connected stepper motors (say, for flow control). Both the speed and direction could be changed at any instant. Toggle (On/off) control of element was achieved with switching relays of 12VDC/2A by utilizing the digital output DC 5V of the DAQ card.

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[2] *More information is available on www.ni.com*

B. System Software Framework

The system software framework architecture is illustrated in Figure 3. It is centered on Application Development Environments (ADE, viz. LabVIEW and Lab Windows). The Measurement and Control Tool (MCT) kits provide the process control and monitoring capabilities. The web server, based on the Component Object Model (COM) is part of the Microsoft® .NET Framework®. It uses the .NET Framework to provide plug-and-play connectivity and interoperability between disparate automation devices, systems, and software, both on the server floor and the client floor. Using PC-based standards such as TCP/IP and OLE Process Control (OPC) makes real-time floor information easily accessible to the online applications.

C. System Demonstration

The photograph of the laboratory model is shown in Figure 4. It can perform the following major tasks through internet connectivity in real time:

- (a) Monitor analog signals like temperature, humidity, pressure, air-velocity etc. and publish it on web.
- (b) Digital toggle (On/off) control of farm machinery and electrical equipment, lighting, etc., is possible by a client through a remote desktop.
- (c) Analog control of farm machinery based on sensor data (no human intervention).
- (d) Visual monitoring of the Polyhouse by an integrated camera.
- (e) Alarm signal generation and transmission to clients on internet and connected via mobile telephones.

V. SUMMARY AND CONCLUSIONS

Web is changing the way we take measurements and distribute results. Many options exist for publishing reports, sharing data and remotely controlling applications. We can incorporate the web into many aspects of farming. Internet based application for control and monitoring of a Polyhouse farm has been successfully developed and demonstrated. At present, initial cost is major concern. However, on one side, cost of such systems is decreasing at a rapid pace. Moreover, the cost can be justified in co-operative community farming paradigms. The system is also typically suited for India as well as other developing nations where farming is a major source of income and needs continues attention. The system can be expanded and implemented in other agro-based industries like Floriculture, Horticulture, Poultry farming, Dairy farming, etc.

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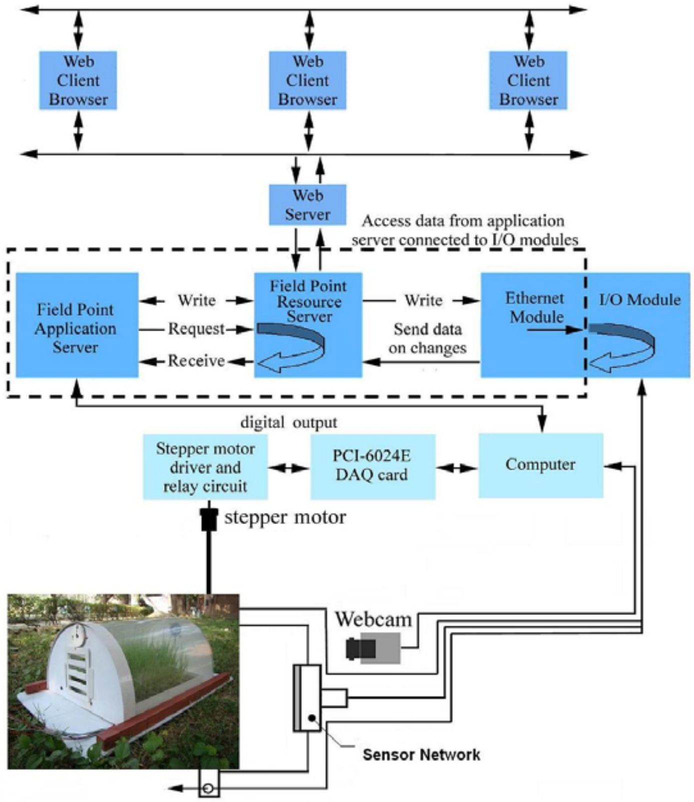

Figure 1: Flow diagram of the web based Polyhouse system, showing data acquisition, and process server computer consisting of different sensors, actuators, servo controllers and other interfacing elements.

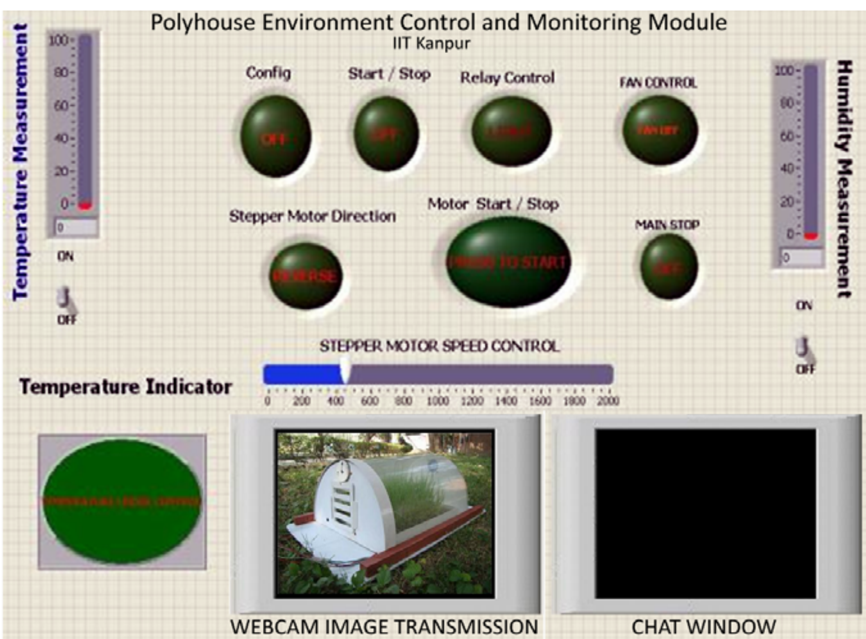

Figure 2: LabVIEW front panel at local host and remote client connected via web server, showing virtual Instruments and control parameters like thermometer, stepper motor control and relay control.

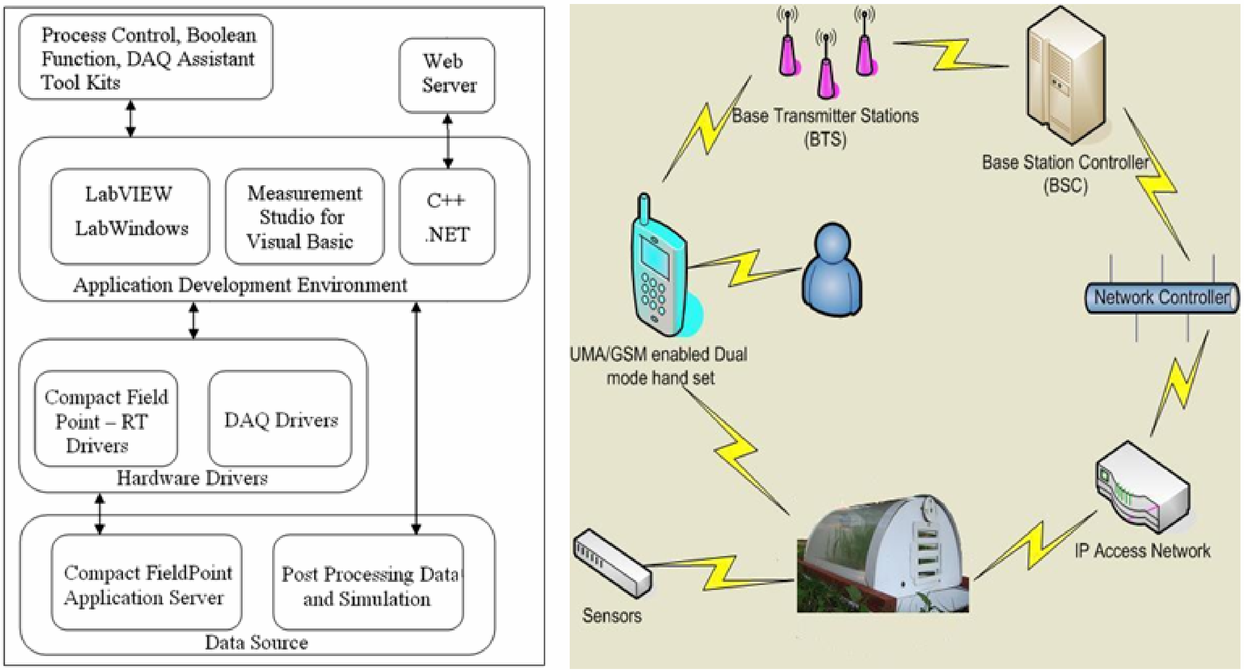

Figure 3: Application development environment for process control and monitoring, showing system network architecture.

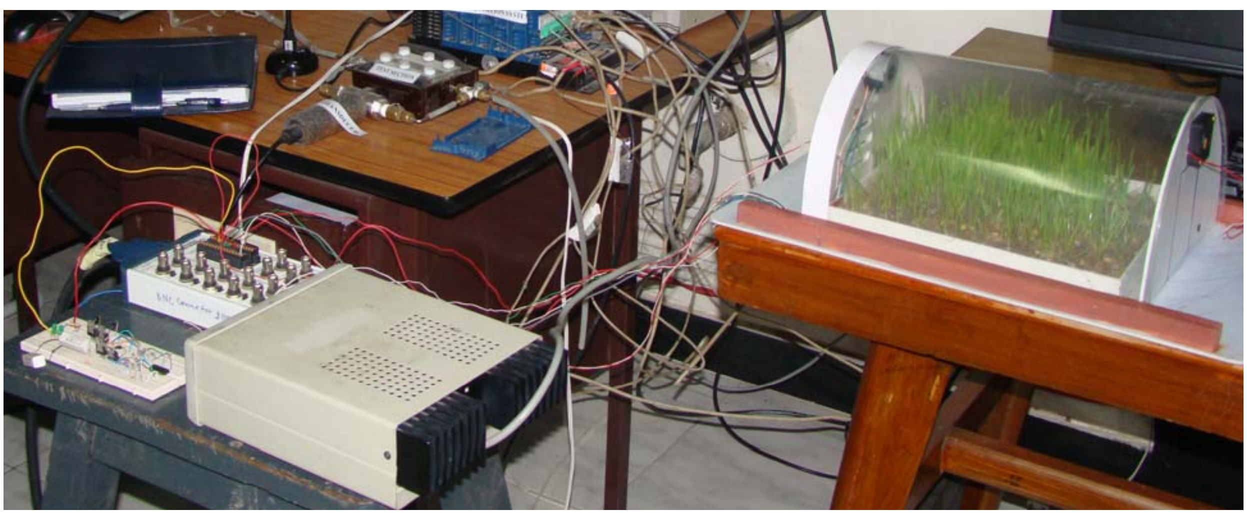

Figure 4: Final prototype of experimental set up showing Polyhouse connections to data acquisition system.

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