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Design of control system for full-fledged automation of a house using CMS & SFD

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Abstract: *Here, in this work, we design and implement an efficient controller for the automation of a greenhouse problem using various types of advanced instrumentation devices and software flow diagrams.*
Keywords: *Greenhouse, Control, Automation.*

I. Introduction To The Green House

A greenhouse means the gardening season doesn't have to end with the onset of winter. It provides a light-friendly location for growing flowers, vegetables or other plants. Enjoy plump, juicy tomatoes in winter and decorate your home with tropical flowers throughout the year. A greenhouse can be built big or small, and designed to suit the casual hobbyist or serious gardener. Thanks to technological advances in building materials and available features, constructing a high-quality greenhouse doesn't necessarily require a lot of money or time. But careful planning is key before starting the project.

The design efficiently utilizes cutting edge technologies, along with an upgrade to futuristic technologies, simulating the environment inside the greenhouse and in turn emulating the natural ambience congenial for crop growth, thus making the greenhouse proficient to grow any crop, in any season, at any place on earth. Greenhouse provides fogging systems that are suitable for small to medium sized greenhouses. Our systems use a high pressure boosting pump and very small nozzle orifices to create a fine vapor that readily evaporates to humidify and cool the air. All components are high quality and high reliability and should provide years of use if properly maintained.

Greenhouse Automation is an initiative to modernize and automate the present day greenhouses with state of the art technologies making it possible not only to enhance productivity but also to yield higher standards of crops. It employs a microcontroller driven architecture powered by an intelligent Real Time Operating System (RTOS), showcasing extended functionalities and customizable features of the design. Remote Surveillance and foolproof Authorization features empowers control of greenhouse through internet, enabling access from virtually anywhere under the sun.

Many greenhouse hobbyists work day jobs and aren't always available to tend to their plants when needed. An automated system to control heating, water, ventilation and more would be ideal. Many of these systems are very expensive and more appropriate for the commercial grower. However, there are some affordable products on the market to help your operation, such as solar-powered vent controls.

Solar-powered vent openers are thermal pistons. A temperature-sensitive wax expands with heat, which drives a leveraged arm to lift the vent. As the temperature is lowered, the wax cools and shrinks. Gravity and "helper" springs close the vent and reset the piston. Opening and closing are gradual adjustments that allow just the right amount of airflow for cooling. Vent controls can lift up to 35 pounds each; combine two for a 70-pound lift.

II. Block Diagrammatic Representation

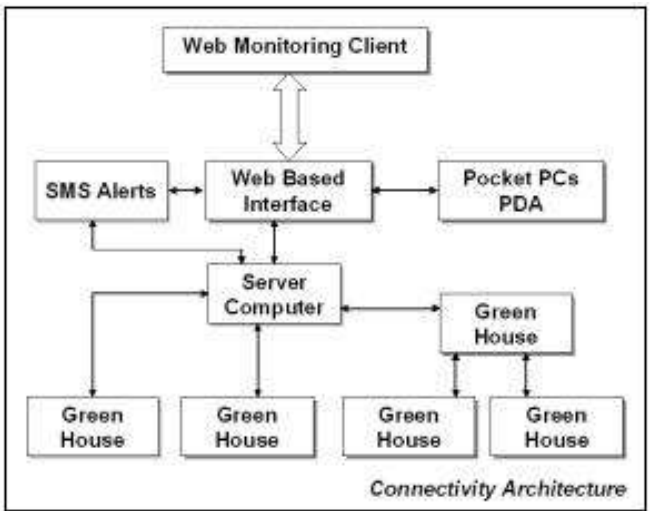

Fig. 1 Block diagram of the greenhouse system

The problem areas of the present day greenhouses:

- Manual Operation
- Lack of Real Time Device Control
- Lack of Automatic Data Logging
- Labour Intensive
- Lack of Predicting Crop Growth
- Lack of R & D System Support
- Lack of Centralized Monitoring
- Lack of Remote Surveillance & Control
- Manual Resource & Inventory Management
- Manual Accounting & BackOffice work
- Lack of Notification in Emergency
- Low Return of Investment
- Lack of Export Quality Products

III. Implementation

Greenhouse Automation is a solution to the problems faced by present day greenhouses. The design promises efficient management of greenhouses using client-server based communication structure along with solutions for present problems. The design is as follows.

The Connectivity Architecture demonstrates unique features of Greenhouse Automation extending its accessibility to the transcontinental level. Various greenhouses are connected in star topology with the central server.

Client greenhouses are connected under a router greenhouse which acts as a data router for the server and the client greenhouse. The central server is connected to internet which deploys an internet site for **Remote Surveillance & Control** of greenhouses.

SMS Notifications alerts the user as configured in the software. On field Pocket PCs & PDAs are used for remote monitoring and controlling thus enabling the user to monitor and analyze functioning of the greenhouse, without accessing the main screen.

Authorization & User-Rights:

The design supports various types of users to the system. Every type of user has different rights assigned. The degree of access to the greenhouse is determined by the type assigned to the user. Any user entering the greenhouse needs to be authorized. This answers the security requirements of the greenhouse.

Analog & Digital Device Compliant:

The design supports two types of devices – analog and digital. Depending on the software settings, every device on the input and output port is configured as analog or digital. According to the type of device, the value it takes is restricted.

Electronic Sensors & Devices:

The different sensing technologies enable the controller to predict and act on situations for perfectly controlled climatic conditions. On sensed parameter being above or below the threshold set in the software, the associated control device is switched on or off depending upon the requirement. Interrupt based monitoring of various alarming situations like fire, smoke, and strong wind integrated in the design makes the greenhouse safe from natural calamities also.

Customizable Plug-n-Play Architecture:

Various analog and digital sensors or control devices are attached to the system. Every device is configured with thresholds by which automatic device control takes place. The design supports 16 input channels (analog and digital) and 32 output channels (16 digital and 16 analog).

Core Microcontroller:

The core AVR microcontroller running on RISC architecture forms the heart of the design. The controller features Internal Oscillators, Timers, USART, TWI, SPI, Pulse Width Modulation, ADC, Analog Comparator and Watch-dog Timers are used to monitor and control various green house functionalities like the Authentication System, Keypads, Embedded PC Communication, Host PC Communication, Electronic Vision & Image Processing, and various external sensors and control devices.

The core AVR microcontroller also communicates with other auxiliary microcontrollers ranging from 8-pin TinyAVR to 64-pin MegaAVR which are application specific. The system features addition of new auxiliary microcontrollers which can upgrade the current design for extending support for new technologies. This capability keeps the system abreast with futuristic technologies.

Embedded PC:

Embedded PC is a single board computer with various features of a personal computer. It communicates with the AVR microcontroller driven architecture which has RTOS monitoring and controlling the greenhouse. It supports 3rd party software plug-ins to analyze and control the greenhouse. The prime benefit being softwares can be platform independent. The Embedded PC is configured for data warehousing where complete crop data is stored on the system which can be used by software modules for data mining applications.

Chrome Filters:

The greenhouse structure uses colored shade nets. These select a particular color, which is created in the greenhouse. These are UV treated and very durable. They are resistant to agro chemicals and provide uniform shadow. The selection of color depends on the plant being grown in the greenhouse. This supports the fact that some plants grow faster when light of a specific color falls on them.

Remote Surveillance & Control:

The design supports Remote Surveillance & Control of greenhouse via internet from anywhere in the world. The greenhouse design deploys an internet site which can be visited for general monitoring and control. The site is deployed on the centralized server of the greenhouse. The site is updated on Real Time and uses authorization features.

Depending on the login to the site, the user can change specific settings according to the degree of access assigned. The design also supports WAP requests making it possible to monitor the greenhouse from a WAP powered mobile phone. Similarly the complete remote monitoring and control is also possible from a Pocket PC, which can be used in the greenhouse and even on the move.

SMS Notifications:

In case of emergency any one configured mobile number is sent a SMS indicating the problem inside the greenhouse. The complete status of the greenhouse is monitored using a SMS reply number and a keyword. The design is configured to reply to specific numbers for security reasons and send a SMS on specific events like person entering greenhouse or changing parameter, depending on the user settings.

Centralized Monitoring:

In a field of many greenhouses operating with the design, the various greenhouses can be connected together enabling centralized monitoring of all the greenhouses on a comprehensive screen. The centralized monitoring server also hosts the internet site for Remote Surveillance & Control functionality of the greenhouse. It also involves notifying the users on their mobile numbers for specific alerts. Along with it maintains a central data warehouse of all the greenhouses.

Data Logging:

Statistical data like temperature conditions inside the greenhouse, various external temperature conditions, and seasonal changes are required for plant growth analysis. Depending on the requirements, the design stores copy of the plant details into its database.

Decision Support System:

The data warehouse contains a large database of crop parameters and the environmental conditions inside the greenhouse. When the database is strong enough to generate crop reports from its previous harvests, data mining is used to extract useful details about the crop. Not only the database would be helpful for enhancing crop standards but would also facilitate decisions made by controller to act on specific situations. Thus the result is higher crop standards and higher productivity.

Multilingual Support:

The design supports multiple languages thus extending the support to a wide variety of users. The System eases the complexity of computing in a multilingual environment by providing different options designed to make it easier and less costly to get work done, regardless of the location or the language.

Real Time Operating System (RTOS):

The software design is powered by an intelligent Real Time Operating System (RTOS) which resides in the microcontroller memory monitoring and controlling all the sensors and devices in the greenhouse. It also performs other software functions like authorization of users, data storage, reading and updating keyboard and display, processing plug-n-play device code for advanced control of devices, forwarding and replying to the central server based routing requests.

The designed Software Class Diagram demonstrates the various functionalities each device exhibits in the designed system architecture. Depending upon these functionalities methods of all the classes are referenced in the software. The referenced code enables execution of the class method which gets the parameters from the stack. This class based architecture enables the processor to extend its operating system for new devices on the designed system. The class based architecture enables the design to assign various rights to users, describing which methods of which class to be allowed and which to be denied. The degree of access to the system is thus limited depending on the type of user, making the system foolproof.

The design has the efficacy to store debug information for analyzing the fault condition if there is a software failure in the operating system. The debug information is stored during an error and is passed on to the central server on restart.

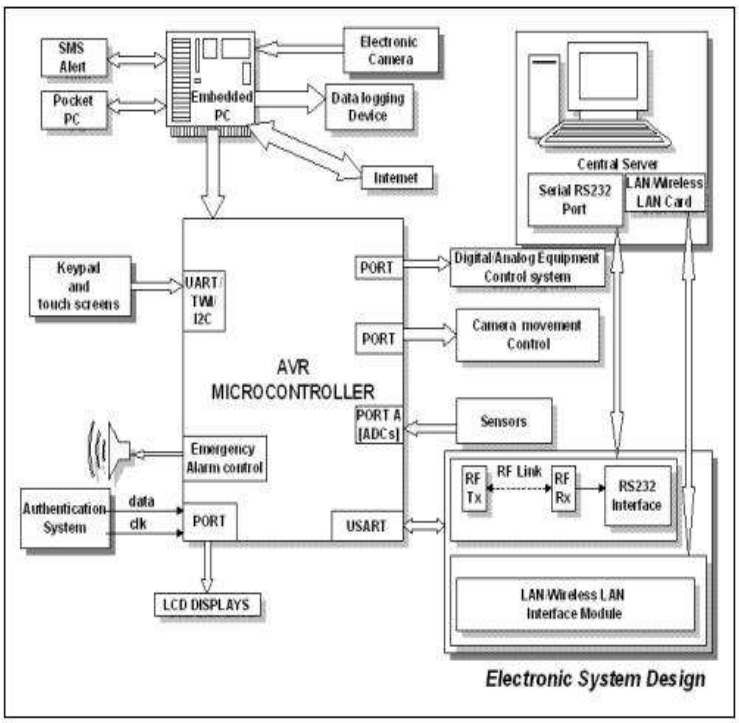

Fig. 1. Controller design of the greenhouse problem

Serial sensing and control devices which are required in the greenhouse require special kind of protocol to communicate. Plug-in manager provides a functionality to store the driver plug-in to make the device functional. The system also efficiently manages and updates the display depending upon on the user inputs on the keyboard or touch screen which ever acts as an input device.

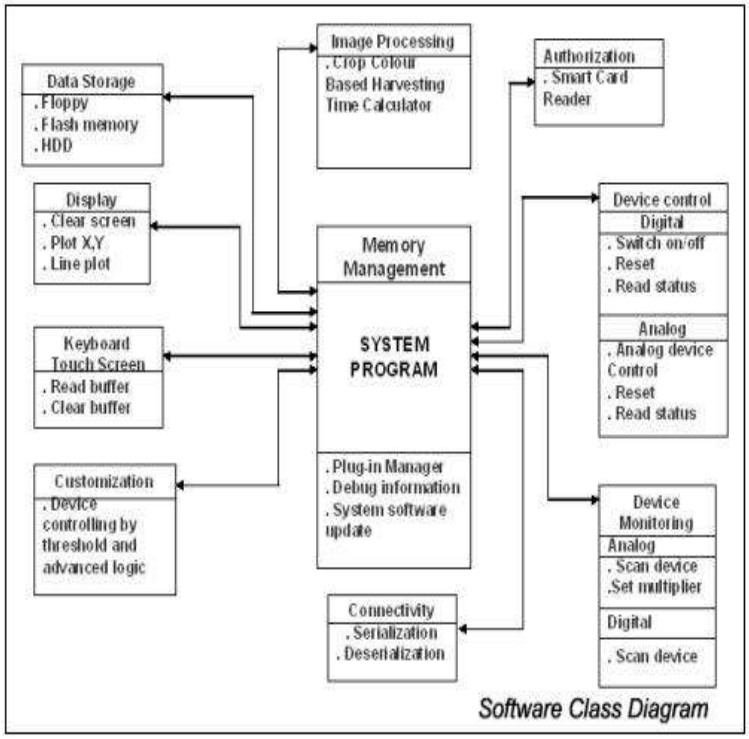

Fig. 3 Software Class Diagram

User Interaction Flow Diagram:

The Flow Diagram demonstrates User and Software interaction. The first column shows the user interactions with the software, the second shows the software functions, third shows the database entries affected and fourth shows the devices controlled due to user interaction. The diagram acts as a classified software architecture according to the type of operation performed.

Greenhouse Prototype:

The design is implemented as shown. The prototype is a real sized greenhouse measuring at least 6x4x8 feet, the structure contains actual greenhouse devices. The structure employs exhaust fans – for ventilation, flap system – for light intensity control, polycarbonate sheet – for trapping heat, magnetic lock doors – for electronically controlled authorization, cooling pads – for moisturizing and cooling, temperature, light intensity, oxygen, carbon dioxide sensor – for maintaining controlled environment. Also devices like soil moisture, drip irrigation pipes, sprinklers &foamers, nutrient sensor and fertilizer mixer.

All these devices control the environmental conditions inside the green house with maximum accuracy. Being connected to the design, the devices are scanned at regular intervals for monitoring the ambience inside the greenhouse.

Business Benefits:

Summing up the prime business benefits of the system:

- Increased Productivity
- Higher Return of Investments
- Lower Maintenance costs
- Upgradeable to Futuristic Technologies
- R & D support
- Non-seasonal Crop Growth
- Foolproof with Authorization and User-Rights
- Real Time SMS Alerting

- Transcontinental Access (Global Presence)
- Server based Inventory & Resource Management
- Online tie-up with clients (B2B)

The Greenhouse sector still remains an unexplored one with technology in mind. With the use of latest technologies, the sector has a large scope of development. Thus resulting in win-win situation both for the owner and country people.

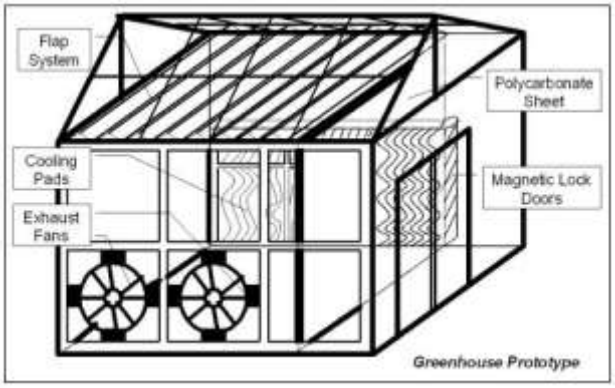

Fig. 4 The designed and implemented greenhouse

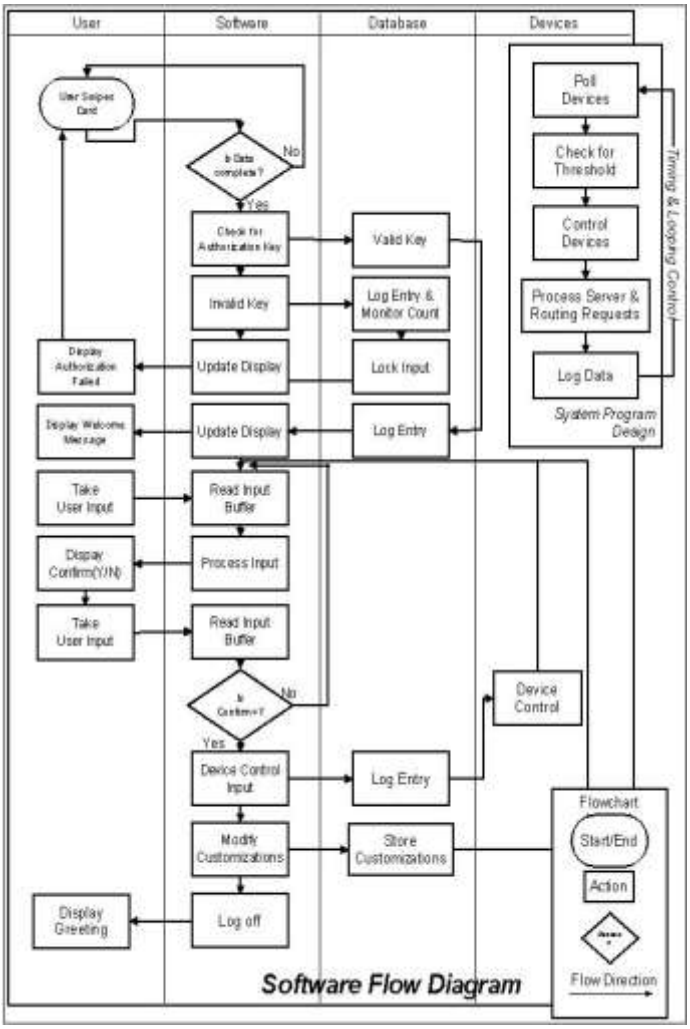

Fig. 5 Software Flow Diagram

IV. Conclusions

A complete automation of the greenhouse was performed and also implemented to some extent in real time. The entire hardware and software design was performed and the design is shown in the relevant diagrams.

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