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A Survey on Automatic Field Irrigation System

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ABSTRACT: The users of modern buildings require more and more comfort and for fulfilling habitation requirements they expect more achievements. Air-conditioning, refrigeration, lighting system, security and camera system, telecommunication system and computer network have been added beside the traditional heating and ventilation. Concurrently with the requirements of the users, the demands of the operation economy of these kinds of objects with multifunctional technology grow, too. The paper describes a creation design of automated control and remote management of irrigation system by the use of low-cost device Arduino and operating system Android. The irrigation system consists of several modules which can be divided into three parts: control part, regulatory part and server part. The design brings comfort, automation and mostly energy savings for intelligent systems.

KEYWORDS: Embedded System ■ Arduino Micro Contoller ■ Irrigation • Wireless Communication

I. Introduction

The term of smart house is known by experts of modern building technology and their control is known for decades. It is a control system integrating all the cooperating technologies in a house or an apartment. The importance of technology control is increasing by the number of systems which are found in the object. The bigger the comfort and building function requirements of the users are, the bigger are the demands of the control systems.

Most of end-users cannot simply choose an affordable smart house system which they can rely on as a comprehensive system. This is because although recent works are done in designing the general overview of the possible remote access approaches for controlling devices [1], or in cases simulating the smart home itself [2] [3], and designing the main server [4], the design and implementation of an affordable smart home remote control application has been limited to simply the computer applications and just in cases mobile and web application development [5].

Irrigation is an effort to fulfill water needs of plants so that they can grow optimally with the provision of additional water [6].

The monitoring activity is closely related to data transmission and the most crucial thing in data transmission is how to transmit data from one place to another where the data received should be same to data sent. Data monitoring of irrigation is important because it will be used in the decision-making process. This is one possible way of automatic irrigation, such as how to control setting of irrigation network, how to open or close the floodgates, and how much flow of water to be used so that it can conserve water usage later [7].

II. AUTOMATED IRRIGATION SYSTEM

The irrigation system allows the user to control the irrigation in the household. The system is controlled fully by online interface and requires active connection to the Internet. In the case of Internet connection failure, the irrigation system works based on the saved settings.

The irrigation system consists of several modules which can be divided into three parts: control part, regulatory part, and server part. The control part consists of the Android application which represents the frontend of the whole system

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and it is possible to implement it on any kind of mobile phone with OS Android 4.0.3 and above. The regulatory part consists of hardware elements where the microcontroller Arduino Yun represents the core and enables the switching of the solenoid valve according to the demands coming from the controller. Arduino is an open-source platform [8] used for constructing and programming electronics. It can receive and send information to most devices, and even through the Internet control the specific electronic device. It uses a hardware called Arduino uno [9] circuit board and software programme (Simplified C++) [10] to programme the board. The server part serves as a mediator between the control and the regulatory part by which the communication is enabled across the Internet without the need of a public IP address, or if the regulatory part was found in the local network.

A. OPERATING SYSTEM ANDROID

Operating system Android is a broad one based on an open-source platform. It is computer software with an open source code. The user can use the software for free and when fulfilling certain conditions, the licensing policy enables him the access to source codes which he uses consequently or modifies according to his needs. However, all the codes should be accessible under the same license (open source initiative, 2014).

The system is built on a Linux core which uses its own virtual machine enabling the security of the system as a whole, memory management, process management, access to network and the control of all the internal sensors and components (Figure 1). Each application does not approach directly to the core function but by Android API. Android is then a progressive operating system primary developed for mobile devices (smart phones, PDA, navigation and tablets). It was built and constructed from the bases which enable the developers to create impressive mobile applications. These applications can fully use all the features which the device offers [11].

Android is popular with technology companies which require a ready-made, low-cost and customizable operating system for high-tech device Android's open nature has encouraged a large community of developers and enthusiasts to use the open-source code as a foundation for community-driven projects, which add new features for advanced users or bring Android to devices which were officially released running other operating systems.

APPLICATIONS
HomeContacts Phone Browser
APPLICATION FRAMEWORK
Activity Window Content View Notification
ManagerManager Providers SystemManager
PackageTelephonyResourceLocation XMPP
ManagerManager Manager ManagerService
LIBRARIES **ANDROID RUNTIME**

SGL SSL libc
LINUX KERNEL
Display Camera Bluetooth Flash Memory Binder (IPO
Driver Driver Driver Driver Driver

USB Keypad WiFi Audio Power
Driver Driver Driver DriversManagement

Figure 1. Android's architecture diagram

B. REGULATORY PART OF AN INTELLIGENT IRRIGATION SYSTEM

The regulatory part of the system includes the description of the hardware design and also the design and the software part programming. The regulatory module is responsible for the correct interpretation of the values found in the database, their treatment and representation on a physical layer. It consists of control electronics and of a power cable section [13].

The hardware used for regulatory part realization contains a logical unit Arduino Yun (Figure 2), module of a real time DS 1302, two humidity sensors, relay module containing two relay for switching the solenoid valves,

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solenoid valves with the possibility of manual control, and a power supply ZSR-30.

Figure 2. Microcontroller Arduino YUN

The microcontroller Arduino Yun is the core of the regulatory module which is based on the chip ATmega32u4 and the processor Atheros AR9331.

This processor supports the distribution of Linux-based on OpenWrt called OpenWrt-Yun. The device possesses the support of inbuilt Ethernet, WiFi, USB-A port, micro-SD slot, twenty digital input/output pins, 16MHz crystal oscillator, micro USB connector, and three reset buttons. It has appeared that this device is a good choice because it connects several advantages. The chip ATmega32u4 provides reading and writing data on the output port in real time. Thus their processing runs quickly and with minimal echo.

The circuit DS1302-0902A4 (Figure 3a) was used as a module of real time. The module is able to remember and compensate time (leap year etc.) with an accuracy of seconds until 2100. It is connected to an hour battery and is able to work with the consumption of less than 1pW. it requires connection of at least five wires while two of them serve to connect and the microcontroller communicates through three signal wires SCLK, I/O, CE.

The circuit LM393 (Figure 3b) was used as humidity sensor which is used not only as a humidity sensor but also as a motion sensor and has other use. The communication with it runs through analog input on the microcontroller. Consequently, this value was processed and transferred to humidity percentage.

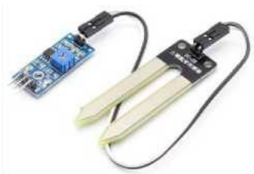

Figure 3. a) Real Time Clock, b) Humidity Sensor of Soil

Since the solenoid valves were used to be switched of 12 V or 24 V and output ports of the microcontroller work with tension of 5 V, it was necessary to solve this problem. As an adequate alternative there was an offer to use relay module by the use of which it was possible to switch higher tensions. The used relay module SRD-05VDC-SL- C contained two independent relays which provided galvanic isolation of power cables from switching electronics. It is possible to switch up to 10A 250VAC with it.

Solenoid valves serve to system control without manual interference. From the amount of valves which are accessible nowadays, the valve 1" has been chosen with external threads switched with the tension of 24VAC. The valve was without any variable electronic control; however, it was possible to set the flow manually. It was possible to fully control it manually and put the electronics out of operation. The type of the valve was Hunter PGV-101MM-B1". Two valves of this kind were used because two separate irrigation circuits were to be controlled.

The power supply ZSR-30 (Figure 4) was a variable and stabilized power supply which serves for connecting various devices and appliances by safe tension with full galvanic isolation from the net. Connecting tension of the power supply was AC 230V. The power supply provided output tension DC 5-24V, stabilized 24 V and volatile AC

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24V. Transcendence of the current limit was indicated by LED flicker. In the case of full short circuit, the output was disconnected; the output current was restricted with electronic fuse. It provided consolidation n DIN lath and has a size of three modules (3 - modules).

III.CONCEPT OF COMMUNICATION AND APPLICATION DESIGN

A. CONCEPT DESIGN OF SYSTEM COMMUNICATION

While designing the communication concept, system requirements were taken into consideration. One of the main requirements of the system was that it would be possible to control the system wirelessly not only in a local network but from any place on earth in a case that in the phone, serving as a control unit, there would be Internet connection.

The first possibility was to create a connection Client- Server (Mobil-Arduino). In this concept, it would be a necessity to guarantee that Arduino would be accessible on the Internet. It would require static public IP address for Arduino in order to be make a possible contact to the server running for Arduino. Another possibility was to have a static public Ip address on the router in the local network and to enable the redirection of requirement on the server in Arduino.

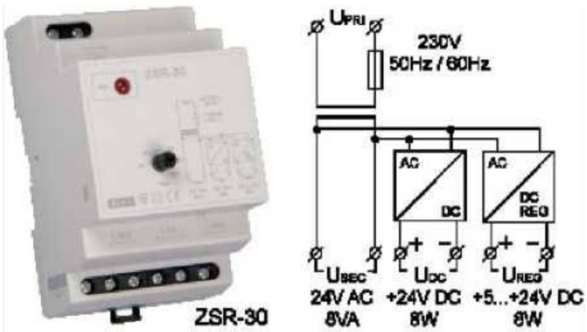

Figure 4. Regulated power supply ZSR – 30

At regular intervals the microcontroller Arduino measured the actual humidity and sent it to the database on the server on the bases of time interval saved in settings. Each second Arduino polled into its local database and surveyed the actual state of manual and planned irrigation and evaluates whether the particular circuit should be switched on or turned off. Through Android application commands came into the database which are taken over by Arduino. Application Android served to create plan and entering commands. The application saved the commands into the database through php scripts. Each change in the database was recorded into a chart new events. By the use of the chart, the irrigation unit surveyed whether the synchronization of the database was needed or not. Update and deletion functioned on the same principle.

The real scheme of connection irrigation system is on the Figure 5. The irrigation system consisting of the following blocks:

1. Arduino Yun
2. Module of Real Time Clock
3. The humidity sensor
4. Module of Relay
5. Solenoid Valves
6. Power supply ZSR - 30

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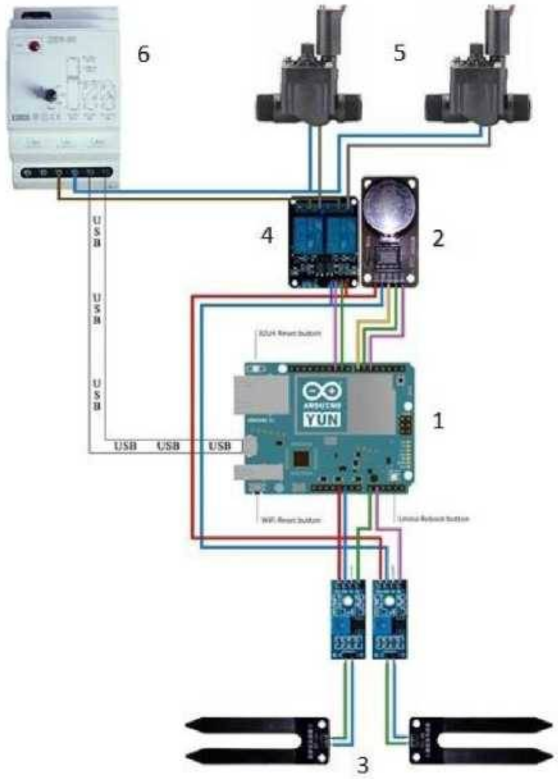

Figure 5 the scheme of connection of wiring irrigation system

B. APPLICATION STRUCTURE DESIGN

For simpler application structure design description, a class diagram was used to show the main classes and the relations between them (Figure 6).

One of the main classes of the whole application was DataModel which describes the data model. This class was programmed according to design pattern “Singleton” which enabled that during the application work in the memory there would be always only one instance of the class and thus it would guarantee the consistency of data. To DataModel classes such as “PlanItem”, “Manualltem”, “Settingtem” were connected which are the image of the SQLdatabaze on the server.

Another but not less important part of the application was the class DB Handler which provided communication of the application with the server. In order to reach a faster communication, there were subclasses for this purpose: "GetManualDataFromServer", "GetPlanDataFromServer", "GetSettingDataFromServer", and “PostDataToServer". Each of this class had its own fiber operating on the background of the main fiber the purpose of which was to render properly GUI.

User interface

User interface of the application consisted of four basic screens. The screen of manual control, the screen of weekly schedule, the screen of settings and the screen for plan processing.

Server part

Web server was rented as a free hosting on hostinger.sk. Hosting provided PHP and MySQL without restrictions. PHP engine had all the functions allowed. It was possible to pass to any version PHP with one click and to manage the database with the tool phpMyAdmin.

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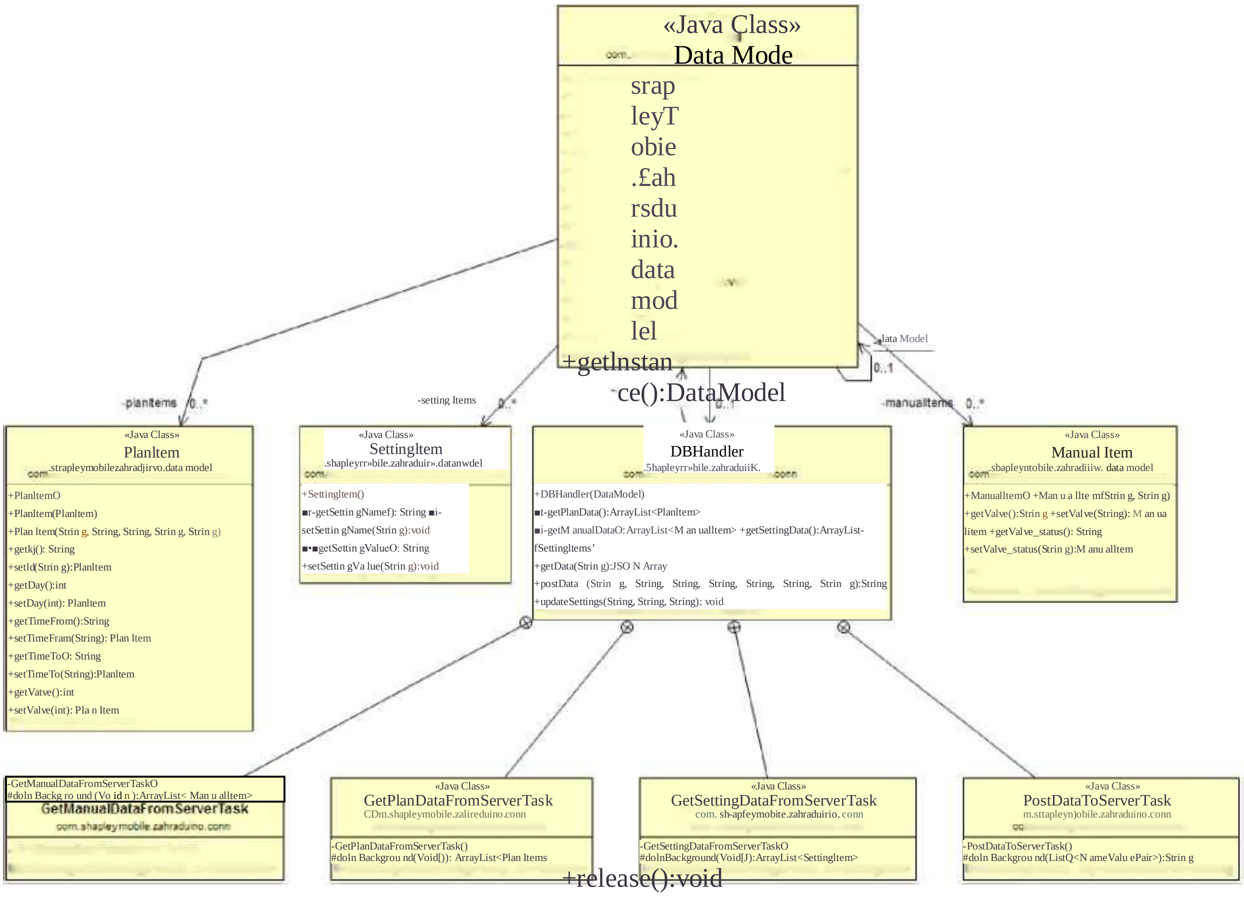

Figure 6. Class diagram

The database consisted of four basic charts: manual, plan, settings and humidity. The humidity chart was composed of two columns (valve, vlave_status) and recorded data about manual control. The column valve was identification of

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the specific valve and valve_status marked the actual state. The plan chart contained five columns (id, day, time_from, time_to, valve) and served to record planning cycles. The day column identifies the particular day in the week, time_from column and time_to column reserved the time period when the system should be active and the valve column represents the same as in the manual chart the specific valve. Settings chart contained three columns (id, setting_name, setting_value) and there were the settings of the system. The setting_name column indicated the specific item of the setting and setting_value its value. The humidity chart contained collected data about humidity of irrigated soil and consisted of four columns (id, timestamp, value, sensor). Timestamp was the time of recording, value contained the measured humidity percentage and the sensor was marking the particular circuit. The chart new_events served as a notification chart for Arduino. It drew information about which chart has been modified. According to recordings in this chart Arduino synchronizes its local database.

IV. DISCUSSION

The irrigation system allows the user to control the irrigation in the household. The system is controlled fully by online interface and requires active connection to the Internet. In the case of Internet connection failure, the irrigation system works based on the saved settings.

Intelligent irrigation system consists of several modules which can be divided into three parts:

- control part,
- regulatory part,
- server part.

The application which enables the hardware control part of microcontroller Arduino Yun runs under the operating system Android 4 and above.

The advantage of the irrigation system is its autonomous control of solenoid valves which enable water into the irrigation. User can fully control the whole irrigation system by the use of his mobile device.

Another advantage of the system is:

- possibility of operation in the case of Internet connection failure,
- report of the system through web interface,
- possibility to refill the system by other sensing unit.

Disadvantages of the system are:

- the created application runs only under operating system Android 4 and above,
- necessity to calibrate the used humidity sensor to reach the highest effectiveness of the irrigation system.

V.CONCLUSION

To sum up, it is possible to say that mutual influence and operation of automatic control theory, informatics and, the last but not least, the science of artificial intelligence is a characteristic feature for current automation. According to this, it is possible to formulateobjectives of automation and to realize intelligent systems with user's comfort above standard and economically effective operation [14].

The irrigation system irrigates also in absence and turns off when the plants do not need any water. The system irrigates regularly according to needs. It is possible to save the half of water consumption than while manual watering. The return on investment of the system is approximately one year. By connecting to another alternative source, it is possible to increase the return faster.

The acquired results would be analyzed by various statistical methods and optimal results for monitoring would be searched for [15]. By the use of data from various model situations [16, 17] it would be possible define the effectiveness and reliability of the system.

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