One solution of web application for data acquisition from remote sensing devices

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Abstract - **In a world where the need for food is increasing, the number of cultivable lands is decreasing. It is very important that the available arable areas are put to maximum usage by introducing the 21st century technologies to agriculture, so-called precision farming. Thanks to the precision farming, the user knows the exact amount, location, time and type of resources that he needs, in order to treat the crops. This paper describes a system of support for this type of agriculture. A web application has been developed, by using ASP.NET MVC technology, which gathers data from the wireless sensor nodes and gives the user the possibility to see the current status of the crops at any time. The paper contains a description of the technology that has been used for developing a system, block diagram of the system and displays user interface screenshots. In addition to that the possible future improvements of the system have been analyzed.**

Key word – ***Precision agriculture, Automatic weather station, ASP.NET, SQL, MVC, GSM***

I. INTRODUCTION

Field measurements in the environmental sciences still depend upon the pencil and paper for data collection. Although robust, this method is labor-intensive and susceptible to recording and geo-referencing errors during transcription [1]. In the modern agricultural world these mistakes are unacceptable, therefore it is essential to replace this approach with modern technologies that will not only reduce errors, but also will improve business operations. Instead of spending human and other resources, today, there are instruments and devices that monitor the environment of agricultural farms and gather significant data.

The working principle of these units is that they are placed on agricultural farms to gather and monitor data through installed sensors for environmental changes. The gathered data are after that sent to a server in order to be processed, filtrated and prepared for display to the user. The user can, at any moment, access the web application where he can see all of the required data. In that way user has true insight in the environment and conditions in which the plants are being developed. This form of management is everyday more and more represented and the development of information technologies has left an important trace in the way of modern management of agricultural farms.

It is easy to see that almost every segment of management and business activities is more and more intertwined with the according technologies, which are there to give support and upgrade management. Aware of the development situation, the engineers have seen a space for application development of this type, and with that, enable more confortable work for the users. The sheer fact that the farmers do not need to check their crops physically very often to find out whether or not the rain had a negative influence on them, or to check if the right conditions have been achieved for the fecundation and protection of the plants, shows that this kind of support development in the agricultural management is more than welcome.

There are many ways of approaching to the development of the application, it has to try to keep up with any possible demands from the user, that its functionality covers all of the necessary segments and that the speed of its work is at satisfactory level. In today's world, it could be said that the MVC pattern is one of the best possible approaches. This conclusion could be drawn based on its architecture, its “loosely coupled” components open up more possibilities and freedom in the development of the application. Besides that, the code is much clearer, which leads to the fact that the maintenance and development of the application will be simpler.

Rest of this paper will present the papers that have had some studies about this subject and have worked on it – section II. After that, in section III the functionality of the application will be described and what the user can expect from it. In section IV the process of the development of the application and the technologies that have been implemented will be shown, while at the very end, in section V, the conclusion about the described application as well as the possibilities for further development and growth will be presented.

II. RELATED WORK

It could be said that MVC has become one of the most popular patterns in application development. Many researchers have conducted the studies on the subject of this pattern, the width of its usage and the development style. The data gathering has sparked the interest of many researchers in the same way as the development of a monitoring system. There are a large number of approaches and various types of technologies for the development of such a system, and in the following text, the papers that are significant for our work and reflection will be discussed.

Authors of [2] demonstrated a wireless sensor/actuator network that has been developed at Carnegie Mellon

University to facilitate operations at a plant nursery. Their project consisted of placed sensors in fields that gather data from the environment and then send them to a centralized database. For the presentation of the data they have developed a world wide web-based GUI, which incorporates an option of showing real time data as well as the historic views of the data.

Also, in a paper [3] was described a way of monitoring and gathering data from the environment. Sensor Web system for forest environmental monitoring was proposed and implemented to provide an approach for sensor data sharing and interoperability by combining Wireless Sensor Network (WSN) [4] and Open Geospatial Consortium (OGC) SWE standards [5]. Field experiment results demonstrate that system can continuously acquire environmental data from remote desertification area in over one year's observation, suggesting that the system is stable and robust, and is feasible for long term forest monitoring application. A monitoring web page was also developed based on Sensor Web interfaces, indicating the feasibility of Sensor Web system for data access and sensor node management.

As for the application of the ASP.NET MVC pattern, in the paper [6], the full advantages of using this pattern are well described. All of the possible/potential problems in application development are covered as well as how the usage of the MVC pattern can overcome the problematic issues. As the authors state, the need for a single website that could serve all of the users in an acceptable way, has become of great importance with the appearance of smart phones. ASP.NET MVC 4 uses standard Web techniques (HTML 5 [7], CSS 3 [8], JScript [9], JQuery [10], Ajax [11]) for the adaptation of Web content which allows good design and support of a wide range of devices. Furthermore, device and Web reader recognition is supported, that allows additional possibilities of adaptation.

III. FUNCTIONALITY

One of /the most important problems in agricultural management of a farm is delayed information. The circumstances and the conditions of the environment change rapidly and the timely reaction to those changes is of most importance. If something like this was done "by hand" without any technical support, the development of the farm would be very slow, very often the farmer would have delayed reactions, which would lead to unnecessary consequences and their repair.

One of the possible solutions for this type of problems is the use of the application with which the user can monitor the newest changes in the environment at any given moment. The basic idea of this application is that the user can access the wanted data, monitor the current conditions and plan future actions in the best way possible. The most important thing here is the accessibility of information. At every moment the user can reach the data on the Internet via the web browser and monitor the conditions of every station, which leads to great savings in time and resources, and the collected data is up to date and reflect the current conditions of the observed field.

On the functionality basis the application shows the information in graphical and table forms. There is a possibility to filter the data depending on the time interval, as well as selecting a certain group of devices, a single device or sensor in the device itself. The user also has the ability to see the geographical location of a device.

Remote sensing devices have the following sensors, so the application can present their measurements:

- air temperature,
- air humidity,
- solar radiation
- UV radiation,
- precipitation,
- soil moisture,
- soil temperature,
- leaf wetness,
- wind speed,
- wind direction.

Images that represent the appearance of the environment weather monitoring application could be seen below. The Login page is presented in Fig. 1, where the user enters his/hers username and password. After entering the correct username and password, a page will open up where the user can select a desired cluster, field, device, and also set the parameters and the timeline that he/she wishes to see (Fig. 2.). After the parameter selection has been achieved, the wanted data will appear for the user in a graphic chart view (Fig. 3.).

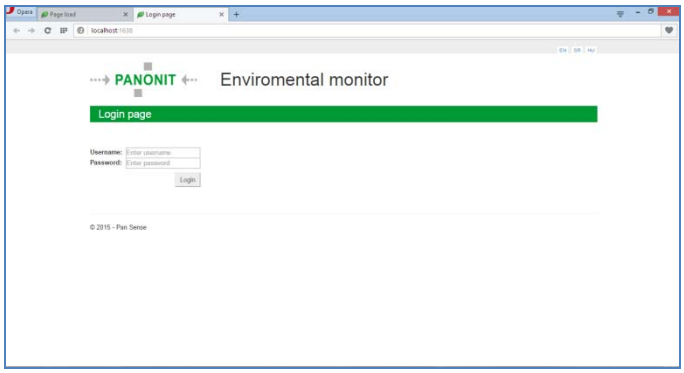

Figure 1. Login page

Also, the user has the ability to choose a predefined set of sensors that want to observe. It works by the Predefined view page, where he can select the desired sensors, provide a selected group name and save it (Fig. 4). The group becomes a predefined set of sensors, which the user will be able to select on the main page without any additional configuration. That is very useful when user frequently observe the same set of sensors. In that chase there is no need to select the same sensor each time, but only to select predefined view created earlier.

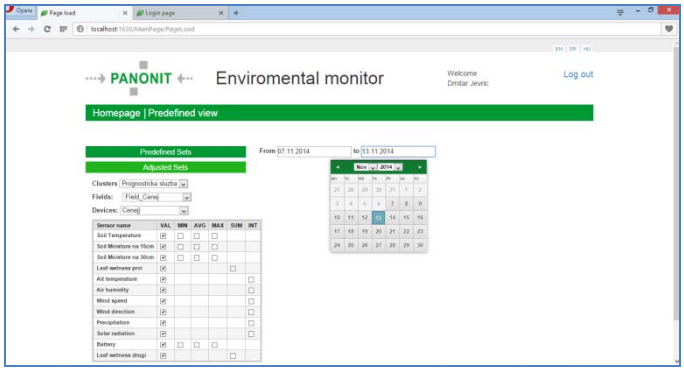

Figure 2. Main page with selected parameters

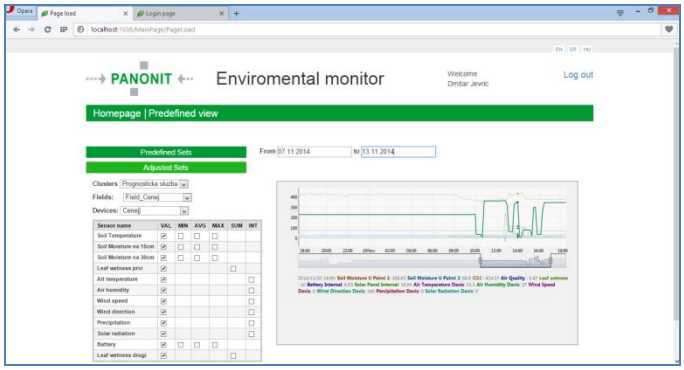

Figure 3. Graphical view of selected parameters

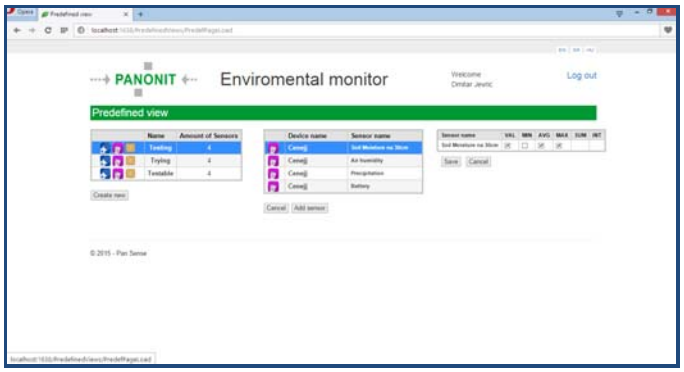

Figure 4. Page for setting predefined views

IV. DEVELOPMENT

For the development of the weather conditions monitoring application the following technologies have been used: ASP.NET MVC [12], Microsoft SQL Server [13], GSM network [14], IIS WEB server [15].

Database for the application has been developed on the Microsoft SQL Server. The Microsoft SQL Server is a system for management, deployment and analysis of the database. It can be defined also as a modern relation database with additional tools like the question console, database management tools, database work supervision [13]. Developed database contains 36 tables. Most important, including their relations are displayed in the Fig. 5.

Figure 5. Most important database tables

ASP.NET MVC is an architectural pattern that encourages isolation between the individual parts of an application. This isolation is better known as separation of concerns, or, in more general terms, "loose coupling" [16]. Just because of these characteristics this architecture has shown itself as the most suitable for the needs of this sort of applications.

The Model-View-Controller design pattern itself, is very useful for architecting interactive software systems [17]. The MVC architecture, as it could be seen from its name, consists from three layers, Model, View and Controller. Model is the layer in charge of the communication with the database. It delivers all of the data from and to the base and gives them to the disposal of the Controller. View represents an interface through which the user accesses the data with the web browser. Data are saved in the database by sending the HTTP GET request method on the Controller. Also, through the client application it is possible to insert data in the database by sending a HTTP POST request to the server side. The appropriate method on the Controller (server) responds to this demand of the client and writes in the newest data in the database through the Model. Every user - client application is made of HTML, JavaScript and CSS. For the cooperation between the View and the Model to be successful, the Controller is used as a binding link. The Controller represents the server side, and all of the definitions and methods that are used in the application are stored in its units. Its main assignment is to control everything that goes on while the application tasks are being performed.

Application code is written in C# programming language in Microsoft Visual Studio 2010 [18].

For the data to reach the final user, it needs to go through certain stages. In the beginning, the devices that are set up in the fields, gather the data through the installed sensors and save them up to the specified moment of sending them. At that time the device turns on its GSM module and through it with the HTTP POST protocol sends the data to the WEB server using GPRS data transfer [19]. A dedicated web page on the server is used to receive the data. The received data are then processed and saved in the database, where certain calculations will be made so they can take a form that the user expects (Fig. 6). The application user can see the minimal, maximal, average and total values, radiation integral, filtered by interval.

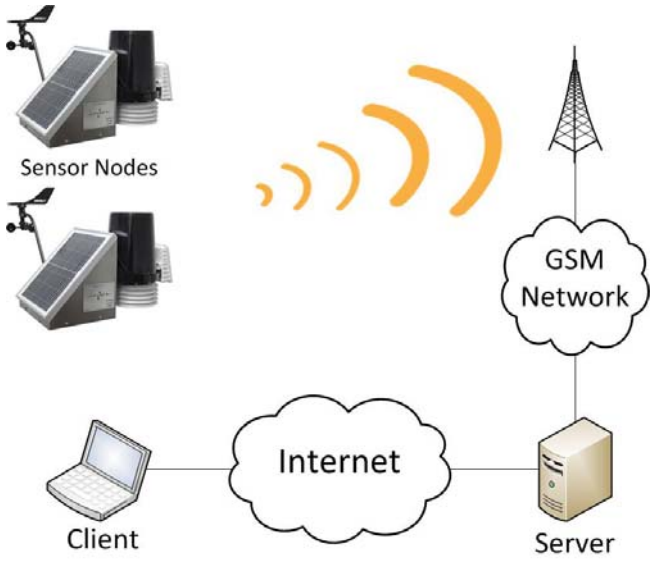

Figure 6. Data acquisition system block diagram

V. CONCLUCIONS AND FUTURE WORK

For long it has been clear that this type of support has great value for the agricultural world. With the savings of resources and the possibilities of quick responses to changes and developed conditions, the farmer also has the "upper hand" on his competition that still use the older methods. Also, it is especially important the fact that every information, that he needs, is just one click away.

As already mentioned, MVC type of architecture has shown itself to be a great choice for the development of this type of application. Because of its loosely coupled components, it allows changes on a single layer and doesn't affect the other two. Also, it is very important to state that, the applications developed with the MVC pattern are supported on almost all platforms for application viewing. It doesn't matter if the device is a computer, tablet or phone, the web pages will work uninterrupted, and the farmer will always have the access to the desired data.

When the topic is improvement and further development of the application, one of the possible directions can be related to the prediction of certain weather conditions. Thus, for example, certain data mining algorithms could enable the system to provide some local weather predictions, will it be some rain or not in the nearly future, according to current measurements.

Similarly, the system could be expanded in order to make some predictions of potential disease conditions of the plants.

As an example, the system could monitor air temperature and leaf wetness, and based on these parameters to detect conditions for the appearance of certain diseases in apple’s field, like *Venturia inaequalis* [20].

The system would be using a SMS messages to inform user about new conditions in order to react in a proper time to prevent low-income of fruit.

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