IoT and Energy Efficiency for Smart Agriculture using Adcon Telemetry Devices

George Suciu, Teodora Uşurelu, Cristian Beceanu, and Marius Alexandru Dobrea

***Abstract*— The IoT concept has grown in recent years and has transformed people's lives by making them easier, regardless of the scope of application. The global population is projected to grow more and more, reaching 9 billion by the year 2050, so IoT devices are needed in agriculture to increase crop yield and therefore feed sources. However, this solution is not exempt from challenges. Weather conditions, climate change and the environment have a great impact on farming practices. To reduce the costs and losses involved in these activities, we analyze the use of the equipment provided by Adcon Telemetry, such as solutions for plant monitoring, disease detection, frost warning, decision support, management and water quality. All data collected by Adcon equipment can be viewed on the addVANTAGE Pro platform, which can be accessed anywhere using a web browser and Internet connection, in graphical or tabular form.**

***Index Terms*—energy efficiency, IoT, smart agriculture, telemetry, Adcon.**

I. INTRODUCTION

IoT is a set of devices and software elements, sensors that allow connection, collection, visualization and data sharing, which through their properties improve energy efficiency and reduce human effort while also bringing economic benefits [1].

The IoT devices are divided into four classes as follows [2]:

- portable devices - clocks and physical activity monitoring devices. Their running time is between a few days and a few weeks;
- Set-And-Forget devices (SAF) - This category refers to the devices used to automate the processes inside the buildings. Their running time is several years;
- geophysical infrastructure monitoring devices or Integrated Grant Management System (IGMS), which have a service life of several years;
- computers or Transient Powered Computers (TPCs) with temporary power, battery-free devices that depend on remote power sources.

A recent study argues that by 2020 approximately 50 billion smart IoT devices will help solve telemetry, health, energy minimization, and building automation issues [2].

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US retailer Kroger has developed the Retail Site Intelligence platform by adopting IoT technologies. This enables video, video and wireless video analysis to improve the customers' shopping experience by quickly finding shelf products and shrinking time at the cash register [4].

This paper covers the research we have done regarding the use of IoT devices in the field of agriculture and telemetry to bring about significant improvements in crop monitoring and efficiency of the consume energy.

The article is structured as follows: Chapter 2 presents related work, Chapter 3 contains information about IoT telemetry solutions, Chapter 4 describes the results of our studies, and Chapter 5 concludes the paper.

II. RELATED WORK

Agriculture faces many problems to ensure the need for food for the entire population. Ideally, agricultural production will increase as the population grows. Some of the problems encountered in agriculture include climate change, the environment, limited water resources, etc. To address these issues, the agricultural sector needs to adapt to new technologies. Farmbot [5] is a device that is used to solve problems in agriculture, but on a small scale. It also has an application that can configure and control Farmbot from your browser, laptop, tablet, or phone. The application has real-time manual commands and a module that allows creating routines for Farmbot execution. The application receives the user input commands so that it can create the type of farm. The MQTT Gateway is the interface between the web application and the Farmbot device. Decision Support System analyzes the data collected by sensors and based on them they use algorithms that will optimize the events programmed by the system. For example, considering meteorological forecasting, soil moisture and crop type, Farmbot can decide what water needs to be used to irrigate the plants. All information collected is stored in a database [6].

FarmBeats [7] is an IoT platform for agricultural practices that collects data from various sensors and drones with cameras. The FarmBeats system works even when weather conditions are not favorable. Data collected by FarmBeats system sensors is stored in a Cloud that allows them to store and analyze indefinitely. For testing, the solution was used for 6 months in 2 farms located in the US. The architecture of the FarmBeats system consists of [7]:

Sensors and Drones - sensors measure soil-specific parameters

(eg humidity or pH) and transmit collected data to the IoT station using a Wi-Fi protocol. Unlike other solutions used in agriculture, the system is equipped with video cameras and drones that capture images and send them to the station via a Wi-Fi connection [7].

IoT Base Station - the IoT base station is powered by solar panels and consists of:

- TVWS device that transfers the data from the base station to the gateway and then to Cloud;
- The connection between the sensors and the base station is provided by a Wi-Fi module;
- Base station controller works as a cache for data collected by sensors that synchronizes with the IoT gateway. At the same time, it sets the operating time depending on battery status and weather forecast.

IoT Gateway - represented by a PC device form factor device. It provides an interface and a web service for users. Gateway services are also available when offline.

Cloud and Cloud Services: Cloud allows three functions: remote access, cross-farm crops and cross-farm analysis applications and suggestions [7].

The British pioneer technology Kevin Ashton proposed in 1999 the term Internet of Things (IoT) defining interconnected devices that can communicate with each other [8].

The internet of thing automatic station is an automated weather station which is constructed on the Internet of Things (IoT) platform, which completely integrates the real-time data interoperability, data fusion and other features of the IoT technology. With the advent of the IoT, it will become increasingly widespread [9].

This telemetry cloud testing platform uses different types of RTUs and sensors that monitor and transmit relevant information from selected locations, such as temperature, precipitation, light, or wind speed. The cloud testing environment provides to the platform a processing data from several different sensors that allow the analysis of environmental data through a large sample of RTUs [9].

RTUs transmit data to GSM / GPRS sensors to the cloud platform, where the data is processed in real time, is displayed in the web viewer application, with detailed information on power generation and optimized energy revenues. The system can be connected to other systems management for better use of resources, considering certain factors such as energy price, consumption trends and improved risk management [10].

One of them is SlapOS which is based on a grid computing daemon called slapgrid which is capable of installing any software on a PC and instantiate any number of processes of potentially infinite duration of any installed software. Slap Grid daemon receives requests from a central scheduler the SlapOS Master which collects back accounting information from each process. SlapOS Master follows an Enterprise Resource Planning (ERP) model to handle at the same time process allocation optimization and billing. SLAP stands for “Simple Language for Accounting and Provisioning” [10].

This structure is implemented for cloud automation of ERP, CRM and M2M programs for small businesses in the renewable energy field, and some issues are being developed within the European research project "Cloud Consulting" [10].

M2M telemetry software consists of a client / server architecture that collects data from one or more Adcon telemetry gateways and makes it available for viewing or for specialized analysis. The server is that part of the software in which all the actual processing takes place. The server is that part of the software where all the actual processing takes place. The server is the area where all the actual processing takes place. Taking responsibility for downloading data from Telemetry Gateway, storing data in the database, starting and stopping extensions, and serving customers during the connection [11].

IoT is not only an evolution of the present situations in which devices can be remotely controlled, being also considered a major issue for efficiency applications for several reasons:

- number of connected objects: It is estimated that by 2020 there will be installed 26 billion units, some of which will not be used for energy efficiency applications;
- business Opportunity: $300 billion in additional business by 2020;
- nature of objects: It refers not only to smart devices but also to simple devices up to an LED bulb;
- techniques and architectures involved, based on technical ecosystems: Vertical integration into one supplier environment will be less common;
- sensor revolution: IP camera, geo-location, personal contextual information from devices such as sensors that can be worn;
- Big Data Disruption: Ability to collect large amounts of unstructured data, analyze and predict future behavior;
- smart phones and applications become the primary user interface to IoT [12].

III. IoT Telemetry Solutions

ADCON Telemetry [13] is a company founded in 2003, located near Vienna. In 2011, the company was taken over by OTT Hydromet [14] and moved its headquarters to Germany, Kempten. Adcon works by providing solutions for monitoring, analysis and decision making in the meteorological, hydrological and agricultural field. Telemetry solutions are based on radio and GSM / GPRS / UMTS technologies.

Among the features and benefits of using Adcon equipment are [13]:

- minimum power consumption due to the use of small solar panels;
- data transmission over long distances due to the high sensitivity of the receiver;
- the ability to integrate all devices into a single Gateway;
- recording, sharing, storing, processing and viewing all data collected by devices on a common platform.

The solutions and technologies provided by the Adcon Group can be applied in:

- irrigation management;

- protecting crops;
- support decisions;
- water quality monitoring;
- water management.

Agriculture has always played an important role in the lives and well-being of people, being a process of producing food and a source of food for both the population and domestic animals. Over time, the climate has undergone changes that people have had to adapt to, and implicitly adapt the solutions used to ensure food or water quality, both irrigated and used daily [13].

In the field of agriculture, crops need to be irrigated when needed and only with the amount of soil required at the time of irrigation.

Determining the right time and quantity for irrigation is a complex process that takes into account certain information and parameters such as:

- the phenological phase of the culture;
- the amount of water lost through evapotranspiration;
- the amount of water that comes from the rainfall;
- moisture level from, below and above plant roots;
- the amount of water used for irrigation.

Irrigations are important in terms of:

- harvesting and quality;
- efficiency of fertilizer application;
- soil salinity and oxygen content at its level;
- the balance of soil microorganisms;
- energy consumption;
- the service life of the pumps and equipment used.

A. Monitoring soil moisture

With the growth of plants, their roots move through the soil. Ensuring the need for water and fertilizer becomes a very important aspect. Too much water can cause the loss of fertilizer. Too little water causes the fertilizer to be blocked in the upper layers of the soil and therefore unnecessary consumption. For these issues Adcon offers a solution based on a multitude of soil moisture monitoring sensors. The solutions offered are for all types of crops and soil.

Adcon sensors not only measure humidity but also salinity and soil temperature. They are easy to install, do not modify the soil structure and provide data at short intervals [10].

The data and parameters recorded by these sensors refer to:

- soil moisture;
- the depth of irrigation;
- rate of infiltration;
- water consumption per day;
- date and time of irrigation;
- running time;
- the total amount of water used per week, month or season.

The big advantage of using these sensors is the precision of reading the data at the desired location of the farmer.

B. Disease Models

The pests and diseases can affect the health and development of crops. Applying spray protection should only be done when it is really necessary and at the same time protecting the environment. To ensure that the spray is applied when computer models are being used, they process meteorological data and issue warnings and recommendations for treatments only in the event of an outbreak of high-risk disease.

Adcon offers solutions developed by specialists to combat pests and diseases, regardless of crop type. Solutions have been implemented by specialists and are based on algorithms that detect diseases such as Apple Scab or Phytophthora in potatoes [13].

The stage of plant evolution is presented in a table where all phases of development can be viewed. Users are also emailed about the disease index and treatment recommendations. For better evidence and vision of the crop stage, farmers can create their own database where they can introduce all the actions related to the applied treatments and irrigation.

C. Frost warning

Another phenomenon faced by farmers is frost. With the coming of the cold season, they must take crop protection measures.

The most common methods of protection against frost are: Wind machines, Heaters, Irrigation systems. The parameters to be monitored for frost risk are: air temperature, wet bulb temperature and dew point. Extremely low temperatures are a challenge for battery monitors, not just crops. It is recommended that they are well loaded and set for multiple alarms with yellow and red warnings [13].

D. Decision support

The agricultural decision-making system is software that collects multiple input data (eg data from crop sensors, chemical agents, pathogenic data, etc.) and that helps the farmer make a decision about problems that may occur at the level crops (e.g. diseases, frost or need for irrigation).

Complex agricultural operations involve making daily decisions about chemical spraying, measures taken against frost, when to harvest, etc. All these decisions take into account a multitude of parameters.

The decision-making system should include a monitoring station equipped with crop sensors and addVANTAGE Pro [12] software for viewing all collected data. The software is designed to process data from sensors and to suggest actions beneficial to crops according to their status. These suggestions may be recommendations for treatment, frost alarms, or disease installs, all of which allow the user to take action before affecting crops [13].

Adcon's decision-making support system evaluates and sends suggestions for the following situations: Soil temperature (recommended seed time, seed emergence, nematode activity), Leaf Wetness (foliar spray timing), Temperature (foliar spray timing, plant stress), Precipitations

(spray timing, spray wash-off), Relative Humidity (foliar spray timing, Pruning Time), Wind (Spray timing and reporting, Plant Stress, Irrigation) [13].

E. Water quality monitoring

Determining the quality of water involves analyzing its physical, chemical and biological characteristics. Water pollution can endanger both human health, the aquatic environment and the entire ecosystem. Detecting and acting quickly in such situations is very important in order to minimize the impact on the environment and to determine the source of the pollution.

Adcon A705 and A753 devices are compatible with water quality sensors. Also, the OTT PLS-C [14] sensor provides data related to the level, temperature and water conductivity. In special cases, Hydrolab water quality probes can be used to measure 16 parameters at the same time [13].

Depending on the needs and demands of farmers or crops, sensors can be implemented to monitor: water temperature, conductivity, pH, dissolved oxygen, REDOX potential, turbidity, blue algae, ammonia, nitrate, chlorophyll, rhodamine, etc [13].

F. Water Management

Water management refers to monitoring, distribution and purification of water, irrespective of where the water comes from. Adcon offers all the necessary components for an outdoor monitoring system, whether it is GSM / GPRS / UMTS mobile communications or UHF radio, they are very resistant and are protected by aluminum enclosures with stainless steel connectors [13].

It also provides support for the following applications [13]:

- leak detection and pipeline damage, pressure and flow monitoring;
- remote monitoring of meters and, implicitly, consumption;
- level monitoring in tanks, rivers or lakes;
- water quality monitoring, determined by 16 parameters that transmit data simultaneously;
- control of irrigation systems;
- remote actuation of pumps, valves and motors;
- wireless data transfer via radio or GSM;
- compatibility with SCADA [14] industrial systems (Siemens LSX [15], WinCC [16], Rittmeyer [17]);
- data visualization software;
- data processing, alarm functions for many parameters.

IV. RESULTS

Our telemetry research activity has focused on acquiring Adcon equipment, assembling and testing it. On this line, in 2013 Beia Consult International has put in place a monitoring system for Danube waters and its tributaries. A total of 21 stations have been installed, 9 of which are located on the Danube. All monitoring systems consist of the A753 remote monitoring unit, the SDI-12 temperature sensor, the OTT-RLS [18] level sensor, the A850 data storage unit and the addVANTAGE Pro platform [19]. The architecture of the telemetry system can be seen in Fig. 1.

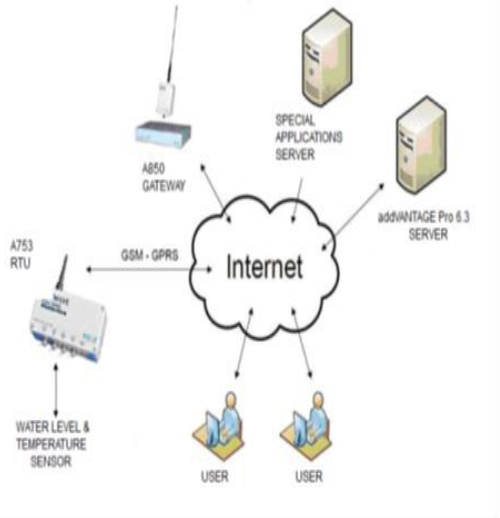

Fig. 1. Beia – Adcon solution

All the data collected from the stations can be accessed, viewed and downloaded, as a table or graph. Every 15 minutes, addVANTAGE Pro [19] receives data related to water level and temperature. You can see the addVANTAGE Pro interface in the Fig. 2.

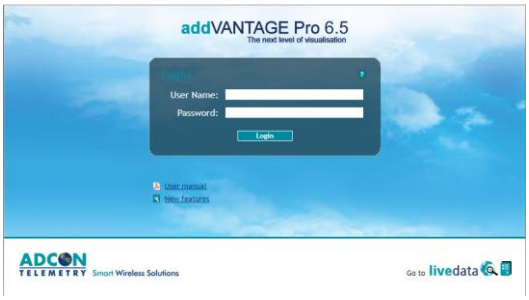

Fig. 2. addVANTAGE Pro 6.5 interface

We have continued the research by experimenting the addSWITCH A724 device in order to create an automated irrigation system using decision support notions. It is a telemetry device (RTU) capable of transmitting an electrical impulse to the solenoid control valve. In Fig. 3 it can be seen that the addSWITCH equipment has a VALVE port that can transmit variable voltage pulses. An advantage of this equipment is the possibility of power supply generated by small photovoltaic panels.

Fig. 3. addSWITCH

Also, a small valve shown in Fig. 4 was used in the experiment. This can be controlled in a voltage range of 9-20V with pulse with 20-100mSec at a maximum pressure of 10 bar.

Fig. 4. Valve

The A850 Gateway is the core of every Adcon [13] monitoring network that knows precisely how to recover data from each RTU, indifferent to the RTU communication mode. So, it is necessary to use the A850 Gateway to configure the addSWITCH RTU, where the data specific to the addSWITCH and the characteristics of the valve used are entered, as can be seen in Fig. 5.

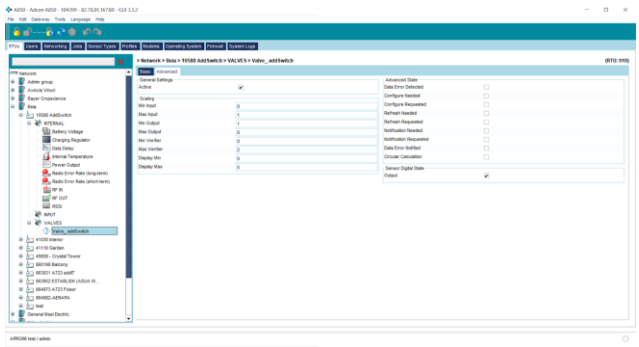

Fig. 5. A850 Gateway GUI

Until now, we have made communication between Adcon [13] and solenoid valve.

For remote control of the solenoid valve, it is necessary to install a server for Adcon [13] equipment and implement the addVANTAGE Pro 6.5 platform [19]. The addVANTAGE Pro 6.5 [19] can be accessed anywhere as any public IP, which gives us the achievement of this experiment. Thus, we created a link between addVANTAGE Pro 6.5 [19] and Gateway where it provides us with the ability to generate reports for the data received from the sensors or to command other equipment, such as the solenoid valve, as shown in Fig. 6.

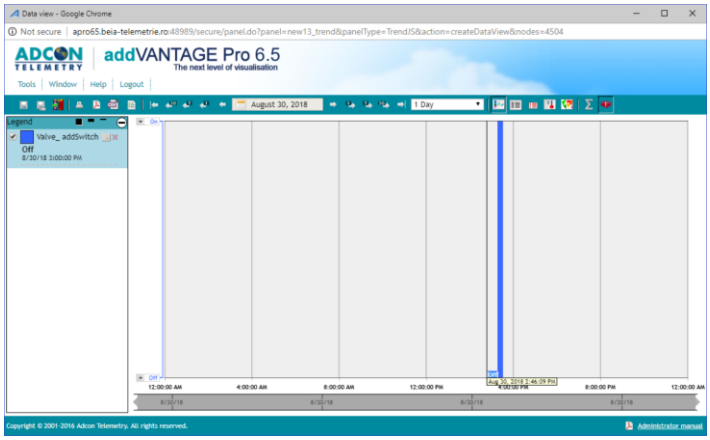

Fig. 6. Time graph of solenoid valve operation

The addSWITCH RTU was selected for the experiment in particular for the options offered in the solenoid control, so in the Fig. 7 you can see that we can set the exact time of the valve's operation using the Switch ON / OFF function.

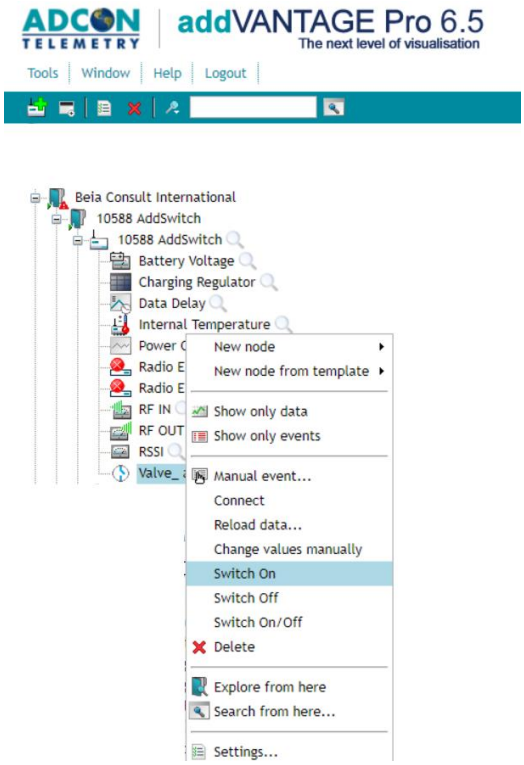

Fig. 7. Interface addVANTAGE Pro 6.5

In case of our experiment, we set the output voltage to 9 V. If we desired, the addSWITCH has the option to adjust the voltage to 15 V, depending on the power required to operate the valve at different flow rates. When closing the solenoid valve, a 9V voltage was measured using a multimeter, this value reflecting that a positive pulse on the valve phase was generated by equipment A724, as can be seen in Fig. 8.

Fig. 8. Parameters generated by A724 when closing the solenoid valve.

When the solenoid was opened, the voltage was again measured with a multimeter. It showed a voltage value of -9V, the value indicating that a negative pulse on the valve phase was generated by addSWITCH, as shown in Fig. 9.

Fig. 9. Parameters generated by A724 when opening the solenoid valve.

The "condition" function is a handy tool because there are several types of comparators in the list of options. For example, to create a decision support system, it is necessary to meet certain conditions such as: if the soil moisture value drops below 40% AND the temperature value is between two intervals then a TRUE signal is transmitted. If one of the conditions is not met, the signal will be FALSE. In Fig. 10 is the graphical representation in time of the signal sent by the function.

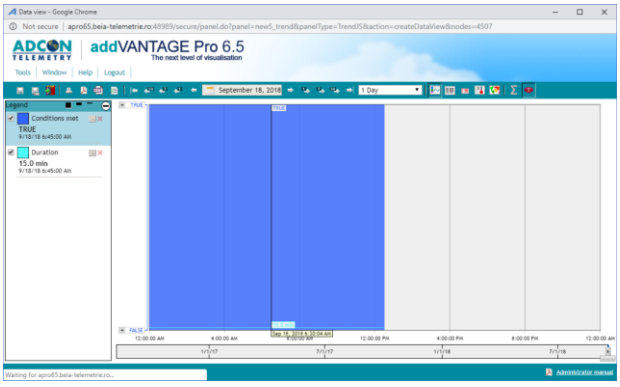

Fig. 10. The graph of the "Condition" function signal

V. Conclusions

The role of IoT is to make life easier for people regardless of their scope. Integration of IoT in the field of agriculture brings real benefits in terms of crop monitoring, considering the weather conditions, the environment, and finally the right decision to act to increase yield and agricultural production.

Our proposal helps farmers with a crop monitoring solution, a warning in the case of preventing the installation of diseases or in the event of freezing conditions and making decisions in these situations.

In the future, we aim to create a friendlier interface for users and building a more advanced decision support system where under normal irrigation conditions a part of the solenoid valves act, and in exceptional cases, such as drought, commanding all valves would be a priority.

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