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INTELLIGENT WATER MANAGEMENT SOLUTION FOR SMART AGRICULTURE

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Abstract. The use of technologies offers a way of providing the total amount of water needed for plant irrigation. Within this scope, the Internet of Things (IoT) is one of the best options for smart water applications, although the development needs to be integrated with the technologies required. The basis of the article is the SWAM project, from which the results of the research carried out were extracted. For Smart Agriculture (drinking water, respectively irrigation), the project aims to provide a trustworthy, intelligent, integrated water management solution based on the IoT. It was demonstrated that this solution is useful for cost-efficiency management, smart environmental management, monitoring, security considerations and environmental pollution detection. The SWAM project provides an end-to-end solution, including probes (hardware) and services (software). SWAM's primary concern is smart irrigation, which is required to mitigate the impacts of drought and boost agricultural productivity by providing a controlled supply of additional water quantities to the soil compared to those received under natural conditions, ensuring high and consistent agriculture production. The aim of this article is to present a Smart Platform that operates and manages water quality and enhances the functioning of the surface water network. The data is collected from a sensor network that is connected to a Cloud database in order to monitor climatic conditions, water and air quality, which are required for irrigation in Smart Agriculture. Furthermore, Blockchain is a security solution for the system presented, as each transaction carried out by the system will be monitored throughout the process. This capability will provide not only security but also privacy aspects.
Keywords: water, IoT, architecture, smart agriculture, irrigation

1 INTRODUCTION

Water is vital to human existence and since the beginning of time, it has represented the main reason and base for human settlements. Billions of litres of water are lost every day due to inefficient water networks and damaged or old pipes that are leaking and wasting fresh water. Besides that, municipalities are now facing a new problem - Global Warming affecting the global reserves of drinking water which represents less than 1% of the total water on the planet, a value that is constantly declining (Ramachandran et al., 2018).

The Internet of Things (IoT) field has significantly and constantly grown in the last years, thus improving the management of water by digitalising it, optimizing consumption, and raising the efficiency of the whole process.

Certain factors such as climate change, population growth and deteriorating urban infrastructure systems are causing results that call for pressure on cities around the world. Cities are required to carefully and efficiently manage scarcer and less reliable water supplies as a result of the constant demand for enormous amounts of water. One of the possibilities that are not recommended to be considered is business.

The objectives involve new technologies and system solutions for the total management of urban water, such as flexible and adaptive urban water systems, water-sensitive urban design and water (beneficiaries) in urban areas; promoting efficient governance and institutional structures for urban water management; and identifying and disseminating the best solutions from an economic and geographical point of view in developed countries.

Agriculture is the world's largest consumer of freshwater, accounting for up to 70% of worldwide consumption. The ratio is different if we refer to it per continent where, for example, in Europe, agriculture

represents only 21% of its total amount of freshwater. In comparison, it goes up to 82% in Africa, mostly due to how efficiently it is used (Nouri et al., 2019).

The SWAM solution is a novel product for better environmental sustainability addressing a new water market integrating emerging technologies.

One of the leading technical innovative aspects of this project is adopting an agnostic approach to gain interoperability by utilizing a multiprotocol technology (being the future of IoT wireless connectivity). The second one is the conception for long-term deployments (modular, scalable). The third one is represented by providing a trustworthy environment addressing cybersecurity, IoT-based threats and traceability by design based on blockchain.

If the SWAM solution is adopted, the following benefits could be generated: improvement of the quality of service (QoS) and the client's experience; Optimization of Operation and Maintenance of the water infrastructures targeting operational costs reduction, water leakage reduction and/or better preventive maintenance; reduction and optimization of the consumption; better adaptability and easier expansion of the system by a modular design of the system.

From the hardware point of view, the SWAM product has a relevant asset: the type of power supply employed, enabling installation in remote areas. In most cases, for current products, data transmission is done through a wired connection. In addition, the objective is to reduce 50% of the average rate of maintenance interventions for the re-calibration of the sensors available in the market.

The main goal of this paper is to monitor weather conditions, water and air quality necessary for irrigation in Smart Agriculture and a Smart Platform to manage and operate the water quality and improve the operation of the surface water network.

The paper's structure, which is separated into five chapters, is also noteworthy. Section 2 explores the state of the art of water management solutions. Section 3 describes the data and methods used in the article. Section 4 discusses the results and the last section brings the conclusions of the article.

2 RELATED WORK

For the environment, economic development and the sustainability of life, water is an indispensable and critical resource. In a research made by the United Nations, it was predicted that 70% of the world population would live in cities and the inadequate water infrastructure will be a problem for them.

Water management efficiency is directly influenced by technology like the Internet of Things, sensors and blockchain. This paper is approached by the impact of blockchain and the Internet of Things on water management. Also, it is analyzed the feasibility of blockchain adoption in different scenarios (quality monitoring, stormwater management, smart contracts and payments). The main advantages are represented by technical benefits, socioeconomic gains, low operational cost and efficiency (Eustace et al., 2019).

Cities' development acceleration in an innovative and integrated way leads to smart cities emerging. This development includes the evolution using the Information and communication technology, which is based on investments and public policies innovation. The idea of this article is to execute an innovative and ICT use in potable water public supply diagnosis of a city. The collaboration between SANEPAR and Parana Meteorological System (SIMEPAR) led to the development of a project which consists of a smarter system of water supply. This system is built to predict possible floods in the water catchment plant. The implementation of smart technologies starts with the catchment protection of the water, which can be extended to the whole city (Nakahashi et al., 2019). IoT technologies, along with cloud-based services and big data analytics have a huge impact for smart agriculture, but at the same time represent a concern regarding the understanding of challenges and compelling impacts of the Internet of Things in large-scale pilots. Brewster et al. (2017) defined technologies and potential solutions that can be found in the agri-food domains (fruits, meat, vegetables, dairy supply chain). An example to increase water productivity and improve irrigation techniques using precision irrigation management platforms without direct use of IoT, is represented by the FIGARO project (Doron et al., 2017). Another IoT limited platform is described by Popovic et al. (2017), which had the aim of the study the collection of data and monitoring of all the domains.

3 DATA AND METHODS

In order to reduce the effects of drought and increase production in agriculture, irrigation is required for the controlled supply of soil with additional water quantities compared to those received under natural conditions, to ensure high and constant agriculture production.

The development of plants is determined by a complex of factors: humidity, aeration, heat, light and nutrients. Water consumption of agriculture plants is one of the main elements of appreciation of the need for irrigation, i.e., zoning of irrigated agriculture. Irrigation largely corrects climate, the only variable production factor. At the same time, it creates optimum conditions for highlighting the other factors of production. Based on the measurement solution, the water requirement of a local crop will be established using various processing methods. One of the methods of saving water in the use of irrigation systems is irrigation with the variable rate, depending on the humidity and characteristics of the soil, as well as the water requirements in the development of plants.

The system is based on monitoring the water, air and weather conditions for irrigation in Smart Agriculture by managing, operating the water quality, and improving the operation of the surface water network. The sensors network are connected to a cloud platform by means of a reconfigurable wireless transceiver and integrate several low-cost sensors that can measure different parameters such as water level, water temperature, pressure, pH, conductivity, turbidity, pollutant from the air (PM10, PM2.5, NOX, SO2, CO) and meteorological parameters. The measurements will be sent via an operative communication node, which should be capable of ensuring reliable communication while adhering to time and variation delay requirements.

The sensors must be able to perform self-configuration and calibration, and they have to adapt to these environmental conditions. All of this data is stored on a software platform that collects environmental parameters. In order to secure the data and the platform used, several aspects will be taken into account. One aspect is the utilization of an Identity Management module, which will cover several aspects involving users' access to networks, services and applications, including secure and private authentication from users to devices, networks and services.

SSH protocol was used instead of Telnet to provide a secure (encrypted) management connection to a remote device. Also, the users will use strong passwords and change them often. The utilization of standard insecure HTTP websites will be avoided instead of using the more secure HTTPS.

Another security solution for the system proposed in the article is Blockchain. Each transaction performed by the system will be tracked during the processes. This ability will not only provide security, but will also provide privacy features. Smart devices act as nodes and each node has a copy of the blockchain network in its construction. If a user of the system wants to use it, then each node must be checked before a transaction takes place. If the majority is considered valid, then each of them will be registered with a hash code in the blockchain structure and each copy is sent on, so that it can be used in the system. The proposed system will be updated every 15 minutes, so it will be impossible to hack and falsify the security system. Subsequently, requests for data received from each device will be secured through the Blockchain.

4. RESULTS AND DISCUSSION

The platform provides an interface that users can access anywhere via the Internet. In Figure 1 it is presented the management of water quality that is used in SWAM Smart Agriculture.

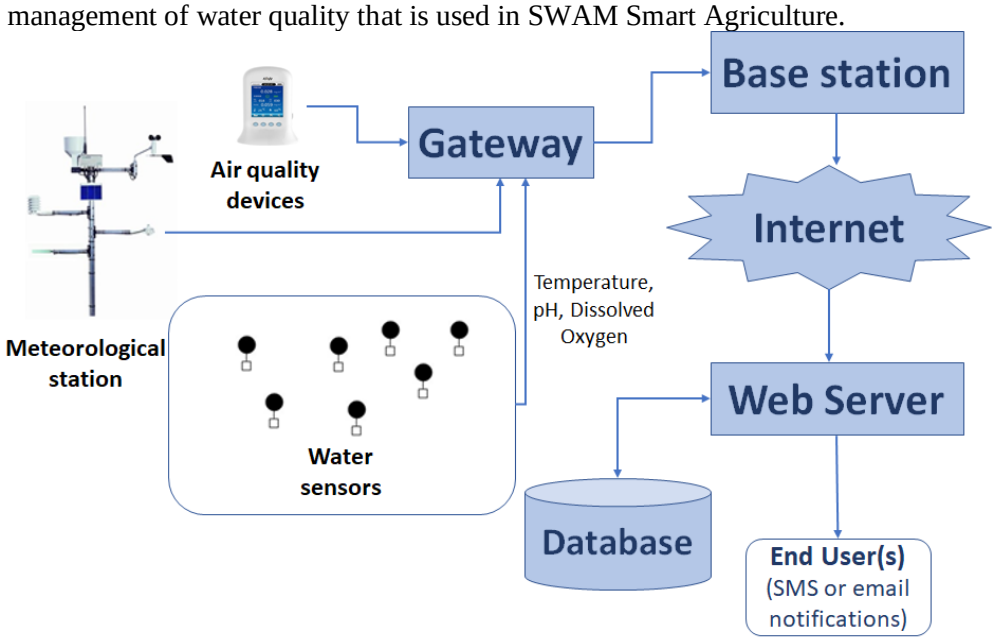

Figure 1. Management of water quality used in Smart Agriculture

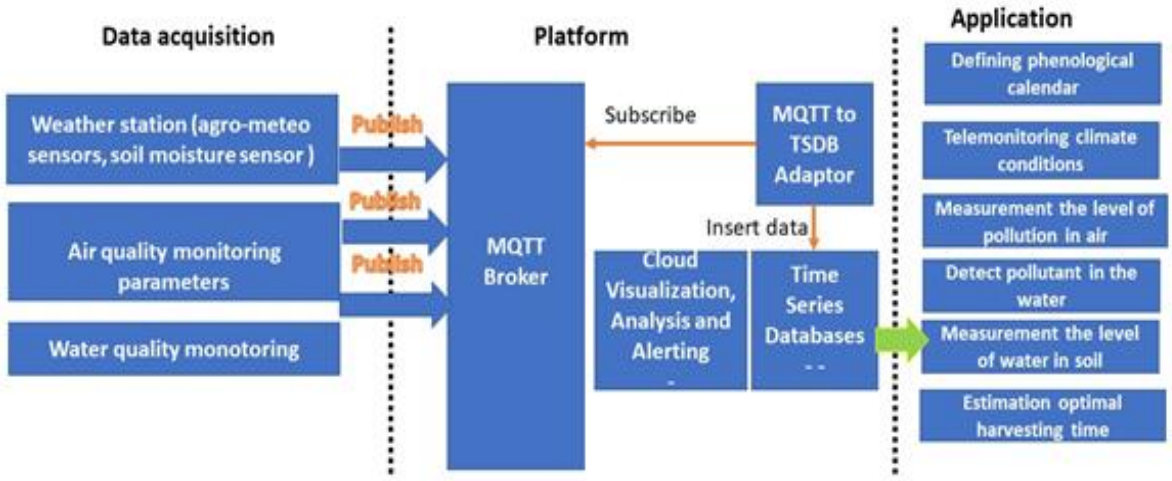

Figure 2. Functional diagram of the system

In Figure 2 is presented the communication protocol between the server and the platform by MQTT and HTTPS. These are the communication/integration options of the water use, which will depend on several factors such as meteorological (air quality water parameter), battery (periodicity of the communication) and signal reception (where is going to be located the probe, underground, outside, etc.).

MQTT is an open-source protocol, specifically designed to be easy to implement and use minimal resources, based on Subscription/Publish interactions.

For the SWAM system architecture, the produced assets were used, such as conceptual model, specification, components interfaces and the design of the architecture, for guidance in the implementation of the techniques, methods and protocol. In Figure 3 it is presented the system architecture.

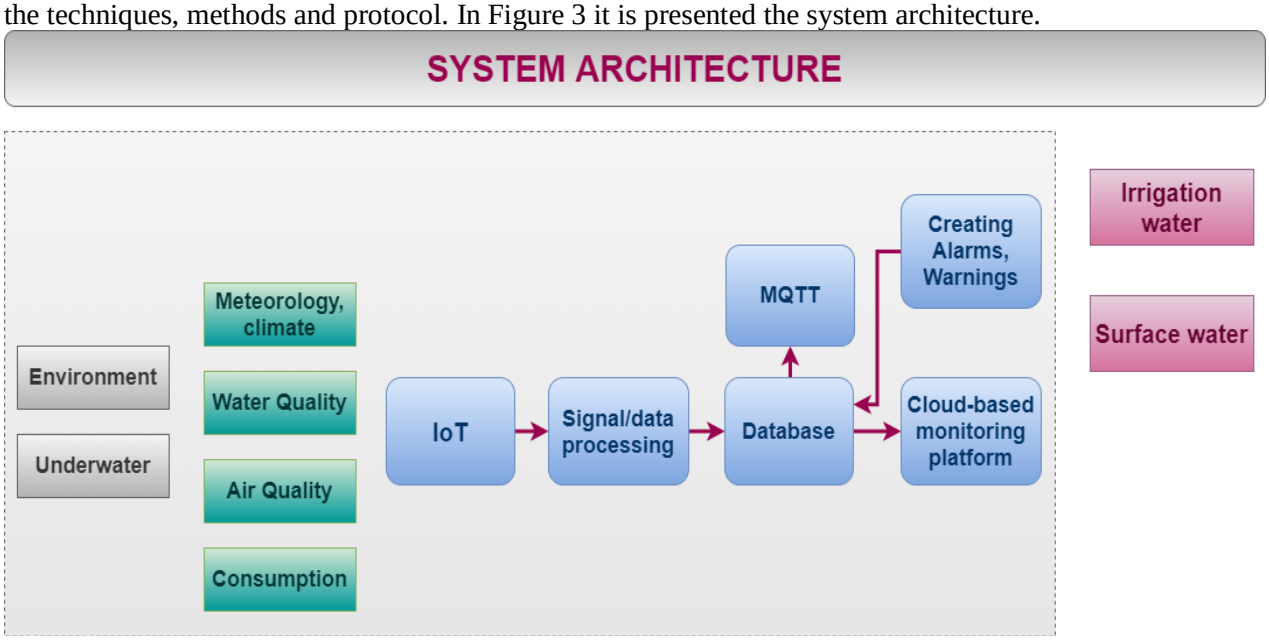

Figure 3. SWAM system architecture

An example of application is when a farmer would like to monitor weather conditions, water and air quality necessary for irrigation in smart agriculture. It can also use a Smart Water Platform to manage and operate the water quality and improve the operation of the surface water network. The main objectives of the application are: detection of pollutant from air and water, decrease in maintenance costs of water distribution network, protecting environmental hazards.

CONCLUSIONS

This paper aims to present a trustworthy, intelligent and integrated water management solution for Smart Cities and Smart Agriculture that is based on the Internet of Things. The solution has been demonstrated to be useful for smart environmental management, historical analysis and profiling, monitoring, cost-efficiency management, security considerations and environmental pollution detection.

The software solutions allow the client to control and operate the primary actuators of a Water Distribution Network and improve the performance network, due to the integrated approach of the entire value chain of the water network. At the hardware level, SWAM advantages are low-cost and reduction of the sensor size for water quality metering and less intrusive (by-pass solution).

To ensure a constant and high agriculture production it is necessary to reduce the effects of drought and increase production in agriculture and it is required irrigation for the controlled supply of soil. The platform and security solutions were designed with the goal of ensuring the security and safety of accurate data, contributing to the high quality of data monitored in the SWAM project.

The most precise controls on cyber risks, such as a Gateway that checks the platform's authenticity, and communication protocols between the Gateway and the platform that use TLS / SSL security (MQTTS / HTTPS), will be examined in future work.

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