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Review paper

INTERNET OF THINGS (IoT) IN A FUNCTION OF SMART AGRICULTURE DEVELOPMENT

Radovan Vladisavljević[1,*], Dragan Soleša[1], Nikola Puvača[2]

[1]University Business Academy, Faculty of Economics and Engineering Management, Department of Informatics, Cvećarska 2, 21000 Novi Sad, Serbia
[2]University Business Academy, Faculty of Economics and Engineering Management, Department of Engineering Management in Biotechnology, Cvećarska 2, 21000 Novi Sad, Serbia

*Corresponding author:
E-mail address: radovan.vladisavljevic@fimek.edu.rs

ABSTRACT: In the internet sector, the internet of things is the hot point. These ideas assist to link physical items fitted with the sensing, actuating, and computer energy, thereby enabling them to cooperate with the internet, known as the "Internet of Things" or IoT. The concept of the intelligent object is realized using sensors, actuators and integrated microcontrollers. These smart objects collect data, process them and initiate appropriate actions from the development environment. The internet of things will thus bring inconceivable advantages and help people lead smart and affluent lives. The internet of things turned out to be an important topic of scientific studies because of the prospective applications. In sizzling debate and studies, the use of these technologies is significant, however, they were less relevant in agriculture and forestry. This paper also concisely introduces IoT technology, agriculture IoT, the list of prospective applications where IoT is relevant for smart agriculture, IoT's advantages for the agriculture sector.

Key words: *Internet, IoT, smart agriculture, agricultural IoT*

INTRODUCTION

International Telecommunication Union defined the Internet of things as the technology that mainly resolves the interconnection between human to a thing, thing to thing, and human to human. The Internet of things is a global technology that represents the future of computers and the exchange of data (Ud Din et al., 2018). Data exchange is based on the communication between intelligent sensors, radio-frequency identification (RFID), global positioning systems (GPS), infrared sensors (IS), remote sensing (RS), mobile communication (MC), and other communication networks (Ruiz-Garcia et al., 2009). It refers to a network of objects and is often a self-configurable wireless network (Ud Din et al., 2018). Internet of things was intended to build a massive network through the integration of various sensors including GPS, RS, RFID, laser scanner (LS), and networks to grasp global information exchange (Duan et al., 2019). Internet of things can encompass millions of networked embedded smarts devices also called smart things (Jaafar et al., 2019). According to statements of Chamoso et al. (2018), these smart things may collect and tie the data about themselves and interconnect to other devices or structures via the internet (Figure 1). The internet of things platforms covers various fields, including traveling, smart farming and agriculture, air quality, marketing, supply chain management, hospitals, monitoring of facilities, etc. (Khanna and Kaur, 2019). All external entities can be integrated and handled separately according to the accepted procedure according to the different applications of detailed expectations, smart storage and efficient communication between devices and information sensing equipment (Tuli et al., 2019).

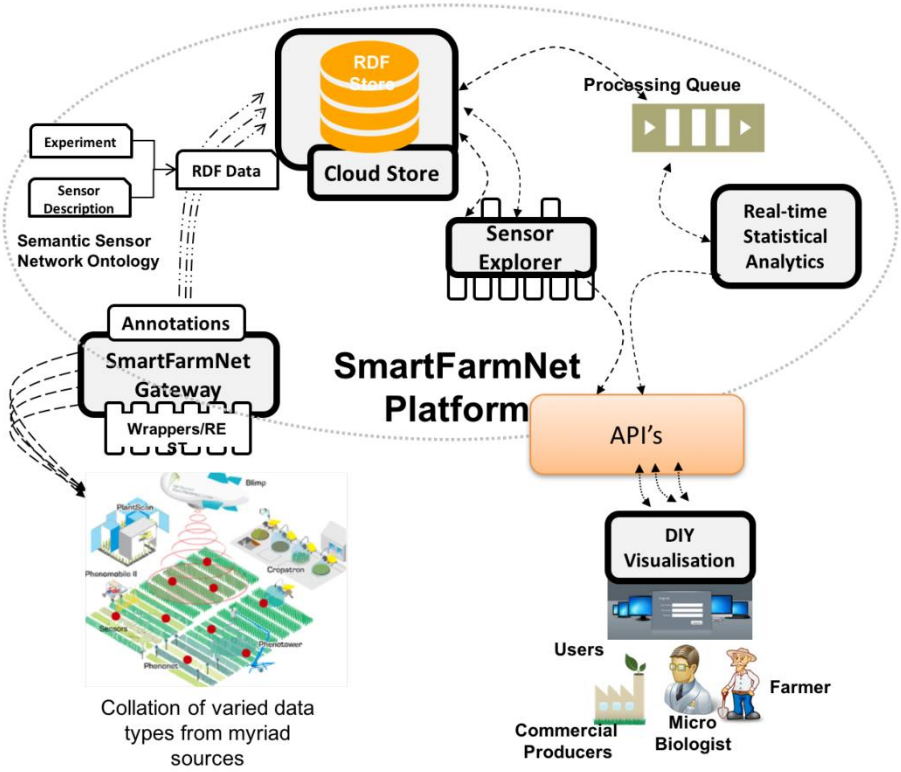

Figure 1. Conceptual model of IoT

PROBLEMS FACING IoT AT AGRICULTURE SECTOR

This paper focuses on an agricultural market that is closely linked with the well-being of any country and the welfare of its citizens (Rivera et al., 2018). In countries where the agriculture sector is shrinking disturbing the ecosystem production capacity, necessity is to resolve the problem in a specific area and to reestablish vitality and place it back on higher progression (Xin, 2019). All developing and developed economies have been affected by an ongoing global recession (Aghimien et al., 2018). In order to guarantee comprehensive food security, agriculture requires to be more professional and irrepressible (Bogoeva, 2018; Thong and Zhang, 2020). Some farmers are at an excessive detriment in terms of technology, size of farms, government policies, trade, etc. Internet of things technology can diminish some of the problems of such farmers (Elijah et al., 2018). As agriculture is industrialized worldwide, creating an "agricultural information network" is very necessary (Puvača et al., 2015). Agricultural data networks have become the theme in international agriculture expansion (Kelly et al., 2018). In many countries, there are many problems in the agricultural information system such as hardware part, instead of software which cannot deliver high eminence information to get production requirements of agricultural producers (Capitanio and De Pin, 2018). Therefore, the farmers do not make proper use of data and it is not noteworthy that land, agricultural or agriculture knowledge is affected (Pan and Zhang, 2018). Nonetheless, the difference in crop and output due to the changing climate, a shift in farmland planted area, insect damage, crop disease, etc., could not be properly forecast, due to the demand and consumption of crops, the statistical prediction could not be produced (Purola et al., 2018). In order to change this circumstance and promote the rapid growth of the agricultural information network, smart agriculture requires the IoT to improve (Taneja et al., 2019).

APPLICATIONS OF IoT IN AGRICULTURE

Internet of things serves a range of applications in the area of digital agriculture, including soil and crop control, animal production, plant growth analysis and distribution, precision agricultural production, assistance in irrigation evaluations, greenhouse monitoring systems, the food supply chain monitoring, etc. (Vuran et al., 2018). Following are the established technologies that are used in applications of IoT in agriculture:

- Intelligent irrigation (II) technology: Based on satellite positioning network and "shallow wells underground cables + field + automatic irrigation system pipe" technology, it can accumulate irrigation water, irrigation, electricity, and time data to accomplish automation of farmland irrigation and through a complete analysis of information technology software to monitor irrigation
- Precision seeding and spraying techniques: Depending on the technology combined with GPS navigation technology, seeding technology, and fertilization at a variable rate, it can achieve identical implementation of the spraying, planting, and refining the consumption of pesticides, seeds, and etc.
- Radio transmission technology in agriculture: Self-organizing wireless data transmission can be achieved with different wireless sensor networks. In large-scale farming, it has been widely used for data transmission
- Radio-frequency identification technology: RFID is extensively used in animal tracking and identification. It helps to achieve intelligent monitoring, recognizing, traceability of animals, and their management
- Sensor technology in agriculture: Vast variety of sensors are used in agricultural products such as soil moisture sensors, water-level sensors, equipment used to sample the state of the atmosphere at a given time meteorological sensors, heavy metal detection sensors, biosensors, and gas sensors
- Technical quality safety of agricultural products: In the agricultural production–circulation–sales chain, recording and monitoring of the chain can understand the entire procedure of regulation

Table 1. Benefits of IoT in agriculture

Influence	Benefits	Source
Efficiency of input	Improves the efficiency of inputs of agriculture like soil, water, fertilizers, pesticides, etc.	Taylor (2018)
Cost reduction	Reduce the cost of production	Tu et al. (2018)
Profitability	Increase the profitability of farmers	Koshy et al. (2018)
Sustainability	Improves sustainability	Bocken et al. (2019)
Food safety	Improves food safety	Fan (2019)
Environment protection	Plays an important role in the environment protection	Thibaud et al. (2018)

IMPORTANT ROLE OF IoT IN SMART AGRICULTURE

In the field of agriculture and forestry, Gubbi et al. (2013) research discussed numerous IoT and cloud computing applications. The research of the same authors says the use of IoT in smart agriculture plays a major role. These technologies can be used to make great advances in agriculture using the technologies of IoT such as laser scanners, RFID, electromagnetic photoacoustic detectors, etc. Basically in agricultural information transmission, precise irrigation, intelligent cultivation control, agricultural product safety, and many more. Integration of IoT and cloud computing could become a tendency in smart agriculture. Luthra et al. (2018) presented and identified possible applications of the IoT in agriculture for sustainable rural development. Various business opportunities related to the agriculture domain and its benefits that can be generated, using the Internet of Things (Luthra et al., 2018). Luthra et al. (2018) in their research intended in practical ways to stimulate strategies on the acceptance of IoT in agriculture and to intensify contemporary rural development. Developers can use IoT technologies to build country-specific technologies based on the agricultural domain. The development of technology will uplift the standard of people and support poverty alleviation. In research of Mohanraj et al. (2016), several agricultural field issues have been addressed. According to the research of Mohanraj et al. (2016), agricultural producers should be guided at the right time during different stages of plants grown in the field until the final product. In this research work, a knowledge base is created. Tongke (2013) investigated smart agriculture based on cloud computing and IoT. His research concerning agriculture, countryside and farmers have been hindering China's development. The only solution to these three problems was agricultural modernization. However, China's agriculture is far from modernized. The introduction of cloud computing and the internet of things into agricultural modernization would probably solve the problem according to the research of Tongke (2013). Based on the major features of cloud computing and key techniques of the internet of things, cloud computing, visualization, and SOA technologies could build massive data involved in agricultural production. Internet of things and RFID technologies could help build plant factory and realize automatic control production of agriculture (Tongke, 2013). Cloud computing is closely related to the internet of things. A perfect combination of them can promote the fast development of agricultural modernization, realize smart agriculture and effectively solve the issues concerning agriculture, countryside, and farmers.

On the other hand, according to Karim et al. (2017), water supplies become scarce because of climatically change, and the urgent need to irrigate more efficiently in order to optimize water use becomes a very important issue. In that context, the usage of a decision-support system by farmers becomes unavoidable. Indeed, the real-time supervision of microclimatic conditions is the only way to know the water needs of a culture (Karim et al., 2017). Wireless sensor networks are playing an important role with the advent of the IoT and the generalization of the use of the web in the community of the farmers (Figure 2). Same research points out that judicious will make supervision possible via web services. The IoT cloud represents platforms that allow creating web services suitable for the objects integrated on the internet.

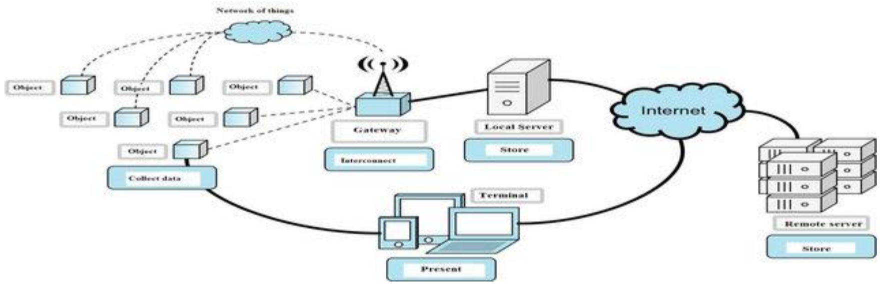

Figure 2. IoT architecture

Architectural components of IoT show some application areas where IoT is applicable. With the rapid momentum due to advances in sensing, actuating, and RFID technologies IoT getting a very important place in smart agriculture development. It aims at blending the virtual world with the real world seamlessly (Figure 3).

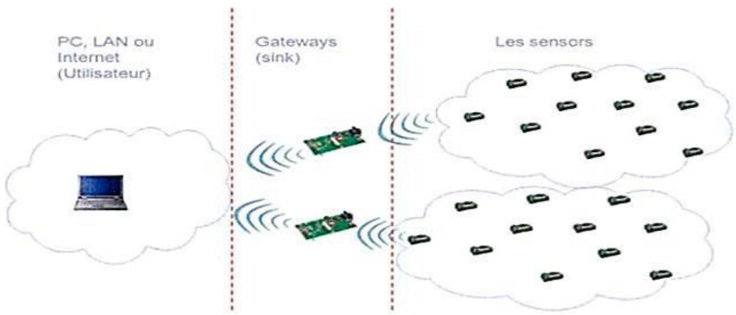

Figure 3. WSN architecture

An application for precision agriculture, a customized architecture for agriculture, based on IoT was researched in recent years (Kamienski et al., 2018; Swain et al., 2019). Cloud-based IoT architecture is applicable to various precision agriculture applications, through the several layer architecture. According to the research of Swain et al. (2019), ARM processors are receiving more attention as per IoT customized devices are concerned. The tool is the best suit from ARM-based platforms like Raspberry pi, Beagle Bone, Intel Edison, etc. The proposed technique uses different toolchains for kernel customization. Swain et al. (2019) represent an integral framework that integrates all the cross-compiling tools and simplifies the overall process. The framework has been used for the development of a customized kernel for Raspberry Pi on Ubuntu 14.04 host computer. The custom kernel has been ported into Raspberry Pi and the performance evaluation has been done. Furthermore, the analysis aims to help users choose and configure their tracers based on their specific requirements to reduce their overhead and get the most out of them. The testing of the customized OS with the raspberry Pi device in the field of agriculture. The smart node/mote is designed based on it to deploy in the agriculture field to test its feasibility. The group of nodes data is gathered using the ThingSpeak cloud server. The gathered sensory data is analyzed and forecast on a farmer's mobile phone in the form of an APP or handheld device for the farmer (Swain et al., 2019).

CONCLUSIONS

Agriculture, rural and farmers ' problems have always been a source of a disincentive for undeveloped countries. The only solution to these three issues is agricultural modernization. The Internet of things is likely to solve the problems of agricultural modernization. The perfect use of and integration of modern technology and IoT will stimulate the rapid development of agricultural system modernization. The use of smart IoT in agriculture can effectively solve farmers' agriculture and rural issues. Modernizing agriculture will increase agricultural production and management, achieving the aim of protecting the environment and saving energy. The use of IoT is playing an important role in the development of the world's modern and smart agriculture which sets a foundation for industrial development.

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