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Development of an Advanced Irrigation Tool-Agrobot Project Based on Wireless Sensor Networks

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Abstract:

The present research uses wireless sensor networks (WSN) to create a smart watering system. The system’s ability to perform real-time monitoring and management of irrigation makes sure that crops get the right quantity of water depending on their unique needs. The suggested method boosts agricultural yields, decreases labor costs, and improves water usage efficiency. The system uses a fielddeployed network of inexpensive wireless sensors to track the soil moisture levels in real time. The central controller utilizes the wirelessly sent sensor data to decide when and how much water should be applied to the crops. Utilizing wireless protocols like Zigbee, these nodes connect to a central gateway, where the data is processed and examined to establish the ideal watering needs for each crop. The technology is scalable and simple to install in larger agricultural fields. The study’s findings indicate that the system can boost crop yields by up to 30% while boosting water usage efficiency by up to 60%. Farmers may decrease their water use, save time and money, and enhance their profitability by adopting the smart irrigation monitoring service powered by WSN.

Keywords: Smart irrigation, Soil moisture, Crop yields, IoT, Zigbee protocol.

The industrial revolution and recent advances in electronic technology and wireless communication have led to the development of highly intelligent small sensors with low power and low cost solutions[1]. Sensor nodes are miniaturized autonomous systems characterized by lower cost, smaller size, and wireless communication medium, but with limited resources. These nodes consist

of a sensing unit, a processing unit, a transmission unit, and a limited power supply. This combination of integrated systems and wireless communication has also led to a special type of network, namely the wireless sensor network, which is helping to change the way we live, work, and interact with the environment. WSN is often considered as the successor of ad hoc networks. It defines a network of wireless devices called nodes that combine processing, communication, and acquisition capabilities and communicate via wireless links. WSN collects physical or environmental conditions for collective and autonomous transmission to treatment points to monitor a specific event. The sensor network performs three main functions, including: communication, detection and sensing, and computation and analysis, which makes it active in creating smart environments[2].

Agriculture is the backbone of the world economy and is often the main source of income for many farmers around the world. Irrigation is a key factor for agriculture, one of the most important services in this sector. It is an important practice for most crops in areas with low rainfall to meet the water needs of crops, as insufficient irrigation usually leads to a decrease in crop quality and yield. Despite the important role that agriculture plays, some reasons are seriously affecting this sector, especially irrigation[3]. The global water crisis is a major problem in the world, which is leading to a sharp decrease in water resources and poses increasing threats in recent years. It is noteworthy that freshwater reserves are decreasing, accounting for only 2.5% of the total water on Earth, with most of the water stored in deep groundwater or glaciers and only a small amount of it available for human use. In addition, among these reasons: climate change, the risk of salinization and water pollution. In addition, the agricultural sector is the world's largest water-consuming activity, especially for irrigation, where 70% of global water is withdrawn. Globally, it is estimated that about 70% of global water withdrawals and about 90% of water consumption are used for irrigation services[4].

Wireless sensor networks have unique features at the level of sensor nodes and at the level of the network created by these nodes, e.g. The possibility of applying WSN in almost all types of environments, both in urban and rural environments, the dynamic topology of WSN, its flexibility, self-control, scalability, accuracy and cooperation of sensor nodes with each other, which allows the involvement of wireless sensor networks in several sectors. application areas including agriculture, military, industry, home and healthcare. One of the promising areas of application of WSN is agriculture, where WSN technology offers significant support, leading agriculture, and thus irrigation, in a very positive direction and offering efficient and cost-effective solutions, as well as precise and automated irrigation system management and planning. with a high level of efficiency, automation and accuracy[5].

The purpose of this article is to comprehensively review the application and deployment of wireless sensor networks in the irrigation sector.

Wireless Sensor Networks:

The proliferation of MEM systems (i.e. Micro-Electro-Mechanical) and the tremendous developments in wireless technologies in recent decades have introduced and developed low-cost and energy-efficient smart sensors. These sensor nodes are autonomous, low-cost nodes, characterized by processing and computing capabilities and miniature sizes[6].

A wireless sensor network consists of many sensor nodes connected to each other via a wireless link module. These nodes have different capabilities (e.g. processing, transmission and sensing), so they can be self-organized and can be precisely or randomly placed[7].

In a WSN, sensor nodes are distributed across an area (i.e. sensor field). Each node uses its capabilities to collect and route data to create a global view of the controlled area. The collected data is routed directly or through other sensors to a collection point known as a base station for further processing using a multi-tier architecture. The base station can also serve as a gateway node

when there is a need to communicate and connect to the external network for data analysis and decision making[8].

Sensor Nodes:

A sensor node emerges as a miniature autonomous system with advanced sensing capabilities that forms the basic unit of a WSN. A sensor node is a microelectromechanical system that measures or detects physical or environmental attributes (such as emission, pressure, humidity, and temperature) and converts them into signals for monitoring and control[9].

A sensor node is mainly composed of four main units, a transmission unit, a sensing unit, a processing unit, and a power supply, as shown in Figure 1.

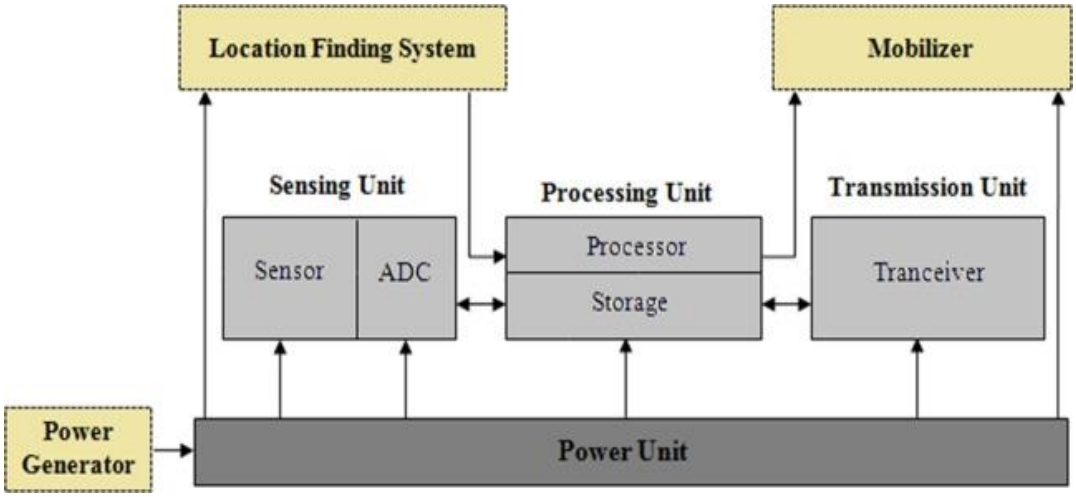

Figure 1. Sensor node block diagram.

Wireless Communication Technology:

A wireless sensor network uses several wireless communication technologies to efficiently transmit data to improve irrigation systems. There are many technologies such as Wi-Fi, ZigBee, and Bluetooth, which are the most common[10].

- Wireless Fidelity: or Wi-Fi Alliance (Wi-Fi Alliance Organization, 2020) is a wireless local area network technology introduced by the Institute of Electrical and Electronics Engineers (IEEE 802.11, 802.11 a/b/g/n) (IEEE Information Standard Technology, 2012). It provides wireless data exchange or wireless Internet access based on these standards (IEEE 802.11). The Wi-Fi communication range is approximately 20 m indoors and up to 100 m outdoors. It can also operate in the 2.4 GHz UHF and 5 GHz SHF ISM (i.e., industrial, scientific, and medical) frequency bands[11].
- Bluetooth: Bluetooth (Bisdikian, 2001 , Bluetooth Special Interest Group, 2020) is a wireless personal area network technology based on the IEEE 802.15.1 standard (IEEE Standard for Information Technology, 2005). It provides proximity connectivity between multiple electronic devices, such as tablets and mobile phones, over short distances. In addition, Bluetooth operates in the 2.4 GHz ISM frequency, which allows for short-range data transmission and exchange with very few devices.
- ZigBee: ZigBee (Baronti et al., 2007 , Wang et al., 2016) is a wireless communication technology introduced by the ZigBee Alliance (ZigBee Specifications, 2020). It is based on the IEEE 802.15.4 standard (IEEE Information Technology Standard, 2006), which defines a number of communication protocols used in the design and implementation of a personal wireless local area network with low-power radio signals and low data rates. IEEE Std, 2011). In addition, Zigbee operates at frequencies of 915 MHz, 868 MHz, and 2.4 GHz, and its data

rate is 250 kbps, which is best suited for transmitting periodic and intermittent data from an input device or sensor. ZigBee is low-cost, simple, easy to use and install, consumes less energy, and uses unlicensed radio bands and low current (Hamami and Nassereddine, 2018a)[12].

- GPRS: GPRS (Ghribi and Logrippo, 2000 , General Packet Radio Service, 2020) (i.e., General Packet Radio Service) is a wireless communication service that operates on a mobile network (i.e., 2G, 3G, and 4G cellular networks). It uses IP transmissions. It is used to transmit data packets over cellular networks (i.e., GSM-based mobile phones) and to offer Internet services on a mobile phone. GPRS is an integral part of the switching subsystem of the GSM network. GPRS operates in the 2.4 GHz frequency band and its range is extended up to several kilometers[13].

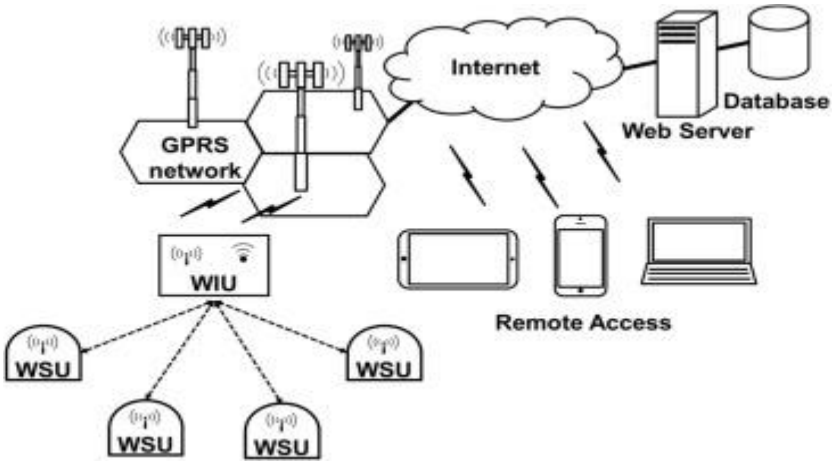

Figure 2. Automated irrigation system (wireless data unit and wireless sensor unit configuration) using WSN, ZigBee and GPRS (Gutierrez et al., 2014).

Application of WSN in irrigation:

Wireless sensor network is one of the best options for accurate monitoring and control of the environment. In recent decades, the rapid development of communication technology and sensor technology has brought about great changes in WSN, which has enabled the successful application of wireless sensor network technology in the irrigation field. Many advantages have enabled WSNs to add and provide cost-effective and efficient strategies to support, improve and strengthen irrigation systems. Dynamic network topology, large number of embedded sensor nodes, self-organization and homogeneity of embedded nodes, cooperation between nodes to achieve the target goal, sensing, control and wireless communication functions, adaptability to various devices. environments and transfer the collected data through intermediate nodes without increasing energy or cost[14].

Conclusion:

The integration of wireless sensor networks with the irrigation sector helps to provide efficient and cost-effective solutions to support, improve and strengthen irrigation systems. Therefore, this integration is also beneficial to ensure efficient and rational use of water for irrigation and to alleviate the severity of the global water crisis to some extent. This article has comprehensively reviewed the application and deployment of wireless sensor networks in the irrigation sector. First, we introduced and explained various aspects of sensors and wireless sensor networks. Next, we highlighted various WSN applications in the irrigation sector, and then presented a synthesis of various works and studies in this context. After that, we discussed the application and use of wireless sensor networks in irrigation by introducing the different wireless communication technologies used, the different sensors and irrigation strategies used, the soil types and the crop

types grown to study the role of WSN in the irrigation area. Based on the results of this survey, we conclude that a smart irrigation system can be effective and has great potential for saving irrigation water, if it is well and properly planned, operated and maintained. Finally, a proposed methodology is presented for implementing an automated system for intelligent irrigation management using wireless sensor networks.

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