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DESIGN AND IMPLEMENTATION OF ZIGBEE-BASED LOW POWER WIRELESS SENSOR AND ACTUATOR NETWORK (WSAN) FOR AUTOMATION OF URBAN GARDEN IRRIGATION SYSTEM

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Abstract:
Urban agriculture has gained significant attention due to its potential to provide fresh produce in densely populated areas. However, managing irrigation in urban gardens poses challenges due to limited resources and space constraints. This paper presents the design and implementation of a Zigbee-based Low Power Wireless Sensor and Actuator Network (WSAN) tailored for automating urban garden irrigation systems. The proposed system aims to optimize water usage while ensuring adequate hydration for plants, thus promoting sustainable urban agriculture. The WSAN comprises sensor nodes distributed across the garden to monitor soil moisture levels and environmental parameters. Actuator nodes control irrigation valves based on real-time data and predefined thresholds. The Zigbee protocol enables low-power communication between nodes, extending network lifetime. Experimental results demonstrate the effectiveness of the WSAN in maintaining optimal soil moisture levels and reducing water wastage, thereby enhancing the efficiency of urban garden irrigation systems.

Keywords: Zigbee, Wireless Sensor and Actuator Network (WSAN), Urban Agriculture, Irrigation System, Low Power, Sustainability.

I. Introduction:

Urban agriculture plays a crucial role in addressing food security and promoting sustainable living in densely populated areas. However, managing irrigation in urban gardens poses unique challenges due to limited space and resources. Traditional irrigation methods often result in inefficient water usage and may not adapt to dynamic environmental conditions. To address these challenges, this paper proposes a Zigbee-based Low Power Wireless Sensor and Actuator Network (WSAN) designed specifically for automating urban garden irrigation systems. By leveraging wireless sensor technology and intelligent actuation, the proposed system aims to optimize water usage, improve plant health, and promote sustainable urban agriculture.

II. Existing system:

Exisiting of design and implementation of zibgee based low power wireless sensor and actuator for automation of urban garden irrigation systems in a brief explaniation. The design and implementation of a Zigbee-based low-power wireless sensor and actuator system for automating urban garden irrigation systems involves several key components. Firstly, the sensor network comprises various sensors like soil moisture, temperature, and humidity sensors strategically placed across the garden to collect realtime data. This data is then transmitted wirelessly using Zigbee protocol, known for its low power consumption and reliability, to a central control unit. The control unit processes the data and triggers actuators such as water pumps or valves to automate irrigation based on predefined parameters, ensuring optimal water usage and plant health. This system enhances efficiency, reduces water wastage, and enables remote monitoring and control of the irrigation process, making it ideal for urban garden automation.

III. Proposed system:

Designing and implementing a Zigbee-based low-power wireless sensor and actuator system for automating urban garden irrigation involves several key steps. First, a thorough analysis of the urban garden's layout, size, and irrigation requirements is essential to determine the number and placement of sensors and actuators. Next, selecting Zigbee as the communication protocol offers advantages like low power consumption, mesh networking capability, and reliable communication over short distances. For sensor deployment, choosing sensors capable of measuring soil moisture, temperature, and light levels would be crucial for efficient irrigation control. These sensors should be connected to Zigbee-enabled microcontrollers or sensor nodes placed strategically throughout the garden. Actuators, such as water valves or pumps, would be controlled wirelessly via Zigbee based on the sensor data and predefined irrigation schedules.The system's design should include a central Zigbee coordinator that manages communication between sensors, actuators, and a central controller or gateway. The gateway could be connected to the internet for remote monitoring and control, allowing users to adjust irrigation settings, view sensor data, and receive alerts or notifications.

IV. Methodology:

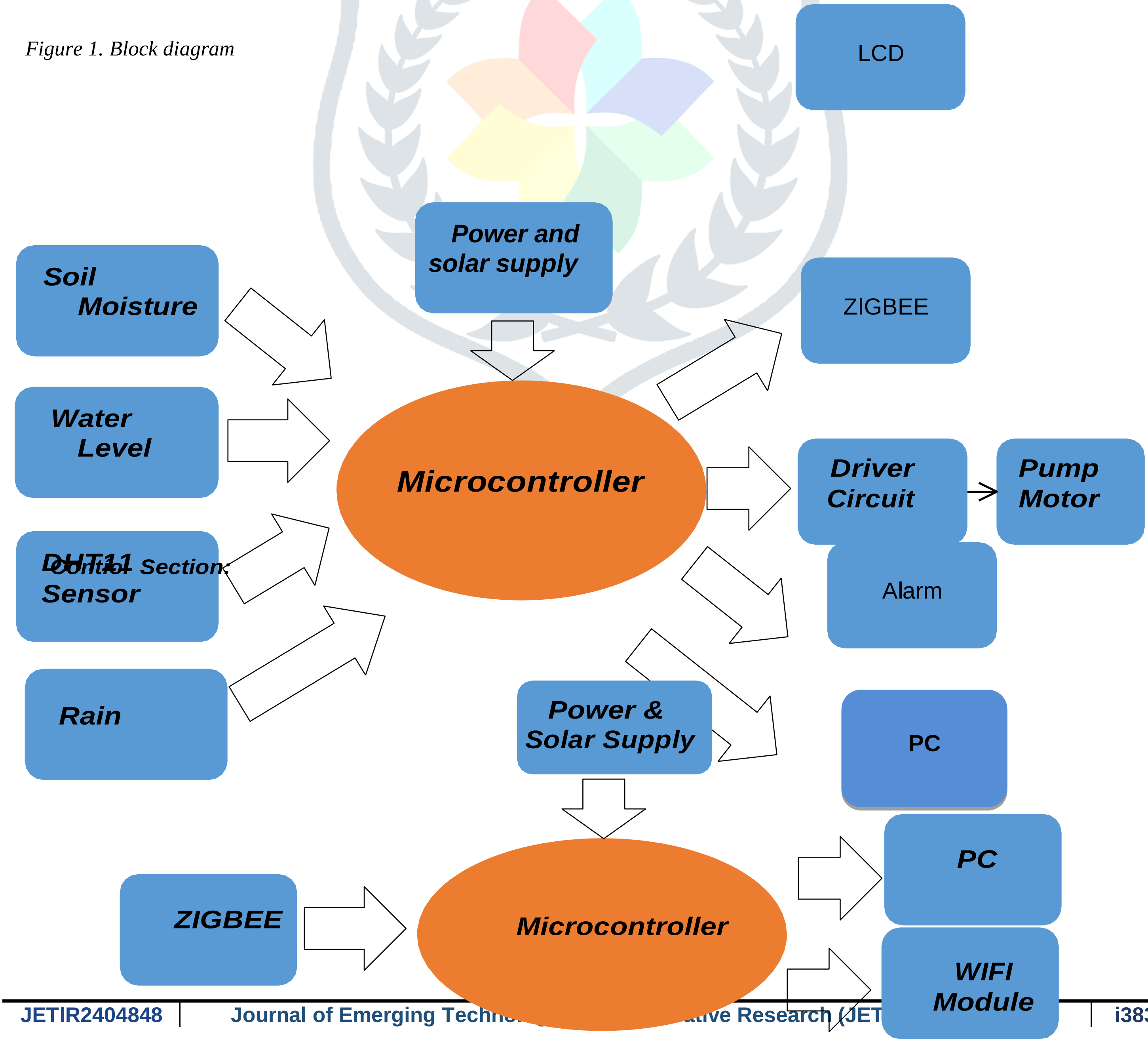
The design and implementation of the Zigbee-based WSAN for urban garden irrigation system automation involve several key components and stages.

Sensor Nodes: The WSAN comprises sensor nodes distributed strategically across the garden to monitor soil moisture levels and environmental parameters such as temperature and humidity. Each sensor node is equipped with soil moisture sensors, temperature sensors, and humidity sensors to collect real-time data.

Actuator Nodes: In addition to sensor nodes, the WSAN includes actuator nodes responsible for controlling irrigation valves based on the data received from sensor nodes. Actuator nodes are connected to irrigation valves and can adjust water flow rates.

V. Block diagram:

Figure 1. Block diagram



VI. Applications:

- Smart Agriculture: Efficient irrigation based on real-time data.
- Water Conservation: Minimization of water wastage, optimal schedules.
- Energy Efficiency: Reduced energy consumption with Zigbee technology.
- Remote Monitoring: Manage irrigation systems remotely, anytime.
- Environmental Monitoring: Monitor soil, temperature, humidity, light intensity.
- Urban Farming: Support for rooftop, vertical, community gardens.
- Education and Research: Tool for teaching, platform for research.

VII. Hardware details:

The hardware components of the project "Design and Implementation of Zigbee-Based Low Power Wireless Sensor and Actuator Network (WSAN) for Automation of Urban Garden Irrigation System" are carefully selected to ensure efficient and reliable operation in the context of urban gardening. At the heart of the system lies the microcontroller, which acts as the central processing unit responsible for executing control logic and managing the flow of data between sensors and actuators. The microcontroller coordinates the activities of various peripherals and interfaces with external devices.

Several sensors are integrated into the system to gather essential environmental data. The DHT11 sensor accurately measures temperature and humidity levels, providing insights into the overall climatic conditions influencing plant growth and water requirements. A water level sensor enables precise monitoring of irrigation levels within the garden reservoir or irrigation system, ensuring optimal water usage and preventing overflows or shortages. Additionally, a soil sensor measures soil moisture content, allowing for real-time assessment of soil hydration levels to guide irrigation decisions effectively. A rain sensor complements these measurements by detecting rainfall events, enabling the system to adjust irrigation schedules accordingly and avoid unnecessary watering during wet weather conditions.

Zigbee technology is employed to establish a low-power wireless communication network, enabling seamless data exchange between sensors, actuators, and the central controller. Zigbee's energy-efficient design ensures minimal power consumption, making it ideal for battery-operated sensor nodes deployed across the garden area. This wireless connectivity enables remote monitoring and control of the irrigation system, facilitating convenient management of garden operations from a central location.

Actuators such as pump motors are integrated into the system to automate the irrigation process based on sensor readings and user-defined settings. The driver circuitry controls the operation of these actuators, ensuring precise and timely delivery of water to the plants. Additionally, a buzzer provides audible alerts to notify users of important system events, such as low water levels, sensor malfunctions, or irregularities in the irrigation schedule. These alerts help users stay informed and take prompt action to address any issues that may arise, ensuring the efficient and reliable operation of the urban garden irrigation system.

VIII. Description of software:

The software components of the project "Design and Implementation of Zigbee-Based Low Power Wireless Sensor and Actuator Network (WSAN) for Automation of Urban Garden Irrigation System" play a crucial role in orchestrating the functionality of the hardware components and facilitating efficient communication and control within the system. The project utilizes a combination of software tools and programming languages to implement various functionalities and ensure seamless operation of the WSAN.

The Arduino Integrated Development Environment (IDE) serves as the primary software platform for developing and programming the microcontroller firmware. Arduino IDE offers a user-friendly interface and a rich set of libraries and tools that simplify the development process, allowing developers to write, compile, and upload code to the microcontroller seamlessly. Embedded C programming language is employed to write firmware code that implements control algorithms, data processing logic, and communication protocols required to interface with sensors, actuators, and external devices.

In addition to firmware development, the project leverages Micropython, a lightweight version of the Python programming language optimized for microcontrollers, to implement higher-level functionalities and application logic. Micropython offers a familiar syntax and a comprehensive standard library that enables rapid prototyping and development of complex applications. By using Micropython, developers can implement advanced features such as data logging, sensor fusion, and wireless communication protocols with ease, enhancing the overall functionality and versatility of the WSAN.

Overall, the software components of the project provide the necessary tools and programming environment to design, implement, and deploy a robust and scalable WSAN solution for automating urban garden irrigation systems. Through the integration of Arduino IDE, Embedded C, and Micropython, developers can leverage the strengths of each platform to create an efficient and reliable irrigation system that meets the unique requirements of urban gardening environments.

IX. Schematic diagrams:

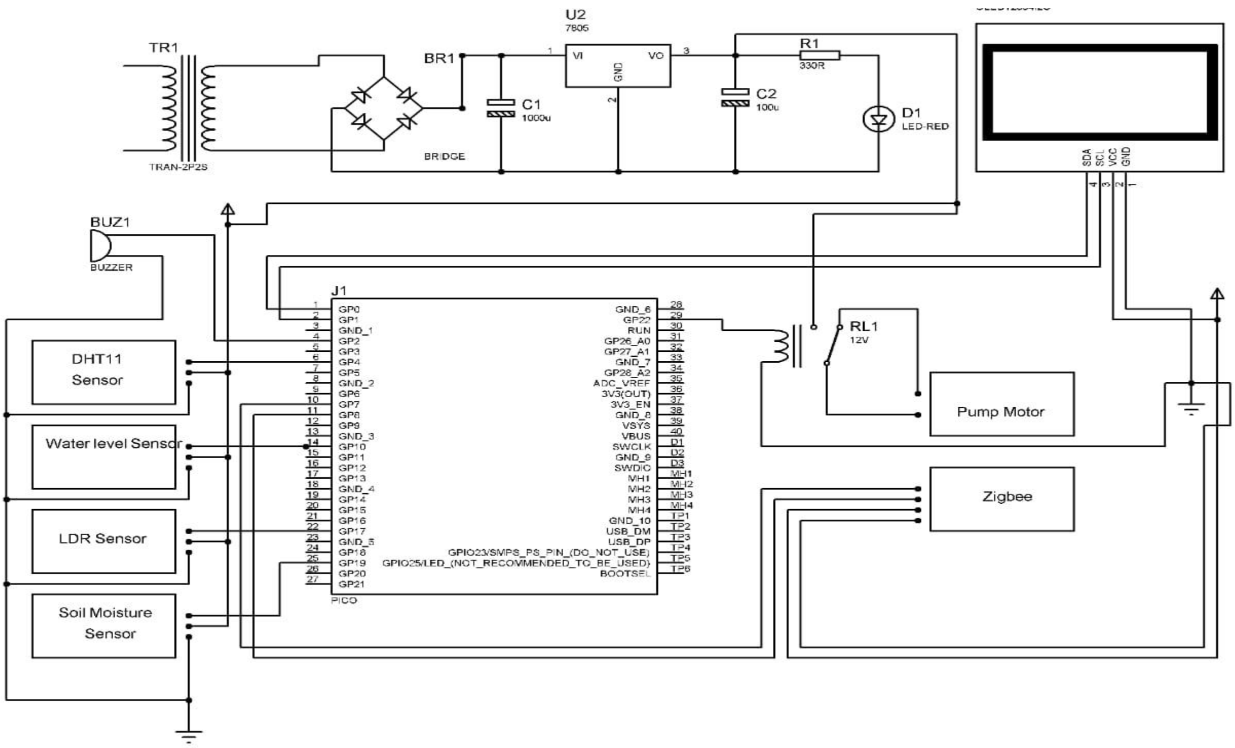


Figure 2. PROTEUS SIMULATION

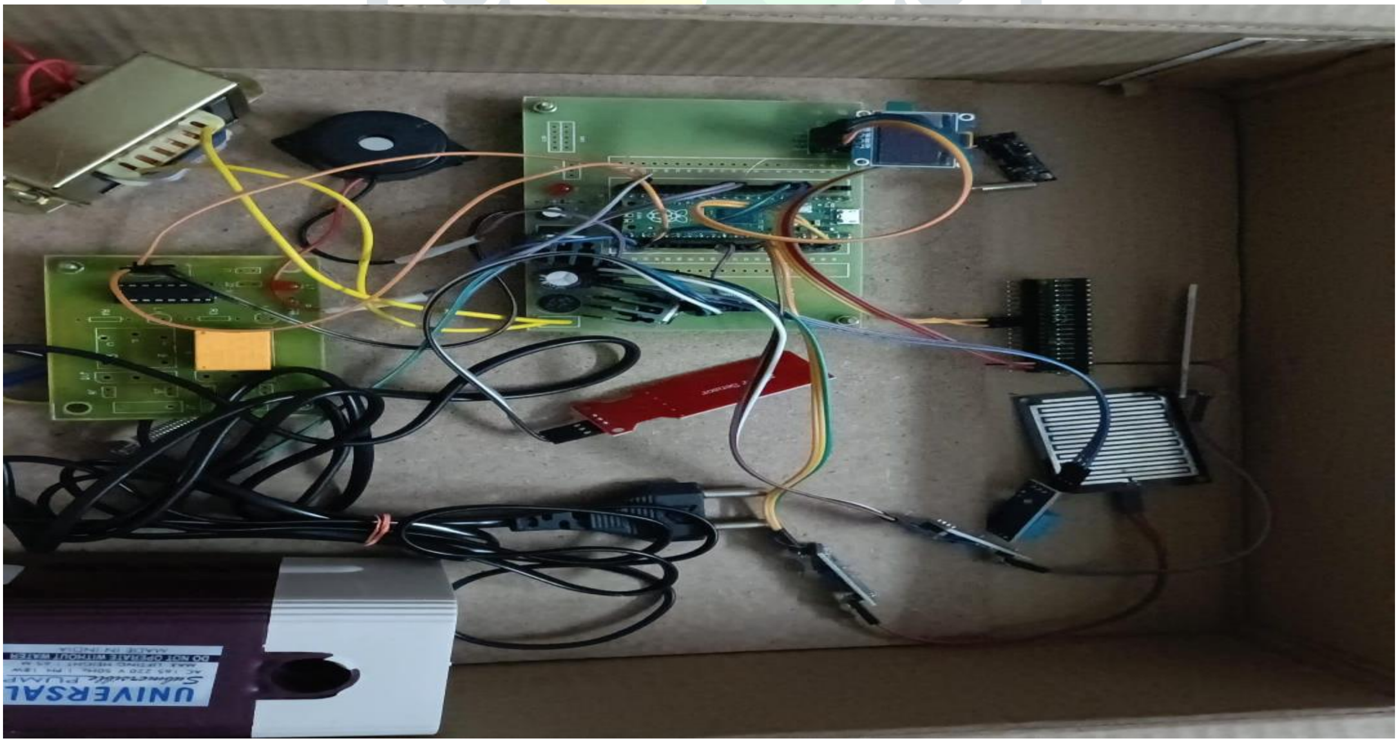


Figure 3. Hardware

X. Simulation result:

table 1. comparison of existing system with proposed system

Aspect	Existing System	Proposed System
Irrigation Method	Manual	Automated
Control Mechanism	Human intervention	Sensor-based, automated control
Monitoring	Limited	Real-time monitoring through WSAN
Water Usage Efficiency	Inefficient	Optimized through sensor data and automation
Maintenance	Labor-intensive, manual	Reduced through automation and remote monitoring
Dependency	Human scheduling and intervention	Automated scheduling based on sensor data
System Intelligence	Low	High, with intelligent control and optimization
Environmental Impact	Potential water wastage, less efficient water usage	Improved water conservation and environmental impact

Table 2. Comparison of Integrated and Manual locking system

Criteria	Integrated Locking System	Manual Locking System
Installation	Easy	Requires expertise
Cost	Higher	Lower
Maintenance	Automated	Manual
Security	High	Variable
User Convenience	High	Moderate

Acknowledgment:
We express our heartfelt gratitude to all those who have contributed to the completion of this project. Special thanks to our project supervisor for their invaluable guidance and support throughout the journey. We also extend our appreciation to the faculty members for their encouragement and feedback. Additionally, we acknowledge the contributions of our peers and friends who provided assistance and motivation. Finally, we are grateful to our families for their unwavering support and understanding.

Conclusion:
In conclusion, this paper presents the design and implementation of a Zigbee-based Low Power Wireless Sensor and Actuator Network (WSAN) for automating urban garden irrigation systems. By leveraging wireless sensor technology and intelligent actuation, the proposed system optimizes water usage, improves plant health, and promotes sustainable urban agriculture. Experimental results demonstrate the effectiveness of the WSAN in maintaining optimal soil moisture levels and reducing water wastage, thereby enhancing the efficiency of urban garden irrigation systems.

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