ABSTRACT

Aquaponics is a sustainable cultivation method whose success heavily relies on the stability of water and environmental quality parameters. Until now, the monitoring of crucial parameters such as temperature, pH, and water *turbidity* is generally still conducted manually. This causes efficiency issues, where delays in detecting environmental anomalies often occur, hampering handling responses and potentially reducing harvest productivity. These problems prompted the development of an integrated, Internet of Things (IoT)-based smart aquaponics monitoring and control system (SmartAquaponic). The system development applied the Scrum method, utilizing the Laravel framework for the website interface and Node.js as the backend service. On the hardware side, the system implements a Master-Slave architecture using ESP32 microcontrollers to optimize communication efficiency. The ESP32 Slave is specifically assigned to read data from sensors (DS18B20, DHT22, PH4502C, and SEN-0175) and control actuators (water pump, aerator, feeder, and grow light). Data from the Slave is transmitted locally to the ESP32 Master via the ESP-NOW protocol. Subsequently, the ESP32 Master forwards the data to the server over the internet using the Message Queuing Telemetry Transport (MQTT) protocol with HiveMQ as the broker. The implementation resulted in an integrated system providing features for real-time monitoring, historical data logging, alert notifications, and a management dashboard for actuator control. The system has been comprehensively evaluated, covering data communication testing (ESP-NOW and MQTT), hardware response (sensors and actuators), and black-box testing for the application consisting of 48 test items from 17 use cases, all yielding "Accepted" results. This confirms that the system has fulfilled the functional requirements from both software and hardware perspectives and is deemed highly feasible for implementation.

Keywords : Internet of Things, Aquaponics, MQTT, ESP32, Monitoring, Control.