SmartWater Plus

A Big Data and IoT Enabled Water Purification system

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TDTU and GSF Partners

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1. Introduction

- **Background and Motivation:**
  - Highlight the growing demand for efficient water management solutions and the limitations of conventional systems.
- **Objectives and Contributions:**
  - Introduce the SmartWater Plus system, focusing on leveraging IoT, LoRa, MQTT, and AI for real-time water purification.
- **Addressing Rural Needs:**
  - Recognize the critical need for reliable data communication platforms in rural and agricultural areas.
  - Highlight the system's potential to evolve into a long-term climate change adaptation project, addressing water scarcity and environmental impacts.

2. Applications in SmartWater Plus

- **Agriculture:**
  - Real-time monitoring of soil and crop health via IoT sensors.
  - Automated irrigation systems optimized with multi-gateway LoRa networks.
- **Aquaculture:**
  - Monitoring water quality across multiple sites with enhanced LoRa coverage.
  - Automated oxygenation systems driven by sensor data.
- **Village Water Supply:**
  - Multi-gateway-enabled monitoring of water distribution and maintenance.
  - Optimized maintenance and resource management.
- **Industrial Parks:**
  - Advanced systems for water recycling with real-time compliance monitoring.

3. Technological Framework

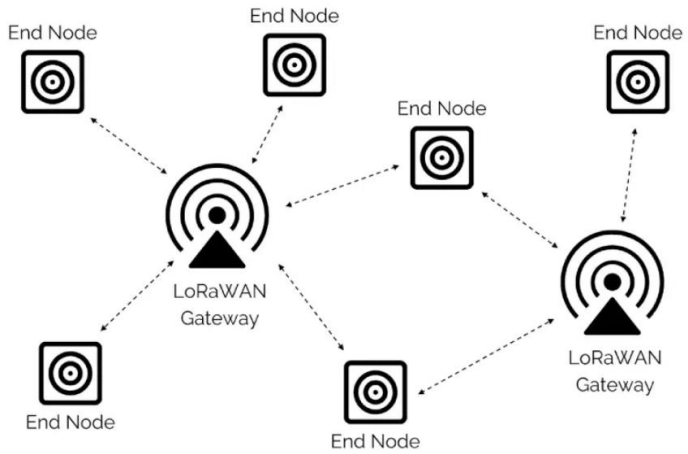
- **Multi-Gateway LoRa Networks**
  - Ensure reliable communication across large and remote areas.
  - The network supports easy expansion and provides redundancy for uninterrupted data transmission.
- **LoRa-Based MQTT Communication**
  - LoRa data communication with MQTT's lightweight protocol to enable efficient real-time data exchange in IoT systems.
  - Utilize multi-gateway architecture and QoS configurations to ensure network scalability, redundancy, and secure data transmission.
- **Integration with Open Source Platform**
  - Open-source platforms in SmartWater Plus enable tailored IoT solutions
  - By utilizing open-source technologies, the system reduces development costs

3.1 Multi-Gateway LoRa Networks

- **Benefits of Multi-Gateway Deployment:**
  - Increased reliability through redundant gateways.
  - Extended network coverage for larger areas.
  - Reduced communication bottlenecks in high-density deployments.
- **Applications in SmartWater Plus:**
  - Centralized control with decentralized network access.
  - Efficient scaling of IoT solutions across multiple project sites.
  - Optimized maintenance and resource management.

Multi-Gateway LoRa Architecture Configuration

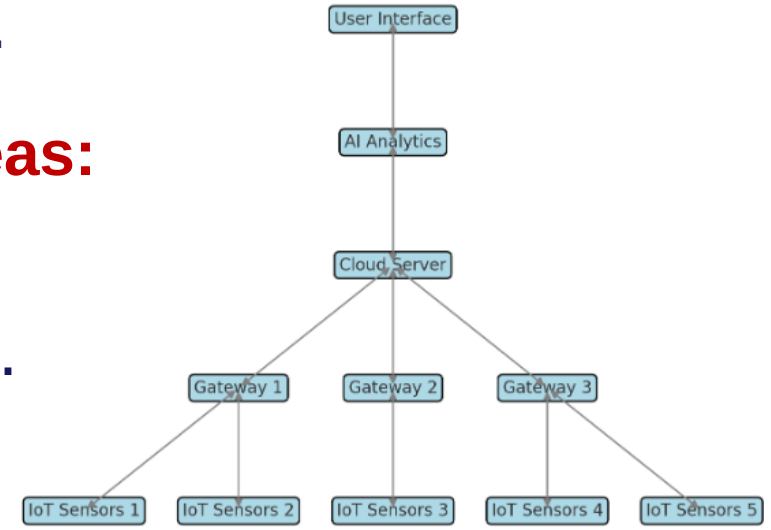
- **Network Components:**
  - **Gateways**: Collect data and forward it to the central server.
  - **Network Server**: Manages data routing and integration.
  - **Cloud Platform**: Processes data and provides analytics.



- **Key Features:**
  - **Redundancy**: Ensures data transmission even during gateway failure.
  - **Scalability**: Expands to large or additional project areas.
  - **Low Power Consumption**: Optimized for remote locations..

Applications of Multi-Gateway LoRa

- **Centralized Control with Decentralized Access:**
  - Unified management of multiple sites.
  - Simplified monitoring and decision-making.
- **Enhanced Coverage for Remote Areas:**
  - Deployable in large or diverse regions.
  - Supports rural water and agricultural needs.
- **Optimized Resource Management:**
  - Real-time data enables efficient resource allocation.
  - Minimizes waste and operational costs.



3.2 LoRa-Based MQTT Communication

- **Architecture Configuration**
  - Node (IoT Sensors): Collects data and transmits it to the gateway via LoRa.
  - Gateway: Converts LoRa data into MQTT messages and forwards it to the broker.
  - MQTT Broker: Manages cloud-based data processing and real-time communication.
- **Key Technical Considerations**
  - Enhanced Security: Implement SSL/TLS encryption and authentication mechanisms.
  - QoS (Quality of Service) Settings: Configure QoS levels (0, 1, 2) based on application requirements.
- **System Scalability and Maintenance**
  - Support for multiple gateways improves network scalability.

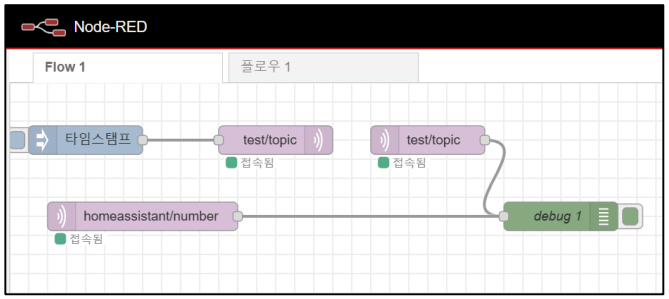
MQTT server and Node-RED

MQTT Server

- **Lightweight Protocol: Enables real-time message delivery with minimal bandwidth and resource usage, optimized for IoT devices.**
- **Scalability: Supports thousands of simultaneous connections, with QoS settings ensuring reliable data delivery.**

Node-RED

- **Visual Programming: Allows easy design of IoT workflows and data flows using drag-and-drop functionality.**
- **Extensive Plugin Ecosystem: Offers seamless integration with MQTT, HTTP, databases, and other systems.**



3.3 Integration with Open Source Platform

- **Cost-Effective:**
  - Affordable and accessible for scalable IoT deployments.
- **Built-In Connectivity:**
  - Integrated Wi-Fi and Bluetooth for seamless communication.
- **Open-Source Ecosystem:**
  - Extensive libraries and community support for rapid prototyping.
- **Energy Efficiency:**
  - Low power consumption suitable for remote and portable applications.
- **Flexible Integration:**
  - Supports various interfaces (GPIO, I2C, SPI, UART) for diverse applications.

Display-Integrated ESP Devices

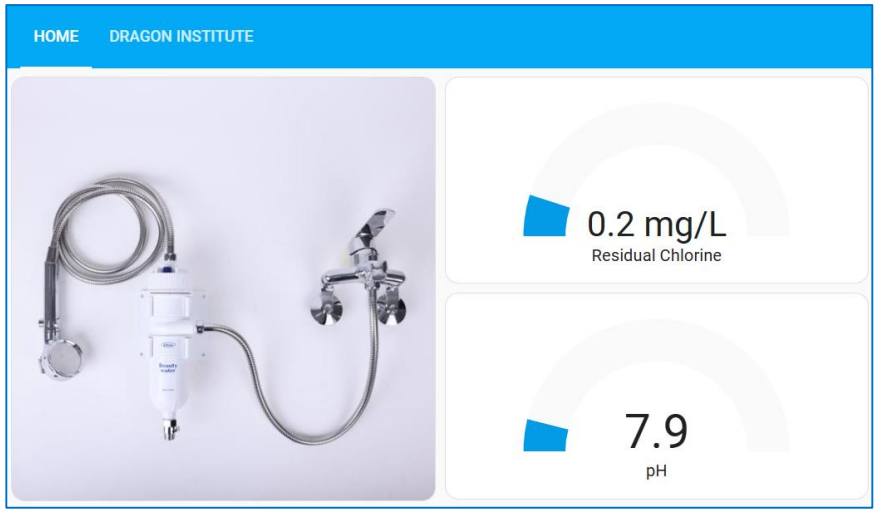
- **Compact and Cost-Effective**
  - Combines processing power and display in one unit, reducing overall system cost and complexity.
- **Wireless Connectivity**
  - Built-in Wi-Fi and Bluetooth for seamless IoT network integration and real-time MQTT communication.
- **Enhanced User Interaction**
  - Real-time visualization of data, system status, or alerts directly on the device.

Performance and Ecosystem Benefits

- **High Performance**
  - Dual-core processors and ample memory support multitasking and graphical rendering.
- **Open-Source Ecosystem**
  - Extensive libraries and tools (Arduino IDE, MicroPython) simplify development and customization.
- **Energy Efficiency**
  - Features like deep-sleep mode extend battery life, making it suitable for portable and remote applications.

3.3 Versatility and Applications

- **Sensor Integration**
  - GPIO, I2C, SPI, UART compatibility for connecting sensors and actuators.
- **Ideal Applications:**
  - Home Automation: Smart displays for monitoring and control.
  - Industrial Systems: Visualize equipment status in real-time.
  - Agriculture: Portable monitoring devices for field environments.



4. System Operation

- **Data Collection:**
  - ✓ On-site measurement of water quality and equipment performance.
  - ✓ Data input through mobile or computer terminals.
- **Data Transmission:**
  - ✓ LoRa communication and MQTT protocol to transmit data to the cloud server.
  - ✓ Two-way data transmission for equipment control and status updates.
- **Information Sharing:**
  - ✓ Processed data sent to ESP devices for real-time display on each system.
- **Big Data Utilization:**
  - ✓ Build a Big Data repository from collected data.
  - ✓ Use AI models for maintenance and performance optimization.

5. Integration of Big Data and AI in SmartWater Plus

Big Data Processing

- ✓ Apache Spark and Hadoop for large-scale analysis.
- ✓ Elasticsearch for efficient data queries.

AI for SmartWater Systems

- ✓ Predictive maintenance for timely repairs.
- ✓ Water quality optimization through pattern analysis.

Integration Frameworks

- ✓ MQTT for real-time communication.
- ✓ Node-RED for IoT orchestration.

Research Directions

AI Model Accuracy and Customization

- ✓ Develop and optimize AI models to accurately predict outcomes, customized for specific local requirements.

Scalability and Performance

- ✓ Enable seamless scaling of AI systems across diverse deployments while maintaining high performance and reliability.

User-Centric System Design

- ✓ Design user-friendly interfaces that deliver actionable insights, ensuring efficient interaction and decision-making for users.

Sustainability and Cost Reduction

- ✓ Research energy-efficient algorithms for cost savings.

Implementation Framework

Input

- ✓ Sensor data: pH, turbidity, filter pressure, Current measurements for motors, pumps and equipment.

Processing

- ✓ Analyze data with Big Data tools: Use tools like Apache Spark or Hadoop to process and analyze large datasets, extracting insights for optimization and decision-making.

AI Output

- ✓ Generate predictive maintenance alerts and actionable insights to enhance system efficiency and reliability.

Feedback Loop

- ✓ Continuously refine AI models by integrating user feedback and real-world data for enhanced performance.

6. Pilot Projects in the Mekong Delta

❑ Implementation Highlights:

- ✓ LoRa networks with multi-gateway coverage.
- ✓ Water Supply Monitoring System in House
- ✓ Agricultural monitoring for improved water efficiency.
- ✓ Sustainable aquaculture practices powered by IoT.
- ✓ Aquatic Food Processing Industrial Zones.

❑ Outcomes:

- ✓ Reduced operational costs and enhanced water quality.

6.1 Deployment of LoRa networks with multi-gateway coverage

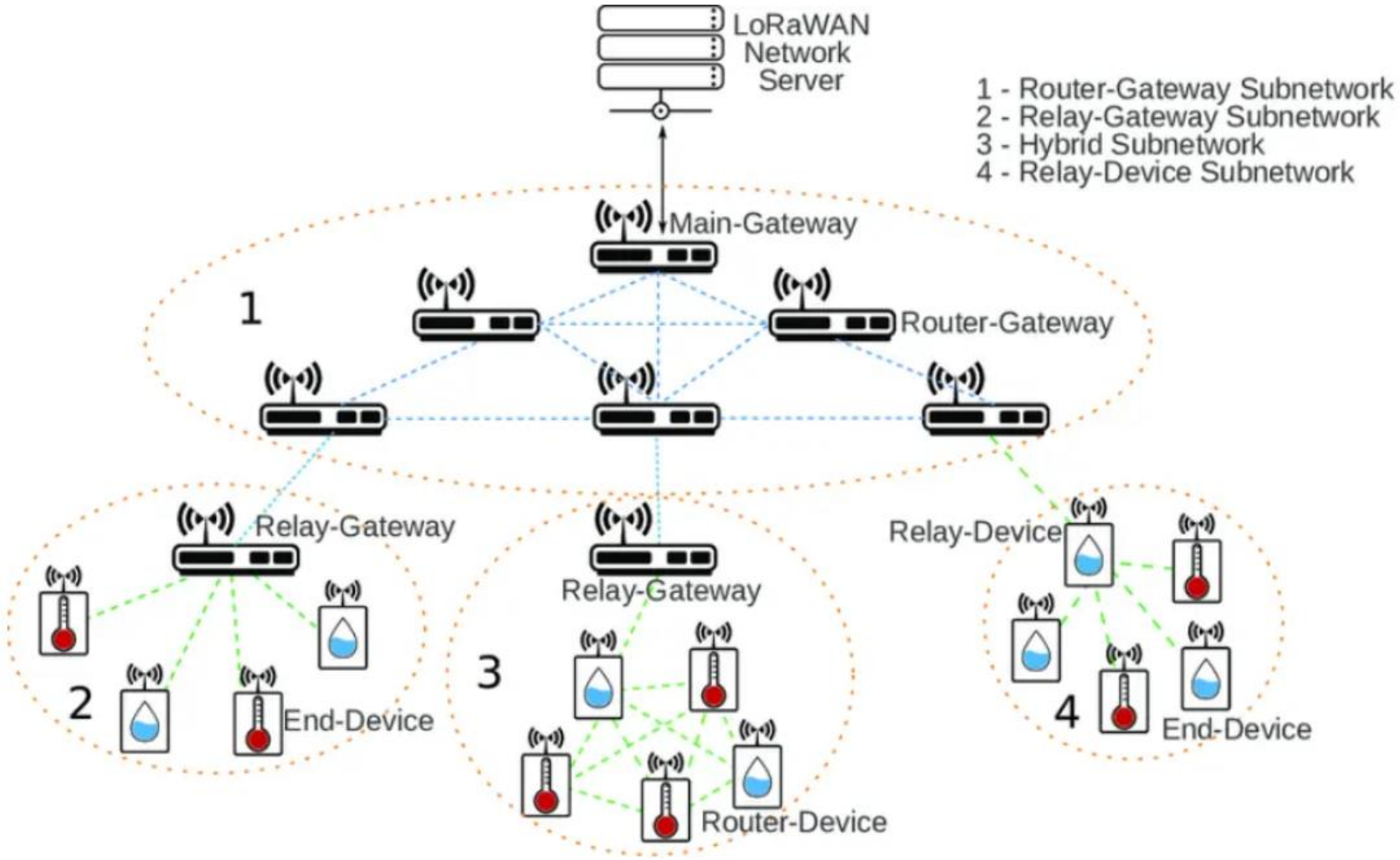
LoRa Multi-Gateway Deployment

- ✓ **Multi-Gateway Network Design**: Combines multiple gateways to create a reliable, scalable IoT network for real-time data communication.
- ✓ **Wide-Area Coverage**: Covers large and diverse geographical regions, including agricultural fields, aquaculture farms, and rural communities.

Key Benefits in the Mekong Delta Context

- ✓ **Resilience**: Redundant gateways ensure uninterrupted communication even in challenging environments.
- ✓ **Scalability**:Easily expandable to new sites and projects without major infrastructure changes.
- ✓ **Efficiency**:Low-power operation supports long-term sustainability for remote sensors and devices..

Architecture of LoRa networks with multi-gateway



6.2 Water Supply Monitoring System

- **Deployment of IoT Sensors:**
  - ✓ Locations: Install IoT sensors at key distribution facilities, water tanks, and pipelines.
  - ✓ Measurements: Monitor pH, chlorine, turbidity, pressure, and flow rates.
- **Centralized Data Platform:**
  - ✓ Functions: Real-time data collection and visualization.
  - ✓ AI Integration: Analyze supply patterns and predict demand for optimal resource allocation.
- **Community Engagement:**
  - ✓ Collaborate with local residents to share data insights and conduct educational programs.
  - ✓ Establish a community-led maintenance network for sustainability.

6.3 Agricultural monitoring for improved water efficiency.

- **Deployment of IoT Sensors:**
  - ✓ Location: Select agricultural plots in the Mekong Delta.
  - ✓ Technology: IoT sensors capable of measuring soil moisture, temperature, and environmental factors.
- **Real-Time Data Collection:**
  - ✓ Sensors communicate via a LoRa multi-gateway network, transmitting data over long distances with minimal power usage.
  - ✓ Centralized platform aggregates data for analysis and visualization.
- **Automated Irrigation Systems:**
  - ✓ Integration of smart valves and pumps controlled by IoT sensors.
  - ✓ Real-time adjustments based on soil moisture levels to prevent over- or under-watering.

6.4 Sustainable aquaculture practices powered by IoT.

- **Real-Time Monitoring**
  - ✓ IoT sensors continuously measure key metrics such as dissolved oxygen (DO), pH levels, salinity, temperature, and turbidity.
- **Energy Efficiency**
  - ✓ Solar or wind power systems can be integrated with IoT devices to minimize energy usage.
- **Health and Disease Management**
  - ✓ Sensors track waste buildup, enabling targeted removal to maintain a healthy aquatic environment.

6.5 Food Processing Industrial Zones

- **Deployment of IoT Sensors:**
  - ✓ Installation Sites: Water inlets, pipelines, storage tanks, and wastewater treatment plants.
- **Real-Time Monitoring Platform:**
  - ✓ Centralized dashboard for real-time water quality data visualization.
- **Automated Water Management Systems:**
  - ✓ Integration of smart valves and pumps controlled by IoT sensors..

7. Expanding as a Climate Change Platform

❑ Goals for Climate Resilience:

- ✓ Strengthen rural communities' capacity to adapt to climate change.
- ✓ Develop disaster warning systems for floods and droughts.

❑ Platform Expansion:

- ✓ Collect and analyze real-time climate data using IoT devices.
- ✓ Detect abnormal climate patterns early using AI models.
- ✓ Optimize agriculture, water resource management, and energy consumption based on large-scale data.

❑ Enhanced Partnerships:

- ✓ Collaborate with local governments, research institutions, and industries to expand technology applications.
- ✓ Partner with international climate adaptation programs (e.g., KOICA, AKCF).

8. Conclusion: IoT in SmartWater Plus

- **SmartWater Plus initiative leverages IoT, LoRa, AI, and Big Data to revolutionize water management in the Mekong Delta. By integrating cutting-edge technologies, the project addresses critical challenges in agriculture, aquaculture, and community water supply, driving sustainability and efficiency.**

- **SmartWater Plus delivers innovative solutions, ensuring economic growth, environmental preservation, and improved quality of life. This initiative sets a benchmark for future projects, combining technology and sustainability for scalable impact across Vietnam and beyond.**

- **Together, we can build a cleaner, smarter, and more sustainable water future.**

Collaboration Framework

- **TDTU FEEE:** IoT sensor interface and LoRa Data Communication Platform
- **TDTU AI Lab:** Advanced analytics for data-driven decision-making in water management.
- **Can Tho University Dragon Institute Mekong :** Research on sustainable practices tailored for the Mekong Delta.
- **KVIP (Korea Vietnam Incubator Park):** Industrial application testing and infrastructure support.
- **VLTECH:** AI-based predictive analysis.
- **AGU(ICT Center):** IoT implementation and data transmission.
- **IoT Vision:** Deployment of LoRa multi-gateway networks
- **LFO:** User-friendly visualization tools for monitoring water systems.
- **YHS:** Advanced water purification technologies integrated with IoT.
- **VINABS:** Regional support in Khanh Hoa and Nha Trang.
- **JBC Group:** Coordination of partnerships and operational support.


SmartWater Plus
IOT
Clean
Water
Plus
IOT
Thank You
Your Attention
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