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University of Applied Sciences

Bachelor thesis

Designing and Optimizing a Low-Power IoT LoRaWAN-Based Water Level Monitoring System for Flood Detection

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Background

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Flood risks in small tributaries (side streams or minor rivers) often lack real-time monitoring solutions. The increased frequency and severity of flooding due to climate change and extreme weather events highlight the need for cost-effective, energy-efficient monitoring systems.

Challenges of traditional systems:

- **High energy consumption and power dependency:** Many traditional systems require connection to the power grid or rely on large batteries, making them difficult to deploy in remote areas. Frequent data transmission in traditional sensors further drains battery life quickly, limiting long-term usability.

- **High communication costs**: GSM-based solutions incur recurring expenses for mobile data (SIM cards, network fees), increasing operational costs.

- **Infrastructure-heavy**: Advanced weather stations or radar-based monitoring solutions require costly installations and regular servicing.

Advancements through LoRaWAN

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The adoption of LoRaWAN technology has addressed many of these limitations by offering:

- **Low power consumption:** LoRaWAN devices operate in low-power modes, allowing battery life to extend for years without replacement.
- **Long-range communication:** LoRaWAN supports connectivity over several kilometers, making it ideal for remote and large-area monitoring.
- **Cost-effective operation:** Unlike GSM-based solutions, LoRaWAN eliminates recurring data transmission costs, as it operates on unlicensed frequency bands.

Despite these advancements, there is still room for improvement and optimiziation.

Objectives

This project aims to enhance existing approaches by developing a prototype with the following objectives:

Advanced Power Management Strategies: Comparison of different energy sources (solar, kinetic, battery) for long-term deployment. Implementation of hardware-level power optimization and low-power modes.

Two-Way Communication for Adaptive Monitoring: Downlink communication to allow remote configuration and dynamic parameter adjustments, addressing the gap that existing solutions are primarily one-way.

Cost-Effective and Adaptive Sensor Design: Evaluation of different sensor types to optimize cost and efficiency. Development of a dual-layer approach: a simple conductive wire triggering a secondary, more precise sensor when a threshold is exceeded.

Anomaly Detection and Adaptive Sampling Rates: Dynamically adjust sampling rates based on detected anomalies, increasing measurement frequency only when unexpected readings occur to conserve energy.

Integration with Disaster Preparedness Initiatives: Conducting a small-scale case study in collaboration with local authorities (Oberallgäu). Testing real-world applicability and optimizing the system.