Proposal Bachelor Thesis

Development and Evaluation of a Hybrid Approach for Automated Error Detection and Classification in LoRaWAN-Based IoT Data Pipelines Using Log Data

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Motivation & Research Gap

- LoRaWAN-based IoT data pipelines generate large volumes of semi-structured log data
- Manual log inspection does not scale and provides limited prioritization
- Rule-based methods are effective for known error patterns but struggle with variability and new patterns
- ML-based methods can detect unknown patterns but often lack operational simplicity and transparency
- Research gap: systematic evaluation of hybrid log analysis strategies in real IoT contexts

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Research Questions

Main Research Question

- How effective is a hybrid approach for automated error detection, classification and aggregation in LoRaWAN-based IoT data pipelines?

Sub-Questions

- Which practically relevant error and warning events can be identified from real LoRaWAN pipeline logs and formalized into a consistent class catalogue?

- How do rule-based, Machine Learning-based, and hybrid approaches differ in measurable performance at log-line and time-window/incident level?

- Which error classes are better addressed by deterministic rules, which benefit more from Machine Learning–based classification, and which characteristics explain these differences?

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Research Design & Methods

- Engineering-oriented research design combining prototyping and quantitative evaluation

- Literature Review

- Prototype for log parsing, classification, and aggregation

- Rule-based baseline detector for stable error signatures

- ML Classifier with engineered features and confidence estimation

- Hybrid decision logic with confidence-based rejection of unknown events

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Expected Results

- A clear error and warning class catalogue from real LoRaWAN log data
- A reproducible prototype for automated log classification and aggregation
- A quantitative comparison of rule-based, ML-based, and hybrid methods
- Measurable insights into handling unknown and unseen error events
- Practical guidance on when to use rules, ML, or a hybrid approach

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Implications & Outlook

- An overview for selecting rules, ML, or hybrid approaches in log analysis
- Reduced effort and MTTR through structured and aggregated log views
- Transferability of the approach to other IoT or backend logging domains
- Future work potential: feedback loops, and active learning mechanisms

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