TFB3012 FINAL YEAR PROJECT 1 (FYP 1)

INTERIM REPORT

DEVELOPMENT OF A SMART WATER METER SYSTEM WITH LEAKAGE DETECTION USING IOT AND LORAWAN FOR RESIDENTIAL APPLICATIONS

(MAY 2025)

Name	Yasmin Hii Binti Abdullah
Student ID	21001780
Programme	Bachelor of Information Technology (Hons)
Project Title	Development of a Smart Water Meter System with Leakage Detection using IoT and LoRaWAN for Residential Applications
Supervisor	Assoc. Prof. Ts. Dr Koh Tieng Wei
Examiner	Assoc. Prof. Ts Dr Hitham Seddiq Alhassan Alhussian

Table of Contents

Abstract

This project proposes the development of a smart water meter system using IoT and LoRaWAN technologies to improve water monitoring and management efficiency. The system aims to provide real-time data on water usage, detect leaks, and enhance water conservation practices. By integrating an ultrasonic water meter with a LoRaWAN gateway and a cloud-based dashboard, the system will enable remote monitoring and analysis of water consumption patterns. The project includes device configuration, field testing, and simulated data analysis using The Things Network (TTN). This report outlines a structured plan for designing, implementing, and evaluating the prototype during the final year project. The outcomes are expected to support sustainable water management initiatives, especially in regions such as Perak where traditional water metering methods are still widely used.

1. INTRODUCTION

1.1 Background of Study

Traditional water metering systems in many regions of Malaysia, including Perak, continue to rely on manual readings. These systems often result in delayed leak detection, inaccurate billing, and inefficient water usage monitoring. The increasing demand for efficient water management has prompted the exploration of smart solutions using Internet of Things (IoT) technologies.

Smart water meters are designed to collect water usage data in real time and transmit it wirelessly to a central dashboard. These systems offer features such as remote monitoring, leak detection, consumption trend analysis, and integration with cloud platforms. LoRaWAN (Long Range Wide Area Network) is particularly well-suited for smart metering due to its long-range communication capabilities and low power consumption.

The proposed project will develop a prototype smart water meter system incorporating LoRaWAN and IoT components. This system will be evaluated for technical feasibility, data accuracy, and real-time monitoring capabilities.

1.2 Problem Statement

In many areas of Perak, water utilities still depend on manual meter reading, which is labour-intensive, prone to errors, and lacks real-time monitoring capabilities. This outdated system often leads to delayed identification of leaks, inefficient usage tracking, and customer dissatisfaction due to billing inaccuracies.

Furthermore, existing IoT water metering solutions are not widely adopted in the region, creating a gap for innovation and research. Therefore, there is a need to design and evaluate a functional prototype of a smart water meter system that can address these limitations through wireless data transmission, remote monitoring, and automated visualization.

1.3 Objective

i. **To design the system architecture** of a smart water meter for residential applications, including the selection of IoT sensors, a microcontroller and communication technology using LoRaWAN.

ii. **To integrate the smart water meter system with a cloud platform**, The Things Network and a dashboard for real-time data transmission and leak alert functionality.

iii. **To develop and implement a cloud-based dashboard** capable of visualizing real-time water flow data and detecting potential water leakage for effective residential water usage monitoring

1.4 Scope of Study

The project scope includes the hardware setup for water smart meter, LoRaWAN gateway, firmware and network configuration, dashboard development, and testing. It focuses on proof of concept (PoC) development and field testing, without commercial deployment. The study also considers environmental and technical challenges such as signal stability and simulation limitations.

2. LITERATURE REVIEW

2.1 Introduction

Smart water meters offer an opportunity to overcome outdated systems of manual water usage and billing, which are often prone to errors and delays in data collection (Ahmed & Li, 2020). This literature review explores key technologies, communication protocols, implementation case studies, and potential future developments relevant to the proposed project.

2.2 Smart Water Meter Technologies

2.2.1 Traditional Water Meter

Traditional water meters primarily use mechanical or electromechanical components to measure water consumption. These meters require manual reading, which is time-

consuming, labour-intensive, prone to human errors and
unable to support real-time monitoring (Sharma & Patel,
2018).

Figure 2.2.1: Traditional water meter

2.2.2 Ultrasonic Water Meter

Ultrasonic water meters use sound waves to measure flow,
enabling accurate, maintenance-free readings. Their lack of
moving parts improves durability and supports seamless
integration with IoT platforms for real-time monitoring and
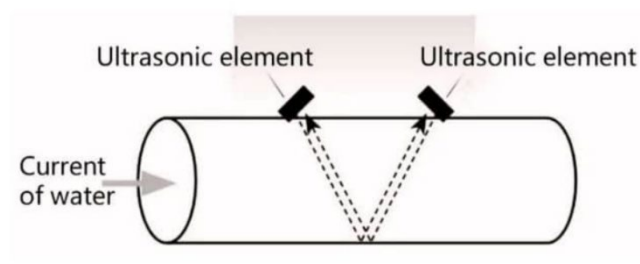data transmission (Zhou et al., 2019).

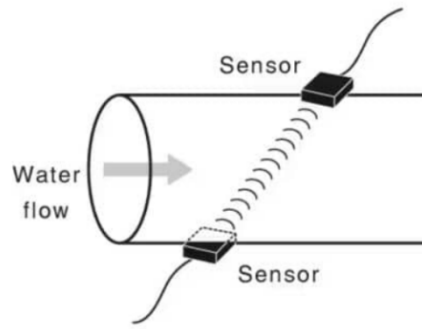*Figure 2.2.2.1: Principle operation of Ultrasonic Water Meter*

Figure 2.2.2.2: Working principle of Ultrasonic Water Meter

2.3 Communication Technologies for Smart Water Meter

2.3.1　LoRaWAN for IoT-Based Water Metering

LoRaWAN (Long Range Wide Area Network) is a low-power, long-range communication protocol designed for IoT applications, including smart metering. LoRaWAN does efficient transmission of data at long distances while conserving battery, thus making it suitable for large scale water distribution networks. It is providing bidirectional communication for remote monitoring and control of water meter readings.

Technology	Range	Power Consumption	Data Rate
LoRaWAN	10-15 km	Low	Low
NB-IoT	1-10 km	Moderate	Moderate
Wi-Fi	100 m	High	High

Table 1: Comparison of communication technologies for smart water meters

2.4 Cost Analysis of Smart Water Meter Implementation

Implementing a smart water metering system involves various cost components, including hardware, installation, and data management. While smart meters require a higher initial investment than traditional

meters, they offer long-term benefits such as reduced maintenance, improved billing accuracy, and automated data collection (Kumar & Tan, 2020).

The estimated cost breakdown for key components of a smart water meter deployment is in Table 2.

Component	Estimated Cost (RM)
Ultrasonic Smart Meter	~650 per unit
LoRaWAN Gateway	1,000 - 5,000 per unit
Cloud Subscription	50 - 200 per month
Installation & Maintenance	Varies

Table 2: Estimated cost breakdown for smart water meter deployment

To assess the feasibility of smart water meters, a comparison with traditional meters is necessary. Traditional meters have a lower upfront cost but require manual reading, higher maintenance, and lack real-time data capabilities.

The following table compares the cost and operational aspects of traditional versus smart water meters.

Component	Traditional Meter (RM)	Smart Meter (RM)
Meter Cost	~67	~650
Installation	50 - 100	100 - 200
Data Collection	Manual (labour-intensive)	Automated (LoRaWAN)
Maintenance	Higher (wear & tear)	Lower (no moving parts)
Billing Accuracy	Prone to errors	High precision
Long-term Savings	No early leak detection	Detects leaks, saves costs

Table 3: Comparison of Traditional and Smart Water Meter Costs

While traditional meters may seem cost-effective initially, the benefits of smart meters such as real-time monitoring, leak detection, and improved accuracy, it can lead to significant operational savings over time (Alvarez & Kim, 2022). Additionally, automation reduces labour cost of manual readings and prevents errors in billing.

Long-term return on investment (ROI) for smart water meters must be the focus of future studies, considering network infrastructure, data security, and large-scale deployment.

2.5 Theoretical Background

Smart water metering systems are part of Internet of Things (IoT) applications used to monitor water usage efficiently (Chong et al., 2021). These systems typically include sensors to measure flow rate, a microcontroller to process the data, and a communication module such as LoRaWAN to transmit the data wirelessly over long distances.

LoRaWAN (Long Range Wide Area Network) is chosen for its low power usage and long-range capabilities, making it suitable for residential areas (Semtech, 2021). It enables sensors to send data to gateways, which then forward the data to cloud platforms for storage and visualization.

Leak detection is based on monitoring water flow patterns. For example, if water continues to flow for long periods when no one is using it, the system may identify this as a leak. Some systems in the future may use advanced techniques like AI to improve accuracy, but this project focuses on simple flow-based detection methods.

2.5.1   Real-World Case Studies

Several cities and utilities have successfully deployed smart water meters using LoRaWAN. These case studies highlight benefits such as reduced water losses, improved billing accuracy, and better customer engagement. However, some challenges, such as environmental interference and integration issues, have also been reported. These examples demonstrate the importance of careful planning and robust infrastructure.

9

Smart Water Metering in Lyon, France

The city of Lyon implemented a large-scale LoRaWAN-based smart water metering system aimed at reducing water waste and enhancing billing transparency. Thousands of smart meters were installed to collect real-time data on water usage, which was then relayed to utility providers and consumers. The system led to a 15% reduction in water loss and improved customer trust through accurate billing and proactive leak alerts. However, the initiative initially faced challenges such as signal penetration issues in older buildings, requiring investment in additional network infrastructure to maintain connectivity (Smith et al., 2021).

Singapore's National Water Smart Meter Initiative

Singapore's national water agency, PUB, launched a smart metering program to monitor water consumption across residential and commercial properties. The system, which also uses LoRaWAN, aimed to enhance water conservation efforts through real-time monitoring and leak detection. Early detection of leaks led to measurable reductions in water wastage. However, high humidity conditions in the region affected the hardware lifespan, necessitating frequent maintenance and component replacement. Despite these challenges, the initiative demonstrated the effectiveness of IoT-based water management in urban environments (PUB Singapore, 2020).

2.5.2   Challenges in Real-World Deployments

Despite the numerous benefits offered by smart water meters, real-world deployments present several challenges. One common issue is environmental interference, as obstacles such as buildings, trees, and varying terrain can weaken LoRaWAN signals (Hassan et al., 2021). This necessitates the strategic placement of gateways to ensure reliable connectivity. Another

challenge involves cost overruns, where unanticipated expenses, such as additional network infrastructure or maintenance, can increase the overall cost of deployment (Yusof & Nordin, 2020). Additionally, integration difficulties arise when attempting to connect new smart meters with existing legacy billing systems, often requiring significant software development and adaptation to ensure seamless data integration

2.6 Summary and Future Directions

The reviewed case studies demonstrate the effectiveness of smart water meters integrated with LoRaWAN and cloud dashboards in supporting real-time monitoring and leak detection (Smith et al., 2021; PUB Singapore, 2020). Cities like Lyon and Singapore highlight the potential for improving water conservation, billing accuracy, and customer awareness.

For future improvements, efforts can focus on enhancing network reliability and device durability, particularly in challenging environments such as areas with high humidity or limited infrastructure (Chong et al., 2021). Expanding integration with cloud platforms and refining leak detection logic may also improve system performance and scalability for broader residential adoption

2.7 Conclusion

In summary, smart water metering systems that incorporate IoT sensors, LoRaWAN communication, and cloud dashboards provide a significant advancement over traditional metering approaches (Ahmed & Li, 2020). They not only improve water conservation efforts but also enhance user experience through real-time feedback and alerting. However, challenges such as environmental interference, hardware limitations, and integration complexity must be addressed through careful design and planning. Continued research and innovation will be essential to improving the

effectiveness and resilience of these systems in real-world residential applications (Zhou et al., 2019; Yusof & Nordin, 2020).

3. METHODOLOGY

The development of the smart water meter system was conducted through a systematic methodology comprising system planning, hardware configuration, gateway setup, cloud integration, and dashboard development. Initially, the project involved identifying the essential hardware and software components required to implement the system. A commercially available ultrasonic smart water meter was selected as the primary sensing device, featuring integrated sensors for monitoring water flow rate, total consumption, temperature, and battery level. Additionally, the device offers internal diagnostics such as leakage detection and empty pipe alarms.

Communication between the smart meter and the cloud infrastructure was facilitated using a RAK7289V2 LoRaWAN gateway, operating on WisGateOS. This gateway was configured to function within the AS923 frequency band, which is suitable for deployment in Malaysia. The gateway served as the intermediary node, transmitting sensor data from the smart water meter to The Things Network (TTN).

Laboratory testing was performed by simulating a controlled water flow environment using a submersible pump and PVC tubing to evaluate the meter's real-time data acquisition capabilities. The system was tested under various scenarios, including normal flow, dry pipe conditions, and leakage simulations. The gateway was connected to the internet and programmed to forward LoRaWAN packets to TTN. Device identifiers such as DevEUI, AppEUI, and AppKey were registered within the TTN console to ensure secure and authenticated communication.

On the cloud layer, data from TTN was decoded using custom payload formatters to extract relevant parameters including daily water usage, instantaneous flow rate, temperature, and leakage status. These decoded values were then integrated into a custom-built web and mobile

dashboard for real-time visualization. The dashboard also incorporates alert functionalities to notify users in cases of leakage or empty pipe conditions.

System validation involved several testing iterations to ensure reliability and accuracy. A LoRa field tester was used to evaluate signal strength (RSSI) and quality (SNR) in different locations, ensuring stable connectivity. Additionally, water consumption readings from the smart meter were cross verified against manual measurements to confirm the precision of the data collected. These methodological steps ensured that the system met the necessary functional requirements for implementation and further development in the subsequent phase of the Final Year Project.
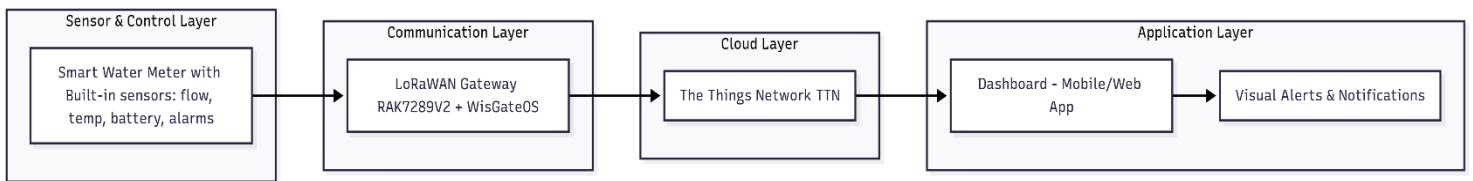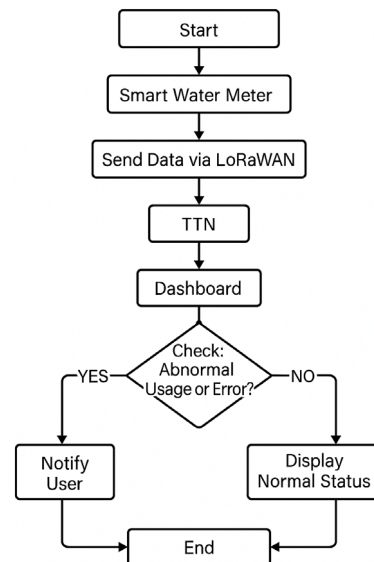

Figure 3.1: System architecture

Figure 3.2: Flowchart

4. PROJECT DELIVERABLES PLAN

FYP 1: Planning & Research

No	Task	Weeks											
		1	2	3	4	5	6	7	8	9	10	11	12
1	**Planning & Research**												
2	Define project title and concept	▇											
3	Identify key problems and propose solution	▇											
4	Discuss with supervisor and refine idea		▇										
5	Complete and submit Form 01A		▇	▇									
7	**Requirement Analysis**												
8	Conduct background research on smart water meter systems				▇								
9	Study IoT, LoRaWAN, TTN, and dashboard technologies				▇								
10	Identify functional and technical requirements					▇							
11	**System Design & Proposal Preparation**												
12	Draft and revise proposal						▇						
13	Design initial system architecture and data flow						▇						
14	Prepare proposal slides and documentation							▇	▇				
15	**Proposal Defense**												
16	Present proposal defence									▇			
17	Update feedback and document suggestions for improvement										▇		
18	**Report Writing**												
19	Begin drafting Interim Report									▇	▇		
20	Include problem statement, literature review, methodology										▇		
21	**Finalization & Submission**												
22	Finalize and format Interim Report											▇	▇
23	Submit complete FYP1 documentation											▇	▇

▇	Completed
▇	In Progress

FYP 2: System Development & Implementation

No	Task	Weeks												
		1	2	3	4	5	6	7	8	9	10	11	12	13
1	**Sprint 1: Initial Development & Integration**													
2	Set up LoRaWAN gateway (RAK7289CV2)	▇												
3	Register water meter on TTN		▇											
4	Begin create dashboard backend and user interface			▇	▇									
6	Discuss progress with supervisor				▇									
7	**Sprint 2: System Development & Data Handling**													
8	Finalize dashboard structure					▇								
9	Implement water flow visualization and leak alert logic					▇								
10	Improve dashboard layout						▇							
11	Continue supervisor consultations						▇							
12	**Sprint 3: System Implementation & Testing**													
13	Deploy full system to testbed (lab setting)							▇						
14	Evaluate LoRaWAN reliability and sensor accuracy								▇					
15	Refine alert rules and data sync								▇					
16	**Phase 4: Documentation & Validation**													
17	Conduct full system testing									▇				
18	Document performance results and screenshots									▇				
19	Submit dissertation draft										▇			
20	**Phase 5: VIVA & Final Submission**													
21	Prepare and practice VIVA slides										▇			
22	VIVA presentation											▇		
23	Submit hardcopy dissertaion												▇	▇

▇	Completed
▇	In Progress

5. CONCLUSION AND FUTURE WORK

In conclusion, the first phase of this project, FYP1 has focused on the research, analysis, and planning required to develop a smart water meter system using IoT and LoRaWAN technologies. This phase involved an in-depth study of related technologies, including ultrasonic smart water meters, LoRaWAN communication, and cloud-based data visualization platforms. Key components such as the smart water meter device, LoRaWAN gateway, and The Things Network (TTN) were identified and reviewed for their suitability in supporting the proposed system's objectives.

Through this planning process, the system architecture was designed, and a clear development methodology was established. The proposal outlines how real-time water usage data, leakage detection, and environmental monitoring will be achieved using the selected hardware and platforms.

For Future Work, the next phase is FYP2 will involve the actual development and implementation of the system. This includes setting up and configuring the hardware, integrating the smart water meter with the LoRaWAN gateway, establishing communication with TTN, and building a real-time monitoring dashboard. Field testing and validation will be conducted to evaluate the system's performance, reliability, and data accuracy. Additional improvements, such as advanced analytics or alert mechanisms, may also be considered based on the results.

6. REFERENCES

i.   Ahmed, T., & Li, X. (2020). Integration of IoT with ultrasonic water meters for real-time consumption tracking. International Journal of Smart Water, 6(2), 87–94. https://doi.org/10.1016/j.smartwater.2020.06.005

ii.   Aishwarya, M., & Vidya, R. (2020). Smart water metering system using IoT. International Journal of Scientific Research in Engineering and Management (IJSREM), 4(5), 1–5. https://www.ijsrem.com/download/smart-water-metering-system-using-iot/

iii. Akhbar, M. F., Nayan, N., Isa, M. M., Ismail, W., & Ali, A. (2021). IoT-based water monitoring system in smart city: A review. International Journal of Advanced Computer Science and Applications (IJACSA), 12(1), 426–431. https://doi.org/10.14569/IJACSA.2021.0120152

iv.   Alvarez, M., & Kim, H. (2022). Cost-benefit analysis of smart water infrastructure in urban settings: A case study approach. Sustainable Cities and Society, 79, 103675. https://doi.org/10.1016/j.scs.2022.103675

v.   Apure. (2022, May 30). Ultrasonic flow meter working principle - Apure. https://apureinstrument.com/blogs/ultrasonic-flow-meter-working-principle/

vi.   Chong, S. Y., Lim, Y. H., & Teo, K. M. (2021). Comparative study of communication protocols for smart metering applications. IEEE Internet of Things Journal, 8(3), 1234–1242. https://doi.org/10.1109/JIOT.2020.3034821

vii. Fu, X., Wang, Y., Belkacem, A. N., Cao, Y., Cheng, H., Zhao, X., Chen, S., & Chen, C. (2022). Interictal spike and loss of hippocampal theta rhythm recorded by deep brain electrodes during epileptogenesis. Sensors, 22(3), 1114. https://doi.org/10.3390/s22031114

viii. Gungor, V. C., Sahin, D., Kocak, T., Ergut, S., Buccella, C., Cecati, C., & Hancke, G. P. (2013). Smart grid technologies: Communication technologies and standards. IEEE Transactions on Industrial Informatics, 7(4), 529–539. https://doi.org/10.1109/TII.2011.2166794

ix.   Hassan, R., Zulkifli, M., & Baharuddin, A. S. (2021). Addressing signal interference in LoRa-based smart utility systems in Malaysia. Journal of Telecommunication, Electronic and Computer Engineering, 13(1), 95–101.

x.   Kerkez, B., Gruden, C., Lewis, M., & Montestruque, L. (2016). Smart water systems: Bridging the gap between science and implementation. Environmental Science & Technology, 50(13), 6843–6852. https://doi.org/10.1021/acs.est.5b05870

xi.   Khawaja, T., Bachani, B., & Yousaf, M. (2020). Challenges and opportunities in IoT-based water management systems. Journal of IoT Engineering, 4(2), 112–125. https://doi.org/10.3390/w14223621

xii.   Kumar, A., & Tan, S. H. (2020). Review of smart water meter technologies and their comparative performance. Journal of Water Resources and Protection, 12(7), 613–628. https://doi.org/10.4236/jwarp.2020.127038

xiii.   LoRa Alliance. (2024, June 17). About LoRaWAN® – LoRa Alliance®. https://lora-alliance.org/about-lorawan/

xiv.   LoRaWAN®. (n.d.). The Things Network. https://www.thethingsnetwork.org/docs/lorawan/

xv.   PUB Singapore. (2021). Smart water metering for a smart nation. Public Utilities Board Singapore. https://www.pub.gov.sg/Documents/smartwatermetering.pdf

xvi.   RAKwireless. (2024). RAK7289 WisGate Edge Pro Documentation. https://docs.rakwireless.com/Product-Categories/LPWAN-Gateways/RAK7289/

xvii.   Semtech. (2021). LoRa® devices and the LoRaWAN® protocol: Enabling smart water metering. Semtech Corporation. https://www.semtech.com/uploads/documents/LoRa-Smart-Water-Metering-Use-Case.pdf

xviii. Sharma, N., & Patel, D. (2018). Smart water meter system using IoT. International Journal of Advanced Research in Computer Science, 9(4), 555–558. https://doi.org/10.26483/ijarcs.v9i4.6272

xix.   Smith, J., Dupont, L., & Moreau, P. (2021). Deployment of smart water meters using LoRaWAN: The Lyon case study. International Journal of Smart Infrastructure, 5(1), 22–30. https://doi.org/10.1016/j.smar.2021.01.005

xx.   Welcome Message from the General Co-Chairs. (2018, June 1). IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/document/8419258

xxi. Yusof, N. A., & Nordin, M. A. (2020). IoT-based smart utility metering in Malaysia: Opportunities and challenges. Malaysian Journal of Science and Technology, 3(2), 101–108. https://doi.org/10.22452/mjst.vol3no2.4

xxii. Zainuddin, N. H., Zakaria, N., Mohd Razali, M. N., & Jaafar, A. (2021). Development of smart water meter based on LoRa technology for water management system. Indonesian Journal of Electrical Engineering and Computer Science (IJEECS), 21(2), 891–898. https://doi.org/10.11591/ijeecs.v21.i2.pp891-898

xxiii. Zhou, W., Li, T., & Wang, H. (2019). Design and implementation of LoRa-based smart water meter system. Sensors, 19(20), 4431. https://doi.org/10.3390/s19204431