Automation and Industrial Informatics
Faculty of Automatic Control and Computers
National University of Science and Technology
POLITEHNICA Bucharest

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BACHELOR'S THESIS

Integrating Tuya Smart Devices with the ThingsBoard IoT Platform

Advisor
Prof. dr. ing. Radu-Nicolae Pietraru

Author
Alexandru-Ionuț Bostan

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1 Introduction

The prevalence of smart devices in our homes is on the rise, thanks to the convenience and utility that they offer. One crucial aspect that makes these devices so easy to use is the fact that they are connected to the Internet. This interconnectivity is useful, as it allows different devices to communicate together, or send the data that they generate to a central location.

Typically, smart devices are designed to collect environmental or user data through embedded sensors and transmit this information over wireless protocols such as Wi-Fi, Zigbee, or Bluetooth [1]. These devices often interact with cloud services that make user interaction really easy, through the use of mobile applications and websites. However, the IoT landscape is highly fragmented, with various manufacturers choosing to adopt proprietary platforms rather than open-source ones. This fragmentation hurts interoperability and is detrimental to a cohesive device management system.

Under these circumstances, the ability to integrate devices from different ecosystems becomes a concern, especially for developers and organizations seeking to develop custom IoT solutions. Building a bridge between proprietary smart devices and open-source platforms is a very challenging target.

1.1 Scope

This thesis aims to investigate some methods that can be used to integrate Tuya Smart devices with the ThingsBoard platform. These methods have different implementations, some harder to execute than others. In order to do this successfully, research is required on the architecture of these smart devices. After all, this is the embedded systems field, which means no two different devices have the exact same solution.

ThingsBoard is an open-source IoT platform designed for data collection, device management, and visualization through protocols such as MQTT, CoAP, and HTTP [2].

The integration of Tuya smart devices with ThingsBoard is non-trivial, as these devices are typically designed to operate within a proprietary cloud-based system. Achieving such integration requires reverse-engineering device communication protocols, or employing intermediary services or firmware modifications. This document is mainly focused on uploading custom firmware by physically connecting to the device or Over-The-Air (OTA).

A fundamental part of this work involves analyzing the architecture of Tuya smart devices, which vary significantly depending on the manufacturer and intended application. Given that these devices function as embedded systems, it is expected that integration strategies are unique to each device.

1.2 Description

This thesis comprises a technical investigation into the communication mechanisms and system architectures of both Tuya devices and the ThingsBoard platform. The aim is to establish a reliable integration path, enabling the ingestion and visualization of telemetry data from Tuya devices within the ThingsBoard environment. The study includes the following key components:

- An overview of the Tuya ecosystem, including device provisioning, cloud services, and developer tools.
- A technical analysis of the ThingsBoard platform, focusing on its extensibility, supported protocols, and data processing model.
- An identification and evaluation of potential integration strategies, including the use of APIs, custom gateways, and firmware-based solutions.
- A practical implementation of one or more integration methods, including system setup, configuration, and experimental validation.
- An assessment of the performance, reliability, and security of the implemented integration pipeline.

The results of this study aim to inform future development efforts in heterogeneous IoT environments, offering insights into how proprietary systems may be incorporated into open-source frameworks for enhanced interoperability and control.

1.3 Thesis Structure

I have organized this document into five different chapters:

- **Chapter 1: Introduction**: Introduces the topic, outlines the motivation, objectives, and structure of the thesis.
- **Chapter 2: Background**: Presents a review of existing literature and relevant technologies, with a focus on Tuya and ThingsBoard systems.
- **Chapter 3: Benefits**: Describes the internal architectures of Tuya smart devices and the ThingsBoard platform, highlighting integration challenges.
- **Chapter 4: Methodology**: Details the research approach, experimental setup, and tools employed in the study.

- **Chapter 5: Conclusions**: Summarizes key findings and suggests directions for future research and development.

2 Background

This chapter introduces the foundational concepts and technologies relevant to this thesis. The first section contains an overview of the Internet of Things (IoT) Ecosystem, highlighting its structure, components, and significance in modern technological development. The second section focuses on Tuya Smart, an important player in the IoT field. Together, these sections aim to help understand the integration strategies that will be discussed in the next chapter.

2.1 Internet of Things (IoT) Ecosystem

The Internet of Things (IoT) represents a network of interconnected physical objects, such as devices, vehicles or appliances. These objects are equipped with sensors, software, and network capabilities that enable them to gather and exchange data [3]. This concept has led to the surfacing of complex applications, from Home Automation to Agriculture and Health Care [4].

The core idea behind the IoT ecosystem is to create a seamless network of devices that can operate autonomously or semi-autonomously, interact with each other, and provide valuable insights through continuous data generation and analysis. These devices are typically embedded with sensors and actuators, which allow them to monitor environmental conditions (such as temperature, humidity, motion, or light levels) and respond to inputs by performing physical actions.

Communication within the IoT ecosystem is enabled by various wireless and wired technologies, including but not limited to Wi-Fi, Bluetooth, Zigbee, LoRaWAN, and 5G. These protocols vary in range, bandwidth, power consumption, and reliability, making them suitable for different use cases and deployment environments. For instance, Zigbee is often used for low-power smart home devices, while 5G is better suited for high-speed, latency-sensitive industrial applications.

Data generated by IoT devices is processed through a combination of edge and cloud computing. Edge computing involves handling data locally at or near the source of data generation, thereby reducing latency and improving responsiveness. Cloud computing, on the other hand, enables scalable storage, advanced analytics, and global accessibility, making it ideal for managing large volumes of data across distributed systems.

Security, privacy, and interoperability are critical challenges in the IoT domain. As more devices become connected, ensuring secure communication, safeguarding user data, and facilitating integration across products and platforms are essential for the reliability and scalability of IoT deployments. Addressing these challenges requires not only technological innovation but also standardization efforts and robust governance models.

Overall, the IoT ecosystem continues to expand rapidly, driven by advances in hardware miniaturization, energy-efficient networking, and artificial intelligence. Its applications are reshaping industries by enabling predictive maintenance, real-time monitoring, energy optimization, and enhanced user experiences.

2.2 Tuya Smart

Tuya Smart is a leading global IoT development platform that provides a full-stack solution for smart product development, including hardware design, cloud services, and mobile applications. Since its inception in 2014, Tuya has played a pivotal role in democratizing access to IoT technology by offering manufacturers, brands, and developers the tools needed to create, deploy, and manage smart devices with minimal development overhead.

The company's platform-as-a-service (PaaS) model supports a wide array of smart device categories, such as lighting, climate control, security systems, and home appliances. What sets Tuya apart from many other IoT solution providers is its comprehensive and modular approach. Developers can use Tuya's hardware development kits and reference designs to rapidly prototype and manufacture devices. Simultaneously, Tuya's cloud infrastructure provides the backend needed for secure device connectivity, real-time data processing, and firmware updates.

A key feature of Tuya's platform is its emphasis on cross-brand and cross-device interoperability. Devices that are developed using Tuya's technology adhere to a common communication standard and are compatible with each other, regardless of the manufacturer. This approach simplifies the smart home experience for consumers, allowing different devices to work in harmony within a single ecosystem. The Tuya Smart app, which serves as the central user interface, enables users to configure, control, and automate their devices through a unified platform.

Tuya also integrates with major third-party ecosystems such as Amazon Alexa, Google Assistant, and Apple HomeKit, extending the reach and compatibility of Tuya-based devices. This interoperability allows end users to control Tuya devices via voice commands or integrate them into broader smart home routines.

From a business perspective, Tuya Smart operates in a rapidly growing market characterized by increasing demand for smart home solutions and industrial IoT deployments. The company supports a global network of partners and has made significant inroads into both consumer and commercial sectors. In 2021, Tuya was listed on the New York Stock Exchange (NYSE), further cementing its position as a major player in the global IoT landscape.

In addition to consumer-facing products, Tuya has also developed solutions for industry

and enterprise, including energy management, smart lighting in commercial buildings, and municipal infrastructure for smart cities. These offerings reflect the platform's scalability and adaptability to different use cases.

Tuya's open, flexible, and developer-friendly environment has made it a preferred choice for companies seeking to enter the IoT market without building everything from scratch. By abstracting away much of the complexity traditionally associated with IoT development, Tuya accelerates time-to-market and lowers barriers to innovation.

3 Benefits

This chapter outlines the primary benefits associated with integrating commercial smart devices with the ThingsBoard platform. These advantages are relevant from both technical and user-centric perspectives, particularly for developers, system integrators, and organizations seeking to improve the flexibility, longevity, and control of their IoT deployments.

3.1 Repurposing Devices

One of the most compelling motivations for integrating smart devices with an open-source IoT platform such as ThingsBoard is the ability to repurpose existing hardware. Commercial smart devices, including those manufactured under the Tuya ecosystem, are often tied to proprietary applications and cloud services. This dependence may limit their utility in custom or enterprise-grade IoT projects, where greater flexibility is required.

By enabling communication between Tuya-based devices and ThingsBoard, it becomes possible to decouple the hardware from its original ecosystem. This decoupling allows the devices to serve new functions beyond their initial consumer-oriented use cases. For instance, a smart temperature sensor initially used in a residential environment can be integrated into an industrial monitoring system, or a Wi-Fi-enabled smart plug can be incorporated into an energy optimization platform.

Repurposing not only reduces the need for additional hardware investment but also contributes to sustainability by extending the useful function of existing devices. This aligns with broader trends in circular economy practices and resource efficiency within the IoT sector.

3.2 Extending Product Lifespan

The integration of commercial smart devices with open-source platforms can significantly extend their operational lifespan. Many proprietary IoT ecosystems have limited long-term support, and devices may become obsolete when cloud services are discontinued or mobile applications are deprecated. This can lead to premature device obsolescence, even when the hardware remains fully functional.

By migrating device control and data management to a platform like ThingsBoard, users can maintain full operational control of their devices regardless of vendor support. This is particularly beneficial in scenarios where long-term device availability is critical, such as industrial deployments, research installations, or rural infrastructure projects.

In addition, ThingsBoard's modular and scalable architecture allows for continuous system

upgrades without affecting device compatibility, thereby future-proofing the IoT ecosystem and protecting investments in hardware over time.

3.3 Privacy

Another substantial benefit of integrating smart devices with ThingsBoard is the increased control over user data and privacy. Many commercial IoT solutions rely heavily on cloud infrastructure owned and operated by third-party vendors. As a result, users often have limited visibility into how their data is stored, processed, or shared. This raises concerns related to data privacy, security, and regulatory compliance, particularly in sensitive domains such as healthcare, home security, and industrial operations.

In contrast, ThingsBoard can be deployed on-premises or in a self-hosted cloud environment, giving users full control over data flow and storage. This enables compliance with data protection regulations such as the General Data Protection Regulation (GDPR) and allows for the implementation of organization-specific security policies.

Moreover, data ownership remains with the user or the organization operating the ThingsBoard instance. This autonomy enhances transparency and trust, especially in applications where data sensitivity is a key consideration. The platform also allows for fine-grained access control and audit logging, further strengthening the security posture of the integrated system.

4 Methodology

methodology

4.1 Custom firmware

moretxt

4.2 Bluetooth Low Energy (BLE)

moretxt

4.3 Wi-Fi

moretxt

4.3.1 MQTT

mqtt

4.4 ThingsBoard API

moretxt

5 Conclusions

conclusions

6 References

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7 Appendices

appendices