IoT Solution for HVAC Systems

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What is IoT?

Definition

- Vermesan et al. [1] defines IoT as the interaction between the physical and virtual world, whereby this interaction takes place through sensors and actuators.
- Pea-Lpez et al. [16] defines IoT as a paradigm in which computing, and networking capabilities are embedded into kind any physical object.

[1] Pallavi Sethi and Smruti R. Sarangi. Internet of Things: Architectures, Protocols, and Applications. Journal of Electrical and Computer Engineering, 2017, 2017. ISSN 20900155.doi: 10.1155/2017/9324035.
[16] ITU. ITU Internet Reports. The Internet of Things. International Telecommunication Union, page 212, 2005. ISSN 1556-5068.

IoT for HVAC systems

- Heating, Ventilation and Air Conditioning is the technology of indoor and vehicular environmental comfort.
- As the ecosystem of home automation kept growing, there was a need for centralized control and automation of its functions which led to the advent of Building Management Systems (BMS).

Problem Statement

While the user wants more comfort, the trade-off at the HVAC manufacturer’s end is one of considering the IoT solution that benefits them the most.

Summary:

- How to provision an optimal IoT infrastructure for the current functional HVAC modules?
- How can the existing products be IoT-enabled at the time of manufacturing?

Research Questions

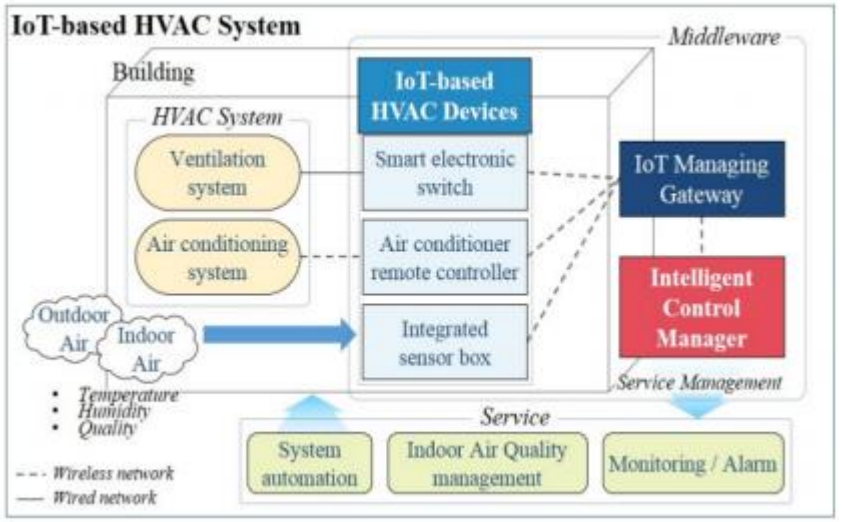
- How can HVAC manufacturers achieve IoT-connectivity between its units?
- What are the challenges faced when proposing an IoT solution for HVAC system?
- Are there suitable countermeasures that can be proposed?

Methodology

- Review of General IoT architecture and taxonomy.
- Review of IoT for HVAC research work
- Definition of project scope and deliverables
- Supervision
- Collaboration with JPI
- Presentation of each case scenario

Related Work: Review of IoT for HVAC

- Myeong-in Choi et al [4] proposes a design and implementation of an IoT-enabled HVAC system(I-HVACS)..



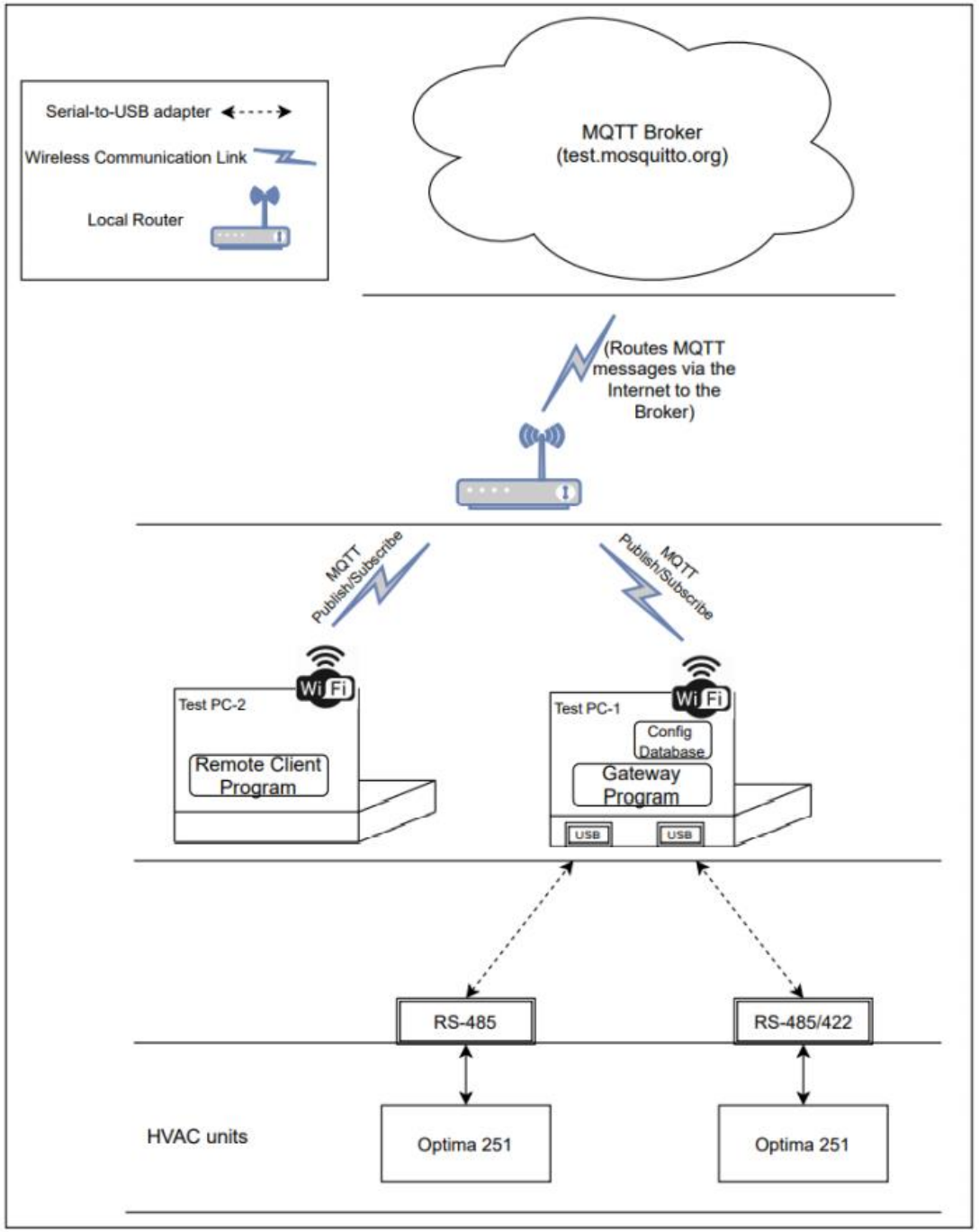
[4] Myeong In Choi, Keonhee Cho, Jun Yeon Hwang, Lee Won Park, Kyu Hee Jang, Sunghwan Park, and Sehyun Park. Design and implementation of IoT-based HVAC system for future zero energy building. 2017 IEEE International Conference on Pervasive Computing and Communications Workshops, PerCom Workshops 2017, pages 605–610, 2017. doi: 10.1109/ PERCOMW.2017.7917631.

Research Gap

- A few covered an architectural assessment of IoT Solutions for HVAC systems from HVAC modules to the Cloud.
- Also, none of the research reviewed elaborates into the challenges encountered in the implementation of an IoT solution for existing HVAC systems.

First Case:
Optima 251 - PC – MQTT Broker
(Proof-of-Concept)

Architecture



Selection, Procedure and Characterisation

- Optima-251

Selection, Procedure and Characterisation

- IoT Protocol: MQTT

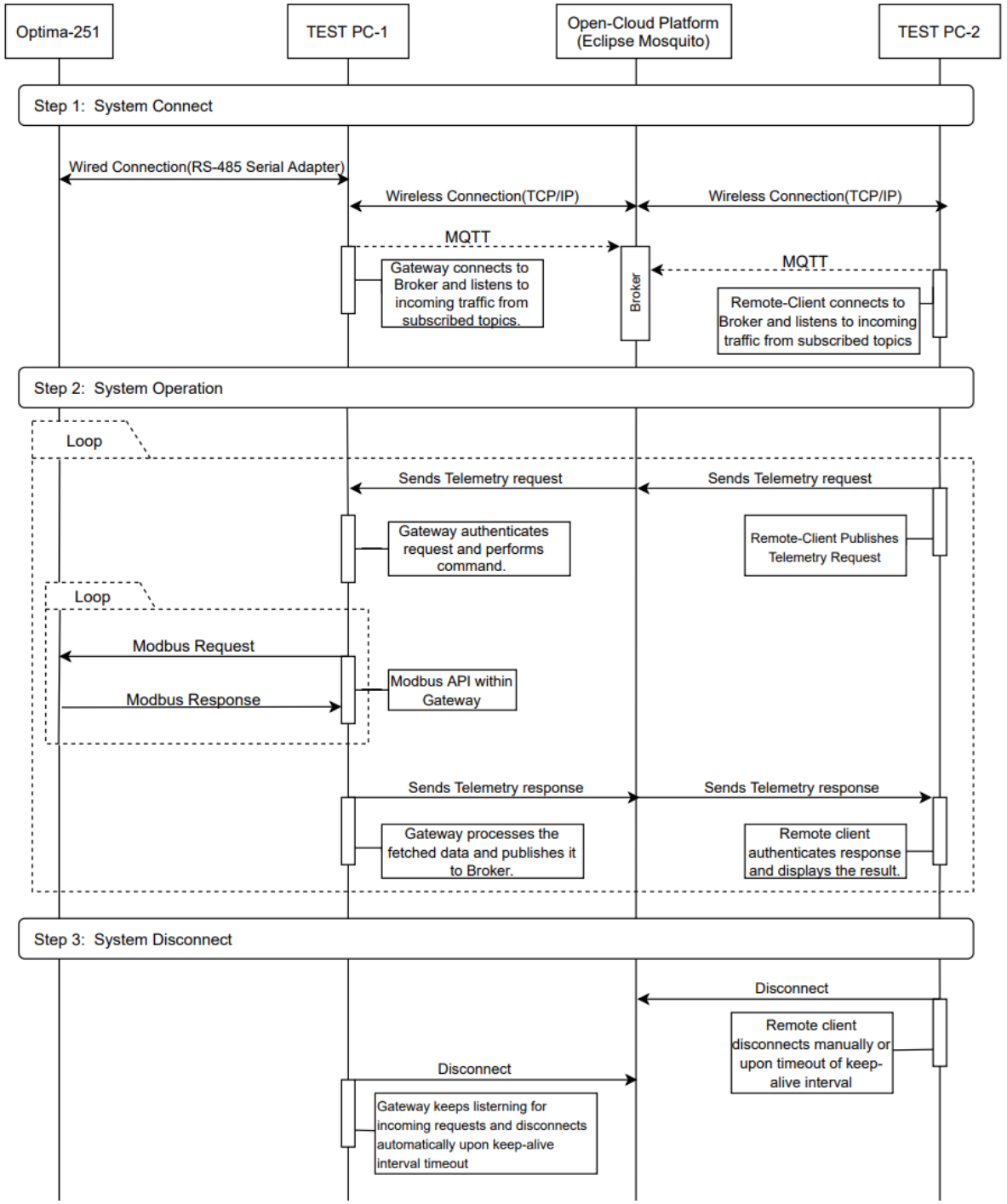
> *"MQTT is a Client Server publish/subscribe messaging transport protocol. It is lightweight, open, simple, and designed so as to be easy to implement. These characteristics make it ideal for use in many situations, including constrained environments such as for communication in Machine to Machine (M2M) and Internet of Things (IoT) contexts where a small code footprint is required and/or network bandwidth is at a premium."*
>
> **Citation from the official MQTT 3.1.1 specification**

Selection, Procedure and Characterisation

- Cloud Platform

  A cloud platform can be defined as the operating system and hardware of a server in an internet-based data center. Thus, cloud platforms provide compute services such as servers, database, storage, analytics networking and software.

  The Cloud platform used here is Eclipse Mosquitto and it hosts the MQTT broker/server, test.mosquitto.org which is used for this first part of our IoT scenario.



Implementation: Sequence Diagram

Demonstration

Method of Analysis

- Errors and Exceptions in ModBUS-RTU

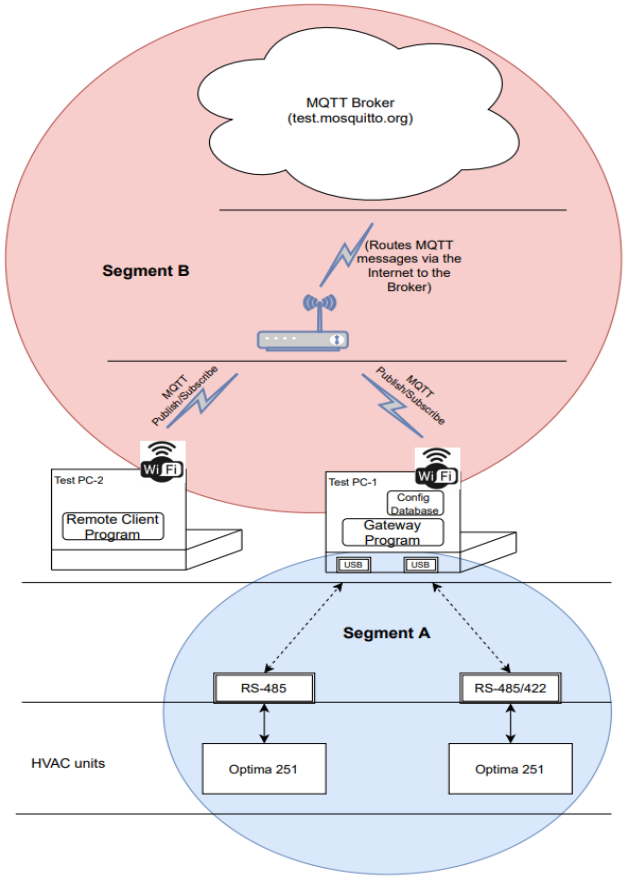
  According to Urrea et al. [44, 45] and Belliari et al. [46], Modbus-RTU errors and exceptions can be addressed better when categorised. They then went ahead to categorise these errors and exceptions as follows:

  - Connection errors
  - Modbus exceptions
  - Parameter exceptions

Method of Analysis

- Security

  From a security perspective, the proposed architecture can be subdivided into two Security segments

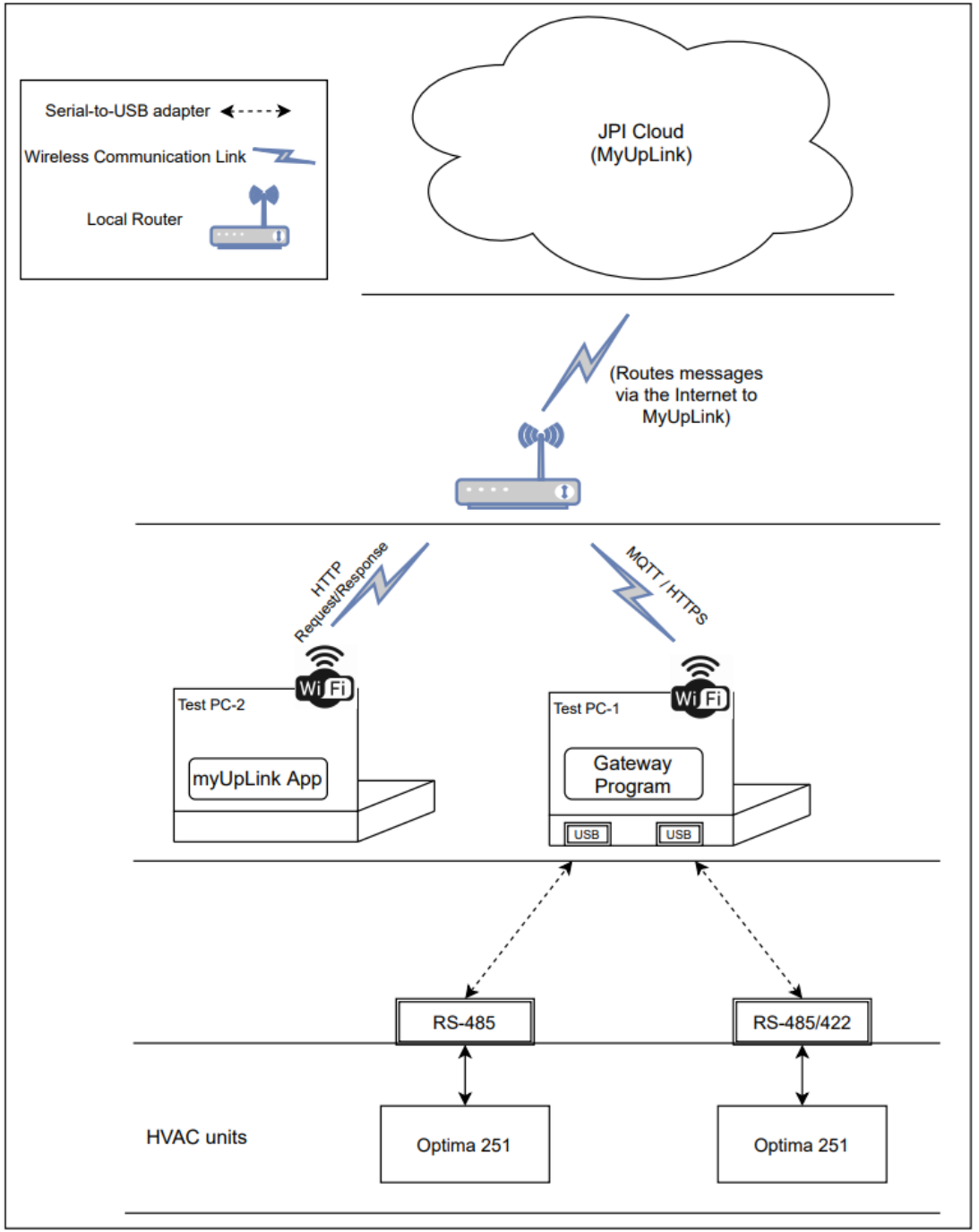


Limitations

- Lack of cloud infrastructure for data storage and analytics
- Local storage of sensitive data which can be manipulated upon
- Unsecured access to Access List Database

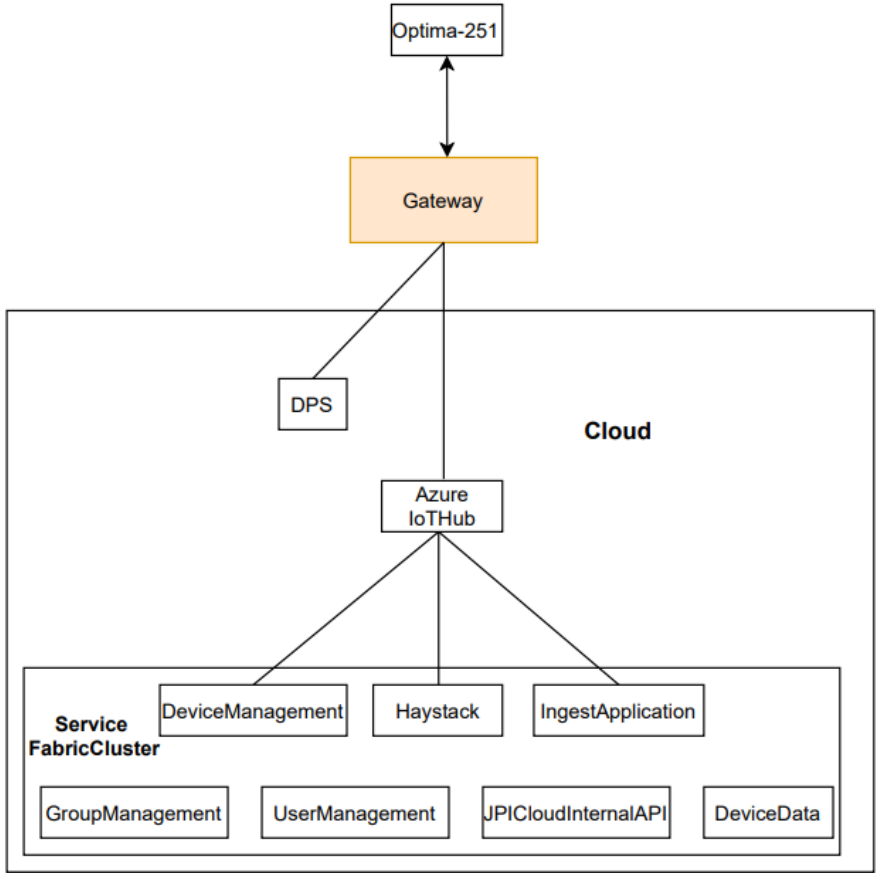
Second Case:
Optima 251 - PC - JPI Cloud

Architecture



Selection, Procedure and Characterisation

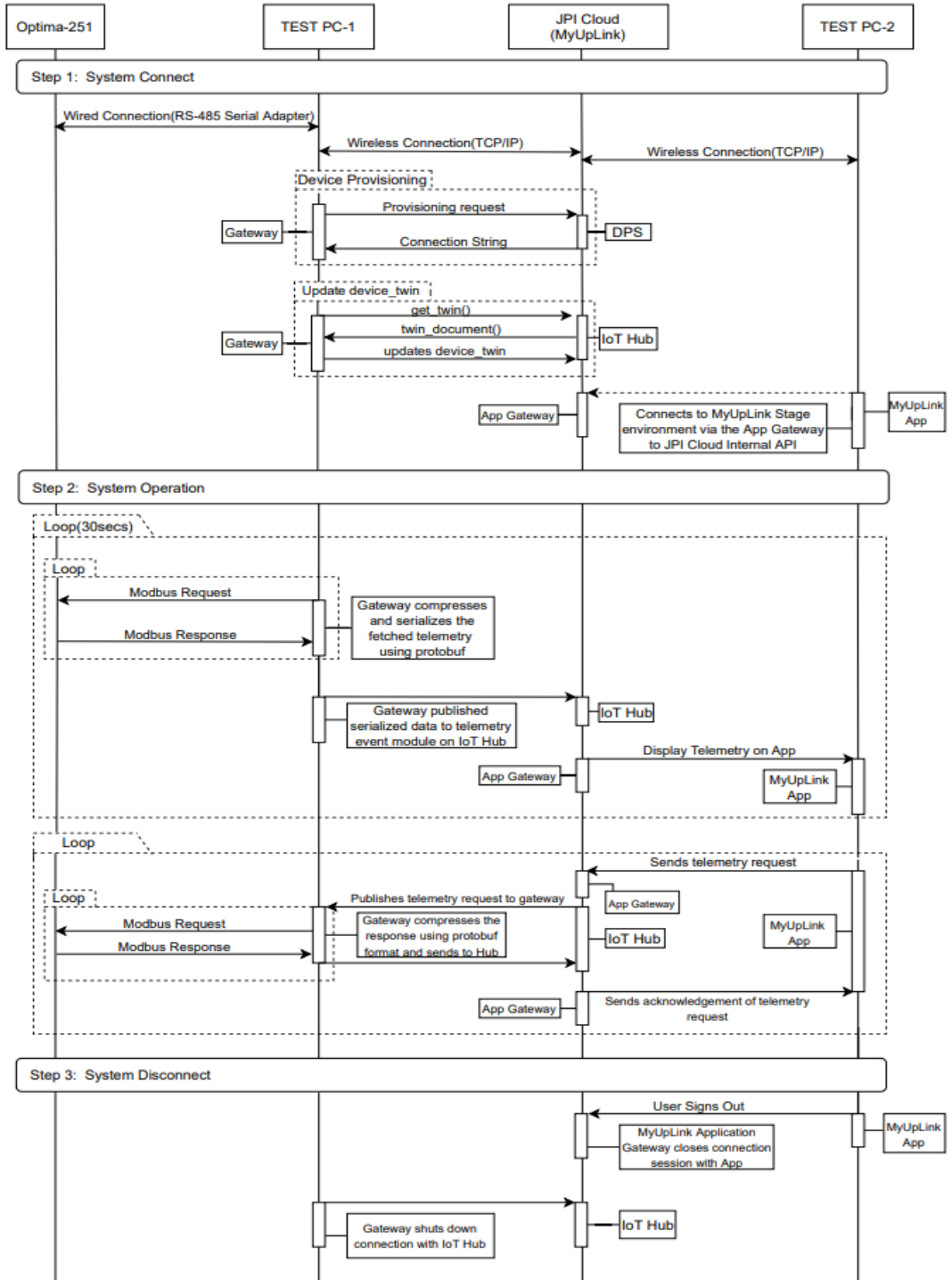
- JPI Cloud (MyUpLink)
  - JPI Cloud Connection



Selection, Procedure and Characterisation

- JPI Cloud (MyUpLink)
  - Project Haystack

```
id:@297986329025
dis:"Optima-251"
equip
accessLevel:"All"
hvac
--
id:@100
dis:"Main Menu"
accessLevel:"All"
menu
menuRoot
--
id:@101
dis:"Fan Speed"
menuName:"1"
accessLevel:"All"
menu
menuRef:@100
menuPrio:1
--
id:@1011
equipRef:@297986329025
menuRef:@101
dis:"Fan Mode"
defaultVal:0
minVal:0
maxVal:4
enumVal:0,1,2,3,4
enumText:"Standby,FanSpeed-1,FanSpeed-2,FanSpeed-3,FanSpeed-4"
modbusHoldingReg:100
modbusRegSize:1
writable
accessLevel:"All"
tile:"fanMode"
```



Implementation: Sequence Diagram

Demonstration

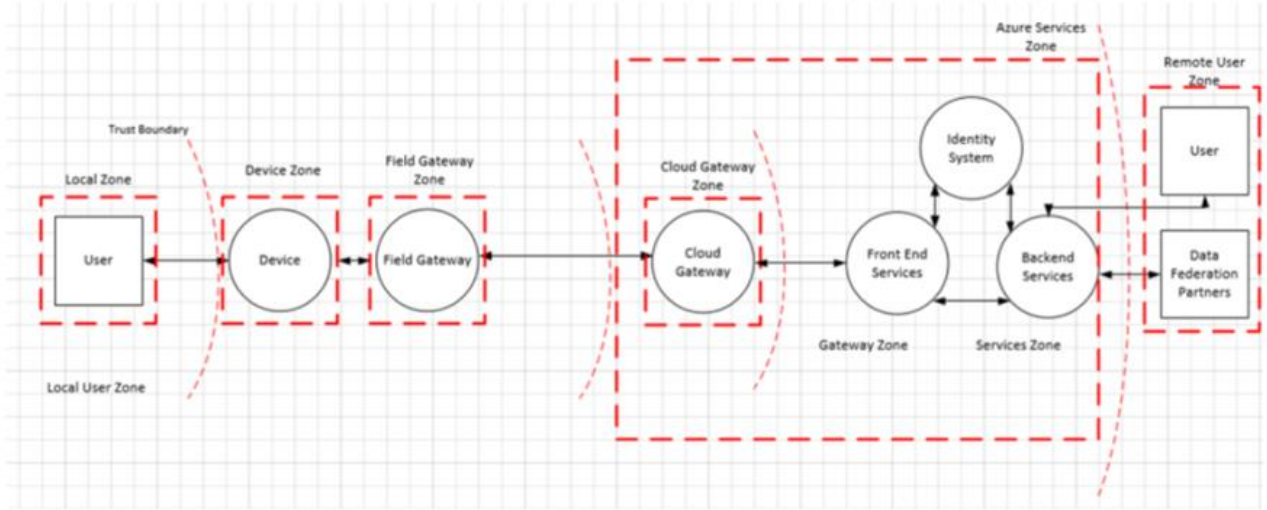
Method of Analysis

- Security

Joing Shi et al.[52], present an integration of Azure Sphere and Azure Cloud Services for IoT solutions, thus discuss extensively the analysis that will be presented hereon.

Yu Lui et al.[53] present a data-centric IoT framework based on Azure Cloud where security matters of Azure IoT are mitigated using solutions provided by Microsoft Azure modules from a data-centric perspective.

Mahmoud Ammar et al.[54], present a survey on the Security of IoT Frameworks, therefore comparing the analysis presented here-on with what other IoT Frameworks have to offer in terms of Security.



Discussions

- First Case
  - Conceptualization and Presentation

The first case acts as a baseline for conceptualization of the solution.

  - Assumptions

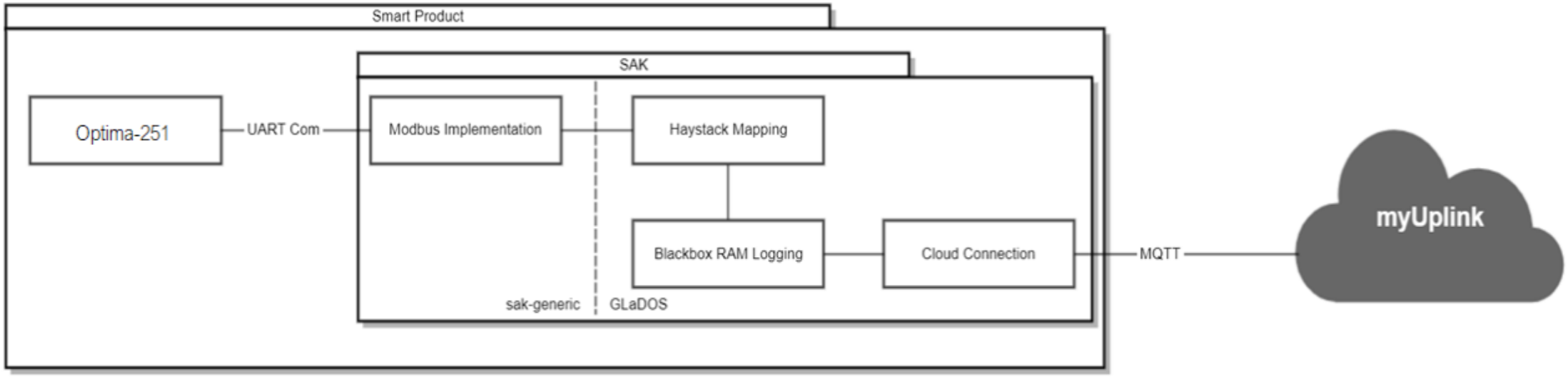
An assumption made in the method of analysis with regards to the implementation of a Message ID as a security measure for the MQTT transactions is that the TCP overheads generated by TLS end-to-end encryption causes more delay in communication than the ID tag implementation.

Discussions

- Second Case

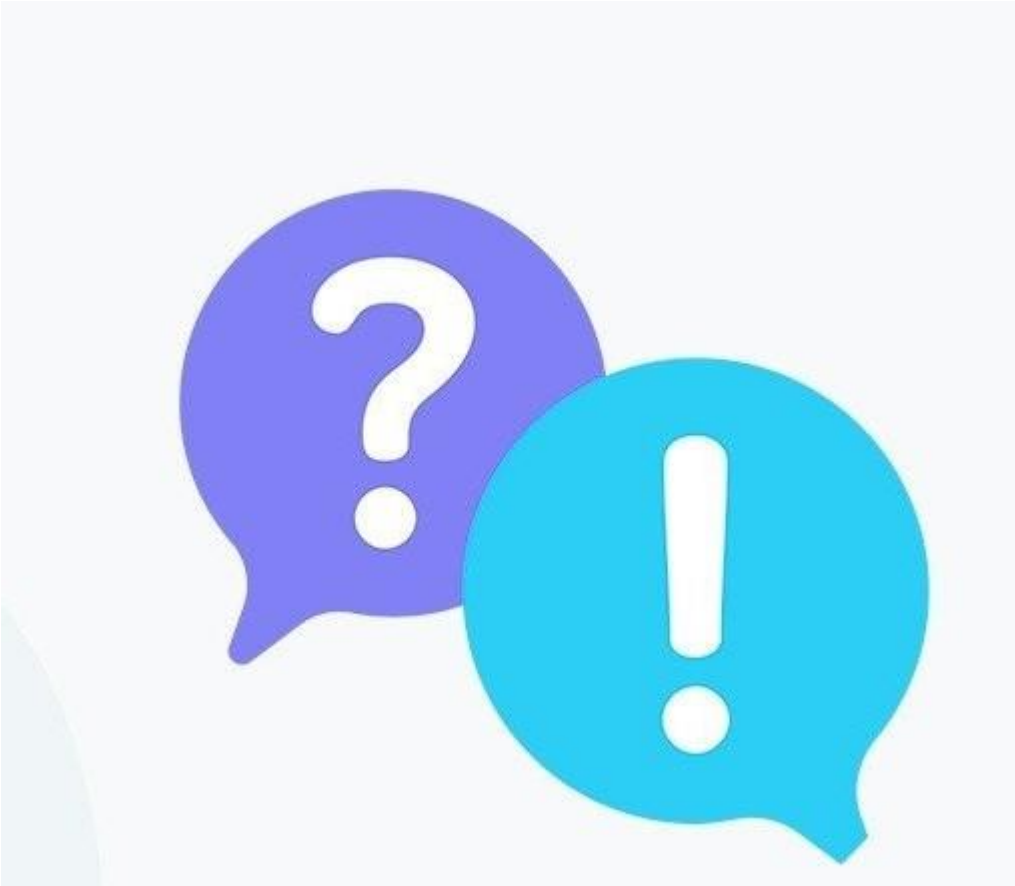
  The second case builds on the conceptualization blueprint of the first case, with an in-depth analysis and elaboration of the IoT solution towards the Cloud platform used. Therefore, the greater part of the characterization is focused on the Cloud platform used.

Towards an Operational Solution: Optima 251 - SAK Module - MyUpLink


Smart Product
SAK
Optima-251
UART Com
Modbus Implementation
Haystack Mapping
Blackbox RAM Logging
Cloud Connection
MQTT
myUplink
sak-generic
GLaDOS

Conclusion

- Recapping Research Questions
- Contributions
- Further Work



Q & A Session