Delivery no.: D2.7d
Report on system stability issues, solutions and future recommendations

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Preface

EnergyLab Nordhavn – New Urban Energy Infrastructures is an exciting project which will continue until the year of 2019. The project will use Copenhagen's Nordhavn as a full-scale smart city energy lab, which main purpose is to do research and to develop and demonstrate future energy solutions of renewable energy.
The goal is to identify the most cost-effective smart energy system, which can contribute to the major climate challenges the world are facing.

Budget: The project has a total budget of DKK 143 m (€ 19 m), of this DKK84 m (€ 11 m) funded in two rounds by the Danish Energy Technology Development and Demonstration Programme (EUDP).

Forord

EnergyLab Nordhavn er et spændende projekt der løber til og med 2019. Projektet vil foregå i Københavns Nordhavn, og vil fungere som et fuldskala storbylaboratorium, der skal undersøge, udvikle og demonstrerer løsninger for fremtidens energisystem.
Målet er at finde fremtidens mest omkostningseffektive energisystem, der desuden kan bidrage til en løsning på de store klimaudfordringer verden står overfor nu og i fremtiden.

Budget: Projektets totale budget er DKK 143 mio. (EUR 19 mio.), hvoraf DKK 84 mio. (EUR 11 mio.) er blevet finansieret af Energiteknologisk Udviklings- og Demonstrationsprogram, EUDP.

Disclaimer

[Add disclaimer, if applicable]

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Table of Contents

Resumé

The scope of this document is twofold. The initial part is about the experience from the day-to-day operation of the Data Management System (DMS) solution. The later part of the document includes some reflections about the development of the Data Management System (DMS), the chosen solution and some recommendation for the continued development.

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1. Introduction

The scope of this document is twofold. The initial part is about the experience from the day to day operation of the Data Management System (DMS) solution. The later part of the document includes some reflections about the development of the Data Management System (DMS), the chosen solution and some recommendation for the continued development.

It is assumed that the reader is familiar with the use and implementation of the Data Management System (DMS), as described in other deliverables from WP2.

2. Stability and monitoring issues

The day-to-day operation and experienced stability and monitoring issues are addressed in two other deliveries:

- D2.7a: MTBF or similar system stability analysis report
- D2.7b: System and data validation and warning tool manual

To summarize from these deliveries the Data Management System (DMS) developed in the EnergyLab Nordhavn project is characterized by:

- Stability of the Data Management System (DMS) is acceptable.
- The “weak link” in the Data Management System (DMS) is the local deployed equipment which is vulnerable and when it fails requires manual operation to correct – this applies to the deployed meters and routers. The embedded sensors are reliable.
- There is a need for data validation of received data in order to identify misbehaving sensors, this must be implemented.
- Data communication link supervision is acceptable.
- The data backup solution is working but is not sufficient because measurement data is vulnerable for disasters at the datacentre housing the Data Management System (DMS), therefore backup must be improved.

The Data Management System (DMS) has been in a development phase and has gradually been taken into operation while still being developed. This has worked well for the EnergyLab Nordhavn project but as the plan for the Data Management System (DMS) is that it shall serve as a Data Management System (DMS) for many project and store data from many energy data sources, this is not an applicable set-up. Therefore, it must be considered to separate the development and operation of the Data Management System

(DMS) with defined “Service Level Agreements” (SLA) and a roadmap for the development of the Data Management System (DMS).

3. Recommendations

In this chapter, a number of recommendations are discussed. Some of the recommendations are “lessons learned”, i.e. knowledge gained through the development and operation of the Data Management System (DMS). Other recommendations are reflections over the development process.

3.1 Lessons learned

In this chapter, the learnings from the day-to-day use and development of the Data Management System (DMS) are described and discussed.

3.1.1 A need for an improved user interface

The most urgent need for the user of the Data Management System (DMS) is to have an improved user interface to the Data Management System (DMS), either using the GUI or the API. These are some of the requests that have been addressed in the user feedback:

- Better search options for data series
  There is a need for being able to search in meta data for a dataset. Today it is only possible to search in the dataset name making the search process complicated.
- Search for data using multiple “key words” like “Sundmolen” AND “temperature”
- Browsing (graphically) data in order to identify interesting data before making an export of these data
- It must be possible to search for a property ID
- It must be possible to search for a token
- Request data for a complete data set using the API without having to specify each property ID

Further improvements that are required but so far not has been requested is to query the Data Management System (DMS) in the same way as it is possible in SQL. The Cassandra database system has query language CQL (Cassandra Query Language) but Cassandra is not a relational database and therefore all the statements and options that are possible in SQL (e.g. “join”) is not possible in CQL. However improved search and query options are possible by combining CQL and the Spark and this must utilized.

Requirements for the user interface are address in the document “D2.6a Specification of data collection system” and these requirements should be input to a more structured requirement collection and formulation process.

3.1.2 Secure a data validation process

Data validation is addressed in the document: “D2.7b System and data validation and warning tool manual”. As described in the document, there is currently no data validation implemented in the Data Management System (DMS). This is a critical issue and it must be implemented.

3.1.3 Secure in-house development competence

The development of the Data Management System (DMS) has been contracted to an IT development company. Initially this can secure more development resources to project and therefore a faster development. However in the long run, it will be beneficial to have inhouse development competence. This will make it possible to make modification and improvements of the Data Management System (DMS) faster and most likely also at a lower cost.

3.1.4 Plan for operation and maintenance

A plan for the daily operation and maintenance (O&M) of the Data Management System (DMS) is needed. Today the O&M is informally shared (i.e. no formal agreement) between the developing company that does all the supervision and alarm handling and DTU-PowerLab that handle the end user support request.

A formal agreement and plan for the O&M is required. The agreement and plan shall settle how the O&M related tasks are divided between the IT development company and DTU-PowerLab. The agreement shall be formed as a Service Level Agreement (SLA) between DTU PowerLab and the IT development company. Further, a SLA shall be formulated stating what the end user can expect from DTU PowerLab.

3.2 Reflections

This chapter encompasses some of the reflections made during the late part of the development process of the Data Management System (DMS) and made by the author of this report, who has not been part of the project since the very beginning.

3.2.1 A more formal development process

The EnergyLab Nordhavn was launched in the spring 2015, however first in the spring 2018 the Data Management System (DMS) was launched. There are properly many (good) reasons for this long development process. A faster development of a first application and a more strict documentation process would have been to a great benefit for the complete project and continued development of the Data Management System (DMS). A more strict requirement and design process would definitely have been beneficial. This would have improved the development process by reducing the time for

when a first application would have been available. From this first version experience and knowledge for the continued development could have been gained.

3.2.2 Use standard applications

The Data Management System (DMS) is developed from scratch using well-accepted open source application. There exist today several applications for IoT data handling, building management system and time-serie databases.

Some of the benefits of an in-house developed solution compared to use a standard application are:

- It is possible to develop exactly the requested and needed functionality
- No dependencies on third party roadmap (standard application)
- No license fee (open source)
- Benefit from the open source community and improvements in used open source applications

However the downside of developing the application from scratch is:

- You more or less have to invent the wheel – you have to develop a lot of functionality that is already included in standard applications
- It is most likely more expensive
- You become locked-in to the developing company and your own specialist
- You don't benefit from the development in the standard application – you have to do all on your own.

The buy or build dilemma is far too complex and out of scope of this delivery to be thorough discussed, more readings can be found here in these arcticles CIO.com, ComputerWold, Buy or build whitepaper – the result of a quick Google search and not an exhaustive list of papers. In chapter 3.2.3 some of the available standard application are brief described.

3.2.3 Available standard applications

As with the shallow overview of arguments for buy or build in chapter 3.2.2 this chapter presents three "standard" applications that are available today and should be considered for a further development of the Data Management System (DMS).

IBM Cloud

IBM Cloud was formally known as IBM Bluemix. From the IBM webpage, the IBM IoT solution offer:

- **Connect**
  Quickly and securely register and connect your devices and gateways. You can find simple step-by-step instructions for connecting popular devices, sensors, and gateways in our recipes site.
- **Information Management**
  Control what happens to the data that is received from the connected devices. Manage data storage, configure data transformation actions, and integrate with other data services and device platforms.
- **Analyze in real time**
  Monitor real-time device data through rules, analytics, and dashboards. Define rules to monitor conditions and trigger automatic actions that include alerts, email, IFTTT, Node-RED flows, and external services to react quickly to critical changes.
- **Risk and Security management**
  The secure-by-design control capabilities protect the integrity of the IoT solution through secure connectivity and access control for users and applications. Extend the base security with threat intelligence for IoT to visualize critical risks and automate operational responses with policy-driven mitigation actions.

Siemens Mindsphere

MindSphere delivers a wide range of device and enterprise system connectivity protocol options, industry applications, advanced analytics and an innovative development environment that utilizes both Siemens' open Platform-as-a-Service (PaaS) capabilities along with access to Amazon Web Services (AWS) and Microsoft Azure public cloud services.

Through these capabilities, MindSphere connects real things to the digital world and provides powerful industry applications and digital services to help drive business success. MindSphere's open PaaS capabilities enable a rich partner ecosystem to develop and deliver industry applications. Profit from the experience and insights from other users.

Siemens provides business-focused solutions to help drive closed-loop innovation through digital twins for products, production, and performance.

Microsoft Azure IoT Hub

IoT Hub is a managed service, hosted in the cloud that acts as a central message hub for bi-directional communication between an IoT application and the devices it manages. The Azure IoT Hub can used to build IoT solutions with reliable and secure communications

between millions of IoT devices and a cloud-hosted solution backend. It is possible to connect virtually any device to IoT Hub.

IoT Hub supports communications both from the device to the cloud and from the cloud to the device. IoT Hub supports multiple messaging patterns such as device-to-cloud telemetry, file upload from devices, and request-reply methods to control the devices from the cloud. IoT Hub monitoring helps to maintain the health of the solution by tracking events such as device creation, device failures, and device connections.

IoT Hub's capabilities help to build scalable, full-featured IoT solutions such as managing industrial equipment used in manufacturing, tracking valuable assets in healthcare, and monitoring office building usage.

The IoT Hub scales to millions of simultaneously connected devices and millions of events per second to support the IoT workloads.

It is possible to integrate IoT Hub with other Azure services to build complete, end-to-end solutions. For example, use:

- Azure Event Grid
  to enable the business to react quickly to critical events in a reliable, scalable, and secure manner.
- Azure Logic Apps
  to automate business processes.
- Azure Machine Learning
  to add machine learning and AI models to the solution.
- Azure Stream Analytics
  to run real-time analytic computations on the data streaming from the devices.

4. Conclusion

A Data Management System (DMS) solution has been designed, programmed and made available for the EnergyLab Nordhavn project. Despite the outstanding functionality addressed in 3.1 the available solution provides the basic functionality making is possible to accomplish the defined use cases and demonstrations. Further data is available for the planned research in the project.

However before continue the development of the Data Management System (DMS) in a next EnergyLab Nordhavn project or another project it is strongly recommended to

evaluate the Data Management System (DMS) in its current state and what is required to finalize it compared to use a standard IoT dataware house solution, i.e. to complete a “buy or build” evaluation as addressed in chapter 3.2.