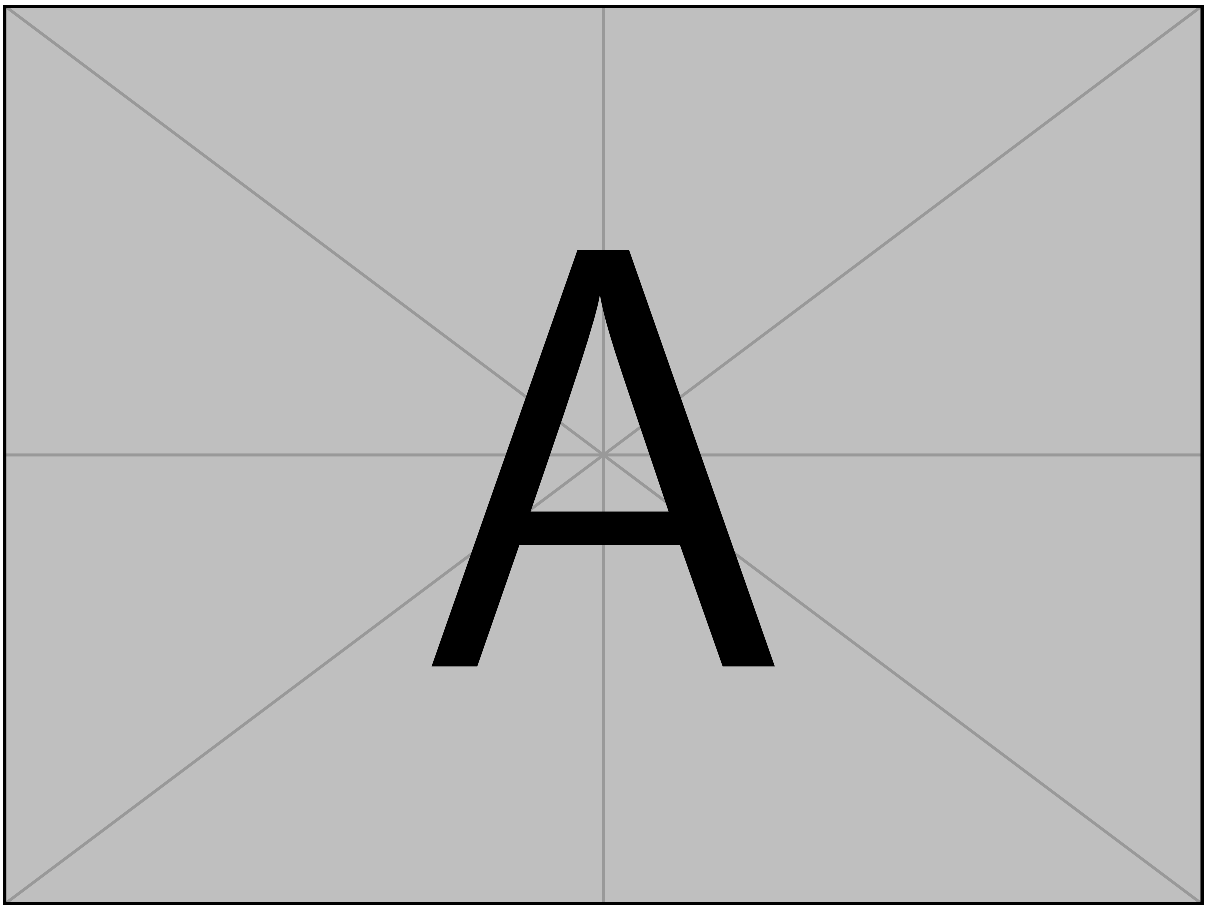
Embedded IoT for Eclipse Arrowhead



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To my dad Bengt-Göran Martinsson a special thanks for proof reading is required...

Abstract

The abstract is a mini thesis on its own. It should contain the briefest of motivation and problem description, what has been done, and summarize the results. The purpose is to give the reader a quick view of the content, and encourage the reader to read the rest of the thesis. It's also helpful to put the reader in the right frame of mind for the rest of the thesis. This section is typically anything between one paragraph for short research papers (of 8 pages) to a page for a full thesis

Contents

Acknowledgments

Here it is supposed to say something really smart about my thesis I think. (Maybe leave this part out)

Chapter 1

Introduction

1.1 Background

The number of devices connected to the Internet has risen from 7 billions in 2018 to an estimated 35 billions in 2021 according to Security Today and that number is only going to increase according to a survey done by security today. [1]

1.2 Motivation

With the numbers of devices connected to the Internet, IOT-devices from now on, rising to an estimated 38.6 billion devices world wide by 2025 the need to enable communication between those devices have never been bigger.

1.3 Problem definition

This project aims to investigate the possibilities, benefits and limitations of using Eclipse Arrowhead framework on embedded devices in contrast to commercially available solutions such as Amazons Amazon Web Services, AWS from now on, and Microsofts Azure.

The way to measure the difference between either using a central broker, the MQTT protocol used by AWS and Azure or using peer to peer, HTTP protocol used by the Arrowhead framework to handle the communication between devices in terms of latency, energy consumption and security.

1.4 Equality and ethics

The ability to own and control your data are becoming more and more rare these days with giant corporations establishing their own cloud services. You as a consumer always takes a risk when pushing sensitive data the a cloud owned by someone else, the right to own your data should not have to be infringed upon.

1.5 Sustainability

The use of small embeded devices instead of monolithic machines used by the industry today provides a much needed decrease in energy consumption.

1.6 Delimitations

This thesis will not cover a solution to the numerous secruity risks and issues associated with IoT-devices. This thesis will also only cover the three core systems of the Eclipse Arrowhead framework, which are the service registry, authorization and orchestrator.

1.7 Thesis structure

In chapter 2 related work is presented, a literature review of IoT, Industry 4.0, security and the Eclipse Arrowhead framework is conducted.

In chapter 3 theory is covered, describing what scientific methods where used in this thesis.

Chapter 4 covers implementation, describing how the different systems used in this thesis uses are designed from a software engineering perspective.

In chapter 5 an evalution of the experimet conducted will be performed.

Chapter 7 presents the conclusion of the work done in this thesis. The chapter also describes how to further investigate the questions raised in this thesis.

In chapter 8 there is a list of references used in this thesis.

Chapter 2

Related work

2.1 Related work

2.1.1 Internet of things

Rob van Kranenburg defines IoT as:

> a dynamic global network infrastructure with self-configuring capabilites based on standard and interoperable communcation protocols where physical and virutal 'Things' have identites, physical attributes, and virtual parsonalites and use intelligent interfaces, and are seamlessly integrated into the information netork.

2.1.2 Industry 4.0

Lasi [2] argues that the term industry 4.0 was coined beforehand as a planned fourth industruial revolution. The use of internet of things devices, IoT-devices from now on, and cyber physical systems, CPS from now on is what defines the fourth industrial revolution Vadiya means [3]. See figure x for a short historic overview of previous industrial revolutions.

According to Vadiya [3] industry 4.0 promotes the connection of sensors and devices both to the internet and to other sensors or devices.

Hozdić [4] states that a sensor is a device capable of providing an appropriate output in response to a measured value. One key feature of intelligent sensor is that in order to increase the level of information proeccesing it processes the information at a logical level Hozdić [4] argues. A Intelligent sensor is capable of executing actions based on the measured value in contrast to regular sensors, making them easier to set up and use means Hozdić [4].

Hozdić defines cyber physical system, CPS, as a new generation of system that integrate both physical and computer abilities. [4] A cyber physical system consists of two

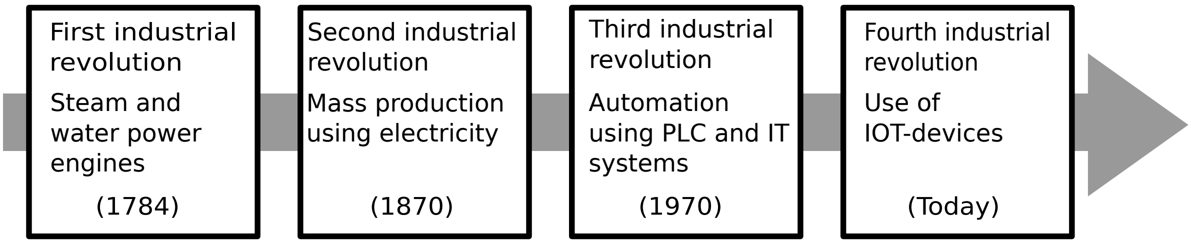
First industrial revolution
Steam and water power engines
(1784)
Second industrial revolution
Mass production using electricity
(1870)
Third industrial revolution
Automation using PLC and IT systems
(1970)
Fourth industrial revolution
Use of IOT-devices
(Today)

Figure 2.1: Historic overview of previous industrial revolutions

parts, one cybernetic and one physical. The cybernetic part of the system can be viewed as a summation of logic and sensor units while the physical part of the system can be viewed as a summation of the accuator units Hozdić adds. [4] Xu et. al. states that cyber physical systems is a key part of Industry 4.0. In contrast to the simple embedded systems of today will be exceeded due to advances in CPS that enables enhanced capability, scalability, adaptibility, resilency, safety, usability and secruity. [5] Hozdić argues that it is the CPS abilities to share and recieve information from intelligent sensors that connect to digital networks is what enables and form an internet of things. [4]

2.1.3 Arrowhead framework

A local cloud is defined as a self contained network with at least the thrre mandatory systems deployed, more on those in a later paragragh. Delsing et.al. also argues that except the three mandatory core systems running a local cloud also needs at least one application system deployed [6].

Two terms have to be introduced in order to further understand what the Eclipse Arrowhead framework aims to accomplish, services and systems. Delsing et. al. defines a system as what is providing or consuming a service. [6] Furthermore a service is defined as what is used to convey information between a provider and a consumer Delsing et. al. argues [6]

The Eclipse Arrowhead framework, Arrowhead from now on, consists of three mandatory core systems according to Delsing et. al. [6] To fully operate a local cloud as defined in the previous section it must according to Delsing [6] contain:

- Service registry system.
- Authorization system.
- Orchestration system.

The service registry system is responsibly for enabling discovery and registring services Delsing et. al. [6] states. According to the Eclipse Arrowhead projects own github page [7] the service registry system provides the database which stores the offered services in the local cloud. The github page also states the three main objectives of the service registry system are:

- To allow application system to register available services to the database.
- Remove or update available services from the database.
- Allow application system to use the lookup functionality of the registry.

The Authorization system is contains two databases for keeping track on which system can consume services from which other system, depending on whether or not the Application system are in the same cloud or not according the projects github page [7] The github documentation also states that if the authorization happens within the same cloud it is called intra-cloud authorization and if it happens accross two local clouds it is called inter-cloud authorization. [7]

The Orchestration system is responsible for pairing and finding service providers and consumer Delsing et. al. declares. [6] Delsing et. al. continues to state that the orchestrator also stores the orchestration requirments and the resulting orchestration rules. [6] The projects documentation argues that the main objective of the orcherator system is to find an appropriate provider for the requesting consumer system. [7] The documentation also states that there are two types of orchestration, store orchestration and dynamic orchestration. Store orchestration uses the database orchestration store to find predefined orchestration rules. Dynamic orchestration on the other hand searches the entire local cloud, or even other clouds, in order to find mathing provider. [7]

2.1.4 Security

Meneghello et. al. argues that the increasing number of IoT-devices and the pervasive nature of new smart home or healthcare devices can pose a real threat to the users integritiy. Sensitive information Meneghello et. al. defines as video recording of the users home, the users location, access to buildings, health monitoring and industrial processes. [8]

Meneghello et. al. states the the secruity requirments of an IoT-system can be divied in to three different operational levels, namely the information, access and functional level. [8] The information level should garantee that the integrity, anonymity, confiidentiality and privacy of the system is preserved. Meaning that messages should not be altered with during transmission, the identity of the data source and the clients private information remains hidden and that data cannot be read by third parties Meneghello et. al. argues [8] The access level provides a guarantee that only legitimate users are allowed access to the network and the devices associatied with that network. It also gaurantees that users within the network only uses resources they are allowed to use Meneghello et. al. states. [8] The functional level should guarantee the continued functionality of a network even in the case of malfunction or a malicous attack.

Zhang also argues that privacy is a big concern with IoT devices and suggests two solutions data collection policy and data anonymization. [9] A policy for that describes how the data is collected from the devices would restrict the flow of data, therefore ensuring privacy preservation can be ensured Zhang states. [9] Data anonymization means that the private information sent by the IoT devices is either encrypted or that the relation of the data and its owner is concealed according to Zhang. [9]

Meneghello et. al. argues that on of the main aspect to security within IoT is to ensure that the data sent is the data recieved and that the data has not been tampered with or read during transmission. The most important operation to guarantee that is the use of encryption, which converts the message sent in plain text to an encrypted message only readable with a decryption key Meneghello et. al. states. [8] Meneghello et. al. states that there are two mechanisms for encryption, symetric and asymetric. Symetric encryption is when the same key is used for encryption and decryption, so it has to be shared to both the sender and reciever. Assymetric encryption on the other hand only shares the public key and the sender and reciever has their own private keys Meneghello et. al. means.

Hassija et. al. states the importance of end-to-end encryption and the challenges it poses for the IoT systems. End-to-end encryption is required to ensure the confiidentiality of the data, the application should not let anyone execept the intended recipient read the messages sent Hassija adds.[10]

Noor, Meneghello and Zhang states the importance of authentification in IoT systems. [11, 8, 9] Noor adds that 60% of all IoT systems uses authentification to grant acceess to the user. Zhang argues that public key cryptosystem provide more security compared to symetric encryption schemes, but has the draw back of having high computional overhead. [9]

Noor argues that conventional cryptographic primativs are unsuitable for IoT devices due to thier lack of computional power and limited battery life and memory capacity. With IoT devices lacking capabilites as background Noor, Meneghello and Zhang all aggree that a push for lightweight cryptography is required in order to ensure secruity of these devices. [11, 8, 9]

2.1.5 Communication

Chapter 3

Theory

3.1 Theory

Primarily this section should be about scientific methods and theories you need to evaluate/compare/invent to solve your problems from 1.3. In some cases it may be ok to describe different technologies, but the purpose is to describe something and then draw a conclusion from that. Example, if you decide to discuss different databases, it may be for the purpose of selecting the best type for your implementation later on (based on for example data representation, scalability, speed, etc.). Optimally the problems in 1.3 are not solved by anyone else yet, in which case this section needs to describe how to solve them (new algorithms, mathematical approaches, etc.).

This section can have a lot of subsections (3.1, 3.2, 3.3, etc).

Chapter 4

Implementation

4.1 Implementation

This is not a step-by-step instruction or diary to your work. Instead, you should describe your technical approach and solution, describe architecture, components, etc. Think software engineering... Perhaps use a few useful uml-diagrams or illustrate the system architecture. Keep in mind that the purpose of the implementation section is to describe your implementation to solve the problems from 1.3.

4.1.1 System architecture

4.1.2 System component

Chapter 5

Evaluation

5.1 Evaluation

Describe the test setup to verify that your problems from 1.3 have been solved. This can be done in different ways depending on focus of your problems. Some problems may purely objective, such as "improve the performance of X compared to Y". These are easy to evaluate since you simply need to compare the performance, and perhaps compare against a few more technologies that you have listed in Section 2 (related work). In other cases the problems may be very subjective, such as "Create a mobile app that can be used while driving, and which shows the most fuel efficient time to change gear". This problem will require a user-study in which several persons drive without the application, you calculate the fuel consumption, then they drive with the application and then you calculate the fuel consumption again. Then you collect the objective measurements (fuel consumption comparisons) and the subjective opinions from the users about whether the application was unobtrusive, usable, etc. (typically via a questionnaire)

Chapter 6

Discussion

6.1 Discussion

Discuss how you solved your problems from 1.3, and what the results were (from section 5). Describe alternative solutions, what you could have done differently, problems you encountered, how your results compare to other peoples' results, etc. Go through each problem individually, and then in the end add general remarks and discussion points which are outside the problems themselves but that you think may be valuable to share with the reader. This section can have several subsections.

Chapter 7

Conclusions and future work

7.1 Conclusions and future work

This section describes the outcome of your work and summarizes your efforts. It also outlines things that are left to do to reach a full solution, or to integrate your solution with something else.

Chapter 8

References

8.1 References

This section should be easy if you always write down your references the moment you read them / use them. There are, however, several acceptable ways of writing references. There are plenty of instructions online to help you get these correct. The typical format is: [1] Authors separated by comma, "Title in cursive and within citation marks", Place of publication, (for articles you also add issue, number, and pages as well), date.

instead of [x] you can also use [First Author (, et. al), year]

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