UNICORN COLLEGE

Department of Information Technologies

EXTENDED SUMMARY

Parking monitoring system with IoT Technologies and BigClown platform

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Content

1 Introduction

This is an extensive summary of my bachelor's thesis on *parking monitoring system with IoT Technologies and BigClown platform.* This work discusses Internet of Things (IoT) and its practical application in designing a parking monitoring system for Unicorn College.

The essence of the bachelor thesis is the design of the system itself, with a description of the individual modules, their tasks, and the communication between them.

The main target of the thesis is to find a solution which will fulfill the following requirements:

1. Functionality: the system will determine the availability of the space, and then send a message to the cloud.
2. Modularity: ability to change one or more parts of the system, while the remaining parts maintain full functionality.
3. Security: at the minimum, the solution should meet basic security standards.
4. Simplicity: finally, beginners in the field should be able to build the same or develop similar solutions based on the thesis.

The intention of this work is to design a system that optimizes the connection of smaller IoT technologies, so that they work together seamlessly to solve a problem.

As a direct result of this thesis, our school will have an implementable solution to effectively manage its parking spaces. The complete project is divided into three phases, which is beyond the scope of this thesis. Thus, only the first phase is covered in this paper.

2 Exploration of facts

The theoretical part of the thesis focuses on the Internet of Things (IoT). The parking space monitoring system is an example of how IoT technologies can be applied to solve real-world problems.

IoT is generally understood as the key player in the Fourth Industrial Revolution (Industry 4.0), which we are currently going through. The thesis frames Industry 4.0 within a historical context, recounting the first industrial revolution in Bohemia. For reference, Řemeslník Český (Czech Craftsman), written in 1863 by Antonín Majer, one of the founders of technical education in Czech lands, is used (1). The thesis also briefly

describes the start of the IoT movement and Industry 4.0. This puts IoT technology into a correlation with the invention of the steam engine, the driving technology of the first industrial revolution.

The work also puts current trends and estimations into a bigger picture. Experts from the field of market research pointed out that by the year 2020:

- There will be internet connectivity in things sold for around US$1.
- There will be 26 billion IoT devices installed.
- The devices will generate a revenue of US$300 billion (2).

Later, it is described how market changes are already visible already today. This is true for smart products, which use internet connectivity, and are already changing the lives of its customers.

The next topic in the theoretical part is the description of the usual components, and the data flows in IoT solutions. In addition, the topic of monitoring places is introduced. Existing examples from the market and their principles are enumerated and described.

The following chapters discuss the essential parts of the solution: microcontrollers, sensors, and connectivity. These entities are introduced and the selected models are compared. The main reason for these chapters was to find and introduce options for solving the problem in the practical part:

1. The BigClown microcontroller is introduced, along with its benefits in comparison with the competitor Arduino MKR 1200.
2. The HC-SR04P ultrasonic sensor is discussed, with a description of how ultrasonic sensors work. The selected model is compared with its competitors (infrared, magnetometer, laser sensor, microwave sensor).
3. The LPWAN SigFox network is described, with an analysis of its benefits and limitations. The main limitations discussed were the maximum number of sent messages (144) and their size (12 Bytes). Other selected networks are brought up as well (GPS, LoRa), with a brief overview of their advantages and disadvantages.

The key role of the theoretical part is to provide a background and introduction for the practical part.

The theoretical part of the bachelor thesis is essential because:

1. It provides a unique look at IoT as one of the tools of the current industrial revolution (Industry 4.0). As previously mentioned, historical context is provided by *Řemeslník Český* (Czech Craftsman). The thesis asserts that there has been no major transformation in people since the first industrial revolution, and they think in the same way as their forefathers did.
2. Market research companies concur that IoT is a growing industry. All selected research companies predict a bright future for this technology.
3. Identification of the main technologies, with an assessment of their suitability for the project. BigClown, sensor HC-SR04P and SigFox network have been selected.

3 Used methods

The theoretical parts focus on introducing the technologies from several angles. As the technologies are relatively new, and the area is dynamic, the internet is used as the main source of information.

The following methodologies were used to complete the work: comparison, analysis and experiments. They are described below.

1. Comparisons - Products from several technologies were compared with each other, using product sheets. Microcontrollers and sensors were compared using this method.
2. Analysis - Two examples of parking monitoring solutions are described and analyzed. Based on the analysis and by using logical deduction, ultrasonic sensors are more suitable for garage parking, while electromagnetic sensors are more suitable for monitoring outdoor parking spaces.
3. Experiment - The product sheets did not provide exhaustive information about the different products. This being the case, several techniques had to be tested through experiments. For example, the behavior of ultrasonic sensors and byte transformations. The experiments are not explicitly stated in the bachelor thesis. They were done as part of the developmental analysis, and the results were used for developing prototypes.

4 Coverage and benefits

The primary objective of the practical part of the bachelor thesis is to design an automated solution for UCL's parking garage. The solution should be configurable, extendable, and potentially pluggable into Unicorn's application framework.

The project is split into three phases; however, this thesis is limited to the first phase. It details devices in the garage (DAQ nodes, aggregators) and the communication interfaces between them and the SigFox cloud. The work also includes the design and development of the functional prototype.

The benefits of the thesis are:

- Consolidation of selected IoT technologies, designed so that they seamlessly work together as a whole to address the problem.
- Presentation on the practical use of IoT technologies by providing a solution to a real-world problem.
- Developing an algorithm for the aggregation of several messages into one. This should reduce the recurring charges from the network operator.
- Finding an algorithm for saving battery power, based on light intensity.
- Generating guidelines for similar IoT projects.

5 Outcomes

The main outcomes from the theoretical part are the following:

- Details about possible solutions to the selected parking systems and a comparison of the differences between garage monitoring systems and outside parking systems.
- Comparison of the BigClown and Arduino microcontrollers – with BigClown being the better option.
- Comparison of possible sensors which could be used for checking parking space availability (ultrasound, magnetometer, infrared, laser radar and microwave radar). Using an ultrasonic sensor is the most ideal.

- Comparison of communication standards – SigFox has been determined as the most suitable provider.

The main outcomes from the practical part are the following:

- Defined list of use-cases, actors, and requirements for all three phases of the project.
- Presentation of system's architecture with a detailed section of the first part of the project (DAQ nodes and aggregators).
- Detailed flow of the behavior of DAQ nodes and aggregators.
- Detailed description of the interfaces between DAQ nodes, the aggregator and SigFox cloud.
- Hardware example of the DAQ node and aggregator – with implemented software (a. k. a. firmware).

6 Comparison of outcomes with subject of the thesis

The following targets were set at the beginning of the bachelor thesis:

- Propose a concept for the remote monitoring of parking spaces in the UCL garage using IoT technologies and BigClown modules.
- The system should be modular in design and should incorporate safety features.
- Build the prototypes and program the software to control the microcontrollers (a. k. a. firmware).

The system was designed, and prototypes for the first project phase were built. Thus, I consider the main target fulfilled. Completion of the next two phases is essential to fully realize the project.

7 List of used resources

Numerous resources were used in writing this bachelor thesis. The ten most essential sources are listed below:

1. **Antonín Majer.** *Řemeslník český.* místo neznámé : Kněhtiskárna Dr. J. Gregra & F. Šimačka, 1863.

2. **Gartner.** Gartner Says the Internet of Things Installed Base Will Grow to 26 Billion Units By 2020. *Gartner.* [Online] 12 12, 2013. [Cited: 11 7, 2017.] https://www.gartner.com/newsroom/id/2636073.

3. **Hardwario.** Welcome to BigClown Documentation. *BigClown.* [Online] Hardwario. [Cited: 4 6, 2018.] https://www.bigclown.com/doc/.

4. **Hardwario** BigClown - Open-source Internet-of-Things for Makers. *github.* [Online] Hardwario. [Cited: 4 5, 2018.] https://github.com/bigclownlabs.

5. **Český telekomunikační úřad.** Využívání vymezených rádiových kmitočtů. *ČTÚ.* [Online] [Cited: 3 2, 2018.] https://www.ctu.cz/vyuzivani-vymezenych-radiovych-kmitoctu.

6. **Spel Smart.** Smart parking. *Spel.* [Online] Spel, a.s. [Cited: 12 20, 2017.] https://www.spel.cz/page/smart-parking.

7. **Unicorn College.** *PA1 Úvodem, Co je to Open Hardware a Internet of Things.* [Skripta k předmětu programování pro Arduino 1] Praha : UCL, 2017.

8. **Unicorn College**. *PA1 Princip funkce a připojení senzorů k Arduino UNO.* [Skripta k předmětu programování pro Arduino 1] Praha : UCL, 2016.

9. **Glen Schatz.** SigFox Vs. LoRa: A Comparison Between Technologies & Business Models. *Link Labs.* [Online] LinkLabs, 1 13, 2016. [Cited: 3 2, 2018.] https://www.link-labs.com/blog/sigfox-vs-lora.

10. **SimpleCell Networks a.s.** SimpleCell Networks a.s. operátorem mobilní sítě SIGFOX pro Internet věcí v České republice. *SimpleCell.* [Online] SimpleCell networks a.s. [Cited: 3 2, 2018.] https://simplecell.eu/simplecell-networks-a-s-operatorem-mobilni-site-sigfox-pro-internet-veci-v-ceske-republice-2/.