Implementing NB-IoT: Communication with a Load Cell

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Abstract

The purpose of this project is to establish a line of communication between a loading cell and the internet. This will be done through the NB-IoT technology, and the data being sent is produced by the loading cell. Using a micro-controller from PyCom and a SIM-card from Telia as the network service provider, [...]

Contents

List of Figures

List of Tables

Chapter 1

Introduction

Vetek is a Swedish scale supplier located in Väddö, situated approx. 100 kilometers north of Stockholm. Vetek constructs their own scales and weighing systems, as well as reselling products from other manufacturers.[18] Vetek aims to improve their services, and as such are interested in the possible use cases of IoT (Internet of Things) technology, and ultimately see how that can be applied to their own products. In this paper, the term IoT will simply mean "(a) device(s) connected to the internet"[11]. In a pilot project, Vetek wants to see how this connectivity can be implemented in a energy-efficient and effective manner. This would entail investigating factors such as power consumption, range and data rate.

Narrowband-IoT (NB-IoT), a new and emerging radio technology, encapsulates some principles suitable for this type of endeavor, such as wide coverage, low power consumption and low complexity.[3] It's a radio access technology standardized by the 3GPP (standardization organization within telecommunications)[1] in 2016, and is a part of the 3GPP's push for IoT technologies alongside LTE-M and EC-GSM-IoT. These are so called low-power wide-area network (LPWAN) technologies that will compete with rivals such as LoRaWAN and Sigfox. Compared to LTE-M and EC-GSM-IoT, NB-IoT has a lower data rate, no voice capability and limited mobility capability. In return, the power consumption and cost of the devices will be lower, and thus more suitable for simple static sensor applications.[19]

According to Swedish telecom company Telia, they were the first to introduce the NB-IoT technology in Sweden, as well as the Nordic countries overall[15]. They further claim that their network will be in range for over 99.9% of Sweden's population, as well as provide a speed of 200 kb/s in more than 95% of the country.[14] The grand opening of the network was on the 24th of May, and pilot projects were conducted as early as a year before this, in multiple locations across the country. Telia currently offers a starter kit for any actor interested in the technology, with a trial period of 6 months that includes access to Telia's IoT portal and APIs as well as 5 SIM cards, each with a 30MB data cap per month. Telia doesn't seem have many competitors when it comes to the Swedish IoT market, though Tele2 have partnered up with Nokia to offer similar services. According to a press release from 2018, they have rolled out both LTE-M and NB-IoT across their networks.[12] Telenor has launched a IoT network in Norway with NB-IoT functionality in 2018, though no mention has been made of when this will be available in Sweden as well.[13] The fact that Telia already has partnered up with a multitude of cities and companies give the indication that they have a head start in the market.

Using some form of NB-IoT compatible microcontroller and hooking it up to a basic load cell should provide sufficient testing grounds to see how this new functionality could improve existing products.

1.1 Purpose and Goals

NB-IoT is a relatively new technology, and as such, implementations and documentations remain sparse.[3] However, even a small project such as this can serve as a guiding post for future work. The goal of this project is to establish a working internet connection with a load cell through the NB-IoT technology. The data sent from the load cell should be functionally identical to the data produced if the load cell was offline. Disregarding problems due to a internet service provider, data speeds and losses should not be abnormal. Using the same components, replication of the project should be feasible with the documentation provided in this thesis, assuming similar software and service providers remain.

The end-goal can be divided into two sub-goals.

- Enable internet communication via NB-IoT from the microcontroller.
- Enable data transfer from the load cell to the microcontroller.

This paper will outline and describe the process from start to finish. Problems and challenges that arise in the implementation will be investigated and analyzed. An agile workflow will be prioritized in the implementation, with small increments of work being added and tested before moving on to the next part. The workflow will flow this rough outline.

1. Enable communication from the microcontroller via another common protocol, such as WiFi.
2. Enable the reading of data from the load cell via the microcontroller.
3. Upload the data to a suitable online platform.
4. Enable communications from the microcontroller via NB-IoT.

The reason for enabling communications via WiFi is to ensure a functioning channel via a more common and well-documented protocol that's easier to setup. Once this is functional at the same time as the data upload of the load cell data, the move to NB-IoT can be done. This setup is due to the aforementioned agile workflow.

1.2 Delimitations

The end goal of the paper is to document and outline the steps needed to implement a functioning data upload from a load cell to the internet via NB-IoT. The final implementation will not be a functional product ready to be taken into commercial use. Any extra improvements upon a NB-IoT enabled load cell will only be done if time remains after the implementation and the completion of the thesis. The reason for this is due to a limited time budget, since this project is done within the framework for a bachelor's thesis.

When starting this project, several factors motivated the choice for hardware (which will be described in greater detail in the following chapter). Since existing work on NB-IoT at Uppsala university has been done on the microcontroller FiPy, and the available expertise would make troubleshooting simpler, a FiPy was chosen for this project as well. Furthermore, since the Computer Communications group at Uppsala University have an ongoing contract(**wording?**) to use Telia's NB network, the choice for which tele-carrier to use was also quite simple. The load cell, a Tedea Huntleigh - Model 1022 was provided by Vetek, as it was deemed a simple and basic model which would be suitable for this kind of pilot project. Since the output of a load cell is measured in mV/V[16], some form of mediator is needed between the microcontroller and the load cell. A similar implementation made at KTH [6] used a load cell amplifier, HX711, to convert the data to a digital format. After some research online, no alternatives were cheap or simple enough to warrant a different purchase. The readily available documentation and tutorials were also a compelling argument for using the HX711.

Chapter 2

Definitions

2.1 Components

- **FiPy:** a microcontroller (not to be confused with the python package of the same name) that gives access to all major LPWAN technologies, originally funded through kickstarter.[8] FiPy is developed by the IoT company PyCom[10] and equipped with an expansion board to enable integration with other components via GPIO pinouts, as well as an LTE-antenna to enable LTE CAT M1 or NB1.[9] The board is programmed via the MicroPython programming language (an implementation of Python 3) which is written in C and optimized to run on a microcontroller.[4]

- **Tedea Huntleigh - Model 1022:** a single point load cell ideally suited for low cost weighing platforms. This specific model has the capacity of 30 kg.[5] It is a type of strain gauge load cell which converts the physical load it's exposed to to electrical signals. When a weight is applied, the metal deforms slightly, which changes the internal electrical resistance and therefore affects the output of the voltage.[7] To utilize the load cell, the four wires need to be hooked up as according to figure 2.1.

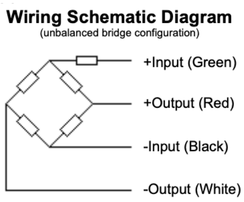


Figure 2.1: Wiring schematic[5]

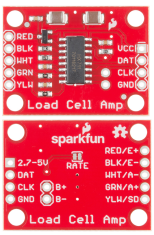
- 

Figure 2.2: HX711[2]

HX711: a breakout board that amplifies the signal from a load cell so that the data can be read more easily. Since the load cell outputs an analog signal in the form of mV/V, a conversion to a digital format is needed. It's important to note the industry standard of the wire coloring in load cells is not definitive.[17] If the wires are from the model 1022 are connected in the sockets as figure 2.2 suggests, the load cell will not work correctly. According to figure 2.2 and figure 2.1 we can see that the green and red wire needs to switch places, because of E+ corresponding to Input+ and A+ corresponding to Output+.

2.2 Applications & Services

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Chapter 3

Methodology

3.1 Preparation

Chapter 4

Results

4.1 Discussion

Chapter 5

Conclusions

5.1 Future Work

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