SU T/A BIL A BILITY OF LORA W A N TECHNOLOGY FOR THE DEVELOPMENT OF MARITIME APPLICATIONS

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( received: 26 July 2018; revised: 24 August 2018; accepted: 22 September 2018; published online: 8 October 2018)

Abstract: The LoRaWAN Technology opens new possibilities for gathering and analysis of distributed data. In the paper we concentrate on its maritime usability which was tested by us in the period from June to August 2018. Measurements of the LoRaWAN network coverage in the Bay of Gdansk area were carried out. Various conditions and places were tested. The research was planned in such a way as to gradually increase the range and control the impact of environmental factors. The results of the measurements confirm the wide application and a broad range of the technology. Combined with cloud computing it leads to new kinds of services and applications.

Keywords: Internet of Things, LoRaWAN, long range telecommunication, maritime environment monitoring

DOI: https://doi.org/10.17466/tq2018/22.4/e

1. Introduction

In recent times, we can observe rapid development of the Internet of Things concept. Owing to the significant advancement in technology in recent years, this approach begins to encroach on almost every aspect of our lives. In addition to smart buildings or cities, this concept can also be used in scientific research. A very interesting aspect in particular is research into the marine environment. It is also very crucial for many institutions, e.g. the Polish Government [1].

The IoT concept assumes communication with devices, vehicles, structures, or objects of the natural environment. By enabling remote monitoring, we have powerful tools to gather data at a very low cost. Nowadays, a major issue faced by developers of the Internet of Things is the problem of wireless connectivity over long distances and low power consumption at the same time. All the popular
transmission techniques IEEE 802.11b/g/n/ac (commonly known as WiFi) or IEEE 802.15 (popular Bluetooth) do not match those requirements. One of the promising technologies is the LoRaWAN which uses a publicly available 868 MHz band (in Europe) and has a very long range (up to 40 km – confirmed in our tests). A LoRaWAN with a huge number of sensors can take an important part in the 5V model of BigData [2]:

- **Volume** refers to the vast amounts of data generated every second. The LoRaWAN technology has not been designed for high data rate transfers (single kbps) but every gateway can handle thousands of devices at one time. We can image that data from dozens of thousands devices can generate quite heavy traffic;
- **Velocity** refers to the speed at which new data is generated and the speed at which data moves around;
• **Variety** refers to the different types of data depending on the sensor architecture; Veracity refers to the messiness or trustworthiness of the data. The quality and accuracy are less controllable with many forms of big data, however, in this case all data is selected by the sensor designer;

• **Value** means that it is important that businesses make a business case for any attempt to collect and leverage big data. It is so easy to fall into a buzz trap and embark on big data initiatives without a clear understanding of the costs and benefits.

The main aim of this paper is to show that the LoRaWAN technology with HPC BigData computations can be used in maritime conditions as a reliable infrastructure for gathering and processing of data.

### 2. Environment for testing the LoRaWAN technology

Maritime conditions are very specific as they require a very large range which can be very difficult in the conditions of the high seas. A common solution in this case is satellite based communication, however, it involves large transmission costs which can significantly increase the cost of research. To meet these needs, it was decided to explore the possibility of applying the LoRaWAN technology in the conditions of the Gdansk and Puck Bays. These reservoirs are heavily exploited by fishing and by sea traffic (there are two large ports nearby: Gdansk and Gdynia).

![LoRaWAN tracker manufactured by 1M2M](image)

**Figure 3.** LoRaWAN tracker manufactured by 1M2M.

For this reason, this area is the subject of many environmental studies on biological aspects, in particular, the state of pollution and the occurrence of birds and fish species. Manual measurements are very expensive and not always possible, especially in harsh weather conditions. Therefore, the possibility of using the LoRaWAN technology in this case could lead to potential savings and enable access to data in real time.

### 3. Test concept

Based on our earlier works [3], tests were planned in order to gain the fullest possible control over the changing environmental conditions such as terrain...
obstacles and the distance from which attempts were made to establish communication. Accordingly, experiments were divided into four stages

- **Stage 1:** Examination of the “shore” range around the Puck Bay.
  A measuring team equipped with measuring devices traveled by car along the coast, stopping at characteristic points in order to check the correctness of transmission.

- **Stage 2:** Trial test cruises.
  As part of this stage, two test cruises were taken on two different types of sea vessels – MILA (Figure 1) belonging to TASK and on a motor-boat belonging to the Institute of Oceanology of the Polish Academy of Sciences (Figure 2).

- **Step 3:** A research cruise to determine the maximum network coverage.
  The MILA laboratory was equipped with a tracker which was mounted at a height of about 8 meters above the sea level.

- **Stage 4:** Demonstration cruise.
  During this stage, a cruise was carried out, a small sailing yacht (Puck class boat), in the Puck Bay waters to demonstrate the possibility of live tracking of the unit position. During this stage, the tracker was mounted on the top of the mast about 6 m above the water level. Moreover, an additional gateway was temporarily set up in Puck to ensure coverage of the missing part of the Puck Bay.

  The basic measuring device in all stages was a 1M2M tracker. It was equipped with a GPS receiver, a temperature sensor and a pressure gauge. The read data was sent via the LoRaWAN network to the data collector.

  The LoRaWAN access network was built on two gateways located in Gdynia (at the student house of the Gdynia Maritime University) and on the building where CI TASK is located.

4. **Test runs and results**

- **Stage 1.**
  During this stage, it was possible to reach the range along almost the whole coast from Rzucewo to the end of the Hel Peninsula. However, the lack of coverage was detected on the section from Puck to Władysławowo. This was probably caused by the landform near Puck making the antenna located in Gdynia obscured. During the research, the largest distance in a straight line to the gateway located in Gdynia was 29 km. At the very end of the peninsula, a measurement flight was also carried out with the multiTASK airplane [4]. At this stage, the suitability of the LoRaWAN technology for the far-range communication was confirmed, especially in marine conditions. The signal strength measured during tests showed that this technology had even greater coverage capabilities.

- **Stage 2.**
  At this stage, it was decided to examine how the devices would behave in maritime conditions at sea. Two different vessels were used for this purpose. The first was MILA which had a tracker installed in the cockpit (at a height of
about 2 m above the water level) during the cruise from Jastarnia to the home port in Górkí Zachodnie. In the second case, the motor boat “Sonda” belonging to the IO PAS was used. During the technical cruise from Górkí Zachodnie to the area around Mechelinki, a tracker was installed at a height of about 1 m above the water level. In both cases, there were no problems with communication in marine conditions.

- Stage 3.
  Next, the maximum network coverage was examined. For this purpose, two cruises of the MILA laboratory were carried out. During the first voyage (from Górkí Zachodnie to Hel) it was possible to reach a distance of about 35 kilometers. After checking and interpreting the results, it turned out that it was not as yet the maximum possible distance. Therefore, on the next day, during the return cruise, an experiment was carried out from a distance of 43 kilometers, which was also successful.

- Stage 4.
  The final stage was to examine the suitability of this technology on small vessels used for recreation and to examine the possibility of live tracking of an object. For this purpose, a temporary gateway was installed on the building of the Scout Maritime Center, which was supposed to cover the missing fragment of the Bay of Puck – from Puck to Władysławowo. The survey crew took a short cruise across the Bay, allowing CI TASK staff to track the yacht on a specially prepared site.

5. Tests results

All data recorded from the tracker is presented on the map below (Figure 4). The obtained results also made it possible to extrapolate the mathematical coverage of the network. The calculated area is marked on the following map. Currently there are two gateways installed (marked with a red circle on the map). The range in the urban area is very difficult to estimate because it is affected by terrain obstacles in buildings and structures. The maritime area is more predictable in this case.

Different test cruises are marked as sets of points and lines on the map. This test shows that it is possible to cover a huge area of over 1500 square kilometers using only two relatively cheap gateways.

6. Potential application and possibilities

Low-cost access to data in real time opens up a very wide spectrum of possibilities for conducting advanced scientific research and creating monitoring systems. According to Figure 5 we can organize a whole architecture to a cloud based service for various users with a model based on IaaS (Infrastructure as a Service) and PaaS (Platform as a Service). The data is gathered by a network of different sensors located in the area covered by a range of gateways. The received data is processed by The Things Network services and published using
Figure 4. Map of Gulf of Gdansk with marked mathematical extrapolation of range

the MQTT protocol [5]. The TASK cloud can obtain data and put it into a database from where it can be processed at any time by users of applications. This organization provides access to the environmental data almost in real time. Such data is very much desired by many research projects such as SatBałtyk [6, 7] or eBalticGrid [8]. Knowing the current status of the environmental data can help to develop mathematical models of changes of different factors, enabling simulation of such changes. In the first place, such actions may be helpful in developing models by comparing simulation results with real data. Another, more interesting aspect is the possibility of conducting advanced simulations of various potentially dangerous events, e.g. various types of natural disasters. Obviously, such research requires high computing power. We can easily allocate resources and data needed for calculations using the CI TASK appropriate HPC infrastructure available in the cloud [9]. With the current approach, all such data is obtained by satellite or aerial photographs or manual measurements only. The proposed architecture significantly simplifies the construction of the measuring infrastructure, making it available even for every type of subscribers.
As we can see there is great potential in the appropriate application of the LoRaWAN technology. The biggest advantage is the ability to build one’s own sensor infrastructure at a relatively low cost with no additional transmission costs. Using The Things Network global project guarantees full roaming of devices between one’s own gateways and those handled by other operators with the same access to the gathered data. Our experiments have showed that the spectrum of frequencies used by LoRaWAN could handle ranges of over 40 kilometers in an open marine environment. In addition to sensors, there are also quite low energy requirements for gateways. It can also be tried to assemble them at various points or platforms at sea, where very large opportunities for data acquisition for other areas could be provided, while ensuring the Internet connectivity (e.g. via satellite communications). Owing to this, for example, the possibility of sending data through thousands of devices within one satellite subscription can be ensured.

7.1. References


[9] Orzechowski P 2017 *TASK Quarterly* 21 (4) 395