A LoRa Network for traffic monitoring in the cities of Fribourg and Bulle

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Abstract
This document describes a smart city project based on a LoRa communication network to monitor road traffic, noise and air quality in the cities of Fribourg and Bulle. The network planning and deployment and the first measurement results are presented.

Keywords
Smart city, Internet of Things, LoRa, network planning, road traffic monitoring, air quality, noise

1. Introduction

The recently developed communication technologies for the Internet of Things (IoT) such as LoRaWAN[1], Sigfox[2], and NB-Io T[3] are now in the deployment phase. This project is a part of a larger project for the cities of Fribourg and Bulle. The idea is to create new services based on LoRa technology such as traffic, noise and air quality control as well as measurements of other environmental parameters.

The goal of this particular project is to monitor traffic on different roads. The data are then computed on a server and depending on the current traffic density, the speed limit of these roads could be adapted to avoid traffic jams. This information could also be used to inform the population about traffic condition.

2. LoRa

LoRaWAN is a long range (10km+) and low power communication protocol. This technology allows data to be transmitted over long distances but with a low data rate. It has the advantage to be license-free, what allows each city to build its own network.

The typical system architecture for a LoraWAN application is shown in Figure 1. The end nodes are simple objects such as sensors sending data to a gateway which translates the LoRa protocol to an IP protocol. The data could then be stored on a Network server and accessed from an application.

Two LoRa gateways have been installed in Fribourg and one in Bulle. Coverage tests indicate that the major part of both cities is covered. By that way, LoRa sensors can be placed at different locations in both cities and send their measurements results to a server with a high network availability.

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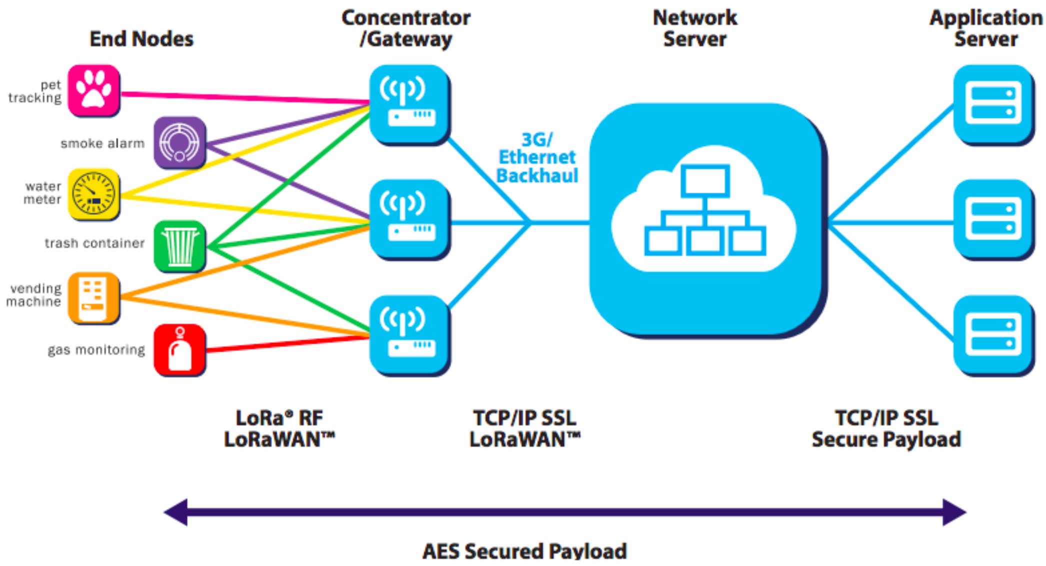

Figure 1: LoRa architecture

3. Network coverage simulations and measurements and deployment in the city of Fribourg

Before the deployment of the LoRa network, several coverage simulations were undertaken. The open access simulation tool: https://www.ve2dbe.com/rmonline_s.asp has been used. By selecting the sites of the HEIA-FR telecom tower and the "rue de l'Aurore" fire station as LoRa gateway locations, the simulations gave the following coverage map of the city of Fribourg. This indicates that an almost complete coverage of the city is obtained with only two antennas.

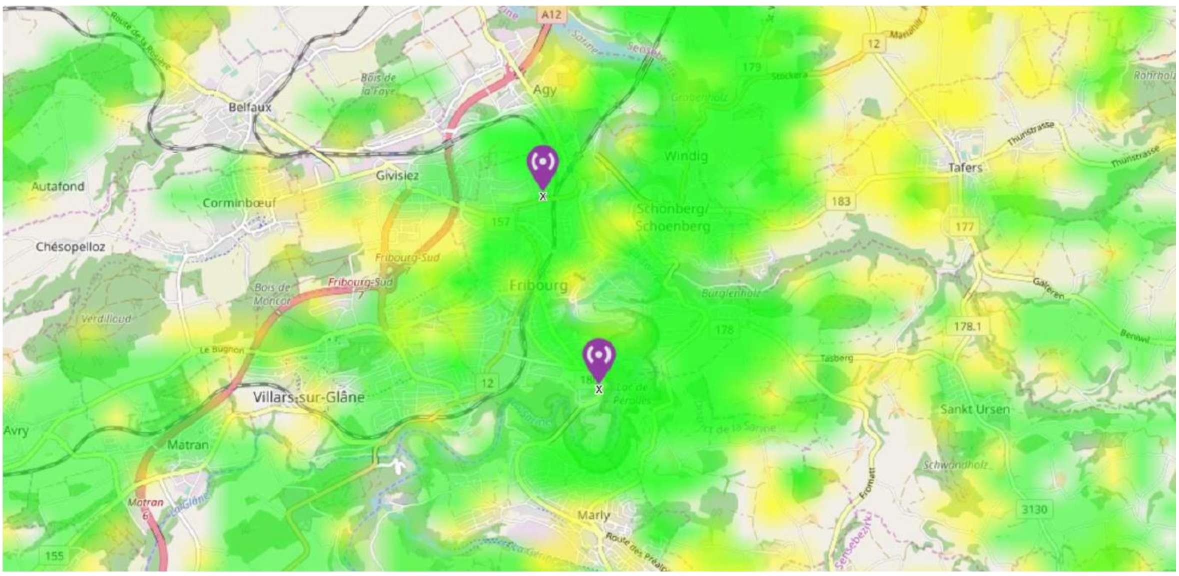

Figure 2: LoRa coverage simulations by using two gateways in the north and south parts of the city of Fribourg

Those prognostics have been tested after a provisory implementation of both antennas in the previously mentioned locations. An end device was used to check the coverage and the reception power at each measured location. The northern, central and southern parts of the city showed LoRa connectivity with receiver powers ranging from -100 dBm to -116 dBm. Only the old city showed a limitation of the coverage pointed out by Figure 3.

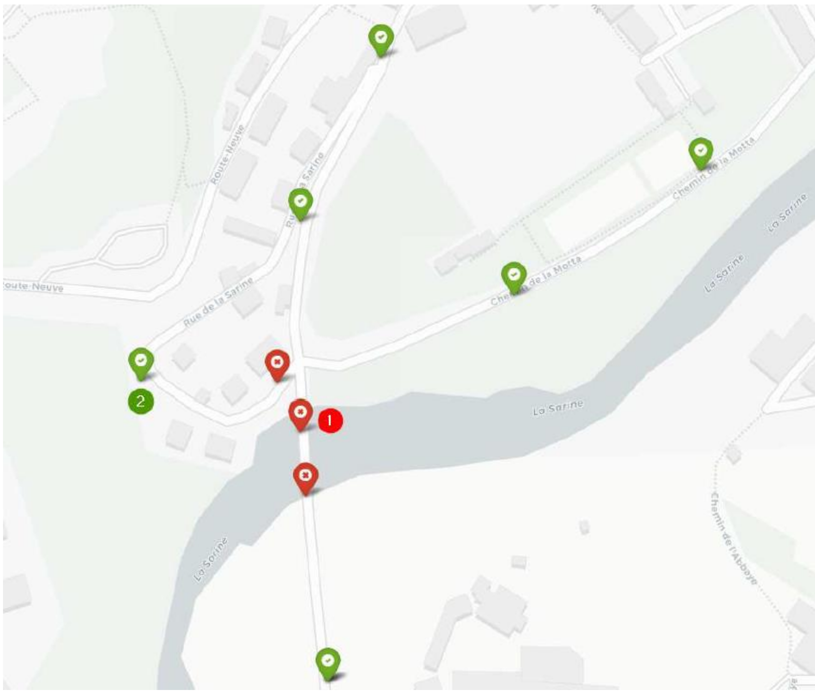

Figure 3: Coverage tests in the old city of Fribourg

Coverage tests have been realized in the old city. Only the "Motta" bridge showed unsuccessful coverage. Based on these simulations and coverage tests, two LoRa gateway antennas were definitely installed on the sites of the HEIA-FR telecom tower and the fire station of "rue de l'Aurore".

4. Concept, implementation and measurements

The setup of the traffic monitoring is illustrated in Figure 4.

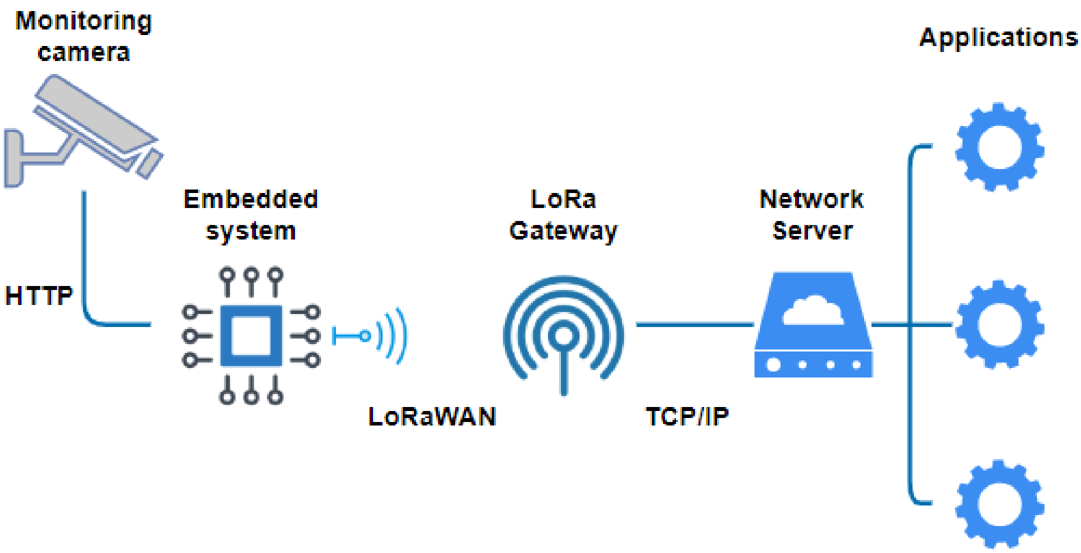

Figure 4: Traffic control system structure

The LoRaWAN protocol allows only a small amount of data to be transmitted and it is not possible to transmit the entire video stream. For this project, a thermal camera (FLIR ThermiCam 2) is used to count cars, trucks, motorcycles, bicycles and pedestrians, and register their speed and the inter-vehicle distances. These data are stored in the camera and can be accessed using HTTP protocol with HTTP GET and POST requests. The camera returns a JSON message with all measured data for a selected time interval.

As defined by the project concept, the measurement data is transmitted every 5-15 mins via LoRa to an application server. The stored data is used for new applications such geographical and historical visualization, traffic analysis and comparisons as well as nearly real time traffic control and management.

5. Results and discussion

For the first tests, a FLIR camera was mounted on the HEIA-FR building to measure the traffic on the "Boulevard de Pérolles". Three measurement zones were defined to count the number of vehicles entering and leaving the city of Fribourg on standard lanes as well as entering the city on the bus lane.

The following diagram shows the number of vehicles per quarter of an hour circulating on each lane (except the bus lane) during 2 weeks of January 2021.

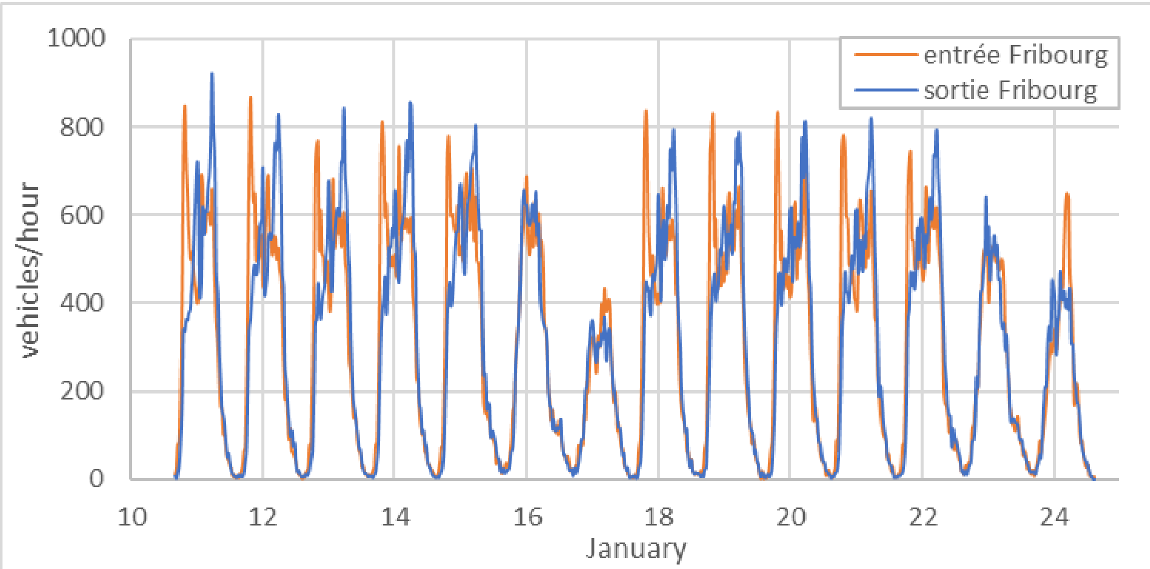

Figure 5: Traffic measurements at Pérolles 80, Fribourg during the 3rd and 4th weeks of January 2021. The red and blue curves correspond to the traffic entering and leaving the city, respectively.

On all working days, we observe a red peak of incoming traffic at 7.30 and a blue peak of outgoing traffic at 17.30. Traffic decreases slightly on Saturdays and is reduced by half on Sundays. If no clear peaks are visible on Saturday, a red entering peak is observed at around 17:00 on Sunday.

While the shape of the daily traffic is particularly interesting, the development over the two weeks also provides crucial information. The Swiss government requirement to perform teleworking after January 18th did not lead to a reduction in traffic: we observed a non-significant reduction of -0.4%. By analyzing the traffic curves of January 18th, one could already deduce at midday, that the obligation was not respected.

This demonstrates that such an IoT traffic measurement tool can quickly inform the competent authorities of the effect of movement restrictions and enable them to quickly take steps to enforce them.

6. Acknowledgements

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7. References

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