Radio Network Planning for Internet of Things (IoT) using SIGFOX Technology

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Abstract* — This document has the goal to make a planning of a radio signal network, using SIGFOX technology, to cover all Lisbon area for IoT devices. In order to do that, a study will be taken about the physical and network layer, the way the access is made to the radio interface and also the parameters used by this technology, such as power, used sensibilities and the antenna gain that are essential for a radio signal communication. SIGFOX is a Low Power Wide Area (LPWA) network, which is known for having high coverage using low emitting power, and uses ultra-narrow band (UNB) technology. For the planning, link budget calculations are necessary (path loss, base station radius) that uses propagation models and Friis formula. Using a RF propagation simulator, simulations will be carried out to determine the accurate position of the base stations.

Keywords: Planning, Radio, IoT, LPWA, SIGFOX, UNB.

I. INTRODUCTION

Internet of Things (IoT) is a new concept which is expected to be the next revolution on the radio signals networks ecosystem, and has the purpose of enabling objects, such as sensors and meters, to manage, collect and exchange data, in other words, to share useful information from objects that need to be accessed remotely, without human action. The new networks that support this kind of objects are LPWA networks which have very specific aspects that limit all kinds of objects that use this kind of networks.

SIGFOX is a LPWA network operator exclusively dedicated to communication machine-to-machine (M2M) and IoT, it is one of the first to develop and explore the LPWA concept. It works with UNB technology which uses much reduced bandwidths (100 Hz) to pass on information, that are hard to be worked due to its necessary precision. So, SIGFOX uses a SDR (Software Defined Radio) to the information transmission and/or reception.

To accomplish the network planning for Lisbon area, it is crucial to know the area to be covered, namely the terrain, the kind of environment in order to apply propagation models that calculate the maximum attenuation of signal propagation in order to determine link budget calculus. Next, a propagation RF simulator is needed to determine the signal level, to decide the position of the base stations and verify the network coverage.

II. STATE OF ART

A. M2M and IoT

M2M is a general concept that works on four basic principles:

- Data acquisition.
- Data transmission.
- Make decisions according to solutions
- To trigger actions.

The telecommunications evolution lead to the increase of communication networks usage, namely internet and mobile communications, in a way that a new concept came up, IoT. It is believed that this concept will spread very quickly and will trigger a whole new dimension of services and applications in several areas. Figure 1 shows the impact of IoT in Telecommunications, by comparing the usage of devices *human-to-machine* (H2M).

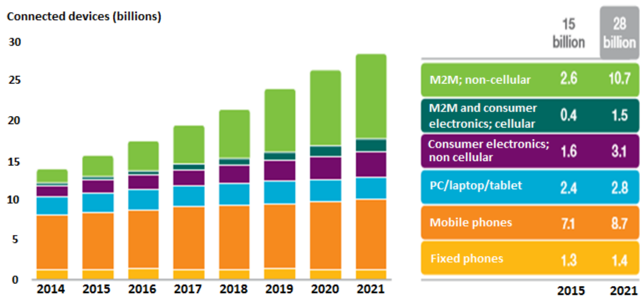

Fig. 1 – Devices M2M vs H2M (source: [1]).

It is expected until 2021, an increase of connected devices M2M of approximately 87%, which expresses around 13 billions of connections until that year, by comparison to 2015. These will represent a 55% increase of connections in 2021, which means, more than an half of all existing connections.

B. LPWA

Low Power Wide Area networks have the goal to support the connection of IoT devices and have the following features:

- Low energy consumption.
- Wide coverage area.
- Low cost equipment.
- Limited transmission capacity.
- Support for an high number of devices.

In order to this kind of technology to obtain great coverage area with low power emission, it is crucial that the transmission bit rate (or bandwidth) is low, so that the equipment used is as simple as possible and consequently, cheaper.

It is possible that LPWA services may achieve a market of over 3 billion connections, in 2023, and generate more than 10 thousand dollars from connectivity income [2]. Figure 2 shows the growth estimate of this kind of networks.

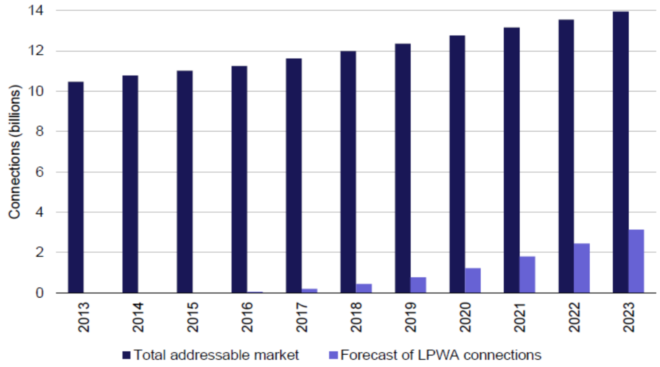

Fig. 2 – LPWA Growth Estimate. (source: [2]).

C. SIGFOX

SIGFOX provides end-to-end solutions to the communication chain of any company. Table 1 shows the features of SIGFOX technology.

TABLE 1

TECHNOLOGY SIGFOX FEATURES [3],[4]

Parameters	*Uplink*	*Downlink*
ISM Frequency [MHz]	[868 – 868.6]	[868.4 – 868.65]
Maximum Power [dBm]	14	27
Duty-cycle [%]	≤ 1	≤ 10
Modulation	BPSK	GFSK
Transmission [bit/s]	100	600
Messages Nr	140/day	4/day
Payload [bytes]	12	8
Radio Interface	UNB	
BW Channel [Hz]	100	-

III. PLANNING

A. Link Budget

For *link budget* calculus it is used the Friis Formula (1) and a Propagation Model (Okumura-Hata). Table 2 shows the link budget data and results, also describes the variables of Friis Formula (1).

$$S_R = P_E + G_E + G_R - M - L_P \qquad (1)$$

TABLE 2

DATA AND RESULTS OF LINK BUDGET CALCULUS.

Data	*Uplink*	*Downlink*
Sensibility (S_R)	-142 dBm	-126 dBm
Transmission Power (P_E)	14 dBm	-
Antenna Gain BTS / Sensor ($G_{R/E}$)	5 / 0 dBi	
Cables and Connectors Attenuation	3.6 dB	
Gain LNA	3.6 dB	
Coverage Margin (M)	20 dB	N.A
Attenuation of Propagation (L_P)	-	141 dB
Results		
Maximum Attenuation of Propagation		141 dB
BTS Power Transmission		27 dBm
Parameters for Propagation Models		
Frequency		869 MHz
BTS Real Height		50 m
Sensors Real Height		1 m
Lisbon Area		100.5 km^2
Results		
BTS Range (Urban)		3.13 km
BTS Coverage Area		25.5 km^2
Distance between BTSs		5.4 km

IV. SIMULATION

The simulations were made with CloudRF software [5]. Figure 3 shows five BTS used to cover the Lisbon area and the coverage level for each BTS. There is a coverage percentage over 95%. You can see an overpal of some BTS, which is good and purposeful, because SIGFOX uses it to minimize interferences between sensors.

Fig. 3 – Coverage with model Okumura-Hata.

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