Comparison Among Lora WAN And Other LPWAN Technologies

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Abstract*- The IoT (Internet of Things) requires the expansion of an invisible, intelligent network that can be controlled and programmed. The devices used on this network, use the embedded technology, which allows them to communicate either directly or indirectly by using the Internet infrastructure.These devices are energy-limited.So, the techniques of saving energy become a significant research need. TheLoRa-WAN is a Low Power WAN Protocol for Internet of Things. It is a data-link layer with long range, low power, and low bit rate.End-devices use LoRa to communicate with gateways through a single hop. While standard LPWAN (Low Power Wide Area Network) technologies covers a large market.This paper presents a comparison among LoRa-WAN and other LPWAN Technologies.*

Keywords- Internet of Things; IoT; LoRa; LoRaWAN; Sigfox; Long range; Low power

I. INTRODUCTION

Many IoT applications, especially in rural regions, need to span considerable range while consuming as little power as possible. LoRa modulation can achieve these goals by spreading the transmission spectrum, say125kHz, but limiting the throughput to a few kilobits per second at most.
The IoT technologies deployed for low power and wireless communications can be classified in the following low power categories: -

i) Low power local networks with a range smaller than 1000m - They are applicable to short-range networks, but when organized in a mesh topology, they can be applied to larger areas, i.e. IEEE 802.15.4, Bluetooth/LE (low energy), etc.

ii) LPWAN (Low power wide area networks) with a bandwidth exceeding 1000m. This category applies to low power cellular networks, where each base station covers thousands of end-devices, i.e. Sigfox, DASH7, etc.

A. LoRa and LoRa-WAN

“LoRa Technology allows data communication over a Long-Range while using very little power. When connected to a non-cellular LoRa WANTM network, LoRa devices accommodate a vast range of IoT applications by transmitting packets with important information. LoRa WAN fills the technology gap of cellular and Wi-Fi/BLE based networks that require either high bandwidth or high power or have a limited range or inability to penetrate deep indoor environments. In fact, “LoRa Technology is flexible for rural or indoor use cases in smart cities, smart homes and buildings, smart agriculture, smart metering, and smart supply chain and logistics”The advantage of LoRa lies in the technology that it has Long-Range capability. A single base station can cover hundreds of square kilometers, but the range is highly dependent on the environment or obstructions. LoRa modulation is based on spread spectrum techniques, and also a variation of the chirp spread spectrum (CSS) with integrated forward error correction (FEC). It operates in the lower Industrial, Scientific, and Medical (ISM) bandwidths (USA: 915MHz, EU: 433MHz and 868MHz). Many different protocol architectures such as Star, Mesh, and 6lowPAN can utilize the LoRa modulation. Furthermore, the LoRa Alliance has standardized the MAC protocol called LoRa WAN.

The LoRa WAN protocol is relatively new and became the focus of several research centers across the world. LoRa (Long Range) is a modulation technique that enables the Long-Range transfer of information with a low transfer rate. Semtech Corporation has patented the LoRa modulation. Lo-Ra is a type of SS- Spread Spectrum modulation, and the novelty of this technique consists of the use of a chirp signal that varies constantly with the frequency. The advantage of using this method is that the offset in time and frequency to the sender and receiver is the same, thus considerably reducing the complexity of the receiver [7]. A LoRa WAN network (Long Range Network Protocol) is of the Low Power Wide Area Network (LPWAN) type and encompasses battery powered devices that ensure bidirectional communication. The LoRa WAN specification ensures the perfect interoperability between the IoT objects, without the need for complex local implementations [8]. The LoRa network is implemented by using the star network topology. The structure of a LoRa architecture can be separated into a back-end and a front-end part. The back-end part consists of the network server that stores the information received from the sensors. The front-end consists of the Gateway modules and the end-device nodes. The Gateway modules act as a bridge between the end-device nodes and the network server. The information between the network server and the Gateway modules is sent through the IP connection. Fig. 1 presents the LoRa architecture.

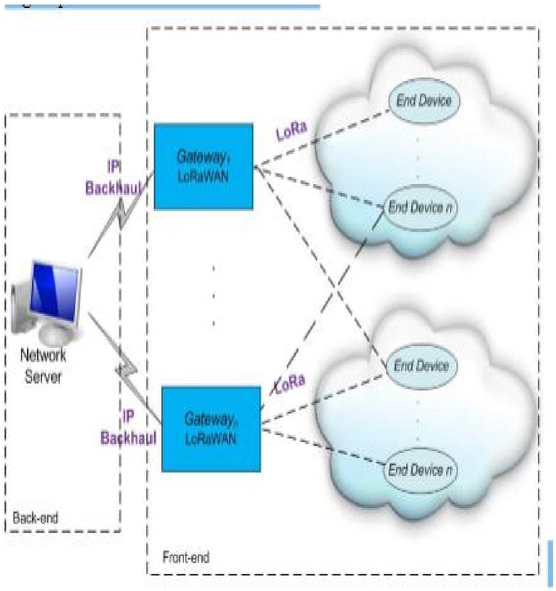

Figure 1LoRa architecture

The end-device modules do not have routing capabilities, and the messages are sent directly to the Gateway concentrator through a one-hop mechanism. The LoRa WAN technology transfer rates range between 0.3 kbps and 50 kbps. To maximize the battery life span, the devices manage their RF communication power and the transfer rate through an Adaptive Data Rate (ADR) mechanism.

A. Bluetooth/LE- With the proposal to replace cables to connect devices used with lower data rates (1Mbps maximum) in a short distance range (in theory, officially up to 100m) with low power consumption, emerged Bluetooth technology. After several releases, appeared the Bluetooth 4.0, i.e., the Bluetooth/LE that provides simpler pairing functions and higher data rate (24Mbps max, Wi-Fi-based) for a lower power consumption, with the purpose of connecting sensors and actuators on IoT environments [13].

B. DASH7- DASH7 is a protocol stack based on the interaction of the OSI model where sensors and actuators operate in the unlicensed bandwidth of 433MHz, 868MHz, and 915MHz [14]. DASH7 aims to provide communication over a range about up to 2km, with low latency, mobility support, multilayer battery, 128-bit AES encryption, and data rate up to 167Kbps. In addition, DASH7 defines the layered architecture, considering protocols from the physical up to the application layer.

C. Sigfox-Sigfox is a cellular system approach that allows end-devices connecting to base stations equipped with software-defined cognitive radios using the BPSK (Binary Phase Shift Keying) modulation[15]. It uses a frequency band of 868MHz, dividing the spectrum into 400 channels of 100Hz. Its coverage is about 30-50 km in rural areas and about 3-10 km in urban environments. An access point can manage around one million of end-devices and each end-device can send about 140 messages per day with a data rate of 100bps. Downlink communication can only precede uplink communication after each the enddevice must wait to hear a response from the base station which makes it interesting for data acquisition. However, for command and control scenarios, it is not interesting.

Together with LoRaWAN, SigFox is one of the most adopted LPWAN solutions. It is a proprietary UNB solution that operates in the 869 MHz (Europe) and 915 MHz (North America) bands. Its signal is extremely narrowband (100 Hz bandwidth). It is based on random frequency and time-division multiple access (RFTDMA) and achieves a data rate around 100 b/s in the uplink, with a maximum packet payload of 12 bytes, and a number of packets per device that cannot exceed 14 packets/day. These tough restrictions, together with a business model where SigFox owns the network, have somewhat shifted the interest to LoRaWAN, which is considered more flexible and open.

II. RELATED WORK

Zanella and et. al. state that the Internet of Things (IoT) is one of the most important topics in scientific and public media. The IoT fascinating idea of having billions of smart devices for sensing the real world is transforming the telecommunications research. Moreover, the interaction between the real world and its digital counterpart using secure and real-time technologies may lead to the solution of many issues related to smart cities, pollution monitoring, transportation, remote health care and more [1]-[3]. According to Xu L.D. et. al. when applied to the industrial automation, IoT paradigm is known also as I IoT (Industrial IoT), Cyber-physical Systems (CPS) or, more generically, as Industry 4.0, the new industrial revolution. Actually, Industry 4.0 term means the use of a series of enabling technologies (including machine-to machine -M2M- communication, real-time industrial communication, and big data analytics) for design, monitor and improve manufacturing process, allowing in a long term more efficient and more sustainable production [4]-[9].

Ascorti L. et. al. state clearly that wireless technologies play a major role in this situation [10]. According to Khan A. et. al. Industry 4.0 wireless applications typically need burst transmission, reduced overhead, and they use a pretty small amount of data per node; hence the bandwidth is not the main criterion. In some cases, large areas most be covered. On the contrary, reliability, availability,

III. STUDY AND FINDINGS

A. Bandwidth

Bandwidth and data rate are used to determine the amount of data, transfer (bit rate) in a given time unit, typically seconds. Bandwidth means the spectrum range in Hertz that a system can use for digital communication. The data rate depends on the bandwidth of the Internet connection. If the bandwidth is high, the bit rate tends to be high whether adequate digital communication technologies are employed. In LoRa WAN, the selection of data rate is by a trade-off between the communication range and the duration of the message. “Virtual” ducts (channels) are created with diversified data rates and without any interference due to spread spectrum technologies.

B. Battery Life

The technical and practical challenges facing energy storage for electronics in IoT cannot be met by anyone incumbent technology [12]. Cost, availability and convenience are the key factors which impose the things to have a power of non-rechargeable batteries. However, the need for replacement, limited energy resources and ecological implications will become a severe problem when powering billions of IoT devices, which employ non-rechargeable batteries as the primary energy storage. LoRa-WAN server controls the RF output (Radio-frequency) and an output rate through an adaptive scheme for each end device to maximize the life of the final device batteries.

The synchronization will consume significant energy and reduces battery life-time. Nodes are asynchronous and communicate with LoRa WAN network via events or previous scheduling. This observation is confirmed in Fig. 2. It presents the power consumption of some wireless communication technologies addressed in this study in purpose of the range coverage and, as may be seen, LoRa WAN covers the highest range with less power consumption, in comparison with Bluetooth/LE, Wi-Fi, and cellular networks. A recent research study performed by Scientific Research Publishing, Inc [16] revealed that LoRa WAN showed an advantage of 3 up to 5-fold in the energy economy compared to other LPWAN technologies.

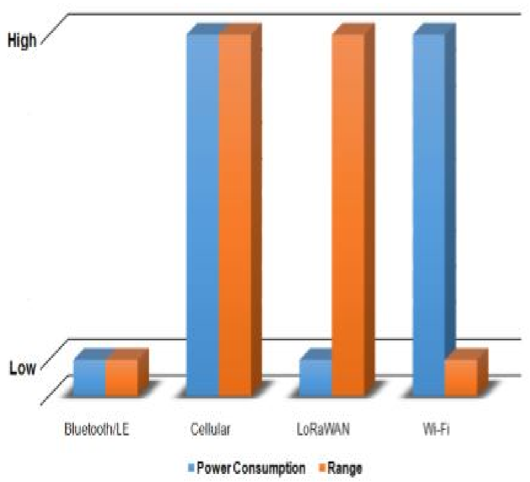

Fig.2 Power Consumption v/s Range for Bluetooth/LE, Cellular, LoRaWAN, and Wi-Fi technologies.

C. Range

New technologies have the objective to provide information access to the Internet to people/things away from the big metropolis. To attain superior distance, the power of the radio should be increased, causing larger consumption of the battery. Thus, new protocols aim to obtain greater distances with lower energy consumption, following green-energy approach. LoRa WAN and other protocols commercially dispute these ideals. Currently, this protocol attains about 2-5 km of coverage range in urban perimeters and about 45 km in rural areas.

D. Latency

Currently, applications (Apps) of social media demand strict requirements on latency. To build up the fifth generation (5G) architecture, one must rethink about how to employ limited resources to serve different kinds of traffic flows under different environments. There is a trade-off between downlink communication latency versus battery life. QoS classes in a LoRa WAN device resolve this.

E. Throughput

LoRa provides a throughput larger than technologies based in ALOHA, with low complexity in the MAC (Medium Access Control), however, LoRa is communicating over extensive range limited for different environments, i.e., 2-5 km urban and 45 km rural, with data rate between 290 bps and 50 kbps.

Several approaches are being used to benchmark LPWAN solutions commercially available. The NB-IoT (NarrowBandIoT) focuses specifically on indoor coverage when the LTE-M (LTE-MTC LPWA standard technology published by 3GPP) standard is employed to provide cellular connectivity for a wide range of end devices/sensors with low power consumption and high interoperability in IoT networks [20]. The LoRa-WAN protocol has several advantages over other LPWAN technologies, namely: the data rate ranges from 300bps up to 5 kbps (with 125 kHz bandwidth) and 11 Kbps (with 250 kHz bandwidth) allowing for better time-on-air and better battery life; communication is bidirectional and unlimited (subjects to ISM - industrial, scientific and medical band localregulations); native payload encryption able to create public and/or private networks; ADR (Adaptive Data Rate) enables base station addition on a scalable network, decreasing the ADR average and reducing time-on-air that, it is the time taken to send chips at the chip rate around it, allowing more end devices to communicate. In short, Sigfox may not be a feasible IoT protocol for fast-moving, since in performed experiments, it was shown that communication is unreliable at low speed, and resource constrained [21]. Thus, the IoT devices need to communicate at high data rates. Table II summarizes a comparison among the most promising LPWA technologies (LoRa WAN, Sigfox, NB-IoT and LTE-M) regarding security, capacity and battery life-time in order to decide the best for a generic application scenario.

TABLE I COMPARISON AMONG LORAWAN AND OTHER LPWAN TECHNOLOGIES.

Feature	LoRaWAN	Sigfox	NB-IoT	LTE-M
Modulation	SS Chirp	GFSK/ DBPSK	UNB/GFSK/ BPSK	OFDMA
Data Rate	290bps - 50kbps	100bps 12/8bytes Max	100bps 12/8bytes Max	200kbps - 1Mbps
Link Budget	154 dB	146 dB	151 dB	146 dB
Battery life-time	8 ∼ 10 years	7 ∼ 8 years	7 ∼ 8 years	1 ∼ 2 years
Power Efficiency	Very High	Very High	Very High	Medium
Security/ Authentication	Yes(32 bits)	Yes(16 bits)	No	Yes(32 bits)
Range	2-5km urban 15km suburban 45km rural	3-10km urban - 30-50km rural	1.5km urban - 20-40km rural	35km - 2G 200km - 3G 200km - 4G

Other LPWAN technologies, such as Weightless-N, Weightless-P from Weightless SIG, and RPMA (Random Phase Multiple Access technology) are also commercially deployed and being used to support specific vertical usecases. There are also several new 3GPP standards, such as EC-GSM, LTE-M, and NB-IoT that are currently being specified to enable future 3GPP networks of support the specific requirements and use-cases of the fast growing IoT markets in the upcoming years.

IV. CONCLUSION

This paper presents an analytical comparison among LoRa-WAN and other LPWAN protocols based on its architecture, battery lifetime, network capacity, and security. It is now clear that LoRa-WAN has an advantage of about 3 to 5-fold as compared to other LPWAN technologies regarding power consumption for long range communications. Moreover, LoRa-WAN networks can be deployed with a minimal amount of infrastructure and with the achieved capacity. In future, more gateways can be added to reduce the amount of overhearing to other gateways and subdivide the data rate. Hence, making the scalable network in 6 to 8-fold of the minimum capacity.

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