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Feasibility of Smart City Applications using LoRa WAN

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ABSTRACT: Recent research on Low Power Wide Area Network (LPWAN) technologies, which provide the capability of serving huge low power devices simultaneously has been very attractive. The LoRa(Long Range)WAN is one of the most successful expansions. Feasible replicas are seen in many countries around the world. However, the probability of largescale deployments, for example, for smart city applications need to be further explored. This project provides a comprehensive case study of LoRaWAN to show the feasibility, scalability, and reliability of LoRaWAN in realistic simulated scenarios, from technical perspectives. In this work use cases of two distinctive cities monitoring applications have been studied. The proposed scheme presents an analysis and develop business models for such networks in order to provide a guideline for commercial network operators, IoT merchants, and city organizers to explore future deployments of LoRaWAN for smart city applications.

KEYWORDS: IoT, Low-Power networks, LoRaWAN, case study, smart city.

I. INTRODUCTION

In this day and age, there is a lot of efforts on the study, analysis and discovery of new keys related to high density sensor networks which are used as part of the IoT (Internet of Things) concepts. It leads exploration of LoRa (Long Range) which is basically a modulation technique that enables the long-range transfer of information with a low transfer rate. It can be envisaged that LoRa will be an exciting technology area for smart cities for many years to come. The Internet of Things (IoT) paradigm refers to a network of interrelated things. The network is normally projected as the IP network and the things are devices, such as sensors and/or actuators, furnished with a telecommunication (predominately wireless) interface and with processing and storage units. In particular, the wireless IoT access system should provide improved indoor coverage, support for enormous number of low throughput devices, low delay sensitivity, and ultra-low device power consumption.

“LoRa Technology has revolutionized IoT by enabling data communication over a long range while using very little power. When connected to a non-cellular LoRa WAN TM network, LoRa devices accommodate a massive array of IoT applications by transmitting packets with important information. LoRa WAN fills the technology slit of cellular and Wi-Fi/BLE based networks that need either high bandwidth or high power, or have a limited range or incapability 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” [2]. Figure 1 shows clearly that LoRa has a greater power economical than Cellular or WiFi and therefore can attain a greater range or deeper in building coverage, by using a much lower data rate.

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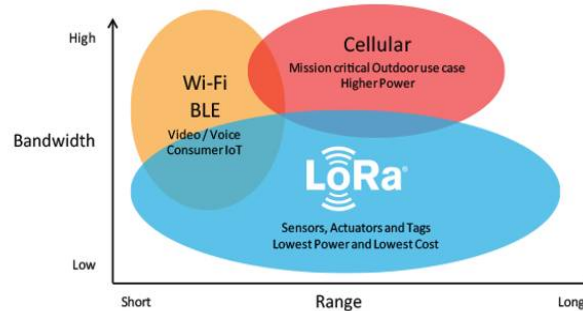


Figure1. Why is LoRa preferable?

II. LITERATURE REVIEW

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 IIoT (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 must be covered. On the contrary, reliability, availability, bounded latency for realtime behaviour, and energy efficiency are the key performance indicators [11].

III. APPROACHES

The project presented a comprehensive study on the feasibility of the LoRaWAN deployment for large city monitoring applications. Two realistic network deployments for the Greater London area based on the requirements of air quality and congestion monitoring have been simulated. The simulator is then used to evaluate the technical performance of the network. The connectivity study showed the capability of Lora WAN in smart home and neighbourhood applications. The performance of Lora WAN was studied and investigated in a vehicular scenario in Finland in 2015 [12]. In the experiment, the device in a moving car was used to upload vehicular data every 5 minutes to the base station located at the top of a building. Lora WAN has also attracted significant interest for commercial deployments. In South Korea, a large network covering 99% of the country's population is currently being deployed [13]. The network operator plans to offer LoRa-based IoT services at attractive prices. More large-scale projects are recently proposed or under consideration in France, Sweden, the UK, and many countries around the world. Realizing the increasing popularity and the commercial importance, this work presents a comprehensive study on the use of LoRaWAN from both the technical and economic perspectives. In particular, a realistic LoRaWAN network covering Greater London is designed using MATLAB. The system performances in terms of the feasibility, scalability, reliability, and cost-effectiveness are evaluated based on different city monitoring applications. The study provides a reference for future commercial LoRaWAN deployments.

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IV. RESULTS

At first we examine the feasibility of the designed network in term of power consumption when three different sized packets are uploaded with various upload frequencies. Fig. 5 depicts the relationship of battery life-time and upload frequency. As observed, when reporting a 20-byte measurement data in every 30 seconds, the end-device can work for around two years, powered only by two industrial AA batteries (2700mAh each). The lifetime increases with the transmission interval, and decreases as the payload size increases.

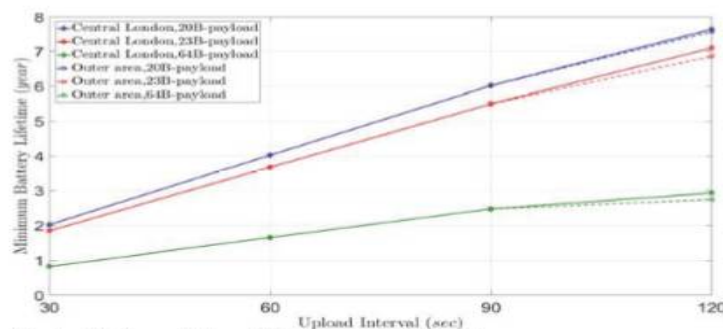


Fig. 5. Minimum battery lifetime vs upload interval.

Besides, because the conditions of wireless communication can vary more in the outer cells, a slightly lower battery lifetime is seen comparing with that of central cells. Based on the above experiments, we consider the network is feasible for ITS applications such as near real-time congestion monitoring, where the road-side devices measure and report the vehicle flow rate and average velocity. With the aid of the such data, advanced traffic-light control optimisation algorithms, as proposed in [17], can be apply to reduce the waiting time and gas emission. For air quality monitoring where retransmission is disabled and uploading interval is much longer, power can be saved by switching the LoRa modules to sleep mode for most of the time. An average of 9 years of battery life is attained for the enddevices in outer cells whereas in Central London it is 6 years. Comparing with the ideal life time of ten years as claimed in [18], we consider our results are acceptable in a realistic setting, and LoRaWAN is a capable low-power technology for such applications. For those devices used in the congestion monitoring, battery can drain faster. The devices operating in Central London and outer area will require battery changes after 2.02 years and 4.02 years, respectively. The percentage of the battery life-time spent in each operation mode is depicted in Fig. 6. As seen, most of the time has been spent in sleep mode, as expected. Approximately 0.3% of the time has been spent in transmission mode due to higher data rate, longer messages, and more frequent uploading. Similar amount of time is spent in idle mode for channel sensing.

V. CONCLUSION

We presented a comprehensive study on the feasibility of the LoRaWAN deployment for large city monitoring applications. Two realistic network deployments for the area based on the requirements of air quality and congestion monitoring have been simulated. The simulator is then used to evaluate the technical performance of the network. The results showed the potential of LoRaWAN as a workable low power long range ICT solution for smart cities. We also carried out a brief economic study and developed business models for the designed LoRaWAN considering different investment return plans. We envisage that LoRa will be an exciting technology area for smart cities for many years to come.

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