The Next Generation Architecture of Low Power Wide Area Network for Energy Platform

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Abstract— The low power wide area has a lot of attraction to research from many researchers in the world due to their ability to offer connectivity to low-power devices over a large area. With the Internet of Things (IoT) systems, the low-power wide area technologies contributed a critical position. It can be complemented and replaced the conventional wireless technologies for smart city, wireless sensor network, smart grid…. In this paper, we survey several LPWA technologies like Sigfox, LoRa, Narrow Bandwidth IoT… Besides that, we proposed the next generation architecture of LPWA network for energy platform using AI/Deep learning to reduce power consumption.

Keywords— LPWA; Low-power; Low-power Wide Area; Internet of Energy, IoE.

I. Introduction

Currently, the Internet of Thing promises to become the technology revolution in the world. It will help the world overcome the upcoming challenges such as: resource depletion, environmental pollution. Population… To adapt this mission, everything needs to connect, share information together to make the intelligent decision for ecosystems. In order to that, we need new communication technologies which use lower energy, longer transmitted distance, lower cost, and scalability. Low Power Wide Area (LPWA) networks shown the advantage compare to conventional techniques. It offers many unique features for IoT system: wide-area connectivity with low-power, low data rate devices, low-cost devices and making the easily scalable network. The market of LPWA devices is expected to be raised in a few years. Currently, approximately 7.5 billion of the overall 30 billion Internet of Thing and Machine to Machine devices [1] using LPWA technologies are connected to the Internet system using either proprietary or cellular technologies [2]. With the transmitting distance of tens of kilometers [3] and alive life of ten years or beyond, LPWA technologies are promising to be widely used in IoT system.

At this moment, the market has many LPWA technologies. The competition between each technology to achieve long distance, low power and low cost to become extremely fierce. Figure 1 highlights a variety of LPWA technologies.

The remainder of this paper consists of three sections which are structured as follow. In section II, we represent the overview of LPWA technologies. In this section, the characteristic of LoRa, Sigfox and Narrow Bandwidth IoT technologies will be proposed and highlighted. Section III represents the characteristics of LPWANs. In section IV, we proposed the next generation LPWA network using AI/Deep Learning to reduce the power consumption. The data will intelligently analyze the requests and extract the traffic pattern to transmit it to the resource for transmission control. A final section concludes the contribution of the paper.

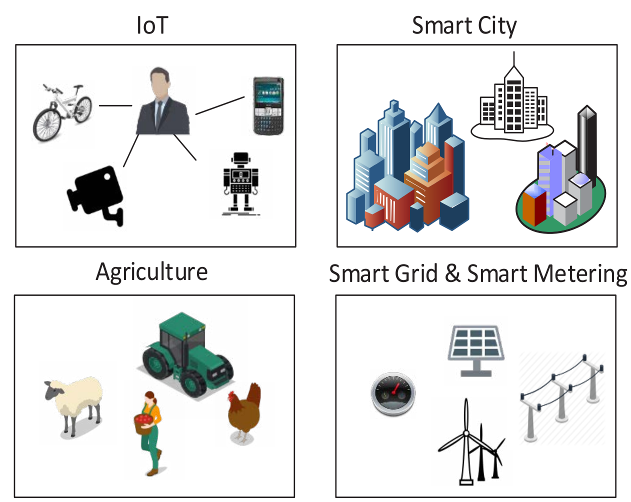

Figure 1. The applications of LPWA technologies

II. Overview of LPWA Technologies

A. Narrow-Band IoT

NB-IoT is one of LPWA technologies developed by a 3rd Generation Partnership Project (3GPP) which offer the flexibility of application by allowing the use of a small part of the spectrum. NB-IoT provides up to 50k devices per cell and the minimum bandwidth is required is 180kHz to set up communication. It can be operated as a single carrier with available spectrum exceeding 180kHz. It focuses on indoor application. NB-IoT uses Orthogonal-Frequency-Division-Multiplex Modulation for downlink and Single-carrier FDMA for uplink communications.

B. Sigfox

Sigfox deployed with two main modulations: the differential binary phase-shift keying (DBPSK) and the Gaussian Frequency Shift Keying (GFSK). In Europe, Sigfox enables communication using ISM radio band of 868MHz. With the United States, Sigfox employed with radio band of 902MHz. Sigfox uses a wide-reaching signal which can pass through easily solid objects. The topology network of Sigfox uses based on one-hop star topology [4]. Especially, the Sigfox signal can be used to easily transmit underground objects and cover large areas. According to the statistics of 2008 year, the Sigfox network has covered areas of 4.2 million square kilometers in the world and continue to increase.

C. LoRa

LoRa (Long Range) is a patent [5] of the digital wireless communication technology, which is developed by Cycleo of Grenoble, France and in 2012, it is acquired by Semtech in 2012. Lora is one of LPWA technology which is a long-range wireless communication protocol. It is created to competes with other LPWA network such as Sigfox, NB-IoT, LTE Cat M1. LoRa uses of frequency bands: 169MHz, 433MHz, 868MHz (in Europe) and 915MHz (in North America). With long-range transmission (more than 10km) and low-power consumption, LoRa shows it is a big challenge for other LPWA technologies.

Table 1. Comparison of LPWA technologies

Technologies	Non-3GPP		3GPP
	LoRa	Sigfox	NB-IoT
Modulation	CSS	BPSK	QPSK
Data rate	< 50 kbps	< 100 bps	< 200 Kbps
Coverage	< 20 km	< 13 km	1 km urban 10 km rural
Spectrum	Unlicensed (867-869 MHz, 802-928 MHz)	Unlicensed (900 MHz)	Licensed LTE frequency band
MAC	ALOHA MAC protocol	TDMA	SC-FDMA
Battery Life	< 10 years	> 10 years	< 10 years

III. Characteristics Of LPWANs

A. Long-Range Connectivity

The goal of LPWANs is to design the technologies which can cover wide-area at low cost and low power. The most of LPWA techniques [4] achieve long communication distance and using a star topology where the devices will communicate with the center device, called the base station(BS). Except to Ingenu RPMA (2.4GHz) [3], most of the non-cellular LPWANs deploy at low frequencies (sub-GHz band). With low frequencies, LPWA technologies offer long-range communication (a few kilometers in urban areas and tens of kilometers in rural areas) [4]. Low frequencies have better characteristics of propagation through objects.

B. Ultra Low Power

With IoT devices, it is expected to deploy with a long time but does not need to replace the battery. To achieve low-power operation, most of LPWA technologies usually form a star topology, which can reduce the power consumption through the routing protocol in multi-hop networks. In addition, the nodes are designed simply by decreasing the complexities to the base station or gateway. And in particular, LPWA technologies use narrowband channels to reduce the noise and increase the transmission distance [5][6].

C. Low Cost

LPWA technologies focus on not only the low-power operation and long range but also the low cost [7]. Without requiring infrastructure and operation on unlicensed spectrum help LPWA technologies offering an excellent alternative to cellular networks. The simplicity of hardware makes LPWANs having affordable.

D. Scalability

LPWANs usually avoid the multi-hop topology. Besides that, it deploys narrow bandwidth [8] to offer a large number of devices to utilize limited spectrums efficiently. In addition, it uses multiple antennas at the base station to support a massive number of nodes.

IV. The Next Generation Architecture of LPWA Network For Energy Platform

Figure 2 shows the architecture of the Intelligent Low Power Wide Area Network using AI/Deep Learning for gateway management to reduce device power consumption. The overall architecture of communication based on LPWA technologies with an unlicensed spectrum (Sigfox, LoRa) and other LPWA technologies proposed by 3GPP working with licensed spectrum (NB-IoT, LTE-M). The network system is divided into three sub-systems: Device management, IoE gateway and Intelligent LPWA using AI/Deep Learning. LPWA network will be used to make a connection among IoE device, the router device and gateway.

In Intelligent LPWA architecture, we define: Definition of the wireless communication to connect IoE service including cellular-communication, unlicensed and licensed spectrum. Definition of AI algorithm to provide the smart control of wireless communication technology, intelligent application, and some IoE service. Definition of Software-defined networking (SDN) architecture technology to improve network performance and monitoring.

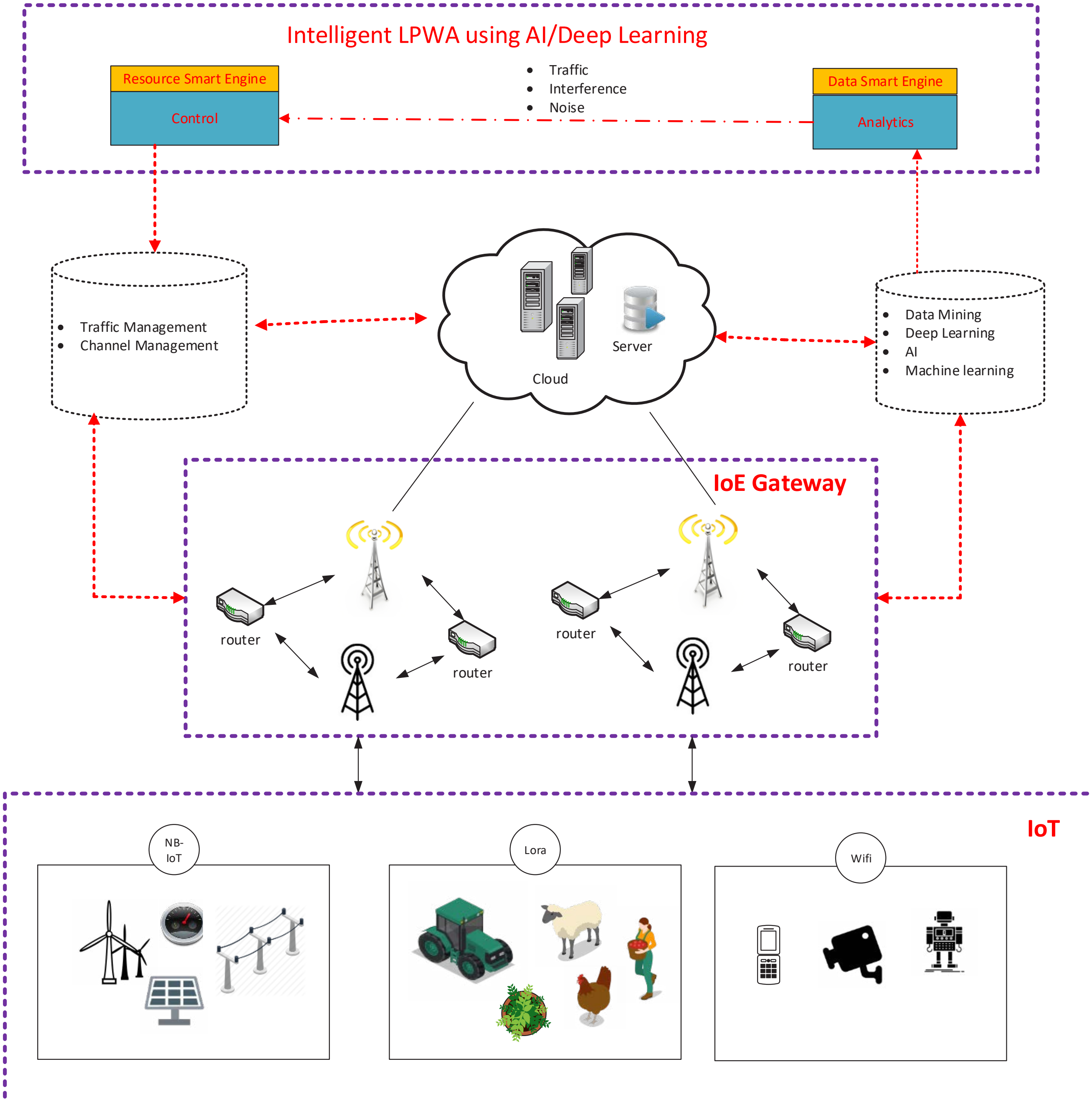

Figure 2. Overview the next generation architecture of LPWA network for Energy Platform

The first sub-system is IoT system. They collect, measurement the data in the network and sends it to IoE gateway. When a user or device in the IoT sends the data to Gateway. The data flow is transferred to Cloud or Server by 3G, LTE, 5G or other technologies. At the same time, the data is thrown over the Intelligent LPWA using AI/Deep learning to analyze. When the Edge Cloud computing node admits requests, the devices launching the requests and determine what type of LPWA wireless communication technology will be adapted to the information back. The service requests will be forwarded to the Cloud by the Edge Cloud computing node and all the information contained in the business flow will also be deal by the engine in each compute node including the application requests, contents requests, data volume, communication capacity, user mobility and transmission rate. The returning information (business content and control information) includes LPWA technology selection, content feedback, service feedback and real-time monitoring. By using AI/Deep Learning to LPWA network, the power of the system is reduced and the interference between another network will be decreased. Therefore, the performance LPWA network is improved simultaneously to reduce device consumption.

The intelligent management is divided into two types, the data engine management and resource engine management. Data engine management: processing the real-time in the network environment, with data analysis and processing power, executing the business logic intelligently, and realizing the cognition to the business data and resource data through modeling method. This includes data mining, machine learning, deep learning and artificial intelligence. The resource engine management can distinguish the computing data, communication data and network data of edge cloud, remote cloud and make the real-time feedback of the resource data to the data engine management. The analysis results of the data engine are received to guide the selection the LPWA technologies and dynamic optimization in real-time and allocation of resource.

V. Conclusion

In this paper, we represented the overview of some LPWA technologies as LoRa, Sigfox, Narrowband-IoT as well as mention about the advantage of each LPWA technologies. In addition, the characteristics (low-cost, long-range connectivity, low-power, and scalability) of LPWA technologies are mentioned to clarify the advantage of LPWANs compare to the conventional technologies. Besides that, the next generation architecture of LPWA networks is proposed with using AI/Deep Learning. The new architecture reduces the power consumption of devices.

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References

[1] Usman Raza, Parag Kulkarni, and Mahesh Sooriyabandara, "*Low Power Wide Area Networks: An Overview*" in IEEE communication survey & tutorials, Volume: 19 , Issue: 2 , Second quarter 2017)

[2] "*LTE evolution for IoT connectivity*," Nokia, Espoo, Finland, Tech. Rep. C401-012006-WP-201606-1-EN, 2016. [Online]. Available: http://resources.alcatel-lucent.com/asset/200178.

[3] J. Petajajarvi, K. Mikhaylov, A. Roivainen, T. Hanninen, and M. Pettissalo, "*On the coverage of LPWANs: Range evaluation and channel attenuation model for LoRa technology*," in Proc. 14th Int. Conf. ITS Telecommun. (ITST), Copenhagen, Denmark, Dec. 2015, pp. 55–59

[4] Dali Ismail, Mahbubur Rahman, Abusayeed Saifullah,"*Low-Power Wide-Area Networks: Opportunities, Challenges, and Directions*", in Proceedings of the Workshop Program of the 19th International Conference on Distributed Computing and Networking Article, January 2018.

[5] A. Saifull, M. Rahman, D. Ismail, C. Lu, R. Chandra, and J. Liu. 2016. SNOW: "*Sensor Network over White Spaces*". In SenSys '16. ACM, 272–285.

[6] Y-P E. Wg, X. Lin, A. Adhikary, A. Grovlen, Y. Sui, Y. Blankenship, J. Bergman, and H S Razaghi. "*A primer on 3gpp narrowband internet of things*". IEEE Comm. Magazine 55, 3 (2017), 117–123.

[7] Zhijin Qin, Frank Y. Li, Geoffrey Ye Li, Julie A. McCann, Qiang Ni, "*Low-Power Wide-Area Networks for Sustainable IoT,"* IEEE Wireless Communications (2018).

[8] Yonghua Song,Jin Lin, Ming Tang, Shufeng Dong,"*An Internet of Energy Things Based on Wireless LPWAN*", Engineering Journal, Volume 3, Issue 4, August 2017, Pages 460-466