Do IoT LoRa Networks Support Emergency Evacuation Systems ?

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***Abstract*—The number of building sites increased considerably these few last years. Emerging countries invest more and more in building and construction sites to overcome the need of citizens like education, residential and administration buildings. Such sites should be equipped with evacuation systems to allow bricklayers and other persons to be evacuated quickly. Furthermore, evacuation systems should communicate with each other to coordinate evacuation of people in the case of an emergency. One of the most important problem of such systems is the need of a powerful wireless network with sufficient range that could make communication in large sites of several square kilometers. The lack of such mechanisms makes the life of billion of citizens in a danger. This problem could be addressed by building a novel evacuation emergency application in Internet of Things (IoT) devices with Low Power Wide Area Networks ($LPWAN$). One of the known $LPWAN$ networks is Long Range ($LoRa$) network. To overcome the need of peer to peer communication between devices, IEEE.802.15.4 technology and particulary 6LowPAN could be used to allow devices to communicate in a mesh network. Our work is motivated by the deployment of an Emergency Evacuation Systems (EES) in building sites. Our goal is to give an overview of the application of IEEE.802.15.4 and LoRa technologies in EES and adapt their configurations to the emergency situation of the site.**

***Keywords*—Emergency Evacuation Systems, LoRa, LoRaWAN network, 6LowPAN, Building sites.**

I. INTRODUCTION

Modern and even old cities have several issues regarding building management, urban mobility and disaster recovery, which can be supported by IoT applications. Actually, different kinds of services appear to help city management by automating tasks and predicting critical situations before they occur. EES for example could help to locate survivors and plans for rescue missions in case of disasters.

EES require high quality level of communication to ensure their proper operations in critical situations. This constraint is more complex when devices need to communicate in a large area like building sites. Thus, the need for a new kind of network technology that could transmit data with a long range and sufficient Data Rate (DR) is very challenging.

First the architecture that we propose are based on three component, IoT devices, smart gateway and edge computing server. IoT applications, especially emergency ones in case of disasters, require data to be received and bounded in time intervals. Hence, the orchestration algorithms should adapt the network configuration to the emergency situation of the site. Furthermore, the delay to adapt network behavior to the emergency situation has to be optimized to react quickly when an alarm is triggered. For this reason, we opt for the use of an edge computing and a smart gateway which could map transmission tuning to the emergency state.

This paper is organized as follows. Section II elucidates summary of related works. Section III highlights the required network technologies that could be used in EES. In Section IV, we propose our architecture scheme for EES. Section V concludes this paper.

II. RELATED WORK

Both research and academic research areas are paying more and more attention in EES, this particular attention is mainly due to the interest of building companies to weaponize their building by IoT devices that are able to communicate to converge to the best evacuation management. For example, finding the path that allows rescues to get out of the building in a short time depending on their initial locations.

The main factors of a good deployment of such systems is the quality of the network that makes all emergency agents communicate and collaborate to make good decisions.

For example, Qiu,et al [1] proposed an emergency response system with sensor nodes for real time applications. They proposed an iterative method to minimize transmission delay and maximize packet delivery ratio Authors tried also to find a trade-off between the increased energy consumption and the reduced network lifetime. The framework proposed by F. Al-Turjman [2] is a multi hop routing method for disaster management in real time.

To achieve better performance, the architecture proposed in this paper is designed for using i) limited multiple hops (mesh topology) when the application requires a peer to peer communication with a high energy cumsumption, and ii) a one hope communication (star topology) when the application requires a low energy cumsumption.

III. BACKGROUND

To select the wireless communication that best fit smart building application requirements, four main parameters are generally used: (i) cost; (ii) data rate; (iii) autonomy and (iv) communication range [3]. Each technology has its Carrier Frequency (CF), Coding Rate (CR) and Bandwidth (BW)

Characteristics	$CF_{[Hz]}$	**6LoWPAN**	**LoRaWAN**
Modulation	2.4G	O-QPSK	-
	915M	BPSK	LoRa
	868M	BPSK	LoRa/GFSK
Channels	2.4G	16	-
	915M	10	64+8 (up), 8(down)
	868M	1	10
$CF_{[MHz]}$	2.4G		-
	915M	902-929	902-928
	868M	868-868.6	863-870 and 780
$BW_{[Hz]}$	2.4G	5M	-
	915M	2M	125K-500K
	868M	600M	125K-250K
$DR_{[bps]}$	2.4G	250M	-
	915M	40M	980-21.9K
			FSK: 50K
$CR_{[dBm]}$	2.4G	-85	-
	915M	-92	
	868M	-92	-137

TABLE I: LoRa and 6LowPAN characteristics [4].

which are compiled in the table below. As data rate and communication range are inversely proportional to autonomy, devices need to consume more energy to communicate at higher bit rates and longer distances. IoT devices in emerging evaluation system are particularly vulnerable to power consumption. This vulnerability is mainly due to the awareness aspect of their task and the need to be powered all the time without carrying about battery level for a long period of time.

Table 1 compiles the two promising standards used in smart building applications, notably LoRa and 6LowPAN.

IV. Architecture

Research in IoT field usually pay attention to energy consumption by optimizing the data transmission rate or by aggregating the data. However, in an urgent situation like a disaster monitoring service, data accuracy becomes very important. Furthermore, these data are required to achieve the network server quickly over Constrained Application Protocol ($CoAP$) or Message Queuing Telemetry Transport ($MQTT$) as shown in Figure 1 and 2 to make the appropriate decisions to evacuate people. For this reason, we use an edge computing server that receives data from IoT devices by means of IEEE.802.15.4 and LoRa technologies. This requires to make the LoRa gateway able to forward received packets to the IEEE802.15.4 border router and vice versa. The most known network server used for LoRa network are The things network (TTN) and KPN. Their role is to remotely adapt the transmission behavior of end-devices to the emergency situation at each time.

V. Conclusion

$LPWAN$, Wireless Sensor Network (WSN) and IoT architecture are the first candidates to ensure disaster monitoring and management systems. Particularly, IEEE802.15.4 and LoRa networks give new insight for effective EES. This work gives an overview of deployment of IoT architecture for EES. Such services and demand for edge computing in real-time poses new architectural and service orchestration challenges. As a future work, we plan to study the efficiency of using a reinforcement learning to adapt these two networks to the emergency situation of the building.

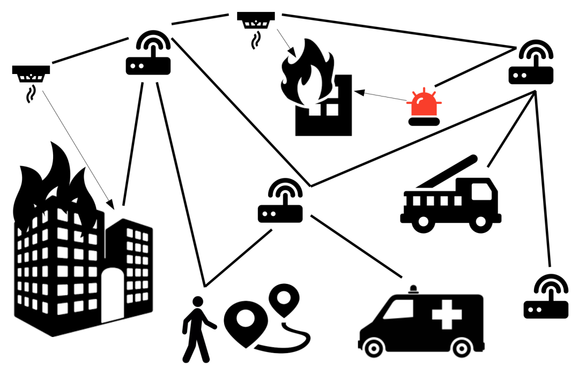

Fig. 1: EES architecture.

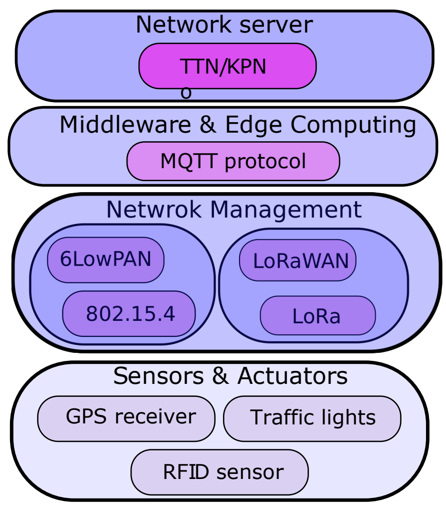

Fig. 2: EES network layers [5]

References

[1] T. Qiu, Y. Lv, F. Xia, N. Chen, J. Wan, and A. Tolba, “ERGID: An efficient routing protocol for emergency response Internet of Things,” *Journal of Network and Computer Applications*, vol. 72, pp. 104–112, Sep. 2016, 00052.

[2] F. Al-Turjman, “Cognitive routing protocol for disaster-inspired Internet of Things,” *Future Generation Computer Systems*, vol. 92, pp. 1103–1115, Mar. 2019, 00050.

[3] S. I. Lopes, F. Pereira, J. M. N. Vieira, N. B. Carvalho, and A. Curado, “Design of Compact LoRa Devices for Smart Building Applications,” in *Green Energy and Networking*, J. L. Afonso, V. Monteiro, and J. G. Pinto, Eds., vol. 269, 00000, Cham: Springer International Publishing, 2019, pp. 142–153.

[4] H. A. A. Al-Kashoash and A. H. Kemp, “Comparison of 6LoWPAN and LPWAN for the Internet of Things,” *Australian Journal of Electrical and Electronics Engineering*, vol. 13, no. 4, pp. 268–274, Oct. 2016, 00010.

[5] R. Zitouni, J. Petit, A. Djoudi, and L. George, “Iot-based urban traffic-light control: Modelling, prototyping and evaluation of MQTT protocol,” pp. 182–189, 2019.