



HAL
open science

Do IoT LoRa Networks Support Emergency Evacuation Systems ?

Aghiles Djoudi, Rafik Zitouni, Nawel Zangar, Laurent George

► **To cite this version:**

Aghiles Djoudi, Rafik Zitouni, Nawel Zangar, Laurent George. Do IoT LoRa Networks Support Emergency Evacuation Systems ?. The 6th International Conference on Information and Communication Technologies for Disaster Management (ICT-DM), Dec 2019, paris, France. 10.1109/ICT-DM47966.2019.9032911 . hal-03575134

HAL Id: hal-03575134

<https://hal.science/hal-03575134v1>

Submitted on 15 Feb 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Do IoT LoRa Networks Support Emergency Evacuation Systems ?

Aghiles Djoudi^{1,2}, Rafik Zitouni², Nawel Zangar¹ and Laurent George¹

¹LIGM, UMR 8049, École des Ponts, UPEM, ESIEE Paris, CNRS,UPE, France

²ECE Research Lab Paris, 37 Quai de Grenelle, 75015 Paris, France

Email: {aghiles.djoudi, nawel.zangar, laurent.george}@esiee.fr, rafik.zitouni@ece.fr

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. 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 particularly 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.

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.

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 hop 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 [1]. Each technology has its Carrier Frequency (*CF*), Coding Rate (*CR*) and Bandwidth (*BW*) which are compiled in the table below. As data rate and communication range are inversely proportional to autonomy, devices

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

TABLE I: LoRa and 6LowPAN characteristics [2].

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

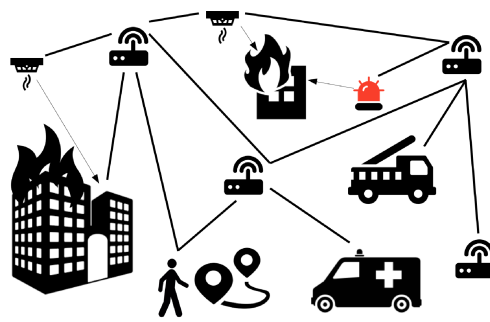


Fig. 1: *EES* architecture.

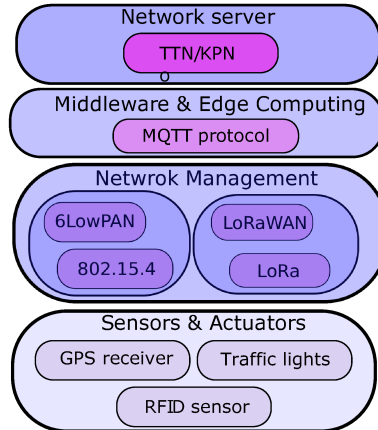


Fig. 2: *EES* network layers [3]

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.

REFERENCES

- [1] 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.
- [2] 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.
- [3] 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.