1 | Emergency Evacuation System

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 emergency of people. One of the most important problem of such systems is the need of a powerful network technology with sufficient range that could make communication in sites of several kilometers squares. The lack of such mechanisms make the life of billion 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. Our work is motivated by the deployment of an Emergency Evacuation Systems (EES) in building sites. Our goal is to measure the Quality of Service (QoS) of IEEE.802.15.4 and LoRa technologies and adapt their configurations to the emergency situation of the site.

1 Introduction

Modern and even old cities have several issues regarding building management, urban mobility, 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 powerful 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. So, service orchestrations is an important rigid constraint. 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 2 elucidates summary of related works. Section 3 highlights the required network technologies that could be used in EES. In Section 4, we propose our architecture scheme for EES. Section 5 concludes this paper.

2 Related work

Research communities are paying more and more attention for EES, this particular attention is mainly due to the interest of building companies to deploy smart sensors in their construction sites.

The main factors of a good deployment of such systems is about the quality of the network that makes all emergency agents communicate and collaborate to make good decisions. In another hand, the need of population of new tools to deal with the permanently dynamic changes of pedestrian and car paths in their city, becomes very challenging. For example, Qiu, et al [1] proposed an emergency response system with sensor nodes for real time application they proposed an iterative method for delay optimizing with the lossless transmission, authors tried to find a trade-off between the increased energy consumption and the reduced network lifetime. The framework proposed in by Al Turjman, et al [2] is a multi hop routing method for disaster management in real time. To achieve a higher efficiency, the system, they propose, is designed for using limited multiple hops with the help of left over energy may sometimes result with loss of data due the exhausted energy level.

3 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 **lopes_design_2019**. As data rate and communication range are inversely proportional to autonomy, devices need to consume more energy to communicate at higher bit rates and greater 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 more promising standards that are being used in smart building applications, notably LoRa and 6LowPan.

Carrier Frequency (*CF*) *DR* Coding Rate (*CR*) Bandwidth (*BW*)

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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↑, 8↓
	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
	868M	20M	LoRa: 0.3K-37.5K
			FSK: 50K
$CR_{[dBm]}$	2.4G	-85	-
	915M	-92	✗
	868M	-92	-137

Table 1.1. LoRa and 6LowPAN characteristics [3].

4 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 **??** 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.

Figure 1. IoT architecture.

5 Conclusion

$LPWAN$, Wireless Sensor Network (WSN) and IoT architecture are the first candidates to enhanced disaster monitoring and management systems. Particularly, IEEE802.15.4 and LoRa networks gives 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,m we plan to study the efficiency of using artificial intelligence/machine learning to adapt these two networks to the emergency situation of the building.

Bibliography

[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] 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, 00000.