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Internet of Things-Based Emergency Response Management

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ABSTRACT

Disaster leads to huge destruction in terms of economic and human lives. While several technologies are available to cater disaster's occurrence, the Internet of Things (IoT) paradigm has opened a promising door toward dealing with disasters. This article proposes IoT-based emergency response management, which is a standalone system that enables wireless connection to trapped survivors, and to the Internet or any extended network during emergency relief operations. The system integrates heterogeneous wireless devices and various communicating technologies to enable end-to-end network connectivity, which is monitored by a cloud IoT platform. The collected data is then pushed to the control center using multi hop device-to-device communication. The overall system performance was evaluated according to relevant metrics including end-to-end link quality estimation, throughput, and delay.

KEYWORDS

Edge Computing, Emergency Response, Internet of Things, Smart City

INTRODUCTION

Disaster is incident that occurs in a sudden manner, complex in nature, resulting in a loss of lives, damages to property or the environment as well as affecting the daily activities of local community. Floods are the major natural disaster threat facing Malaysia. Landslides and droughts are also significant, although most prevalent in the Eastern part of the country. Disaster management has consistently been a focus of Malaysia's development policy. Malaysia's National Platform for DRR was formalized in 2013, which involved various stakeholders from the whole of government, as well as the private sector. This is evident by the amount of resources provided to minimize risk factors and facilitate sustainable development. Malaysia's 11th version of the Five-Year Plan (2016-2020) focuses on strengthening disaster risk management across five phases (prevention, mitigation, preparedness, response and recovery).

The financial impact due to natural and man-made disasters is paramount. However, the impact and loses of disaster can be reduced through effective management of disaster information. The effective management means a prompt action by the emergency response units to reach disaster area supported by appropriate and accurate information. Information of moving object such as police cars, ambulances and fire trucks become important to drive the analyzing task including connectivity analysis. Although GIS application has been used in disaster management, it was designed for individual usage such as evacuation (Pu & Zlatanova, 2005), and different phases of disaster such as mitigation and preparedness and monitoring/visualization (Rauschert, Sharma, Fuhrmann, Maceachren, & Wang, 2002), or only for specific task. During disaster relief operations, two relevant

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challenges arise; setting up an immediate emergency wireless network to interconnect on the field rescuers with trapped survivors and relaying the emergency network to the Internet and extended networks. Such catastrophes' relief operations are impossible to conduct without an alternative data communication system immediately deployable and operational.

Around the world, IoT is playing a huge role in increasing the efficiency and effectiveness of emergency response systems, thus saving lives and making cities safer. Ben Arbia et al. (Arbia, Alam, Kadri, Hamida, & Attia, 2017) developed an emergency and disaster relief system using heterogeneous wireless devices such as Raspberry Pi, smart phones, sensors and various communicating technologies (Wi-Fi and Bluetooth) which was then monitored by a cloud IoT platform. The challenges in a wireless autonomous communication system to offload data from the disaster area (rescuers, trapped victims, civilians, media, etc.) back to a command center were studied. Equally important, the motion detection and links' unavailability prevention based on the recorded data where the main factors (i.e., interference and noise) that affect the performance were also analyzed. Meanwhile, Asensio et. al. (Asensio, Blanco, Blasco, Marco, & Casas, 2015) proposed Smart Signal, to offer the best message to the user, and as a ubiquitous element that contributes with information to the city. Meanwhile, Poslad et. al. (Poslad et al., 2015) presented an IoT early warning system framework based upon a multisemantic representation model that addresses the challenges faced during practical deployments such as scalable time-sensitive data exchange and processing and the need for resilience to changing ICT resource constraints in crisis zones.

Not only disaster situation, fire management system is of importance and part of emergency response system. For this reason, Asensio et al. (Asensio et al., 2015) proposed a decision support tool for the emergency fire management system which integrated the formation and management of Virtual Objects derived from real world physical objects and are virtually connected with each other into the semantic ontology model. A log repository collected all the emergency fire incident logs from Virtual Objects and stored them in a repository. On the other hand, Shamszaman et. al. (Shamszaman, Ara, Chong, & Jeong, 2014) developed an emergency fire management system in the Web of Objects infrastructure.

RELATED WORKS

The proposed emergency response management system is a set of wireless distributed devices equipped with wireless sensors intended to collect real time data such as locations and ambient intelligence, from LoRa nodes as the edge computing element connected to IoT cloud platform. LoRa nodes were developed using a long range; low power, low bit rate and single hop wireless communication technology with low throughput requirements. It is designed to allow low powered devices to communicate with Internet connected applications over long-range wireless connections. Low power wireless networks are a key enabler for the IoT.

Figure 1 depicts the overall architecture of the emergency system response network topology comprising end devices, local controllers, and cloud-based servers used in the proposed system. LoRa RFM95 was used as end devices to be placed at each residential area or local community. The LoRa sensors networks were connected wirelessly to Arduino ESP8266, which were the LoRa gateways.

LoRa Sensors

RFM LoRa Shield (Figure 2) were used as LoRa sensors. It is an Arduino shield which integrates RFM95W LoRa module and based on Open Source Library with any Arduino. It is compatible with Arduino Uno, Arduino Duemilanove, Arduino Mega2560, Arduino Leonardo and possibly other pin compatible main boards.

RFM Lora Shield allows users to send data and reach extremely long ranges at low data-rates. It provides ultra-long range spread spectrum communication and high interference immunity whilst

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